S. HRG. 112–16

DROUGHT AND CLIMATE CHANGE ON WATER RESOURCES

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED TWELFTH CONGRESS

FIRST SESSION

TO

RECEIVE TESTIMONY ON THE CURRENT DROUGHT CONDITIONS AFFECTING NEW MEXICO AND THE STATUS OF REPORTS TO BE ISSUED PURSUANT TO SECTIONS 9503 AND 9506 OF THE SECURE WATER ACT REGARDING A REVIEW OF THE CURRENT SCIENTIFIC UNDERSTANDING OF THE IMPACTS OF CLIMATE CHANGE ON WATER RESOURCES AND AN ASSESSMENT OF THE RISKS ASSOCIATED WITH CLIMATE CHANGE ON WATER RESOURCES IN CERTAIN RIVER BASINS

SANTA FE, NM, APRIL 27, 2011

Printed for the use of the
Committee on Energy and Natural Resources

U.S. GOVERNMENT PRINTING OFFICE

66–455 PDF WASHINGTON : 2011

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

COMMITTEE ON ENERGY AND NATURAL RESOURCES

JEFF BINGAMAN, New Mexico, *Chairman*

RON WYDEN, Oregon
TIM JOHNSON, South Dakota
MARY L. LANDRIEU, Louisiana
MARIA CANTWELL, Washington
BERNARD SANDERS, Vermont
DEBBIE STABENOW, Michigan
MARK UDALL, Colorado
JEANNE SHAHEEN, New Hampshire
AL FRANKEN, Minnesota
JOE MANCHIN, III, West Virginia
CHRISTOPHER A. COONS, Delaware

LISA MURKOWSKI, Alaska
RICHARD BURR, North Carolina
JOHN BARRASSO, Wyoming
JAMES E. RISCH, Idaho
MIKE LEE, Utah
RAND PAUL, Kentucky
DANIEL COATS, Indiana
ROB PORTMAN, Ohio
JOHN HOEVEN, North Dakota
BOB CORKER, Tennessee

ROBERT M. SIMON, *Staff Director*
SAM E. FOWLER, *Chief Counsel*
MCKIE CAMPBELL, *Republican Staff Director*
KAREN K. BILLUPS, *Republican Chief Counsel*

CONTENTS

STATEMENTS

APPENDIX

DROUGHT AND CLIMATE CHANGE ON WATER RESOURCES

WEDNESDAY, APRIL 27, 2011

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Santa Fe, NM.

The committee met, pursuant to notice, at 1:30 p.m., at Santa Fe Convention and Visitors Center, Hon. Jeff Bingaman, chairman, presiding.

OPENING STATEMENT OF HON. JEFF BINGAMAN, U.S. SENATOR FROM NEW MEXICO

The CHAIRMAN. Thank you all for being here. This is a hearing of the Senate Energy and Natural Resources Committee. It's a field hearing. The hearing is to focus on two related subjects. Let me, before I really get into this, give a little description of what we're going to try to do here or talk about.

Let me thank the city of Santa Fe for allowing us to use this wonderful facility. Councilor Bushee is here. Where is she? I saw her here earlier. Thank you for being here and thanks for letting us use this. City Manager Robert Romero is here. We appreciate him being here and the use of the facility as well and all the rest of the city council and the mayor.

The hearing will focus on two related subjects. First we'll hear about the serious drought conditions that are now affecting New Mexico. Despite receiving a little moisture over the past few days at least in some parts of the State, the majority of the State is experiencing a severe drought that has impacted irrigation and municipal and environmental water supplies.

The current Drought Monitor maps indicate that no part of New Mexico is without impacts. The southern one-third of the State is experiencing extreme drought conditions, having had little or no rainfall for several months.

Below normal precipitation and snow pack resulted in flows in the Rio Grande that are forecast to be 39 percent of normal. Irrigators will have to use more water from storage this year than was otherwise expected.

Some municipalities such as the city of Las Vegas will come close to using up a majority of their existing supplies. Environmental flows will also be impacted because of the natural flows in many of the State's stream systems being reduced.

Challenges due to an increased population, environmental demands, and climate change as well are present even during our normal water years. The drought conditions that we're experi-

encing at this time make the ongoing stresses even more difficult to manage.

The current drought provides an incentive for New Mexicans to continue the collaborative efforts that already exist in many basins. For example, water users will have to work together with the Bureau of Reclamation this year to meet the flow requirements called for in the Biological Opinion for the endangered silvery minnow in the Lower Rio Grande area.

Communities throughout the State will need to continue to engage in water planning activities and water conservation efforts. Cooperative efforts such as water banking and shortage sharing agreements will be essential tools to help communities maintain economic stability even in times of drought.

Maintaining cooperation between Federal, State, and local entities to address emergency situations such as fires will be all the more important. So I'm looking forward to hearing testimony on all of the efforts that are underway to address the current drought situation. That will be the subject primarily of our first panel.

The second panel of witnesses will focus on the impacts of climate change on water supplies and will highlight a report issued by the Bureau of Reclamation earlier this week in response to the SECURE Water Act requirement that Congress enacted in 2009.

I would just say for purposes of anybody here in the audience or watching this that that entire report by the Bureau of Reclamation is available on the Bureau of Reclamation web site USBR dot gov. So I recommend any of you who want to, go on there and download that and print it for yourselves, if you'd like.

This issue has been receiving increased attention recently in part due to shortage conditions on the Colorado River. But research has been ongoing for several years. New Mexico's national laboratories and universities are engaged in cutting edge scientific research to help us better understand the potential effects of climate change on our water supplies and to learn how to better manage our existing resources.

For example, researchers at New Mexico State University are studying the resilience of the acequia communities to climate change. Sandia National Laboratory has scientists collaborating on decision support tools to enable water managers to make informed decisions about water uses in the face of an uncertain future.

I'm very glad that the Bureau of Reclamation has completed the report required by the SECURE Water Act. I'm looking forward to hearing about the status of the science on the effects that climate change may have on water supplies.

I'm also interested in hearing about adaptation measures that can be taken to mitigate against negative effects. Even a quick look at the information being presented today indicates that temperatures are rising, precipitation is expected to decrease.

The current conditions emphasize the need to support the efforts to develop a sustainable water supply for the country through the WaterSMART Program which the administration has in place.

So again thanks to everyone for being here today. Let me briefly introduce our first panel of witnesses and then have them go ahead with their testimony.

Dr. David DuBois is the New Mexico State Climatologist. He is here today to give us his views. Esteven Lopez, of course, is Director of the Interstate Stream Commission. Esteven, thank you very much for being here. Corbin Newman is the Regional Forester for the U.S. Forest Service.

If each of you could take a few minutes and tell us the main points that you want us to understand, I'll appreciate that. Then I'll have some questions of the whole panel. So, Dr. DuBois, why don't you start.

STATEMENT OF DAVID DUBOIS, NEW MEXICO STATE CLIMATOLOGIST, NEW MEXICO STATE UNIVERSITY. LAS CRUCES, NM

Mr. DUBOIS. OK. Good afternoon, Mr. Chairman. We thank you again for the opportunity to testify about the status of the drought in New Mexico. As you said I am the State climatologist, I've been here about one year now, coming in from the State of Nevada. I'm originally a native of New Mexico. So it's very dear to me on—this State.

I also meet monthly with several State and Federal agencies including the New Mexico Department of Agriculture, Office of the State Engineer, National Weather Service, Natural Resources Conservation Service, Bureau of Reclamation, and the Farm Services Agency to discuss drought. We've been meeting pretty much every month for many years now. I've been doing it ever since I got here.

So I will give a briefing on the report of the precipitation and drought indicators that we as a group and myself have been tracking over the past year.

I would like to direct your attention to the map. This U.S. Drought Monitor, that's the latest monitor from April 19. Basically it's a community effort that basically incorporates a lot of the local, State, Federal data on drought indicators, local conditions. It comes out every Thursday. That is actually last Thursday's. A new one will come out tomorrow.

That current one, the deep red is the extreme drought, what they call D3. Then the brownish mustard color, that is severe drought, D2. Basically it's sort of an indicator of the extent and severity of the drought.

The latest draft—I'm part of the monitor team. So tomorrow is actually—the draft of it is actually the—D3 is actually starting to encompass more of New Mexico. So it's still draft.

But if you can imagine drawing a line from where it is on the western corner about halfway up Catron County, including most of Bernalillo County, and then connecting with the easternmost portion of the red. So that's our draft extreme drought according to the Drought Monitor for tomorrow. So it's actually worsening compared to what was in the original statement. So that's a very important thing.

Currently the extreme drought covers about 33 percent of the State. I think it's some more—it's going toward more about—maybe nearly half of the State, somewhere around there. So that's a very important—even though there's been a little bit of precip in the Rio Arriba County area, I think there's still—the big concern is Southern New Mexico.

There's been many locations and reports that I've been tracking and working with the National Weather Service. You know, there are many sites that have not—haven't seen any rain in over 3 months. The same with—I manage a station in Las Cruces at the university that's been operating since 1892.

We haven't seen anything since our snow on February 2. That was our only precip that we had. It was only eight-hundredths of an inch.

So basically on a statewide basis, over the past 3 months, so January, February, March, the statewide precipitation has been the second lowest since records have been taken. So that's a very important point.

Then there's another graph that I have in your packet that shows the average precipitation from January through March. This is on a statewide basis, showing every year the average precipitation.

On the far right of the plot is the latest at 2011. Then I highlighted that, circled that. So that was—that basically describes the second lowest amount of precipitation, second to the 1972 very low precipitation.

Just looking at this past March, statewide this has been the third driest on record. So this is on the whole State. There's actually a few stations that are actually—that are actually the driest. But on the statewide, it's the third driest.

Again I just want to magnify that the hardest hit locations are in the southern deserts and along the central valleys. If you look at just the southwest deserts, the precipitation is about 7 percent of the long-term normal. So that's pretty low.

Not much better, the central valley is about 15 percent of normal. So like I said in Las Cruces we have not had precipitation for more than 80 days now.

So in the past 12 months, we've noticed sort of a—what I would call a roller-coaster ride in precipitation. In 2009 to 2010, we were under the influence of an El Nino situation. We had above normal precipitation, lots of good snow.

That sort of waned and we developed a La Nina which is the opposite effect of an El Nino. That started in the fall of last year. We are still under the influence of this La Nina, which means—which tends to be—which trends to translate into drier than normal conditions and warmer temperatures on average.

So this past El Nino was the highest since we had an El Nino back in 1997, 1998, which you can sort of see that on the chart a little bit, if you can look at the highs.

So there's tremendous—on the graph there's tremendous variation in the precipitation from year to year. What I like to do is track the El Ninos over time. The last chart on your handout is labeled a Multivariate El Nino Southern Oscillation, ENSO index. As you can see there's ups and downs, back and forth. That's over the—starting in 1950 to the present. On the far right is where we are right at this moment. We're in the La Nina which is the blue, if you have a color handout.

You can see this going from a very strong El Nino to a strong La Nina. That's sort of—kind of the picture that we as climatolo-

gists look at, is what kind of situation are we in. El Ninos tend to be wetter than normal, La Ninas tend to be drier than normal.

It's not all the same in the whole State. Usually the La Ninas tend to have more—in the past have had more influence on Southern New Mexico. There's sort of a line—if you can draw a line on Interstate 40, below that, that's the highest impacts of the La Nina, a drier than normal. That's kind of what we saw this spring.

So we're expecting to see the La Nina starting to wane to more of an in between pattern for this coming next few months. Then right now we're waiting for the monsoon prediction, which right now they're looking at an equal chance of either high or lower. There's really not a good sense.

But the last statement of this is that during the past La Ninas that were very—that we had very little snow pack, the precipitation in the summer has been about 96 percent of normal. Those are for the conditions when we had a really low snow pack. I think that was like 2006.

So if we look—if we learn from our past to see what kind of things we can potentially see, there's—we can't use it as a perfect predictor. But looking back in time, what happened during the past La Ninas, that will help us.

So there's—that's kind of our discussion with our group, is, you know, what happened—is there a pattern that we were in in the past 30, 40 years, what happened then and can we—what can we learn from that. So right now we're still waiting to see what the predictions are.

But the best guess, educated guess would be maybe tending toward a more neutral, an average start of the summer. But, you know, we have to wait and see. So thank you for the opportunity to report on this. Thank you, Mr. Chairman.

[The prepared statement of Mr. DuBois follows:]

PREPARED STATEMENT OF DAVID DUBOIS, NEW MEXICO STATE CLIMATOLOGIST, NEW MEXICO STATE UNIVERSITY, LAS CRUCES, NM

Mr. Chairman and Members of the Committee: Thank you for the opportunity to testify today regarding the status of the drought in New Mexico. As the State Climatologist I direct the New Mexico Climate Center based out of the Plant and Environmental Sciences Department at New Mexico State University. I have been in this position for just over a year coming from the state of Nevada. Under my direction the Center maintains an archive of climate data collected throughout the state of New Mexico from many public and private networks. As the State Climatologist I meet monthly with the National Weather Service, Office of the State Engineer, NM Dept of Agriculture, NRCS, Bureau of Reclamation, and the Farm Services Agency to track the status of drought in the state.

In this briefing I will report on the precipitation and drought indicators that have been tracked over the past year. The US Drought Monitor assesses drought conditions throughout the US incorporating state and local data on a weekly basis. According to the latest drought monitor map on April 19, 33 percent of the state of New Mexico is in "extreme" drought, 42 percent is in "severe" drought, 20 percent in "moderate" drought and 6 percent abnormally dry. Figure 1* shows a map where these designations appear across New Mexico. Southern New Mexico is seeing the brunt of the drought as the map shows.

There are many locations, particularly in southern NM, that have not seen precipitation for more than three months. Over the past three months state-wide precipitation has been the second lowest since records have been taken. As the chart below shows the start of 2011 is only second to a dry period back in 1972.

---

*Figures 1–3 have been retained in committee files.

Looking at just March 2011 state-wide precipitation is the 3rd driest on record. The hardest hit locations in the state are in the southern deserts and central valleys. In the southern desert region, over the past three months, precipitation is about 7 percent of the long term normal. Not much better, the central valley region is at 15 percent of normal. In Las Cruces we have not seen precipitation for more than 80 days.

Over the past 12 months we have been on a roller coaster ride in precipitation. In the winter of 2009 to 2010 we were under the control of a strong El Niño pattern and during the fall of 2010 a strong La Niña developed. The 2010 El Niño was the strongest episode since the one during 1997-1998. Below is a chart that shows the occurrences of El Niños and La Niñas over the past 61 years. The numbers are a measure of the strength of the El Niño/La Niña signal. Our current status in the La Niña is shown on the right hand side of the chart as the blue shaded area.

Our understanding of the effects of La Niña in New Mexico based on past events showed us that we would expect below normal winter and spring precipitation throughout the state and especially south of interstate 40. This is basically what we observed. While it's not guaranteed that a La Niña will bring drought it tells us that it's more likely.

The current observations are indicating a weakening La Niña and the predictions are trending toward neutral ENSO by the start of the summer. It is difficult to give a prediction of the monsoon at this point in time. Based on the past we do know that La Niña's influence on summer precipitation has not been as negative compared to winter and spring. Summer precipitation in NM during all La Niñas has averaged 96 percent of normal.

Thank you for the opportunity to report on this very important topic. I would be glad to answer any questions that you may have.

The CHAIRMAN. Thank you very much. I appreciate your testimony. Esteven, go right ahead, tell us your perspective from the views of the Interstate Stream Commission.

STATEMENT OF ESTEVEN LOPEZ, DIRECTOR, NM INTERSTATE STREAM COMMISSION

Mr. LOPEZ. Good afternoon, Mr. Chairman. Thank you for this opportunity to speak to you about the drought in New Mexico.

As you've just heard, New Mexico has just suffered through one of the driest winters on record. For several areas in the State, the year-to-date precipitation is the lowest in the State's recorded history. This as you might expect is already creating significant challenges for water managers. Those challenges are simply very likely to grow as the irrigation season advances.

I just want to highlight a few examples of those challenges around the State. In the Gallinas River, the city of Las Vegas, New Mexico, relies on the surface water from the Gallinas River for about 90 percent of its supply.

Given the severity of the drought, the city has already had to ban most outdoor uses. Additionally, they need additional infrastructure improvements. They have a funding request before the New Mexico Water Trust Board for a replacement well that is being considered right now. The current water supply emergency will play a part in the Water Trust Board's deliberations.

In recent years the Office of the State Engineer has worked with the Rio Gallinas Acequia Association to install flow measurement stations that will help in managing water uses there generally, but particularly in times of drought.

More recently both the city and the acequias have been—successfully negotiated a water use rotation agreement that should help minimize conflict between the 2 as they struggle through the summer.

In the Lower Rio Grande, farmers within Elephant Butte Irrigation District have yet to receive any surface water this year. This means that all of the irrigation within EBID is being done through groundwater, the pumping of which as you can well imagine is more and more expensive as fuel prices rise.

Further, given that usable water in Elephant Butte reservoir is less than 400,000 acre-feet, Article VII of the Rio Grande Compact is in effect. Thereby, prohibiting storage in upstream post-Compact reservoirs. This prohibition of storage will likely be in effect through the remainder of the calendar year and probably into next spring.

This year flows in the Rio Grande past San Marcial and into Elephant Butte Reservoir are expected to be about 33 percent of the long-term average. In recent years the New Mexico Interstate Stream Commission working with the Bureau of Reclamation has worked to construct and maintain over 20 miles of pilot channel through the sediment delta to assure that the water that does reach the reservoir actually makes it into the active pool rather than simply spreading on the delta and evaporating.

This has been helpful in terms of our Compact compliance. To date we are carrying forward a Compact credit that is in our deliveries to Texas of 164,000 acre-feet. That will help us manage through the future years as well.

In the Middle Rio Grande, upstream reservoirs started the year with a substantial amount of water in them. However, the projected minimal runoff is still going to create quite a challenge as you noted earlier in terms of meeting the flow requirements for the silvery minnow under the flow requirements required under the 2003 Biological Opinion while still meeting the needs of other middle valley users.

The good news in that front is that the status of the endangered minnow is far better today than it has been in recent years. Thanks to the efforts of the Middle Rio Grande Endangered Species Collaborative program, there is substantially more usable low flow habitat available.

The needs of the minnow are much better understood. There is an experimental population in Big Bend, Texas. Now there are several off-stream refuges that are available to help them weather this drought.

In the Lower Pecos River, water users and water managers are fortunate to have implemented the Pecos River Settlement in 2009 and concurrently having built a 100,000 acre-feet Compact credit. That should help us get through into the next few years as well.

But under the terms of the settlement, when surface supplies are limited, the settlement calls for augmentation pumping of groundwater for the benefit of the Carlsbad Irrigation District. This year the Interstate Stream Commission has already begun augmentation pumping as of March 1. We will likely have to continue pumping through the entire year. This is going to cost the State dearly in a time of very tight State budgets.

On the San Juan, as you can see from the drought map, the San Juan is the one relatively wet area. It's still in drought. But it's relatively wet compared to the rest of the State. The Southern Colorado snow pack that feeds the San Juan is at about 100 percent

of average. Yet the runoff into Navajo Reservoir is expected to be about 80 percent of the long-term average.

Nevertheless, given the fact that there is a multiyear supply sharing agreement in effect amongst the major water users in the basin and the fact that we've successfully installed measuring and metering equipment on all of the surface water diversions, hired some watermasters, we think that we're well-positioned to manage through what we hope will continue to be just a fairly mild drought in this basin.

The preceding are just a few examples of the drought challenges we're facing all over the State. Every community around the State has drought-related challenges of its own.

The State Engineer has recognized the need to actively manage and administer water rights and water uses. Ongoing legal challenges to the State Engineer's proposed active water resource management regulations have hampered his ability to exercise direct priority administration.

However, the advancement of measuring and metering all around the State, the hiring of watermasters, the admin—the alternative administration schemes that have been negotiated including some of the ones cited here, the rotation schedule on the Gallinas, the Pecos Settlement, the supply sharing on the San Juan, all demonstrate that we are slowly but surely getting our act together in terms of the State Engineer's ability to manage and administer water uses around the State. So that's going to be critical through drought periods.

Finally, as you well know, a major element of effective administration is the adjudication of water rights. Progress is being made on that front. The negotiation, settlement, authorization, and partial funding of the Navajo Nation, Aamodt, and Taos Indian water rights settlements are certainly major elements of that progress.

I want to take this opportunity to thank you, Senator, for your continued assistance in helping New Mexicans improve our ability to better manage our water supply. That support has come in the form of continuing funding to the Federal water management agencies, the support for the endangered species programs around the State, and most recently your heroic efforts in securing the Federal authorizing legislation and direct funding for the Indian water rights settlements. Thank you.

[The prepared statement of Mr. Lopez follows:]

PREPARED STATEMENT OF ESTEVEN LOPEZ, DIRECTOR, NM INTERSTATE STREAM COMMISSION

Thank you for this opportunity to speak to you about the drought situation in New Mexico. New Mexico has just suffered through one of the driest winters on record. Snowpack conditions around the state are generally very poor and consequently, flows in the state's streams and rivers are expected to be extremely low. For several areas in the state, year-to-date precipitation is the lowest in the state's recorded history. As you might expect, this is already creating significant challenges for water management in the state and these challenges will likely grow as the irrigation season advances.

Since the start of 2011, the drought in New Mexico has been intensifying. According to the United Stated Department of Agriculture/National Agricultural Statistics Service's "US Drought Monitor for New Mexico", drought conditions worsen as you move south through the state. Currently, only the northwestern corner of the state, roughly corresponding to San Juan County, has the least severe Drought Monitor characterization—that is, "abnormally dry." The rest of the northern third of the

state is experiencing "moderate" drought conditions, the middle third of the state is in a "severe" drought condition and the southernmost third of the state is experiencing "extreme" drought conditions.

Recognizing the intensifying drought, State Engineer John D'Antonio, Chairman of the New Mexico Drought Task Force convened a meeting of the Drought Task Force on March 21, 2011. This was the first Drought Task Force meeting under Governor Martinez' administration. The meeting was intended to acquaint the new members of Governor Martinez' team with the Task Force, its charge and of the need for coordination among state agencies.

At the Drought Task Force meeting, the New Mexico State Forestry Division reported that year-to-date as of March 18th, there had already been 160 fires that had burned over 91,000 acres—more burned acreage than in all of 2010. Given the intensity of the drought, the potential fire outlook is severe. The representative of the New Mexico Agriculture Department reported that the state's drought conditions are having "definitive negative impact" on the state's agricultural activities. Moreover, the Department of Agriculture has characterized soil moisture conditions around the state as either "very short" or "short", much less than what is needed for normal plant development. At this time, the New Mexico Department of Agriculture is monitoring drought and considering requesting a disaster declaration of the Governor but has not done so yet.

Some of the other challenges have begun to manifest themselves as direct water supply problems. A few examples include:

Gallinas River

The city of Las Vegas, New Mexico relies on surface water from the Gallinas River for about ninety percent (90%) of its supply. Given the severity of the drought, the city has had to implement stage IV drought restrictions banning most outdoor water uses. The city has begun exploring funding options to rehabilitate its surface water reservoir and replace some of its wells. The New Mexico Water Trust Board will be considering a funding request for a replacement well by the city and will take into account the current water supply emergency in its deliberations.

In recent years, the Office of the State Engineer has worked with the Rio Gallinas Acequia Association to install flow measurement stations that will be critical to managing uses on the Gallinas River effectively. More recently, the city and the acequias have agreed to a water use rotation schedule that will help minimize conflict.

Lower Rio Grande

In the Lower Rio Grande, farmers within the Elephant Butte Irrigation District (EBID) have yet to receive any surface water this year. Although there is over 450,000 acre-feet of water in Elephant Butte Reservoir, only about half of that amount is usable for downstream Rio Grande Project irrigation purposes. Under a 2008 Operating Agreement between the US Bureau of Reclamation, EBID and the El Paso County Water Improvement District No. 1 (EP1), most of the usable project water has been allocated to EP1 leaving EBID with less than 50,000 acre-feet. This means that all irrigation within EBID is being done with groundwater the pumping of which is more and more expensive as fuel prices rise. Further, given that usable project supply is less than the key threshold of 400,000 acre-feet, Article VII of the Rio Grande Compact is in effect—prohibiting storage of water in upstream, post-compact reservoirs. This upstream storage prohibition will likely to be in effect through the remainder of this calendar year and into at least next spring. This upstream storage prohibition is likely to have minimal upstream consequence given the lack of runoff available for impoundment.

This year, Rio Grande flow past San Marcial and into Elephant Butte Reservoir is expected to be about thirty-three percent (33%) of the long term average. In spite of this low inflow, New Mexico has done what it can that to minimize natural losses in the system. In recent years, the Interstate Stream Commission has worked with the U.S. Bureau of Reclamation to construct and maintain over twenty miles of pilot channel through the sediment delta at the upstream end of the reservoir to assure that the water that does reach the reservoir actually reaches the active reservoir pool instead of simply spreading on the delta and evaporating. This has been critical to New Mexico's compliance with its Rio Grande Compact water deliver obligations and has helped build New Mexico's 164,000+ acre-foot Compact Delivery credit.

Also in recent years, the Office of the State Engineer has successfully implemented metering requirements on most non-domestic use wells in the Lower Rio Grande as part of his Active Water Resource Management initiative. Although the Active Water Resource Management regulations are being challenged in court thereby preventing priority administration at this time, this metering information should

be useful in better understanding water uses generally. It could also provide the information that would allow for voluntary shortage sharing agreements.

Middle Rio Grande

Upstream Rio Grande reservoirs in New Mexico started the year with plenty of supply. Still, the projected minimal runoff will challenge water managers in meeting the flow requirements for the Rio Grande silvery minnow under the 2003 biological opinion while also meeting the demands of middle valley users. This should not, however, diminish the fact that the status of the endangered minnow is far better than it was just a few years ago and in spite of the dire water supply outlook the minnow should be able to weather this year's drought. This is the result of the collaborative efforts of the Middle Rio Grande Endangered Species Collaborative Program. There is substantially more useable habitat available at low flow conditions, the needs of the minnow are better understood, there is an experimental population in Big Bend, Texas and there are now several off-river refugia available.

Lower Pecos River

Water users and water managers in the Lower Pecos River in New Mexico are fortunate to have implemented the Pecos River Settlement in 2009 and built a 100,000 acre-foot Pecos River Compact credit. The state is well positioned to meet its Compact delivery obligations. However, the settlement also calls for augmentation of the surface water supplies when water in storage for use by Carlsbad Irrigation District falls below certain threshold values. The Interstate Stream Commission is responsible for monitoring that available supply and has had to begin augmentation pumping since March 1, 2011. The current outlook is that pumping will probably have to continue through the irrigation season unless there are significant monsoons. This pumping is expected to cost the state dearly in a time of diminishing budgets.

San Juan and Colorado Rivers

In many regards, the San Juan is the one bright spot in the state. Or perhaps I should say it's the one relatively wet spot. As indicated earlier, this area of the state is only classified as "abnormally dry". The southern Colorado snowpack that feeds this river is close to average, yet runoff into Navajo Reservoir is projected to be about eighty percent (80%) of average. Still, given that there is a multi-year Supply Sharing Agreement in effect along with successful implementation of metering and measuring of surface diversions and hiring of water masters the state is well positioned to manage through what will hopefully be a fairly mild drought in this basin.

Elsewhere in the Colorado River basin snowpack in the Upper Basin is well above average (in Colorado, Utah and Wyoming) and inflow into Lake Powell is also expected to be well above average. This in turn means that there will be additional releases to Lake Mead under the terms of the 2007 Coordinated Reservoir Operations and Shortage Sharing Agreement. The net effect is that the immediate threat of a Lower Basin shortage has abated and reduced tensions for the time being. Nevertheless, unless we get into a substantially wetter cycle than the last few years, the tensions will increase again soon. The Colorado River basin states, the U.S. Bureau of Reclamation, the U. S. International Boundary and Waters Commission and Mexico need to use this current reprieve to make progress on longer term solutions for dealing with potential shortages before they hit.

Conclusion

The preceding examples are but a few of the illustrations of both how New Mexicans are suffering through the drought and of the challenges facing water managers. Every part of the state is facing its own drought-related issues.

As noted previously, the State Engineer has recognized the need to actively manage and administer water rights and water uses. As the state's population and water demands grow, and given the frequency and severity of drought in the state, this will become increasingly urgent. Also as noted above, the ongoing legal challenges to the State Engineer's proposed Active Water Resource Management regulations has hampered the State Engineer's ability to exercise priority administration. Nevertheless, the advancement in measuring and metering; the hiring of water masters; and the various alternative administration schemes, including those cited here—rotation schedules on the Gallinas, the Pecos Settlement, supply sharing on the San Juan—all demonstrate that the State Engineer's ability to manage and administer water uses around the state continues to improve.

Finally, a major element of effective administration is the adjudication of water rights. Progress is being made on that front, as well. And the negotiation, settle-

ment, authorization and partial funding of the Navajo Nation, Aamodt and Taos Indian water rights settlements are major elements of that progress.

I would be remiss if I did not take this opportunity to thank Senator Bingaman for his continued assistance in helping to improve the state and its water users' ability to manage water resources both in times of drought and in times of plenty. That assistance has come in the form of funding to the federal water management agencies, support for endangered species programs and, most recently, in the Senator's heroic efforts to secure federal authorizing legislation and direct funding for the Indian water rights settlements.

Thank you.

The CHAIRMAN. Thank you very much. Corbin Newman, you're our final witness on this panel. We appreciate you being here as our Regional Forester. Go ahead.

STATEMENT OF CORBIN L. NEWMAN, JR., REGIONAL FORESTER, SOUTHWESTERN REGION, FOREST SERVICE, DEPARTMENT OF AGRICULTURE

Mr. NEWMAN. Thank you, Mr. Chairman. Thank you for bringing us together on this really important topic, one that's become all too common here in the Southwest and particularly in New Mexico.

For me the most obvious and outward appearance of drought is forest fires, it's grass fires, it's woodland fires. I want to talk about those. But first I would like to highlight some of the connections that probably are more important in the long term that we look at.

When we talk about drought, we think about it in sort of 3 phases. The idea that you've got a panel here on climate change I think is critically important, because we think about drought today and how it affects our management that we need to carry on in our national forests particularly in fire.

We think about the persistence of drought, how long has it been around. You know, decades-old changes in many, many things in what we do. Finally it's about climate change and how do we address the management of your national forests around climate change to make them more resilient and able to deal with those impacts that they have.

Here in the Southwest we all know it's dry. All of our systems are fire adaptive. Fire has always been a component of the land around us. For us, though, it becomes more of, well, what has happened over the last century or half century.

What we found is that the climate has really created more and more vegetation on the landscape that set us up for this current long drought that we've had to create these environments. Many of them we're seeing, like Cerro Grande and the Red Sky fire, their impacts on systems where fire is not behaving as it did in the past.

For us that's one of the major emphases we have, is how do we restore some resilience to these landscapes? How do we bring them into an environment that's different today than maybe when they began 100 or 200 years ago.

For us that becomes a major emphasis of long-term management of the national forests. We're making great progress here in the Southwest.

As we think about the impacts of that drought today, as has been mentioned here, this year we're faced with some significant challenges. All of New Mexico is in drought, every—a little over 9 million acres of national forest system lands are affected by drought. The further south you go, the worse it gets.

As we look at what our meteorologists are telling us, we expect that May will be dryer and warmer than normal. We expect an onset of the monsoons to come as they normally do. At least the odds are that will occur. But that means for the next 2 months, 3 months we're going to have some significant issues around drought and its effect on national forests.

As many of you know, the Last Chance fire is now 40,000 acres burning outside of Carlsbad. It's one of those evidences of the things that we're finding are occurring now, sooner than what we have normally had.

We have a Southwest coordinating group made up of the 5 Federal land management agencies as well as the State foresters of Arizona and New Mexico that really are coordinating the resources and preparedness for this fire season. So I would like to talk a little bit about those so folks know what's being done.

We saw early on that this onset was coming based upon what we saw in the first 3 months of this year and what the predictions were. So almost a month ahead of time we brought on significant firefighting resources into New Mexico to be prepared to deal with what we knew would be an active fire season.

We brought in 2 helitankers, we brought in 3 air tankers. We put on 20 crews early in order to be able to deal with these. Now, unfortunately for the last few weeks, they've been mostly employed in Texas. But now they're all back home and work on the fires that are occurring here in New Mexico.

For me that's one of the evidences of how well things are working in the Southwest amongst the folks who are taking care of wildland fire in the Southwest. The Southwest Coordinating Group is as strong as it's ever been. The partnerships are evident in the way that we're sharing resources and working in these interagency environments around fire.

For me part of that is the result of many things you were involved in, Mr. Senator, a long time ago. The National Fire Plan is an example of how it brought together collective awareness about the need to collaborate and coordinate around fire, to leverage our resources to take advantage of all levels of government in our capabilities to fight fire.

We fully expect that as we move forward in this season, that we'll be faced with many challenges around fire. But we feel we're well prepared for those with the steps that we've taken, to bring new resources into the area, to pre-stage them, to deal with fires such as the Last Chance. I think we're going to find that we're able to meet the challenges that are going to be in front of us.

We also are moving forward to quickly and aggressively treat fuels. It's one of those programs that ramped up in 2001, 2002. We have maintained a steady attack on hazardous fuels particularly around communities to do the best we can to protect communities from the effects of wildland fire.

We expect we'll have again a good year of accomplishing many of those objectives. We intend to continue to try to build capacity inside the State of New Mexico to deal with those kind of activities.

One of the things again I would like to thank you for is the CFRP program. That has had a tremendous effect not only in treat-

ing land, but to building institutional capacity and small businesses and communities to deal with this kind of effort.

The panel today is meeting for this year's awards. So for me it's made a huge difference here in New Mexico and our ability to respond to these things quickly.

There's much more I could say. But it seems like it's time I should stop. Hopefully we'll get a chance to respond to more things that are relevant in questions.

Thank you.

[The prepared statement of Mr. Newman follows:]

PREPARED STATEMENT OF CORBIN L. NEWMAN, JR., REGIONAL FORESTER, SOUTHWESTERN REGION, FOREST SERVICE, DEPARTMENT OF AGRICULTURE

INTRODUCTION

Mr. Chairman thank you for the opportunity to appear before you today to provide an overview of the current drought situation in New Mexico and how it relates to the status of the U.S. Forest Service's wildfire suppression capabilities in the Southwest Region.

WILDLAND FIRE MANAGEMENT

The Forest Service, in cooperation with partner agencies in the Department of the Interior, is perhaps the premier wildland firefighting organization in the world. We work together with our State, local, and tribal government partners to maintain our operational excellence and continually improve the safety and effectiveness of the fire management program.

The Forest Service takes seriously its role in managing wildfire with firefighter and public safety being the first priority in any fire management activity. We are prepared for the 2011 wildland fire season and are staffed to provide effective fire management.

We will continue our commitment to aggressive initial attack of wildland fire, where appropriate, with full attention to firefighter and public safety. Last year, our initial attack success rate was 98%. Further, our commitment to informed, performance based strategies will reduce firefighter exposure to unnecessary risk during fire incidents. Additionally, we will continue to provide assistance to fire adapted communities that have been or may be threatened by wildfire to enable these communities to reduce future wildland fire risks. In providing this assistance, we will continue to make hazardous fuels treatment in wildland urban interface areas a priority, assist localities in building their response capability, and work collaboratively with local communities to understand the role of fire and find ways to mitigate risk and to foster individual responsibility for property protection. These commitments are fully in line with the recently completed National Cohesive Wildland Fire Management Strategy signed off by the entire wildland fire community: federal, tribal, States and local officials. The wildland fire community, through the auspices of the Wildland Fire Leadership Council, has developed the Cohesive Strategy. This ground breaking blueprint provides a common underpinning for all entities with statutory responsibilities for wildfire. This is a national collaborative effort among wildland fire organizations, land managers, and policy making officials representing federal, state and local governments, tribal interests, and non-governmental organizations. In addition, the federal, non-federal and tribal wildland fire management partners will continue work this fiscal year on Phase II, Development of Regional Assessments and Strategies, and complete the implementation of the Cohesive Strategy next year in Phase III, a national risk trade-off analysis.

FIRE RISK IN NEW MEXICO

Wildland fire and wildland firefighting are influenced by a complex set of environmental and social factors. In recent years, fires across all jurisdictions have become larger, impacting more acres, due in part to persistent drought and hazardous fuels accumulations. In addition, the expansion of development in the wildland urban interface has increased the complexity of fighting wildland fire. These trends are not expected to change. In fact, it is expected that effects of persistent drought in some areas will continue to increase the probability of longer fire seasons and bigger fire events and declining forest health conditions in New Mexico. Unusually dry areas with above normal potential for significant fire will most likely expand westward

across New Mexico through the spring and persist over much of the state from May through July (See Figure* Below).[1] [2]

WILDLAND FIRE PREPAREDNESS

The 2011 wildland fire season has begun in many parts of the country. As of April 21, 2011 a million acres have burned this calendar year. Most of this has been in Texas and Oklahoma with 124,450 acres burned in New Mexico. The total number of acres burned is above the ten-year average for this time of year.

To prepare for the 2011 fire season the Forest Service, along with our partners in the Department of the Interior, the tribes, and the States have worked to improve the efficiency and effectiveness of our firefighting resources. Fire managers assign local, regional, and national firefighting personnel and equipment based on anticipated fire starts, actual fire occurrence, fire spread, and severity. All federal and state wildland fire agencies are represented in the National Multi-Agency Coordination Group. This group provides oversight to the National Interagency Coordination Center, located at the National Interagency Fire Center in Boise, Idaho, and coordinates wildland firefighting needs throughout the nation. Resources are prioritized, allocated, and, if necessary, re-allocated. Prioritization ensures firefighting forces are positioned where they are needed most. Fire resources such as personnel, equipment, aircraft, vehicles, and supplies are dispatched and tracked through an integrated national system. In New Mexico, firefighting resources are often mobilized from the northern Rocky Mountains in the spring, when fire season in the northern States is still low.

If conditions become extreme and U.S. firefighting resources are determined to be in short supply, assistance is available under standing international agreements for firefighting forces from Canada, Mexico, Australia, and New Zealand. Under specified instances the Department of Defense, and specifically National Guard resources, may also be available to assist.

Firefighting Forces

Responses to wildland fires in the United States involve not only the resources of the Forest Service, but also permanent and seasonal employees from other federal agencies, States, tribal governments, local governments, contract crews, and emergency/temporary hires. For the 2011 fire season, the available firefighting forces—firefighters, equipment, and aircraft—are comparable to those available in 2010 with more than 16,000 firefighters available from the Department of Agriculture and Department of the Interior. The levels of highly-trained firefighting crews, smokejumpers, Type 1 national interagency incident management teams (the most experienced and skilled teams) available for complex fires or incidents, and Type 2 incident management teams available for geographical or national incidents, also are comparable to those available in 2010. Additionally, the Forest Service and the federal wildland fire fighting community work with State and local fire departments, which serve a critical role in our initial attack, and in many cases extended attack, success. We could not achieve the successes we have without them.

For the Forest Service in the Southwestern Region of Arizona and New Mexico, there are 110 Forest Service wildland fire engines available for fire assignment along with an additional 40 engines from other agencies. This spring, the Southwest Area's 22 Type 1 crews (interagency hotshot crews) will be available nationally into September-October. The Southwest Area will start the season with 30—35 Type II crews.

Aviation

Nationally, the wildland firefighting agencies continue to employ a mix of fixed and rotor wing aircraft. The number of these aircraft may fluctuate depending on contractual and other agreements. Key components of the Forest Service 2011 aviation resources include 19 contracted large air tankers, up to 26 Type 1 heavy helicopters, 41 Type 2 medium helicopters on national contracts, and 52 Type 3 light helicopters on local or regional contracts. The Forest Service also leases 13 Aerial Supervision fixed-wing aircraft, owns and operates 1 fixed-wing and 2 aerial supervision helicopters, owns 8 Smokejumper aircraft and contracts for an additional 4, owns 2 heat detecting infrared aircraft, and contracts 2 single engine air tanker air-

* Figure has been retained in committee files.

[1] National Interagency Fire Center Predictive Services. http://www.predictiveservices.nifc.gov/outlooks/monthly__seasonaloutlook.pdf

[2] "See Text" in figure refers to narrative description in the National Interagency Fire Center Predictive Services. Monthly seasonal outlook report. http://www.predictiveservices.nifc.gov/outlooks/monthly__seasonal__outlook.pdf

craft (SEATs). Additionally, there are nearly 300 call-when-needed helicopters available for fire management support as conditions and activities dictate. The Forest Service maintains a contract for a 100-passenger transport jet to facilitate the rapid movement of firefighters during the peak of the fire season. The Forest Service also coordinates closely with the Department of Defense (DoD) in maintaining 8 Modular Airborne Fire Fighting Systems (MAFFS) that can be deployed in Air National Guard and Air Force Reserve C-130s. The MAFFS program provides surge capability for large fire air tanker support.

Due to the fire risk in the Southwest, I have requested that "exclusive use" Type 3 helicopters be located on the Gila National Forest (Silver City, New Mexico) and the Coronado National Forest (Sierra Vista, Arizona) earlier than usual. I have also requested that the national helitanker contract availability dates start three weeks earlier than normal with 2 heli-tankers stationed at tanker bases in Prescott, Arizona, and Silver City, New Mexico.

Budget

The Forest Service Wildland Fire Management Account suppression funds for FY 2011 are similar to FY 2010. In addition, the Forest Service has enough carryover balances to allow us to respond to a worse than average fire season without transferring funds from non-fire accounts. The FLAME Wildfire Suppression Reserve Fund, established by the FLAME Act of 2009, is intended to minimize the need to transfer funds from non-fire accounts to the Wildland Fire Management Appropriation for fire suppression. Thank you, Mr. Chairman, for securing the FLAME account which has enabled the fire community to stabilize its fire budgeting.

IMPACTS OF A CHANGING AND EXPANDING FIRE ENVIRONMENT

The impacts of a high risk fire environment have adverse effects on natural resources and have socio-political ramifications as well. Wildfire has a natural and valuable role in many ecosystems helping to regulate forest and rangeland composition. Currently, many ecosystems across the country are out of ecological balance and are in need of restoration. This ecological imbalance results in ecosystems that are more threatened by wildfire due to factors such as increased fuel accumulation and infestation by invasive pests. These ecosystems contribute to higher fire risks and extreme fire behavior with severe fire effects such as significant impacts to municipal water supplies. By managing vegetation and restoring natural function and land resiliency, we can change fire behavior and the impacts of fire. Through a combination of mechanical treatment and managed fire, we can help improve the health of some fire adapted ecosystems and prevent heavy accumulations of highly flammable fuels. The Integrated Resource Restoration line item as proposed in the President's FY 2012 budget, is a needed tool that will enable the agency to get more of this work done. In FY 2010, the Forest Service treated over 2 million acres in hazardous fuels, with the majority of acres in the wildland urban interface. By mid-April 2011, we have already treated over ¾ of a million acres. In Arizona and New Mexico, to date we have treated over 71,000 acres.

Working closely with our partners, we are continuing to restore watersheds and reduce fuels to enable these forests to be more adaptive to stresses like drought. For example, prescribed fire treatments continue in the Santa Fe Watershed to reduce the probability of severe, high-intensity wildfire threatening the city's municipal watershed and impacting the local community and livelihoods. 7,000 acres of the Watershed were analyzed, followed by thinning and prescribed burning on 5,260 acres. The city of Santa Fe hopes to fund analysis and treatment of an additional 1,000 acres in pine stands in the upper reaches of the Watershed.

In addition, the Collaborative Forest Landscape Restoration Program (CFLRP) has become a very valuable tool in our adaptive and restoration efforts. The 210,000-acre Southwest Jemez Mountains project was one of 10 CFLRP projects selected nationally and received $392,000 in 2010. The project which involves Santa Fe National Forest and its CFLRP fund partner, Valles Caldera National Preserve (VCNP), focuses on thinning and prescribed burning to restore more natural fire regimes. These efforts will be conducted over many ecosystems, from grasslands and low elevation piñon-juniper woodlands to upper montane coniferous, sub-alpine and alpine forests and across multiple administrative boundaries. The project area chosen spans 12 small watersheds within the Jemez River Watershed and across boundaries of the Santa Fe National Forest, Valles Caldera National Preserve, and Jemez Pueblo. The cross-jurisdictional landscape presents an opportunity for collaboration among several agencies and stakeholders on the strategy of treatments.

One community we are focusing on is Ruidoso as it is rated one of the "most at risk" communities in New Mexico. In 2006, the Lincoln National Forest and the Mescalero Apache Tribe signed the 16 Springs Stewardship Project under the au-

thority of the Tribal Forest Protection Act (TFPA, Public Law 108-248). This was the first Forest Service stewardship contract under the TFPA authority, which permits the Federal Government to enter into contracts and agreements with American Indian Tribes for work on public lands bordering or adjacent to tribal lands.

The project strategically thins identified forest stands, providing specialized employment in harvesting, transporting, and processing commercial saw logs and small-diameter biomass. Currently, the commercial saw logs provide and maintain jobs at small local sawmills and a pallet mill in El Paso, Texas. The small-diameter biomass generated will support a new wood pellet mill, currently under construction north of Alamogordo, and provide critical material for facility development and testing. In the future, the biomass will provide the Mescalero Apache Tribe with material to operate a 6-megawatt power generation facility. The project has a cascading affect on maintaining and creating jobs within local tribal communities and area municipalities, enhancing the Mescalero Apache Tribe and Lincoln National Forest relationship.

The fuel reduction work we do nationally not only reduces community fire risk, it is an important contributor to the economic health of many communities as many of the trees that are removed can go into milling infrastructure and create green jobs. We plan to match or exceed these accomplishments in the future.

This concludes my statement. I would be happy to answer any questions that you may have.

The CHAIRMAN. Thank you very much. Let me ask a few questions of each of you here.

First let me just acknowledge Mayor Coss who came in. I expressed earlier the great appreciation for the use of your wonderful facilities here. Thank you very much. Thanks for coming by today.

Let me also mention while we're all paying attention here, Tanya Trujillo who works with me on the Energy Committee in the Senate does a great job in a lot of respects. But particularly she is the one that did most of the work in getting this hearing organized. We appreciate her excellent effort.

She sent me a note here or gave me a note indicating that all the testimony, the full testimony of all of our witnesses today will be on the website of our Energy Committee. That's energy dot Senate dot gov. So if any of you have an interest in reading through that testimony in full, it will be there.

Let me ask the State Climatologist, Dr. DuBois: I think you were saying that predictions as to the so-called monsoons will be coming out soon? Do I take it that your office does predictions looking forward 90 days or some period of time and says this is what we can expect during the summer months or over the next several months or did I misunderstand that?

Mr. DUBOIS. I don't do the predictions myself. I utilize the NOAA, basically the products that come out on a nationwide basis. They start at 1 month, 3 months, 6 months lead in advance. They're real broad predictions of the climate. You know, they will basically say it will be above normal or below normal or equal chance.

Like, for instance, the monsoon for July, the 3 months of the summer. The predictions that I looked at yesterday said it was equal chance of either a wet or dry. So that's where I get my information.

The CHAIRMAN. That's based primarily on the fact that historically, when we have had one of these La Nina situations and significant drought that came with that, it has been followed by a normal monsoon period; is that what you're saying?

Mr. DUBOIS. Yes. On many cases there have—that's kind of what the past has shown us. The forecasts are based off of models and what's been in the past, sort of the climates in the—yes.

The CHAIRMAN. OK. Let me ask, Esteven, your view as to what is the state of the efforts in communities around New Mexico with regard to water planning? Is all of this information about expectations on precipitation in the future, is this all being utilized by communities in making decisions about water usage and ordinances and those kinds of things as you understand it?

Mr. LOPEZ. Mr. Chairman, I think that by and large communities are making use of that information. Obviously some are better—are doing better than others. But I can point to several examples.

If you look at the community of—the communities of Santa Fe and Albuquerque, they're certainly diversifying their supply portfolios. They both now have surface water diversions and also diverse groundwater supplies. Albuquerque is looking at aquifer recharge and recovery.

Las Cruces is also looking at diversifying its water supply portfolio. You've seen and I've talked about Las Vegas and the fact that they've got drought restrictions, that they're already—they're acting pro—in advance of the worst that we expect to see this year.

Similarly Santa Fe has—Santa Fe and Albuquerque all act similarly. I think there are—planning efforts around the State are more and more utilizing these sorts of information in terms of communities making those decisions. But we can always improve.

The CHAIRMAN. OK. Mr. Newman, let me ask you about—I think you referred to the Southwest Coordinating Groups. I'm just unclear. You talked about I think 20 different firefighting teams that were being brought in to deal with the expected problems that we have. A lot of those have been needed in Texas.

How does that work? There's not a lot of national forest in Texas the last time I checked. How does it work that your firefighting teams wind up in Texas fighting grass fires, for example?

Mr. NEWMAN. Sure. When you talk about this coordinating group, this country has an immensely successful interagency structure for fighting wildland fire which includes grass, woodlands, forests. For instance, we have grasslands in Texas that we oversee here. It's a partnership.

So State foresters along with the Park Service, the BLM, Forest Service, BIA, U.S. Fish and Wildlife Service, we join our forces together to attack fire when it occurs in the wildland wherever it may be. So it's sort of a mutual aid, if you will.

So when it occurs, we have the ability to, if you will, mobilize and direct those resources across the country. In the Southwest we use the Southwest Coordinating Group to do that.

Nationally we have an organization called NIFC in Boise that deals with the national interagency fire world. It helps move, if you will, resources around the country when needs are there, depending on where resources exist.

Right now fire is occurring across the south. So from North Carolina over to Arizona, that's where most of the firefighting resources are in the country today, as they take on the fires before they begin to move to the north.

So that's why we'll tend to move resources into Texas where fire is occurring and vice versa. If they didn't have any fires occurring there currently in New Mexico and we needed them, those resources would move to New Mexico.

The CHAIRMAN. Since we're here in Santa Fe, could you just briefly describe what the Forest Service has done jointly with the city of Santa Fe to help reduce the risk of catastrophic fire here in the Santa Fe watershed.

Mr. NEWMAN. You bet. You know, one of the things that as I mentioned before, few people see the outward effects of drought other than fire when they think about the Forest Service.

The reality is most of the water that flows in the streams in the Southwest come off the national forest system lands, either in Colorado or here in New Mexico and Arizona. So the condition of those lands are critically important to that flow of water.

What we found is particularly where municipalities have a dependence on a watershed for a lot of their surface water flow, those are the ones that are most at risk. I think to the city of Santa Fe's credit, they saw that earlier on and realized something needed to be done that probably was not typical.

Management was needed to lower, if you will, the risk of catastrophic fire that could have significant effects on both the quality and quantity of water they would get off of the Santa Fe watershed. So they entered a partnership.

Creatively that's being looked at across the country to begin to help water users realize that connection, to take money that water users pay and invest in those watersheds with the Forest Service.

So we've treated I believe about 7,200 acres through thinning and prescribed fire. We've got about probably 300 acres left to finish the cleanup from the original thinning work and then continue to use fire to keep those fuels at a low level so fire, when it does occur in the watershed, will not be catastrophic.

The CHAIRMAN. Now, this thinning has the effect of heading off catastrophic fires in the area that's thinned. Does it also have the effect of increasing the availability of water or the amount of water coming off of the watershed for use by the city of Santa Fe?

Mr. NEWMAN. To a certain degree. Of course, it depends on how much water actually is input into the system, how much rain you get in a particular year. But I always liken it to trees are like straws. They're in the ground and they pull water out and they transpire it.

So the more we have density management, fewer trees on that landscape, the more water can really land on the ground and filtrate or run off. There's less interception, less evaporation. So it creates that ability.

But the real value there I believe when you look at the treatments is lowering the risk that that—that a significant fire could impact that watershed that would change it for decades, if not a century.

The CHAIRMAN. OK. I gather the same kind of thing has occurred in Southern New Mexico, particularly around the Ruidoso area?

Mr. NEWMAN. Yes, Ruidoso being one of the most threatened communities in the country. We've focused a lot of energy working with various entities including Mescalero in how do we go about

collaboratively treating that area to reduce the chance of catastrophic wildfire.

A significant issue because it's very, very expensive. We're trying to find economical ways, create industries that can utilize that material so we can treat an ever greater number of acres. But great progress has been made in treating around Ruidoso.

Ruidoso Downs was the next on the list. We had the White fire down there that had a—will have a significant effect on Ruidoso Downs this summer. Monsoons there are not going to be welcome.

The CHAIRMAN. Yes. This is very useful testimony. I appreciate it very much. I thank all three of you on this first panel. We will include the full testimony that you've prepared as part of our committee hearing record. Thank you very much.

Why don't we go ahead with the second panel. If they would come forward please.

[Pause.]

The CHAIRMAN. OK. Why don't we go ahead here. As I indicated before we started, at the beginning of the hearing, the second panel is to focus on the impacts of climate change on water supplies and particularly to highlight the report that was issued by the Bureau of Reclamation earlier this week in response to the SECURE Water Act.

Let me introduce our panel members. Honorable Michael Connor who is the Commissioner of the Bureau of Reclamation. Dr. Jonathan Overpeck who is codirector of the Institute of the Environment at the University of Arizona in Tucson. Thank you for being here. Dr. Brian Hurd who is associate professor of agricultural economics and agricultural business at New Mexico State in Las Cruces.

I appreciate you all being here. Let me just—before I let Mike go ahead with his testimony. Mike was working with us in the same kind of—same position that Tanya now is working with us on our Energy and Natural Resources Committee when the legislation, the SECURE Water Act, was drafted up.

He's the person primarily responsible for getting that done and getting it passed. Now he's the person primarily responsible for getting it implemented. So he deserves great credit for what progress has been made on this subject and for the report that he's going to talk about today. So, Mike, go right ahead.

STATEMENT OF HON. MICHAEL CONNOR, COMMISSIONER, BUREAU OF RECLAMATION

Mr. CONNOR. Thank you, Mr. Chairman. I found out that's much easier to think up great ideas than to implement them.

The CHAIRMAN. I heard a great comment a year or 2 ago. Someone said that now—this was in connection with healthcare legislation. They said, you know, now they're going to find out what Moses found out 2,000 years ago, it's a lot easier to write it down than it is to get it done. So go ahead.

Mr. CONNOR. For the record I'm Mike Connor, Commissioner of the Bureau of Reclamation. I thank you for the opportunity to discuss the water issues in New Mexico this year and the longer term subject of climate change and its affect on Western water supplies.

I would like to start by discussing the current water year in New Mexico. As noted the entire State is in drought. The Rio Grande has seen lower than average precipitation and higher than average temperatures. The Pecos River Basin has been even drier, with only 51 percent of average precipitation for this date.

These factors coupled with below average carryover storage in both systems do not bode well for conditions in the spring and summer unless significant spring and summer precipitation occurs. Also while current conditions and projections are positive for the Upper Colorado River Basin, a warming trend during April has the potential to erode the above-average conditions we're presently seeing.

The dry hydrology in the Rio Grande and Pecos River Basins are of a significant concern to Reclamation with respect to its operations in New Mexico. In the Middle Rio Grande, we are working closely with the State, our contractors, and other interested parties to ensure there is sufficient water to meet endangered species' needs and still maintain water operations in 2011.

Notwithstanding these actions, it is expected that reservoir levels will fall over the course of the year. This situation lends urgency to our efforts to put a new long-term Biological Opinion in place upon expiration of the existing opinion at the end of 2012.

In the Pecos Basin, Reclamation is working closely with its partners to acquire additional water that will provide sufficient flows for meeting the 2006 Biological Opinion, assist in meeting Pecos River Compact obligations, and provide efficient irrigation deliveries.

The Fish and Wildlife Service and Reclamation are monitoring conditions and adjusting plans for reduced in-river flow conditions on the Pecos so that the available supply is optimized for the Pecos blunt-nosed shiner while still meeting downstream needs.

To the west and north of here on the Colorado River, the upper basin of the Colorado has received healthy, above-average precipitation so far this year, 120 percent as of April 4. The April to July inflow forecast to Glen Canyon Dam/Lake Powell, which represents the bulk of the inflow, increased 4 percent last month to 120 percent of average.

A favorable precipitation situation will allow for an equalization operation between Lakes Powell and Mead, bringing Lake Mead's storage closer to that of Lake Powell's. While encouraged by the water availability this year, we would caution that it's too early to say that we are out of the long-term drought we've been facing since the year 2000 in this basin.

A final note on this year's water supply challenges. Our ability to successfully react to and address drought conditions requires significant planning, not simply a reactive approach. Our infrastructure has allowed Western water users to withstand significant boom and bust cycles of water supply over the last 100 years.

Today the stresses on existing supplies are so significant that there needs to be new institutional and on-the-ground preventions to address future droughts. More flexibility needs to be built into our water system such as more diversified reserve supplies, efficient markets for short-term water transfers, and the creation of

new habitats to improve the resiliency of important ecosystems. I think Esteven's testimony earlier touched on all those points.

If we aren't proactive, then most likely the only way to address drought is to try and mitigate economic losses. On this point I would like to segue to the issue of future challenges to New Mexico's water supplies and that of the rest of the West.

Climate change and the prospects for reduced water supplies over time are areas of special emphasis and study at the department. Last year, on March 16, this committee held a hearing on a departmental program called WaterSMART, which stands for Sustain and Manage America's Resources for Tomorrow.

The WaterSMART program focuses the efforts of Reclamation and the U.S. Geological Survey on improving water conservation and helping resource managers make strategic decisions about water use.

Much of my statement here today will review WaterSMART activities. But I would also like to discuss future activities and where the current research on climate change is pointing.

As a threshold, Mr. Chairman, I'd like to return the favor and acknowledge and thank you for your leadership in this area. A number of the actions I'm going to discuss were authorized by the legislation you authored, specifically the SECURE Water Act.

This legislation was enacted as part of the landmark Omnibus Public Lands Package that you managed, Secretary Salazar strongly advocated for, and President Obama signed into law in March 2009.

This legislation overall including the SECURE Water Act will benefit the entire Nation well into the 21st century. The science is clear that climate change will add to the challenges we face in managing our water supply, water quality, flood risks, aquatic ecosystems, and energy production.

Certainty and sustainability are the goals Reclamation strives for in the use of the West's limited water resources. Climate change strikes at the heart of those goals. We simply need to adapt.

Earlier this week the department published the report called for under Section 9503 of the SECURE Water Act. The 9503 report synthesizes existing literature on climate change. It also features an original assessment of climate change implications for snow pack, hydrology, and overall water supply in 8 major river basins in the West.

We've got some graphics up there to show those impacts and where they lie with respect to those river basins.

The 9503 report affirms and adds more analysis to the scientific studies which include in the 21st century, temperatures may continue to increase by roughly 5 to 7 degrees Fahrenheit in the Western United States. This increase is in addition to the approximate 2 degree average Fahrenheit increase that's been experienced across much of the West during the 20th century.

As discussed in the report, warming temperatures will significantly impact Western water management. The quantity of what's available, water supply will change, some increases, some significant decreases. Timing of available supplies will change.

April 1st snow pack decreases in all basins. Demand for water will likely increase with increasing temperatures. Environmental

issues will likely be exacerbated for aquatic ecosystems. Finally energy use and generation is likely to be affected.

Speaking to the basins of primary concern to New Mexico, in the Colorado River Basin, the amount of increase varies geographically and seasonally but is roughly between 5 to 6 degrees Fahrenheit.

This temperature increase is changing the dynamics of the basin and changing the growing season with spring coming earlier. Overall annual runoff is projected to decrease by an average of 8.5 percent by the year 2050.

Although as a result of this year's good precipitation in the Colorado River Basin and the prospects for lower basin shortages in 2012 have been eliminated, the risks of shortage in the lower basin are expected to increase over time to about 40 percent in the year 2026.

Risks can be reduced through alternative water management strategies. Reclamation in cooperation with stakeholders basinwide is aggressively pursuing investigation of such studies in its WaterSMART basin studies which I'll describe in more detail.

In the Rio Grande Basin, first our report shows it will be perhaps the most heavily impacted river basin in the West. To be clear the report does discuss the uncertainties that still exist in projecting future precipitation patterns and runoff.

Notwithstanding the use of the best available science, those models still have some inherent uncertainty. Nonetheless, the highly likely 5 to 6 degree Fahrenheit increase in average temperature during this century will have a strong impact on the basin.

Mean annual runoff is projected to decrease by 7.3 percent to 14.4 percent in the Rio Grande Basin by 2050, with late season flows most significantly decreased. These are the post-April 1st flows which are projected to decrease by 14 to 16 percent by 2050.

As noted earlier water management systems across the West have been designed to operate within wide envelopes of hydrologic variability, handling variations from season to season and year to year.

These systems were designed with local hydrologic variability in mind. As a result their physical and operating characteristics vary depending on storage capacity and conveyance flexibility.

For example, the Colorado River Basin has a relatively large amount of storage relative to annual runoff compared to the California River Basin and the Columbia River Basin.

Accordingly, the assessment of water management impacts and appropriate responses must be done on a local or regional level. This is the approach taken within Reclamation's Basin Studies Program and West-Wide Climate Risk Assessments.

In our fiscal year 2012 budget requests, Reclamation is seeking a total of $53.4 million for the WaterSMART Program, of which the Basin Studies and West-Wide Risk Assessments are a part.

The request of $1 million for the Risk Assessments will continue Reclamation's development of consistent baseline projections of risks to Reclamation's operations due to climate change. We're going to start a major part of the Risk Assessments here in the Rio Grande Basin.

Funding of $2.5 million will support the Basin Studies through which Reclamation will continue to evaluate the ability to meet fu-

ture demands within a river basin and to identify adaptation strategies where water supply and demands may not be in balance.

The purpose of the Risk Assessment is to identify and examine water supply and demand imbalances so that Basin Studies can analyze how those imbalances impact operations. The Basin Studies may then develop strategies to mitigate or adapt to operations.

The Colorado River Basin Study, which is a partnership of the 7 Colorado River Basin States including New Mexico as well as other interested entities, is our largest scale basin study.

In 2012 Reclamation will begin providing funding for specific feasibility studies for actions to adapt to and address climate change impacts through the WaterSMART Basin Study Program. We will also continue our support for conservation efficiency improvements through the WaterSMART grant program, the Title 16 water reuse programs, and our river restoration activities.

As I identified in my written statement, adapting to improve water management and infrastructure upgrades, including improvements in our hydroelectric and environmental-related facilities, is a very active area for the Bureau of Reclamation.

Before concluding I would like to mention the USGS Section 9506 report that was released for public review earlier this month. As you know the SECURE Water Act called for a report assessing the adequacy of water resources measurement, modeling, and data sharing systems that are relevant to climate change adaptation.

USGS has taken the lead in preparing the report in collaboration with many agencies at the Federal and State level. In sum the report discusses the need and opportunity to modernize data networks and climate-relevant data collection, data management, mapping, modeling, and information dissemination.

Through this report and its water availability end-use assessment, USGS is ensuring that sound science is the foundation for present and future water resources management.

Chairman Bingaman, once again I would like to thank you for your leadership this area. If I could just take a couple minutes, I would like to clarify something with respect to the SECURE Water Act.

As I noted the SECURE Water Act was your bill. In April 2008 the Santa Fe New Mexican published an editorial lauding the bill and the good science that it was going to promote. But within that editorial the New Mexican stated about the bill—and I'm going to quote this. "It's got one of those too-cute acronyms as a name, the SECURE[Science and Engineering to Comprehensively Understand and Responsibly Enhance] Water Act. Westerners long in need of such legislation no doubt will forgive whoever thought up that mouthful as long as it doesn't turn away prospective supporters." So the good news is——

The CHAIRMAN. I think you're the one who thought up that name.

Mr. CONNOR. I was going to come clean on that point. I'll confess I attribute the ideas and the programs within the bill to your great leadership. I'll take the blame for the name because it was mine. But we're pleased to be implementing that bill. I'll take questions at the proper time.

[The prepared statement of Mr. Connor follows:]

PREPARED STATEMENT OF HON. MICHAEL CONNOR, COMMISSIONER, BUREAU OF RECLAMATION

Chairman Bingaman, Ranking Member Murkowski and members of the Committee, I am Mike Connor, Commissioner of the Bureau of Reclamation (Reclamation) at the Department of the Interior (Department). Thank you for the opportunity to testify before the Committee today regarding the water supply situation in New Mexico and within the Colorado River Basin, as well as the longer-term subject of climate change and its effect on western water supplies. These are areas of special emphasis and study at the Department, and as a long-term New Mexican, I am pleased to report on the many activities we have underway.

Last year on March 16, 2010, the Water and Power Subcommittee of this Committee held a hearing on a Department program called WaterSMART (Sustain and Manage America's Resources for Tomorrow). The WaterSMART program provides the foundation for the Department's efforts to achieve a sustainable water supply for this country. It includes efforts of Reclamation and the U.S. Geological Survey (USGS) to improve water conservation and help water-resource managers make sound decisions about water use. It is a prominent feature in the Department's Fiscal Year 2012 budget request. WaterSMART was established pursuant to Secretarial Order 3297, and the Program functions as the Department's implementation of the SECURE Water Act, Title IX Subtitle F of Public Law 111-11. Much of my statement today will review WaterSMART activities to date, but I'd also like to discuss future activities and where the current research on climate change is pointing the Department and Reclamation.

The science is quite clear that climate change will add to the challenges we face in managing our water supply, water quality, flood risks, wastewater, aquatic ecosystems, and energy production. These new stresses are likely to be felt first in the western United States, the fastest growing region of the nation. From 2000 to 2010, Nevada grew the most at 35.1 percent, followed by Arizona, Utah, Idaho and Texas. Nevada is the only state that has maintained a growth rate of 25.0 percent or greater for the last three decades,[1] with some of the fastest growth in the driest areas.

Earlier this week, the Department published the report called for under Section 9503(c) of the SECURE Water Act (Report). The Report synthesizes existing peer-reviewed literature on climate change, and also features an original assessment of climate change implications for snowpack and natural hydrology. The Report provides a presentation of Reclamation's work to date on assessing the effects and risks from global climate change on water resources in each major Reclamation river basin; the impact of global climate change on operations in each of these basins; mitigation and adaptation strategies to address global climate change; and each coordination activity conducted by the Department within Federal and state water resource agencies.

The Report re-emphasizes other scientific studies which conclude that in the 21st century temperatures may increase by roughly 3 to 4 degrees Celsius (°C) in the Western United States. This increase is in addition to the approximate 1-2 °C average warming experienced across much of the West during the 20th Century. Also, in the coming years, it is likely that the northwestern and north central portions of the United States will have greater rainfall (e.g., Columbia and Missouri basins), while the southwestern and south central portions are expected to have less precipitation (e.g., San Joaquin, Truckee, middle to lower Colorado, and Rio Grande basins). For the areas in between trends in precipitation have not yet been identified, though increasing temperatures may still affect water supply availability (e.g., Klamath and Sacramento River Basins). April 1st snowpacks are projected in the Report to decrease for almost all of the Western United States and annual water supplies may change, with the peak flow in snow-pack dominated watersheds occurring earlier.

Speaking to the Colorado River Basin specifically, the Report shows that the entire basin experienced an increase in temperature in the 20th century. The amount of increase varies geographically and seasonally, but is roughly between 1 and 3 °C. This temperature increase is changing the dynamics of the basin, identified through measurement of the number of frost-free days, length of the frost-free season, and in the growing season length (spring is coming earlier). Results from climate simulations indicate a high degree of agreement on projected changes in temperature. Temperature is projected to increase by 1 to 2 °C by 2040, 2 to 2.75 °C by 2070 and by up to 4 °C by the end of the 21st century.

[1] Source: U.S. Census Bureau, Population Distribution and Change: 2000 to 2010. Summary online at http://www.census.gov/newsroom/releases/archives/2010_census/cb11-cn124.html

Precipitation changes in the basin are more variable than temperature and the distribution of these changes are more complex. Precipitation variability is tied to ocean dynamics, in particular, sea surface temperatures in the Atlantic and Pacific Oceans. This partially explains why Colorado River Basin precipitation varies through time. However, the period from 2000 to 2010, inclusive, has been the driest 11-year period in the 100-year historical record on the Colorado River Basin. It is unknown whether this current drought can be attributed to climate change, as stream flow records reconstructed from tree-rings indicate that droughts of this magnitude have occurred in previous centuries. However, several scientific studies have concluded that the recent drought is likely a harbinger of future conditions. Modeled projections for precipitation indicate that there may be an increase in the Upper Colorado River Basin and a decrease over the more arid regions within the Lower Colorado River Basin.

Despite the significant range of potential changes in precipitation patterns and quantities, the temperature driver is anticipated to continue to alter snowpack conditions within the Colorado River Basin. The trend towards earlier spring runoff is expected to continue, changing the time when snowpack melts and the dynamics of runoff. These changes are already apparent in that the snowpack in the Colorado River Basin has been experiencing a general decline in the spring, reduced fractions of winter precipitation occurring as snowfall, and earlier snowmelt runoff. Reduced mountain snowpack, earlier snowmelt, and reductions in spring and summer streamflow volumes originating from snowmelt could trigger increased reliance on ground water resources. However, warmer, wetter winters could increase the amount of water available for ground water recharge, but this is an area that is poorly understood and in need of further study.

Many studies investigating changes in Colorado River streamflow have been conducted in recent years; in combination, they project reductions from 6 to 20 percent by the middle of the 21st century. The risks of shortage to users in the lower Colorado River Basin (as defined in Reclamation's Interim Guidelines for Lower Basin Shortages and Coordinated Operations of Lakes Mead and Powell)[2], although averted in 2012 due to a reasonably good snowpack and runoff this year, are expected to increase over time to about 40 percent in 2026. With current water management strategies throughout the Colorado River Basin, risks of full reservoir depletion are less than 5 percent through 2026, however these risks increase significantly between 2026 and 2057, inclusive. Risks can be reduced through alternative water management strategies, and Reclamation, in cooperation with stakeholders Basinwide, is aggressively pursuing investigation of such studies in its WaterSMART Basin Study, which I will describe in more detail below.

It is not possible to infer water management impacts, nor develop adaptation strategies, simply from these runoff changes alone. Water management systems across the west have been designed to operate within wide envelopes of hydrologic variability, handling variations from season-to-season and year-to-year. These systems were designed with local hydrologic variability and demand patterns in mind, and as a result, their physical and operating characteristics vary depending on storage capacity and conveyance flexibility. For example, the Colorado River Basin has a relatively large amount of storage relative to annual runoff compared to California basins, and particularly relative to the Columbia basin. Each basin or Reclamation project also has different constraints in which it operates including providing hydropower, managing floods in conjunction with the U.S. Army Corps of Engineers, delivering water to agricultural and municipal water users, and supporting the recovery of threatened and endangered species. The ability to use storage resources to mitigate future hydrologic variability, changing water demands, constraints on operations, and changes in runoff seasonality are key determinants of whether these natural runoff changes will translate into significant management impacts. Assessment of these water management impacts on a local level is the subject of ongoing activities within Reclamation's Basin Studies Program and West-Wide Climate Risk Assessments (WWCRAs).

In its Fiscal Year 2012 budget request submitted to Congress in February, Reclamation requested $58.9 million for the WaterSMART Program, of which the Basin Studies and WWCRAs are a part. Beyond the initial Report, the request of $1 million for the WWCRAs will continue Reclamation's development of consistent and comprehensive baseline projections of risks and impacts to Reclamation operations due to impacts of climate change. Funding of $2.5 million will support the Basin Studies, through which Reclamation will continue to work with state and local partners to evaluate the ability to meet future water demands within a river basin and to identify adaptation strategies where water supply and demands may not be in

[2] http://www.usbr.gov/lc/region/programs/strategies/documents.html

balance. Basin Studies benefit from results generated through the WWCRAs. The purpose of the WWCRA is to identify and examine water supply and demand imbalances so that the Basin Studies can analyze how those imbalances impact operations. The Basin Studies may then develop strategies to mitigate or adapt to impacts to operations. The Fiscal Year 2012 Budget Request included $6.0 million for Basin Studies. As an example, the Colorado River Basin Study is focusing on a more detailed, basin-wide assessment of risk to Colorado River Basin resources from future water supply and water demand imbalances and identification and evaluation of strategies to resolve future imbalances and mitigate risks. As a separate activity from the work developed for the Report, Colorado River Basin stakeholders throughout the Basin are heavily engaged in the Colorado River Basin Water Supply and Demand Study.

The Colorado River Basin Study contains four major phases: water supply assessment, water demand assessment, system reliability analysis, and development and evaluation of opportunities for balancing supply and demand. A scenario planning process has been undertaken to provide a framework to incorporate the high degree of uncertainty in the assessment of future water supply and water demand. This process, which includes input from stakeholders throughout the Colorado River Basin, is being used to develop a broad range of plausible scenarios of future supply and demand. Four water supply scenarios have been formulated and quantified, one of which incorporates future climate projections from Global Climate Models. The remaining three water supply scenarios use approaches applied to observed and paleoreconstructed streamflow records. Four water demand scenarios also have been identified that incorporate plausible future trajectories related to demographics and land use, technology and economics, and social and governance factors.

All of this work is geared toward providing very real-world, practical results: preparing our facilities to continue delivering benefits in the future. Reclamation's customers—farms, cities, power users, recreationalists and our ecosystem programs—all rely on the stability provided by the existing water infrastructure in the West. In 2012 Reclamation will begin providing funding for specific feasibility studies for actions to address climate change impacts through the WaterSMART Basin Study Program. Funding for the studies will require a 50 percent non-Federal cost share, and will pursue strategies previously identified in Basin Studies or equivalent appraisal level analyses. Potential areas include the Colorado, Columbia, Klamath, Missouri, Rio Grande, Sacramento, San Joaquin, and Truckee rivers, to be determined by Reclamation and its partners. In addition, a WaterSMART Funding Opportunity Announcement (FOA) was published by Reclamation and the Department of Agriculture's Natural Resources Conservation Service (NRCS) at the end of 2010 inviting irrigation districts, water districts and other organizations to apply for conservation projects. In partnership with Reclamation, NRCS will provide funding and technical assistance to farmers and ranchers eligible for on-farm conservation practices through the WaterSMART program.

In addition to these programs, Reclamation is completing major projects to recover power plant generating capacity and efficiency in the face of a more than 100-foot decline in the level of water in Lake Mead. These projects include installing new turbine components and modifying or adjusting existing turbine components to increase generation capacity available when the lake level is low. As a result, the total increase in generating capacity achieved at Hoover Dam to date is 93 megawatts (MW), and an additional 7 MW is scheduled for May 2011. Reclamation is also replacing existing turbine runners to wide range turbine runners to improve efficiency and provide wide range turbine operation at Glen Canyon and Hoover power plants.

As you can see, Reclamation's activities in the face of drought and potential climate change impacts are many and varied. In addition to the Programs described above, Reclamation also works with its many partners on a day-to-day basis to better understand and incorporate climate information into western water resource management as well as in the implementation of Section 9503 of the SECURE Water Act. These partnerships include:

- Through the WaterSMART Program Task Force, each bureau and office under the Department is tasked to use available program discretionary authorities, within the scope of its mission. The Task Force is responsible for working within existing relationships and developing new partnerships between Federal agencies, States, and tribes to collaborate on implementation of WaterSMART. Through the WaterSMART Basin Studies, Reclamation is partnering with local water and power delivery entities to develop mitigation and adaptation strategies to meet any water supply and demand imbalances that may exist now and in the future. As noted above, within the Colorado River Basin Water Supply and Demand Study, Reclamation is partnering with the seven basin States

(New Mexico, Arizona, Colorado, Utah, California, Nevada, and Wyoming). Similar partnerships exist for other basin studies.

- Secretarial Order 3289 established the Department's coordinated approach to dealing with climate change through the Landscape Conservation Cooperatives (LCCs) and Climate Science Centers. Reclamation's collaboration within the LCC framework is part of its WaterSMART implementation. Each LCC functions in a specific geographic area and will form a national and international network for applied science to inform resource management. Over the past year, Reclamation and the U.S. Fish and Wildlife Service have formed broad-based scoping committees for the Desert and Southern Rockies LCCs, with participation by multiple State and Federal agencies, non-governmental organizations, tribes and universities. The steering committees for the Desert and Southern Rockies LCCs will be established in April 2011. Reclamation plans to integrate and coordinate its WaterSMART activities with the LCCs. Additionally, the Bureau of Reclamation has begun working with the DOI Climate Science Centers and National Climate Change and Wildlife Science Center to identify develop and begin research specific to water management.
- In 2008, Reclamation collaborated with the U.S. Army Corps of Engineers, National Oceanic and Atmospheric Administration (NOAA), and the USGS to form the Climate Change and Water Working Group (CCAWWG) to bring water managers and climate scientists together to identify common information gaps to assess, forecast, and adapt to climate change impacts on Western water supplies. Additional CCAWWG Federal participants include the Environmental Protection Agency, Federal Emergency Management Agency, and National Aeronautics and Space Administration; non-Federal participants include the Western States Water Council; local municipal water authorities; NOAA's Regional Integrated Science and Assessment (RISA) Centers; and the National Center for Atmospheric Research.
- Department of Commerce—NOAA—Reclamation continues to collaborate with NOAA Regional Integrated Science Assessment (RISA) teams and regional climate centers in the western U.S. to assist in developing climate information to support stakeholders in a variety of sectors, including identifying information needs, development of decision support tools related to climate variability and change, and data selection, interpretation, and understanding. These centers include the Climate Decision Support Consortium, the California-Nevada Applications Group, the Western Water Assessment, the Climate Assessment for the Southwest, and the Southern Climate Impacts Planning Program. Reclamation also continues to collaborate with the former RISA center at The University of Washington, the Climate Impacts Group. In addition to engaging with RISA centers, we are collaborating with NOAA Earth System Research Laboratory to better understand the science surrounding climate variability and climate change.
- NRCS—NRCS's Snowpack Telemetry network provides an extensive, automated system designed to collect snowpack and related climate data in Alaska and the western United States which is used to produce water supply forecasts. NRCS's Soil Climate Analysis Network (SCAN) is an information system designed to provide data on soil moisture and climate information from a number of different sources also used in forecasting.
- The Department of Interior participates on the Interagency Climate Change Adaptation Task Force, co-chaired by the Council on Environmental Quality, the National Oceanic and Atmospheric Administration, and the Office of Science and Technology Policy.μ The Task Force works with Federal agencies to identify actions to better prepare the United States to respond to the impacts of climate change. The October 2010 Progress Report of the Task Force recommends that the Federal Government implement actions to expand and strengthen the Nation's capacity to better understand, prepare for, and respond to climate change. The Task Force's work has been guided by a strategic vision of a resilient, healthy, and prosperous Nation in the face of a changing climate. Reclamation participates on the Water Resources and Climate Change Adaptation Workgroup that supports the Task Force and is developing the National Action Plan for adaptation of freshwater resources management to climate change called for in the October 2010 Progress Report of the Adaptation Task Force (see the October 2010 Progress Report of the Task Force for more information).
- Finally, I'd like to note that the Administration recently transmitted a report to Congress that was required in Section 9506 of the SECURE Water Act. Section 9506 of the Omnibus Public Lands Act (Public Law 111–11) calls for a report to Congress on the adequacy of water resources measurement, modeling, and data sharing systems that are relevant to climate change adaptation. The

Nation invests considerable resources in monitoring, mapping, evaluating, assessing, modeling, and managing water resources. Many of the existing observational water data networks, models, and hydro-statistical methods were developed for specific users and pre-date recent advances in climate change science. As a result, these systems (networks, methods, and models) were not designed to account for the effects of a changing climate on water resources, or to evaluate the effectiveness of climate change mitigation and adaptation strategies. Today, there is a need and an opportunity to modernize data networks and climate-relevant data collection, data management, mapping, modeling, and information dissemination. Of particular importance is maintenance and strengthening of long-term ground-based and remote observational capabilities to detect change. The report addressing these concerns has been reviewed by the multiagency panel authorized in Section 9506(a), and a draft version is out for public comment. The panel looks forward to presenting its findings to the Secretary for transmission to Congress.

HYDROLOGY—COLORADO RIVER AND NEW MEXICO WATER SUPPLY, 2011

Apart from the longer-term topic of west wide climate change, the other focus of the Committee today is the near-term water supply picture on the Colorado River and here in New Mexico for 2011. We've discussed long-term trends on the Colorado above, so let me turn now to the Rio Grande.

In New Mexico, predictions of a strong La Niña, with drier conditions expected in the Rio Grande and Pecos river basins, are proving accurate this year based on the early season conditions in these basins. The Rio Grande is seeing lower than average precipitation (80 percent as of April 17), and higher than average temperatures. The Pecos River Basin has been even drier, with only 51 percent of average water year precipitation for this date (April 17). These factors, coupled with below average carryover storage in the systems, do not bode well for conditions in the spring and summer in these two basins unless significant late spring precipitation occurs. While current conditions and projections are positive for the Upper Colorado River basin, a warming trend during April has the potential to erode the above average conditions that we are currently seeing.

The low precipitation levels that currently exist in the Rio Grande and Pecos river basins are of significant concern to Reclamation with respect to its operations in New Mexico. In the Middle Rio Grande, although there is likely to be sufficient water to meet endangered species needs and still maintain water operations in 2011, reservoir levels will fall and the situation lends urgency to our efforts to put a new long-term biological opinion in place upon expiration of the existing opinion at the end of 2012.

In the Pecos river basin, Reclamation is working closely with its water user partners and the New Mexico Interstate Stream Commission to acquire additional water through lease and forbearance agreements that will provide sufficient flows for meeting the 2006 biological opinion flow targets, assist in meeting Pecos River Compact obligations, and provide efficient irrigation deliveries. The U.S. Fish Wildlife Service and Reclamation are monitoring conditions and adjusting operational plans for anticipated reduced in-river flow conditions on the Pecos so that the available supply is optimized to protect the Pecos Bluntnose Shiner while meeting downstream needs.

Finally, with respect to the Rio Grande Project, forecasted inflow to Elephant Butte Reservoir is 36 percent of average and the reservoir is expected to drop 24 feet this summer impacting the recreational economy of the area. Water users, the states of New Mexico and Texas, and Reclamation are looking at alternatives to conserve storage while meeting irrigation demands for two irrigation districts and treaty obligations for water deliveries to lands in the Republic of Mexico. As part of its primary mission in the Middle Rio Grande, Reclamation continues to improve the Rio Grande channel conditions for the efficient transport of water and sediment to Elephant Butte in collaboration with the New Mexico Interstate Stream Commission, and is working closely with irrigation districts to increase their conservation efforts.

To the west and north of New Mexico on the Colorado River, the upper basin of the Colorado has received healthy, above average precipitation so far this year (121 percent of average as of 4/21). The April to July inflow forecast to Glen Canyon Dam / Lake Powell, which represents the bulk of the inflow, increased by 6 percent since March 1 to 122 percent of average. The above average inflow forecast will result in increased releases from Lake Powell under the equalization rules. These additional releases from Lake Powell will increase Lake Mead's content to approximately 46 percent of capacity by the end of the water year, more closely balancing the contents

between Lake Powell and Lake Mead. While we are encouraged by the water availability this year, we would caution that it is too early to say that we are out of the long-term drought we have been facing since 2000 in the southwest.

As of April 21, 2011, the storage in Lake Mead was 11.1 million acre-feet (43 percent of capacity) and its surface water elevation was 1,096 feet above sea level. Total overall reservoir storage in the Colorado River Basin was 31.4 million acre-feet (53 percent of capacity).

Due to winter storms in the Lower Basin in late 2010, tributary inflows were well above average in December. Inflows resulting from these storms increased Lake Mead's elevation by nearly 2 feet during a 7-day period in December 2010. Also due to the winter storms in late December 2010, and additional storms in February 2011, demands in the Lower Basin were less than projected during the months of January and February 2011. The month of February brought cooler than normal temperatures and precipitation varied with below normal precipitation in some areas and above normal precipitation in other parts of the Lower Basin. During March, temperatures were warmer than normal and precipitation was well below normal throughout the basin. The Climate Prediction Center outlook (dated April 21, 2011) indicates that over the next three months that more likely than not it will be warmer than normal with equal chances for above or below normal precipitation in the Lower Basin.

WATERSMART WATER AVAILABILITY AND USE ASSESSMENT INITIATIVE

The Department of the Interior's High Priority Performance Goal set a target for water conservation through the WaterSMART Program. For Fiscal Year 2012, Reclamation is seeking to achieve 490,000 acre-feet of water savings. In Fiscal Year 2010, Reclamation achieved a savings of 150,000 acre-feet of water. The Fiscal Year 2011 assessment is still underway.

As previously mentioned, the USGS is an important partner of Reclamation on the WaterSMART initiative. I would like to end this statement with a discussion of the USGS's WaterSMART Water Availability and use Assessment Initiative. Many factors affect the amount of water that is available; precipitation patterns, streamflows, groundwater availability, and land uses all affect water availability. The USGS's WaterSMART Water Availability and Use Assessment Initiative will account for the changing amount, quality, and use of water resources across the Nation. It provides a standard way for the Nation to understand water availability using measurements or estimates of the different components of the water cycle, including precipitation, surface water, and groundwater. The President's 2012 budget includes $10.9 million USGS to carry out this initiative. The key components of this initiative include:

- A nationwide system to deliver information about water availability factors that every manager needs when dealing with availability questions—precipitation and evapotranspiration, surface-water runoff and baseflows, recharge to groundwater and changing storage in aquifers.
- Increased knowledge of water use science—withdrawals, demands, consumption, and return flows.
- An investment in the science of ecological flows.
- A new grant program for state water resource agencies to assist them with critical work on their water use databases.
- A series of "focus area" studies that will include a comprehensive three-year technical assessment of water availability with the best available tools.

The ultimate objective of USGS WaterSMART efforts is to provide the ability to track water use from its point of withdrawal, through how the water is used and consumed, and ultimately how it is returned to the environment. The Administration fully recognizes the important role of states in producing water use information, and we realize the heavy burden that states currently bear financially. For that reason, USGS investment in water use science will include a program of grants to state water resource agencies to assist them with critical work on their water use databases.

Finally, throughout the United States there are areas where competition for water resources has reached a level of national attention and concern. Sometimes the competing interests are multiple human needs—needs for potable water, for irrigation, for energy, for industrial processes or for other uses. In other circumstances, the competition is between human and aquatic ecosystems needs. Through WaterSMART, USGS proposes a series of studies, focused on selected watersheds, where there is a desire on the part of watershed stakeholders to conduct a comprehensive technical assessment of water availability with the best available tools.

These studies will provide critical information to land and water resource managers through a comprehensive technical analysis of the factors affecting the availability of water. The first three geographically focused studies of water availability and use will be in the Colorado River (CO, UT, WY, NV, NM, AZ, CA), Delaware River (NY, PA, NJ, DE), and Apalachicola, Chattahoochee, and Flint River Basins (AL, FL, GA). USGS will work with watershed stakeholders and the various agencies involved in these geographic focus areas to scope and conduct these studies. During the early months of 2011, USGS began seeking stakeholder input to develop the scope of the Colorado River geographic focus area study.

The 2012 budget provides $10.9 million for USGS activities in the WaterSmart initiative, $9.0 million above the 2010 Enacted/2011 CR level, to implement the WaterSmart Availability and Use Assessment. USGS will conduct comprehensive water supply and demand inventories to provide the baseline information needed by public and private water managers to work toward sustainable water supplies. This effort will include estimating freshwater resources, how those supplies are distributed, and how they are changing over time; evaluating factors affecting water availability including energy development, changes in agricultural practices, increasing population, and competing priorities for limited water resources; and assessing water use and distribution for human, environmental, and wildlife needs.

CONCLUSION

Droughts and dry weather are nothing new in the Southwest. And as you know, the water infrastructure constructed by Reclamation and our partners in the West was built to mitigate for that reality. This year, we will work with the hydrology in New Mexico and on the Rio Grande and Colorado River together with our partners to maximize water reliability on the rivers, and meet our obligations to the maximum extent practicable.

In the longer term, the Department is working every day to equip our agencies and other resource managers with the data they need to answer the questions they face about water supply and use and to continue delivering water and power in the face of a changed climate.

While the activities described here today are wide-ranging, they are by no means inclusive of every avenue we're pursuing. New ideas are at the heart of innovation, and we value our partnership with Congress to bring the best thinking to the challenge of climate change. In ways both large and subtle, this challenge will impact nearly every facet of Reclamation's operations, so if new thinking on how to anticipate and adapt to climate change comes to our attention, we will pursue those as well.

Chairman Bingaman, thank you for the opportunity to discuss these important topics. I would be pleased to answer any questions the Committee may have.

The CHAIRMAN. Thank you again. Thank you for your testimony here today. Dr. Overpeck, go right ahead.

STATEMENT OF JONATHAN OVERPECK, CO-DIRECTOR, INSTITUTE OF THE ENVIRONMENT, PROFESSOR OF GEOSCIENCES, PROFESSOR OF ATMOSPHERIC SCIENCES, THE UNIVERSITY OF ARIZONA

Mr. OVERPECK. Thank you, Mr. Chairman, for the opportunity to speak with you today on the topic of climate variability and climate change as they relate to water supply in New Mexico and the broader Southwest United States.

My name for the record is Jonathan Overpeck. It's a pleasure to be testifying in a hearing in my parents' hometown of Santa Fe.

In addition to being codirector of the Institute of the Environment at the University of Arizona, I'm also professor of geosciences and professor of atmospheric sciences. I have published over 140 papers on climate environmental sciences and have played a prominent scientific role in the Intergovernmental Panel on Climate Change as well as various U.S. and national science programs.

I've been awarded numerous U.S. Government and professional awards for my climate-related work. Most important at this hear-

ing perhaps, I serve as the principal investigator for the Climate Assessment of the Southwest Program which is an interdisciplinary science program focused on climate variability and change with the goal of helping promote improved decisionmaking.

In my written testimony, I discuss the current drought in some detail, the drought that's affecting New Mexico, Arizona, Texas, Oklahoma, and the adjoining region. But Dr. DuBois and others testifying before me have done a good job on this topic already.

So for this reason I will start by trying to put the current drought in a much longer 2,000 year paleoclimatic perspective that makes it clear that the current drought, although serious, is modest compared to the magnitude of drought that has happened in the past and thus could happen in the future, even in the absence of climate change.

I will start with a focus on the Colorado River and then shift to new scientific results that have serious implications for both the Rio Grande and the Colorado Rivers.

The state-of-the-art published tree-ring based stream flow reconstruction for the Colorado River at Lee's Ferry just below Lake Powell indicates that several megadroughts, those are droughts that last decades, have occurred in the Southwest, with the worst in the 12th century A.D. lasting over 30 years.

Most of these natural droughts were apparently driven by low precipitation during the winter and spring, much like the drought currently affecting New Mexico. Most were also apparently associated at least in part with cool, La Nina-like conditions in the Equatorial Pacific, again quite similar to the current drought in New Mexico. It's important to remember La Nina through this testimony.

The difference between the current drought and the earlier droughts is that the earlier ones were much longer and more severe; that is, a good deal drier than the current drought.

Because a megadrought like that of medieval times lasting not years but decades could occur on top of the reduced Colorado and Rio Grande flows projected in the just released Bureau of Reclamation report, the issue of future drought is a serious concern. Droughts on top of climate change will likely be a double-whammy, much worse than drought alone and much worse than just climate change alone.

However, as serious as the just discussed megadrought sounds, one lasting 30 years, new scientific research not yet published provides evidence that the megadroughts currently believed by scientists and water managers alike to be the worst case possible may not be as bad as it could get.

There is now evidence that even longer and more severe megadroughts apparently occurred in the headwaters of both the Colorado and Rio Grande Rivers. More detail are in my written testimony.

But we now have reason to believe that a drought as long as 49 years interrupted by only one wet year happened in recent history; and thus, this could happen in the future.

Moreover, we now have reason to believe that the worst-case medieval megadrought mentioned in the new Bureau of Reclamation report; that is, 85 percent of normal Colorado flow for 25 years—

University of Arizona work by the way—may have in reality been substantially more severe; that is, substantially drier than we believed before.

Further research is needed to confirm these new results and integrate them into water planning efforts being carried out by the Bureau of Reclamation and others in the Southwest.

Turning to climate change, I would like to start by commending the fine work that is contained in the just released Bureau of Reclamation report. I believe that the scientific evidence strongly supports the Bureau of Reclamation finding that the Southwest and particularly the Colorado/Rio Grande River Basins will become substantially hotter and drier if we choose to let human-caused climate change continue into the future.

What gives climate scientists confidence in these projections is that the change is already happening. It is happening as the climate models suggest it should. The Southwest is already warming rapidly.

The spring snow pack and the Colorado stream flow are already declining. A large majority of climate models agree that we are likely to see less late winter precipitation just as occurring—as it's occurring in the real world.

All of the published peer-reviewed stream flow projections for the Colorado, and that's the river that's received the most scientific attention, indicate that future stream flow will be on average less in volume, with a chief uncertainty being how fast the stream flow will decline into the future.

Most recent work suggests a 10 to 20 percent decline by mid-century with a finite chance that all reservoir storage on the Colorado could go dry absent effective shortage management, which we know will happen. There will be effective management.

My foregoing discussion of possible future megadrought will only make this possibility more likely. The dry will not magically stop at mid-century if we choose to let human-caused climate change continue.

Now, I would like to highlight some factors that should be the focus of greater research because they could have a big impact on our future water supply in the Southwest.

First the future behavior of the El Nino Southern Oscillation or ENSO system as we like to call it is highly uncertain. If it turns out that more frequent or severe La Ninas are likely; that is, La Ninas like this year happening more frequently and in a more severe manner, it could increase future drought risk substantially. Research is needed to unravel the mystery of El Nino and La Nina under changing climate.

Second, new research indicates that state-of-the-art climate models appear to underestimate the true risk of future megadrought. Correcting for this bias suggests that the odds of a megadrought lasting 25 or more years in this century are as high as 1 in 2 for parts of the Southwest. This new result is shocking and needs to be fully researched.

Third, it is unclear whether future changes in the summer monsoon will help offset water losses that could occur in the winter and spring or whether summer drought could make the future situation more challenging. Work is underway to answer these questions.

But definitive results will emerge slowly unless more dedicated funding for monsoon research becomes available.

Fourth, the growing incidence of climate-related tree die-off could further limit water supply. Over 7 percent of Southwestern forests and woodland area has recently seen die-off of trees due to drought and insects. An additional 3 percent of the forests and woodland area has been affected by wildfire.

Recent research, again not yet published but almost published, needs to be tested. But it suggests that it would be prudent for water management to assume that the widespread and growing tree die-off in the Southwest could act to further reduce, not increase, flow in some of our rivers.

Fifth, poor land use and desertification in the Southwest could further reduce stream flow in snow-dominated systems like the Colorado/Rio Grande by allowing greater amounts of dust to blow out of our lower elevations and into our headwaters, where the dust is known to speed the melting of snow and reduce the flow in our rivers.

Research on how sensitive our biggest watersheds, for example, the Colorado and Rio Grande, are to desert dust is needed; just as we need to learn how to reduce the amount of dust that is blowing up into our headwaters.

To conclude Mr. Chairman, I would like to suggest that it is both safe and wise for people and decisionmakers in the Southwest to assume that the future will be hotter, drier, and more drought prone.

Scientists and decisionmakers need to work together to study the details of what lies ahead and to develop strategies to make effective decisions under the uncertainties that will always exist while at the same time reducing these uncertainties.

Scientists and water managers alike should be careful to avoid the belief that the currently estimated worst-case scenario is really the worst that it could get.

But finally, it is critical to realize that we can certainly make the worst case for the Southwest less worse by eliminating the human causes of the climate change that is already affecting the Southwest.

Thank you, Mr. Chairman and colleagues, for giving me the opportunity to discuss climate and water issues with you. I'd be happy to answer any questions that you might have.

[The prepared statement of Mr. Overpeck follows:]

PREPARED STATEMENT OF JONATHAN OVERPECK, CO-DIRECTOR, INSTITUTE OF THE ENVIRONMENT, PROFESSOR OF GEOSCIENCES, PROFESSOR OF ATMOSPHERIC SCIENCES, THE UNIVERSITY OF ARIZONA

Chairman Bingaman and other members of the committee, thank you for the opportunity to speak with you today on climate variability and climate change as they relate to water supply in New Mexico and the broader Southwest United States.

My name is Jonathan Overpeck. I am the founding co-director of the Institute of the Environment at The University of Arizona, where I am also a professor of geosciences and a professor of atmospheric sciences. I have published more than 140 papers on climate and the environmental sciences, and recently served as a coordinating lead author for the U.N. Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment (2007). I have been awarded the US Department of Commerce Bronze and Gold medals, the Walter Orr Roberts award of the American Meteorological Society and a Guggenheim Fellowship for my interdisciplinary research. I also serve as principal investigator of the Climate Assessment for the Southwest

(CLIMAS), an interdisciplinary Regional Integrated Science and Assessment (RISA) project funded by NOAA. In this capacity, and others, I work not only on generating climate system knowledge, but also on supporting use of this knowledge by decision-makers in society. I am a well-known expert on climate variability and change, as well as drought.

OVERVIEW OF TESTIMONY

In this testimony I first discuss the current severe drought that is affecting New Mexico, Arizona, Texas, Oklahoma and adjoining regions. I then put this current drought in a 2000-year perspective that makes it clear that the current drought, although serious, is modest compared to the magnitude of drought that could happen in the future even in the absence of climate change. I then focus on the dominantly human-caused climate change that has already started in the Southwest, and how continued climate change could make the risk and impacts of drought and decades-long megadrought much greater for the region that includes New Mexico. In my discussions of past natural drought and likely future human-caused climate change, I cover the well-established science, as well as provide updates on important new science that is just emerging. The bottom-line is that New Mexico and the rest of the broad Southwest—extending from California through east Texas and Oklahoma—are at an increasing risk of unprecedented warming, drying and drought, and should prepare accordingly to ensure secure water supplies through this century.

THE CURRENT DROUGHT

The current drought is part of a broader western—and southwestern—drought that has persisted on and off across the region since the late 1990's. As such, the current drought is an extension of the worst drought the region has seen in the 100+ years of rain gauge record. At the present time, the drought is most severe eastward from southern Arizona, across New Mexico, Texas, Oklahoma, and into Arkansas and Louisiana (Figure 1).* All of New Mexico is in drought. For New Mexico as a whole, the October to March period has been the 6th driest on record (116 years; according to PRISM data) and two climate divisions in southern New Mexico have endured their 2nd and 3rd driest winters on record (Z. Guido, CLIMAS, pers. comm.). Since the start of the "water year" (October 1, 2010) all climate divisions in New Mexico measured precipitation less than 68% of the 1971-2000 average, and drought has worsened to the present (Figure 2). Headwater regions for New Mexico's large rivers are also experiencing drought, a fact that has led to spring-summer streamflow forecasts across the state being well below normal as of April 1, 2011 (Figure 3).

THE NATURAL RANGE OF DROUGHT VARIABILITY IN THE SOUTHWEST

Although the current drought is quite notable, particularly as part of a drought that has plagued the Southwest off and on over the last decade, it is modest compared to some of the longer and more severe droughts of the last 1200 years (Woodhouse et al., 2010). For example, the state-the-art published tree-ring based streamflow reconstruction for the Colorado River at Lees Ferry (Meko et al., 2007) indicates that multiple "megadroughts" (droughts lasting multiple decades) have occurred in the Southwest, with the worst—in the 12th century—lasting over 30 years. Most of these natural droughts were apparently driven by low precipitation during the winter and spring (Woodhouse et al., 2010), much like the drought currently affecting New Mexico (Figure 2). Most were also apparently associated, at least in part, with cool La Niña-like conditions in the equatorial Pacific—again, quite similar to the current drought in New Mexico (Conroy et al., 2009; Seager and Vecchi, 2010). The difference between the current drought and the much longer and more severe droughts of the last 1200 years is that the latter droughts were likely associated with monger longer periods of below average sea surface temperatures in the equatorial Pacific.

New scientific research, not yet published, provides evidence that the megadroughts currently believed by scientists and water managers alike to be the worst-case possible may not be as bad as it could get. Longer and more severe megadroughts occurred in both the Upper Colorado River Basin and the headwaters of the Rio Grande:

- New paleoclimatic work at the University of Arizona indicates that even the worst southwestern droughts of the last 1200 years (i.e., the 12th century

*Figures 1–7 have been retained in committee files.

megadrought) was eclipsed by a drought in the 2nd century A.D. that lasted 49 years in the headwaters of the Rio Grande, and was interrupted by only one year with above normal precipitation (C. Routson, Woodhouse and Overpeck, in preparation)

- Other new work at the University of Arizona also indicates that the severity of "worst-case" medieval period megadroughts of the last 1200 years (Meko et al., 2007) may have been underestimated by 20% or more. (Ault, Pederson, Cole, Overpeck, and Meko, in prep.; also G. Pederson et al. in prep.)

WIDELY RECOGNIZED LIKELY CLIMATE CHANGE IMPACTS ON THE SOUTHWEST

Climate change is already clearly affecting the Southwest, particularly in terms of increasing temperature (Figure 4), decreasing precipitation falling as snow (Figure 5), decreasing spring snowpack, and decreasing Colorado River flow (Karl et al., 2009; Overpeck and Udall, 2010). These changes were anticipated by climate scientists, and simulated by many climate models (e.g., note current temperature and precipitation projections, Figures 6 and 7). The mechanisms of change observed in nature are similar to those driving the change in the climate model simulations. All of these factors give the climate science community greater confidence in asserting that the current warming and drying trends will continue into the future unless greenhouse gas emissions are reduced significantly, and this spells trouble for water supplies throughout the Southwest, particularly where the supplies are currently snow-fed (e.g., the Colorado and Rio Grande Rivers).

Indeed, all of the published streamflow projections for the Colorado (the river that has received the most scientific attention) indicate future streamflow will be on average less in volume, with the chief uncertainty being how fast. Most recent work suggest a 10 to 20% decline by mid-century, with a finite chance that all reservoir storage on the Colorado could go dry absent effective shortage management (Rajagopalan et al., 2009; Overpeck and Udall, 2010).

ADDITIONAL ISSUES THAT COULD PLACE SOUTHWEST SURFACE WATER SUPPLY MORE AT RISK

1) Future behavior of the El Niño-Southern Oscillation (ENSO) system could increase future drought risk substantially

- The current drought, as well as the worst megadroughts of the last 1200 years, were all apparently associated with cool "La Niña like" conditions in the equatorial Pacific, and this will likely be the case in the future. However, state-of-the-art climate modeling is still not able to determine if there will be more or less La Niña-like conditions in the future. If there are, then the worst-case droughts of the future might be substantially worse than currently simulated (Seager and Vecchi, 2009).

2) More generally, current state-of-the-art climate models appear to be underestimating the true risk of future megadrought

- New research results at the University of Arizona indicate that state-of-the-art climate models underestimate the full range of drought variability exhibited in a variety of paleoclimatic records. Correcting for this bias suggests that the odds that a megadrought like that of the 12th-century could occur in the next 90 years are as high as one in two for parts of the Southwest (Ault, Pederson, Cole, Overpeck, and Meko, in prep.).

3) It is unclear whether future changes in the summer monsoon will help offset water losses in the winter and spring, or whether summer drought could make the future situation more challenging

- Projections of future monsoon rainfall are still highly uncertain because global models lack the realistic regional or "mesoscale" processes needed to simulate the monsoon correctly. However, work at the University of Arizona and elsewhere is employing both global and regional climate models to solve this problem. It also remains uncertain if the large-scale influences on summer precipitation in the Southwest are captured realistically enough in global models for regional modeling results to be robust.
- As with cool-season precipitation (snow and rain), the 20th century record of summer monsoon rainfall variability underestimates the full range of variability that can occur naturally. For example, a new tree-ring reconstruction of monsoon variability over the last 350 years indicates that the 20th century lacked monsoon droughts of the type that occurred in the 19th century. Moreover, comparisons of the new monsoon reconstruction with cool-season drought reconstructions indicate that winter-spring droughts are never compensated fully by

wet monsoons, and that cool-season droughts are frequently accompanied by summer drought (work by University of Arizona climate scientists D. Griffin, C. Woodhouse and colleagues).

4) Growing incidence of climate-related tree die-off could further limit future water supply

- Forests and woodlands in the Southwest appear highly sensitive to drought and warmth, with over 7% of southwestern forest and woodland area in the region recently (since 1997) impacted by die-off of trees due to drought and insects since 1997, and an additional nearly 3% of forest and woodland area also affected by wildfires (Williams et al., 2010).
- Growing drought and infestation-triggered tree die-off in the Southwest will likely affect water supply in different ways, and the latest research (Adams et al., 2011) suggests it would be prudent for water managers to assume the widespread (and growing) tree die-off in the Southwest could act to further limit available water in the future.

5) Growing land-use and desertification in the Southwest could further reduce streamflow in snow-dominated river systems (e.g., the Colorado and Rio Grande rivers)

- Recently published research (Painter et al., 2010) indicates that human land-use and desertification in the Southwest (and particularly in the Four Corners region) is already decreasing the duration of snow cover in the Colorado headwaters by several weeks, and that this in turn is likely contributing to reduced flows in at least the Colorado River. Better land-management could therefore yield greater water supply.

BOTTOM-LINE ADVICE TO WATER MANAGERS IN NEW MEXICO AND THE SOUTHWEST

1) There is broad agreement in the climate science research community that the Southwest, including New Mexico, will very likely continue to warm. There is also a strong consensus that the same region will become drier and increasingly snow-free with time, particularly in the winter and spring. Climate science also suggests that the warmer atmosphere will lead to more frequent and more severe (drier) droughts in the future. All of the above changes have already started, in large part driven by human-caused climate change.

2) However, even in the absence of significant human-caused climate change, the Southwest is prone to drought and megadrought much more severe than droughts witnessed in the last 100 years. The 2000-year record of drought in the region makes it clear that droughts lasting decades are likely independent of human-caused climate change. For this reason, the "no-regrets" strategy is to plan and prepare for droughts no matter the cause—human or natural—and to do so under the assumption that droughts will very likely be hotter and thus more severe in the future than in the past 2000 years.

3) Scientists and water managers alike, however, should be careful not to assume the currently estimated "worst case" drought scenario will remain so for long. As climate science has advanced in the Southwest, there have been a steady progression of new results that imply that today's "worst-case" drought scenario is tomorrow's second-worst case scenario. Water managers should pay particular attention to the emerging science that has been highlighted in the testimony above.

4) Finally, it is critical to realize that the people of New Mexico, the Southwest, and our nation can certainly make the worst case for the Southwest less worse by eliminating the greenhouse gas emissions that are the primary cause of the climate change that is already affecting the Southwest.

Thank you Chairman Bingaman and colleagues for giving me the opportunity to discuss climate and water issues with you.

REFERENCES CITED

Adams, H. D., C.H. Luce, D.D. Breshears, C.D. Allen, M. Weiler, V.C. Hale, A.M.S. Smith, T.E. Huxman. (2011). Ecohydrological consequences of drought-and infestation-triggered tree die-off: insights and hypotheses. Ecohydrology (in press).

Conroy, J. L., J.T. Overpeck, J.E. Cole and M. Steinitz-Kannan. (2009). Variable oceanic teleconnections to Western North American drought over the last 1200 years. Geophysical Research Letters 36: L17703 10.1029/2009gl039558

Karl, T. R., J. M. Melillo, and T. C. Peterson, editors. 2009. Global climate Change Impacts in the United States. Cambridge University Press, New York.

Meko, D. M., C. A. Woodhouse, C. A. Baisan, T. Knight, J. J. Lukas, M. K. Hughes, and M. W. Salzer. (2007). Medieval drought in the upper Colorado River Basin. Geophysical Research Letters 34. doi: 10.1029/2007GL029988.
Overpeck, J. and B. Udall. (2010). Dry Times Ahead. Science 328:1642-1643.
Painter, T. H., J. S. Deems, J. Belnap, A. F. Hamlet, C. C. Landry, and B. Udall. (2010). Response of Colorado River runoff to dust radiative forcing in snow. Proc. of the Natiional Academy of Sciences 107:17125-17130.
Pierce, D. W., T. P. Barnett, H. G. Hidalgo, T. Das, C. Bonfils, B. D. Santer, G. Bala, M. D. Dettinger, D. R. Cayan, A. Mirin, A. W. Wood, and T. Nozawa. (2008). Attribution of Declining Western US Snowpack to Human Effects. Journal of Climate 21:6425-6444.
Rajagopalan, B., K. Nowak, J. Prairie, M. Hoerling, B. Harding, J. Barsugli, A. Ray, and B. Udall. (2009). Water supply risk on the Colorado River: Can management mitigate? Water Resources Research 45, W08201.
Seager, R. and G. A. Vecchi. (2010). Greenhouse warming and the 21st century hydroclimate of southwestern North America. Proc. of the National Academy of Sciences 107:21277-21282.
Williams, A. P., C. D. Allen, C. I. Millar, T. W. Swetnam, J. Michaelsen, C. J. Still, and S. W. Leavitt. (2010). Forest responses to increasing aridity and warmth in the southwestern United States. Proc. of the National Academy of Sciences 107:21289-21294.
Woodhouse, C. A., D. M. Meko, G. M. MacDonald, D. W. Stahle, and E. R. Cook. (2010). A 1,200-year perspective of 21st century drought in southwestern North America. Proc. of the National Academy of Sciences 107:21283-21288.

The CHAIRMAN. Thank you very much, appreciate that testimony. Dr. Hurd, why don't you go right ahead and give us your views.

STATEMENT OF BRIAN H. HURD, ASSOCIATE PROFESSOR, AGRICULTURAL ECONOMICS, NEW MEXICO STATE UNIVERSITY, LAS CRUCES, NM

Mr. HURD. All right. Mr. Chairman and members of the panel and audience members, thank you for the invitation to appear before you today and to provide testimony regarding my views on adaption to climate variability and change.

Specifically I would like to first summarize how investing in adaptive capacity can reduce the possible magnitude and extent of adverse consequences. Then provide some examples that characterize some of the strategies, opportunities, and options available to governments and communities.

In appearing before you today, I'm representing my own individual views and not those of any current or past employer, organization, or association. My views have been informed by nearly 2 decades of research on climate change economics, impact, and adaptation, with a primary focus on agricultural and water resources.

For example, during my current faculty appointment for the past 10 years with New Mexico State University, I've had the opportunity to study and research water, agricultural, and economic systems in New Mexico and across the Southwest including both the Rio Grande and Colorado River watersheds.

We are well aware of many instances and anecdotes that raise our concern about the nature and power of climate and of extreme weather events. Even in the most recent past, we are reminded the power of intense storms including hurricanes, the tornados that are devastating communities around the country these days right now, snow and ice storms; of the human and economic losses from extended periods of both high and low temperatures, wildfires, and persistent droughts and floods.

The chronicle of weather and climate is ever present in our consciousness such that we constantly observe, track, sometimes name, and often recollect those phenomena. "How is the weather" we ask. Answers and stories abound. "Fine, gloomy, worst in decades, not since records have been kept."

Permit me just a moment to give a quick anecdote from my experience this past winter. Late January and early February saw temperatures lower and for longer periods than ever seen before in Southern New Mexico, far West Texas, and Chihuahua, Mexico.

In my 10 years, I had never seen single digits let alone sub-zero temperatures in the deserts near Las Cruces, New Mexico. The mercury hit a low of minus 6 degrees Fahrenheit, and never rose above freezing for 4 consecutive days.

Perhaps most surprising was the incapacity of the electrical system to cope with the event. For a week residents dealt with rolling blackouts, closed schools, universities, and businesses, broken pipes and pumps, and flooded rooms. Crop losses are widespread.

Homeowners and businesses across the region—some are now just beginning to confront the damages and to replace lots of damaged landscape plants and trees. Not to mention the recent heat wave and record high temperatures in March and April that have set West Texas ablaze.

Some might begin to ask questions about this region's capacity to adapt and the capability of utilities, residents, and businesses to cope with such climatic extremes. It is difficult to know and to assign blame to so-called acts of God. Of course, there are limits to what even the best-prepared and well-adapted community can hope to withstand.

But that really is not the point. Rather the point I'd like to make should be focused on future preparedness and what might be done to lessen the losses and damages in the future.

Climate extremes I think we can generally agree present challenges to vulnerable communities, whether or not these extreme events are attributable to normal variability or to climate changes induced by rising greenhouse gas concentrations. It doesn't matter.

How well communities anticipate and assess the likelihood of climate extremes and how well they choose to prepare for them depends to a large extent on 4 key ingredients: First quality and accessibility of climate change scenarios and information including frameworks to use and transform them into relevant forms for decisionmakers, the local decisionmakers. Following the work that's coming out of the SECURE Waters report Mr. Connor had presented is a great step in that direction.

Understanding—second, understanding an assessment of vulnerable environmental and economic systems and their impacts, including the sensitivity to climate, the degree and routes of exposure, and the capacity that these systems have to adapt.

Third, the need—the capacity to identify trends and render plausible scenarios not only of changes in climate and climate extremes, but the demographic and economic conditions, relevant institutions and policies, and environmental stresses and conditions that are expected to emerge over the coming decades.

Finally the fourth ingredient that's very critical is the state of institutional preparedness, our leadership and support for inte-

grating climate science into relevant and appropriate programs, procedures, and policies.

Time does not permit addressing each ingredient. But I will draw attention to the second component; namely, that of assessing vulnerability and quickly illustrate key issues looking at water and adaptation.

Essentially one of the goals of most water supply systems and institutions especially in the West thanks in large part to the Bureau of Reclamation is to help communities cope with a moderate range of climate and water supply variability.

With few exceptions most water system and utility managers agree that U.S. communities, industries, and water users are generally well-prepared and well-adapted to manage successfully within normal fluctuations, often including occasional extremes such as events that typically occur once every decade or 2.

However, problems begin to arise when relatively rare or unexpected events occur and reoccur with unusual frequency. Witness, for example, the flooding along the Red River of the North between Minnesota and North Dakota, where historic floods once thought to be rarer than once in 100 are occurring surprisingly in rapid succession.

If as the accumulated science indicates climate changes can result from rising greenhouse gas concentrations and emissions and if these changes contribute to greater climate uncertainty and extreme events such as those that Dr. Overpeck has just described, then it might be reasonable and prudent to expect more severe and/or frequent extreme events.

Such events can quickly become a significant economic and environmental concern, pushing beyond the prevailing capacities of water users to cope and indicating the need for additional adaptive capacity. Adaptation as such can be viewed as a complement to climate change mitigation activities within a comprehensive and coordinated climate strategy.

It is during the process of assessing vulnerability that the question of adaptation begins to arise. For example, with their primary focus on the physical systems, the earliest climate change impact assessments often neglected expected natural responses from affected people such as farmers once they had realized that a change occurred.

After all, a great evolutionary strength of humans is their capacity to observe and recognize changing conditions and to react accordingly, although it might take some time to realize, confirm, and learn that the observed changes are likely to persist.

This capacity to recognize and react to changing conditions confers economic advantage and success. However, and this is key, even greater advantage and long run economic success follows from the ability to observe patterns and trends; and to combine these with knowledge and understanding of our economic and environmental systems in anticipation of likely outcomes and consequences.

I describe in my written testimony a little bit more about the differences between reactive and anticipatory adaptation. But in the interest of time and to make my presentation right now brief, I'd like to finish with some specific adaptation strategies and opportu-

nities that I feel we have before us. They fall into 4 broad categories.

No. 1, I think we should work toward improving science and technical information including development, integration, education, and dissemination. A great start of that would be the work of the Bureau and the USGS in this regard.

There is a need for continued development of climate, environmental, and resource management sciences and their integration. For example, there has been progress in development of assessment methods. But uncertainties which compound and cascade throughout the process result in often broad and otherwise not-well defined scenarios that are not very useful for local scale planning.

By facilitating partnerships and strategic alliances between Federal and State agencies, the national laboratories, local governments, universities, and NGO's, cross-organization capacities can be better harnessed and focused.

Second, look toward developing more appropriate risk management institutions and policies. Risk management institutions, policies, and insurance programs are often at odds, resulting in inappropriate development in high-risk areas; and then promoting rebuilding without appropriate regard to risks.

It might be prudent to develop programs and policies with greater risk sharing and stakeholder awareness rather than blanket protection from climate-related risks.

Third, increase the use of resource markets and incentive-based policy designs. The goal is to create a context in which communities, organizations, and individuals can make smarter decisions and wiser choices. Institutions and policies that establish and use decentralized approaches help to provide appropriate economic signals to decisionmakers and generally improve compliance and voluntary solutions.

For example, water-use efficiency could be promoted, resulting in more flexibility and responsiveness to climate changes; for example, the work that the State Engineer is doing on water rights adjudication, efforts to make those water rights better defined, rightholders could be compensated or could lease the value of saved water in a similar fashion as we have in electricity cogeneration and buy-back.

Finally and my last example here, add flexibility and safety to infrastructure design and construction and incorporate climate factors in land-use planning and building codes. Especially with long-lived infrastructure, the added costs may provide good value in providing both additional services and reliability.

Risk-appropriate zoning and building codes may also add to short-run costs but provide better long-run protection. An example of this is the LEED certification program for energy efficiency in building design.

That's the end of my remarks. I thank you, Senator, for your interest and contribution to this important topic.

[The prepared statement of Mr. Hurd follows:]

PREPARED STATEMENT OF BRIAN H. HURD, ASSOCIATE PROFESSOR, AGRICULTURAL ECONOMICS, NEW MEXICO STATE UNIVERSITY, LAS CRUCES, NM

INTRODUCTION

Mr. Chairman and members of the Committee, thank you for the invitation to appear before you today and to provide testimony regarding my views on adaptation to climate variability and change. Specifically, I would like to first summarize how investing in adaptive capacity can reduce the possible magnitude and extent of adverse consequences, and then provide some examples that characterize some of the strategies, opportunities and options available to governments and communities. In appearing before you today, I am representing my own individual views, and not those of any current or past employer, organization, or association. My views have been informed by nearly two decades of research on climate change economics, impacts and adaptation, with a primary focus on agricultural and water resources. For example, during my current faculty appointment for the past ten years with New Mexico State University, I have had the opportunity to study and research water, agricultural, and economic systems in New Mexico, and across the Southwest including both the Rio Grande and Colorado River watersheds.

KEY INGREDIENTS FOR SUCCESSFUL CLIMATE CHANGE ADAPTATION

We are all well aware of many instances and anecdotes that raise our concern about the nature and power of climate and of extreme weather events. Even in the most recent past we are reminded of the power of intense storms including hurricanes, tornadoes, snow and ice storms, of the human and economic losses from extended periods of both high and low temperatures, wildfires and persistent droughts and floods. The chronicle of weather and climate is ever present in our consciousness such that we constantly observe, track, sometimes name and often recollect these phenomena. "How is the weather?" we ask. Answers and stories abound. "Fine." "Gloomy". "Worst in decades." "Not since records have been kept." Permit me to give a quick anecdote from my experience this past winter. Late January and early February saw temperatures lower and for longer periods than ever seen before in southern New Mexico, Far West Texas, and Chihuahua, Mexico. In my ten years I had never seen single digits let alone sub-zero temperatures in the deserts near Las Cruces, New Mexico. The mercury hit a low of −6 degrees Fahrenheit, and never rose above freezing for four consecutive days.

Perhaps most surprising was the incapacity of the electrical system to cope with the event. For a week residents dealt with rolling blackouts, closed schools, universities, and businesses, broken pipes and pumps, and flooded rooms. Crop losses are widespread and homeowners and businesses across the region are just now beginning to confront damages and to replace damaged landscape plants and trees. Not to mention the recent heat wave and record high temperatures in March and April that have set west Texas ablaze. Some might begin to ask questions about this region's capacity to adapt and the capability of utilities, residents and businesses to cope with such climatic extremes. It is difficult to know, and to assign blame, to so-called 'acts of god.' And of course there are limits to what even the best-prepared and well-adapted community can hope to withstand. But that really is not the point. Rather the point should be focused on future preparedness, and what might be done to lessen the losses and damages in the future.

Climate extremes, I think we can generally agree, present challenges to vulnerable communities—whether or not these extreme events are attributable to 'normal' variability or to climate changes induced by rising greenhouse gas concentrations. How well communities anticipate and assess the likelihood of climate extremes, and how well they choose to prepare for them depends to a large extent on four key ingredients:

- Quality and accessibility of climate change scenarios and information including frameworks to use and transform them into relevant forms for decision makers.
- Understanding and assessment of vulnerable environmental and economic systems and impacts, including sensitivity to climate, degree of exposure, and capacity to adapt.
- Capacity to identify trends and and render plausible scenarios not only of changes in climate and climate extremes, but of demographic and economic conditions, relevant institutions and policies, and environmental stresses and conditions.
- State of institutional preparedness, leadership and support for integrating climate science into relevant and appropriate programs, procedures and policies.

Time does not permit addressing each ingredient but I will draw attention to the second component, namely that of assessing vulnerability. I will quickly illustrate some key issues using water resources as an example, looking first at the impacts and then at the potential for adaptation.

CAN ADAPTATION REDUCE ECONOMIC AND ENVIRONMENTAL CONSEQUENCES?

Essentially one of the goals of most water supply systems and institutions, especially in the West, is to help communities cope with a moderate range of climate and water supply variability. With few exceptions, most water system and utility managers agree that U.S. communities, industries and water users are generally prepared and well adapted to manage successfully within 'normal' fluctuations, often including occasional extremes (such as events that typically occur once every decade or two). However, problems begin to arise when relatively rare or unexpected events occur and re-occur with unusual frequency (such as flooding along the Red River of the North where historic floods once thought to be rarer than once in 100 years are occurring in surprising rapid succession). If, as the accumulated science indicates, climate changes can result from rising greenhouse gas concentrations and emissions, and if these changes contribute to greater climate uncertainty and extreme events, then it might be reasonable and prudent to expect more severe and/or frequent extreme events. Such events can quickly become a significant economic and environmental concern, pushing beyond the prevailing capacities of water users to cope, and indicating the need for additional adaptive capacity. Adaptation as such can be viewed as a complement to climate change mitigation activities within a comprehensive and coordinated climate strategy.

To determine if and how adaptations can reduce economic and environmental consequences, we need to first identify and estimate vulnerabilities and specific impacts. A general approach would begin with an examination of the physical and environmental systems that support economic and environmental health. For water resources this begins with the question, "What if climate changes and it brings about changes in streamflows, water storage, and water availability?" which draws upon the expertise of climate and hydrology scientists. The result is a scenario analysis which could include a projection of how a river's hydrograph could be expected to change (an example is shown in Exhibit 1).*

Then economic and environmental scientists can proceed to ask: "What might these changes in streamflows imply for ..."

- Water storage and distribution systems
- Urban and rural water users
- Water quality
- Hydropower
- Recreational and cultural functions
- Riparian ecosystems and migratory patterns
- Local employment, jobs, and income?

A quick summary of key climate change impacts estimated for the Rio Grande by Hurd and Coonrod (2007) indicate the likelihood of:

- Earlier snowmelt and peak runoff, greater evaporation losses, and reduced streamflows even if total annual precipitation should increase, and if precipitation should fall, runoff could be reduced by as much as 1/3.
- Rising populations and lower water supplies will raise pressure to tighten and fine tune water management systems. Systems with limited storage capacities are most vulnerable.
- Projected annual economic losses than range from $13 million to $115 million by 2030, and from $21 million to as much as $300 million by 2080.
- Traditional agricultural systems and rural communities are most at risk, and may need transitional assistance.
- Losses to New Mexico's residents, tourists, and wildlife could go well beyond such market-derived figures, including losses to the environment, water quality, and quality of life.

It is during the process of assessing vulnerability that the question of adaptation begins to arise. For example, with their primary focus on the physical systems, the earliest climate change impact assessments often neglected expected natural responses from affected people, such as farmers, once they had realized that a change occurred. After all, a great evolutionary strength of humans is their capacity to observe and recognize changing conditions and to react accordingly (although it might

*Exhibits 1 and 2 have been retained in committee files.

take some time to realize, confirm and learn that the observed changes are likely to persist).

This capacity to recognize and react to changing conditions confers economic advantage and success. However, and this is KEY, even greater advantage and long-run economic success follows from the ability to observe patterns and trends, and to combine these with knowledge and understanding of our economic and environmental systems in anticipation of likely outcomes and consequences. It is worth taking a moment to more clearly illustrate the essential difference between reactive and anticipatory (or proactive) adaptation strategies. This illustration also highlights the importance of investment timing in the effort to build adaptive capacity.

Imagine that we can illustrate these differences using a timeline over which net economic performance is measured (call it something like 'gross domestic happiness' to distinguish from the flawed concept of 'gross domestic product'—which most often shows a boost to economic production after a disaster). Also imagine that a significant climate catastrophe occurs at a given point in the timeline (see Exhibit 2).

Consider the case of reactive adaptation, and note that it can result from either of two situations. The first is when little or no consideration is given at all to evolving trends and future conditions or events. In this case any adaptation that occurs is after-the-fact and in response to events and conditions after they have occurred. The second way that results in a reactive response is when investment decisions are delayed or postponed, either rationally and deliberately because of inherent uncertainties and costs, or inadvertently because of indecision. In either of these cases the outcomes are similar, net economic benefits are positive and continue to grow until the adverse event or change. A significant adverse event then occurs, significant economic losses ensue, and the path to recovery is protracted and costly. After recovery and the economy is reestablished, which now may even perform better than before because degraded and depreciated infrastructure has been replaced (like with the Marshall Plan). But maybe the redevelopment occurs without any change for future defenses, production of economic and environmental services continues—until the next adverse event. Several questions then arise, "Could we have done better?" "Were events and changes foreseeable?" And, "Would better preparations, designs and policies have lessened the damages and speeded recovery?"

Now consider a well planned and executed proactive adaptation strategy, one that tries to anticipate changing conditions and to prepare for them in advance. In this manner, prior and/or continuing investment to build and strengthen adaptive capacity will undoubtedly redirect resources away from current consumption, resulting in lower net economic rewards relative to no-or postponed-investment, but only for the duration until the adverse event occurs. Generally, if the adverse event is not a question of 'if' but rather 'when', then anticipatory adaptation strategies share many similar aspects to a prudent and effective risk management or insurance-type strategies. In this case, when the adverse event occurs there is also the potential for significant economic loss and disruption but with effective preparation it may only be a fraction of what it would have been. In addition, with proactive adaptation the path and duration of economic recovery may be much shorter, resulting in greater net economic performance in the long-run.

STRATEGIES, OPPORTUNITIES AND OPTIONS TO STRENGTHEN ADAPTIVE CAPACITY

Many adaptation strategies and opportunities fall within four broad categories.

1. Improve science and technical information including development, integration, education, and dissemination

There is a need for continued development of climate, environmental, and resource management sciences and their integration. For example, there has been progress in development of assessment methods but uncertainties which compound and cascade throughout the process result in often broad and otherwise not-well defined scenarios that are not very useful for local scale planning. By facilitating partnerships and strategic alliances between Federal and State agencies, National Laboratories, local governments, universities, and NGOs cross-organization capacities can be better harnessed and focused.

2. Develop appropriate risk management institutions and policies

Risk management institutions, policies and insurance programs are often at odds, resulting in inappropriate development in high risk areas, and then promoting rebuilding without appropriate regard to risks. It might be prudent to develop programs and policies with greater 'risk sharing' and stakeholder awareness rather than 'blanket protection' from climate-related risks.

3. Increase the use of resource markets and incentive-based policy designs

The goal is to create a context in which communities, organization, and individuals can make smarter decisions and wiser choices. Institutions and policies that establish and use decentralized approaches help to provide appropriate economic signals to decision makers and generally improve compliance and voluntary solutions. For example, water-use efficiency could be promoted, resulting in more flexibility and responsiveness to climate changes if water-rights were better defined and right-holders could be compensated or could lease the value of 'saved' water. In a similar fashion to electricity cogeneration and buy-back.

4. Add flexibility and safety to infrastructure design and construction, and incorporate climate factors in land-use planning and building codes

Especially with long-lived infrastructure, the added costs may provide good value in providing both additional services and reliability. Risk-appropriate zoning and building codes also may add to short-run costs but provide better long-run protection.

The CHAIRMAN. Thank you very much, Dr. Hurd.

Let me start with a question or 2 about—Dr. Overpeck, your description of these megadroughts in the 12th century and before and since the 12th century leads me to wonder whether or not we are correct in assuming as I have—I have assumed that a lot of the drought problem that we might face in the future in the Southwest was related to climate change.

That as temperatures warmed because of climate change or as they're expected, temperatures are expected to warm, that that would then in some way be a cause of the drought situation or bring about the drought situation. What you described would lead me to conclude that maybe the drought situation has been there, will be there in the future regardless of what happens to the temperature.

I guess I'm just trying to get straight in my head the extent to which hot and dry necessarily go together here in this process or whether we're really dealing with 2 separate phenomena which are somewhat disconnected.

Mr. OVERPECK. Right. You know, the scientific community is trying to disentangle these as we speak. It's not a completely straightforward problem. But we really do have 2 issues going on here.

One is that we live in a drought-prone, dry part of the world. You can see these dry belts on both sides of the equator. That is well-known climate science.

We can see in the Southwest ample evidence, for example, age-old pueblos in ruins, that there has been drought. That's essentially tied to these megadroughts I've been talking about. The best science says that we've been in a drought-prone region, we'll always be in a drought-prone region in the future, meaning it's a no-regret strategy to prepare for these long droughts even in the absence of climate change.

Now, when you add climate change to the equation, it makes the situation a heck of a lot worse. The first and foremost problem is the temperature rise that you've been talking about. You're absolutely right that there's a trend in the average background climate of the Southwest; that is, toward warmer and drier conditions.

That is the climate, the average climate on which these droughts, these extreme events will be superimposed. So now we have these superimposed on a relatively wet Southwestern climate as in the past. In the future it will be drier and drier so the droughts will likely be worse and worse.

That will be driven both by the temperature increases which we have huge confidence is going to occur as well as reductions in, you know, the baseline average precipitation. So these things are pretty tightly connected.

The third aspect of this is that climate theory suggests that, and we're seeing this worldwide, with global warming droughts should be more frequent in these dry zones.

So all things equal, even though we have quite a bit of uncertainty with this one in this region, if you're a betting person, you would say we're going to have more frequent drought in the future. For us that means more frequent megadrought as well.

The CHAIRMAN. OK. Let me ask Mike a question. Then if either or the other of you want to comment, please do.

First let me also commend you for this report. I think it's an excellent first report. As I understand the legislation that both of us worked on here, this SECURE Water Act Section 9503

[C] report is to be done or updated every 5 years, is that the plan?

Mr. CONNOR. That's correct.

The CHAIRMAN. So this is the first of those. I think it's an excellent effort. This chart that's up here on the left, Bureau of Reclamation chart with the heading Climate Change Impacts in Western Basins, again you start out and it says increasing temperature, that's in all basins. I understand that.

Mr. CONNOR. Correct.

The CHAIRMAN. Yes, there's no confusion there. The next 2 categories on your chart are a little—raise other questions, though. You've got decreasing precipitation which is what we've been talking about here primarily, and that is here in the Rio Grande Valley, Lower Colorado River Basin—or Upper Colorado River Basin.

But then the next one is increased precipitation. So we are in a circumstance where your report is concluding that, as we are going to face more and more drought in this area, other river basins are going to face more and more precipitation.

I guess I'm questioning how confident we are in those predictions, where we can say, you know, there's good consensus—as Dr. Overpeck just said, there's good consensus among scientists that the temperature is going to go up worldwide.

Is there also good consensus as to where the droughts are going to worsen and where the precipitation is going to increase?

Mr. CONNOR. I don't think there's as much confidence level in those kind of predictions as there are with respect to temperature rise. Let me just say with respect to—and I think Dr. Overpeck—I'm going to be cautious here because I'm going to be followed up by I think a true expert here with respect to some of the work done by the IPCC, the Intergovernmental Panel on Climate Change.

That's kind of the foundation work for what we did in the SECURE Water Act report. So we used the global climate circulation models there and the climate change projections that were developed by the IPCC.

So from that it's foundational and from our view the gold standard for projections of what's going to change over time. So I think inherent even within those reports done by the IPCC there's the

recognition of some inherent uncertainty with respect to changes in precipitation patterns.

Now, we took that a step further and then we combined that with hydrologic models and then did some downscaling that I think—that's kind of the Reclamation new work that's been put into these reports. That's been peer-reviewed. But there's still—it builds off of that, those models, with respect to changing precipitation patterns, et cetera, that do have some uncertainty. So we've tried to describe that in the report in a way to be transparent.

As you mentioned the idea over time is to get better information, better models, and then reassess risks through these 5-year iterations of our report.

The CHAIRMAN. Dr. Overpeck, did you want to add anything to that?

Mr. OVERPECK. Sure. I think Mike got it right. I do want to say once again I believe his report, having read the whole thing, is definitely state-of-the-art.

The scientific community is inherently quite conservative on some issues. One of the things—and we like to highlight the uncertainties. There is a good deal of uncertainty about precipitation in many parts of the world and how it will change.

But there is—seems to be a higher than average certainty that in our part of the world, the Southwest, we should see a steady decline. Not every year. But decade by decade it should get drier and drier here in the Southwest just as to the north of us it should get wetter.

The reason for this is tied to how climate, global climate, hemispheric climate and warming affects the mean circulation of the atmosphere. It acts to actually drive the late winter spring storm tracks northward as the planet warms.

We see this happening now, we see it in models, we see it in paleoclimates. So in ancient periods, you know, back in the ice ages, for example, when we had warm periods interrupting the ice ages, this same phenomena occurred, the storm tracks moved northward.

The thing that's worrisome to me—and again my job here I see on this panel is to be a little less conservative and look at where are those places where we better make sure we got it right. So we don't—avoid, you know, an earthquake/tsunami situation or are terribly surprised by something really much worse than we anticipated.

One of the things that worries me is that in both hemispheres you see this widening of the tropical belts, movement polar-ward of the westerly circulation, the circulation that brings our late season snow pack. The only difference is in mother nature it's happening faster than the models say it should be happening.

Now, we don't know why that's occurring. It could be because the system is just more sensitive than we thought, some of the models simulate more sensitivity. Again the Bureau of Rec is playing it safe. They're looking at all the models. That's probably the best—wisest move to get the most likely outcome.

Or is it because of the interaction of the climate change problem and the stratospheric ozone problem. That is affecting the circulation as well, because we're developing now an ozone hole in the

northern hemisphere. That also acts to tighten up the circulation in the northern hemisphere. That is also going to continue into the future.

So whatever reason the big uncertainty here is just maybe how far north this dry belt will actually progress through this century. It might be as the Bureau of Reclamation portrayed it, as the IPCC portrayed it. It might be further north, in which case things will be a little less fun in the United States of America.

The CHAIRMAN. Let me ask an obvious question here. Is there—is there—is the modeling that is—that we are relying on here, that the Bureau of Reclamation is relying on in preparing this report, is this accepted as the modeling that best incorporates the data that we have and information we have going forward or is there someone else with a different model?

I mean could we be having a hearing with a different set of experts who made their conclusions based on a different model and they would be telling me just the opposite as to—maybe not as to the temperature rise. But as to the places where the drought would occur and the places where the precipitation would occur?

Mr. OVERPECK. I think you would have a tough time finding any expert who has worked on climate for decades to, you know, say that the general pattern that's reflected in the Bureau of Reclamation report and in the IPCC results is wrong.

The CHAIRMAN. That's the pattern on precipitation as well as the pattern on temperature?

Mr. OVERPECK. Yes. I mean everyone would say it's going to warm. It's a question of how much it's going to warm. We can talk about that if you wish, because again I think it could warm more, especially if we let greenhouse gases go unchecked as we are. It could warm substantially more than is reflected in the results. But again they're looking at the average across many models and scenarios.

The way the scientific community works is there's always a new model. One of the reasons we have the Intergovernmental Panel on Climate Change is because the governments of the Intergovernmental Panel, meaning over 100 nations of the world, said—people like yourself, leaders of these countries said we really need to have, you know, a consensus.

So in these cycles that last approximately 7 years, the new models are brought together and assessed together, the newest results, and brought out and peer-reviewed and essentially work their way—eventually work their way into these management documents.

So we're now in midway through the next cycle that will update the work that's in the Bureau of Reclamation. But I need to emphasize that right now what they've got in there is state-of-the-art and best we know.

The CHAIRMAN. So by the time the next 5-year report is done, there will be a new model or an updated model?

Mr. OVERPECK. There will be many models. They will be analyzed and they might give a different picture. What we will not see, though, is a change away from it's going to warm. It's going to warm a lot.

What we will not see I believe is that it's going to get wetter in the Southwest. What we might see is that it will get drier in some of the places that the Bureau of Reclamation now is saying might get wetter. So there's some uncertainty there. But the big things especially that matter to us in the Southwest are unlikely to change.

What we'll also see in this new report is more addressing of this issue of the droughts I think and incorporating those into the same picture.

The CHAIRMAN. Thank you. Mike, could you give me a little more explanation of this other report that you indicate is forthcoming that the Geological Survey is working on and what will it address that has not been addressed in the report that you've released this week?

Mr. CONNOR. I kind of look at the 2 reports as very much working together. Our report being very much—I guess I would say the primary audience is the water user community and certainly policymakers, about what we can do to best assess the risks out there right now as to how water resources management—water resources supplies are going to change and how management is going to change.

The idea—that's the 9503 report. The 9506 report is more geared toward a scientific basis, which is what kind of inputs do we have, data inputs, observational capabilities to take in data about water resources, about the use of water resources, et cetera, about—more data with respect to climate, and where do we have gaps and how we can improve and update those data systems.

So that's what the USGS in collaboration with a number of Federal and State agencies and other entities was putting together, kind of a very science-based approach on how to get the best data and where we should go from a policy perspective.

The beauty of it, though, is I think the idea here. I think Dr. Overpeck mentioned this earlier, is we need to bring the science community, the water manager community, and the policymaker community all together.

That's hopefully what's going to keep occurring with these separate reports that come out that build upon each other; and we use and we improve our data collection and we improve our modeling; therefore, we improve or risk assessments, et cetera.

So I think they're very much going to work in synergy together, but they do have different purposes coming out of the gate.

The CHAIRMAN. Let me ask a more practical question. For communities that are encountering very severe drought conditions here in New Mexico, are there programs of assistance that the Bureau of Reclamation can provide or through the Department of Agriculture, are there ways that these communities can get assistance in dealing with drought circumstances?

Mr. CONNOR. There are. I guess initially I would go back to saying the best thing that we can do in reacting to the drought is to not do it after it occurs.

So a lot of the assistance or activity that we've got ongoing, whether it be the Middle Rio Grande, with the issues of trying to secure water supplies for—to ensure that we're in compliance with the Biological Opinion or in the Pecos River Basin is to create op-

portunities so that we can access supplemental water supplies, that we have them in hand, that we know other opportunities to get more in a situation like this year, where we may need additional water supplies, because we first want to avoid that crisis from not being in compliance with Federal law. Because that's going to affect not just the Bureau of Reclamation but all water users up and down.

Certainly as Esteven mentioned a lot of the communities have diversified their own supplies, the city of Albuquerque, the city of Santa Fe. So they've got groundwater resources, they've got surface water resources. That's going to help them over time deal with the drought situation.

We do have a drought relief program within the Bureau of Reclamation. We've used that within the last decade on numerous occasions within New Mexico to drill, provide resources to drill supplemental wells. We've still got some activity going on.

We've partnered up with the Indian Health Service on many pueblos to drill some supplemental wells. We don't have a lot of resources in that particular program right now. So we are looking at other opportunities to partner up with USDA which does have drought relief programs.

So there are just inherently those opportunities to react and bring immediate resources to the table. But at this point in time, it's hard to get wells drilled quick enough to provide water when you're in the middle of a drought. Sometimes as I mentioned we're more left in the position of mitigating economic losses in those types of situations.

The CHAIRMAN. Dr. Hurd, let me ask you, one of the—you had your 4 strategies and opportunities and recommendations here in your testimony. You talk about developing appropriate risk management institutions and policies.

You say "Risk management institutions, policies, and insurance programs are often at odds, resulting in inappropriate development in high-risk areas and then promoting rebuilding without appropriate regards to risk." Then you also say "It might be prudent to develop programs and policies with greater risk sharing and stakeholder awareness rather than blanket protection." Could you elaborate on what you—maybe give an example of what you're talking about there so I have a better understanding of what you're recommending.

Mr. HURD. Certainly. Thank you again. One of the ways in which I've observed that risk—risk-prone areas, for example, in sea level coastal communities, where sea level storms or sea level rise could be affecting properties and communities, we have flooding events that are going on unfortunately perhaps as we speak in the Midwest as the rise of the Ohio River and the Mississippi River inundates some communities, protected ostensibly by levees that may or may not be well-developed or well-managed for flood protection and in protecting or ostensibly protecting areas that may in the future, if we gave regard to the climate science, the changing risk-prone nature of some of these areas might be affected.

In the Southwest what—we will see that—similar types of events again related to flood risk, development near arroyos. We saw the floods that were quite tremendous in 2006 that flooded the commu-

nity of Hatch and great floods through the city of El Paso as well and making sure that we are aware of what those flood risks are along the arroyos and riverbanks.

I do know the flood—the FEMA agency has been developing new flood risk maps. Those are often quite contentious as you are probably well aware and affecting how risk—flood insurance is provided and which communities are at risk.

Oftentimes those—even those updated flood risk maps are not reflecting anything to do with changes in climate. So what I'm suggesting is that we ought to develop some ways and tools and methods to enhance those kinds of development.

Similar things with drought risk and crop insurance. We ought to be able to provide better information and better tools to farmers on crops that are likely to succeed in certain areas and reduce our coverages of—in regions where drought risk is rising or changing. Maybe we need to have better information to promote awareness and responsible behavior from resource owners.

The CHAIRMAN. OK. I appreciate very much the great testimony of all of you and appreciate the hard work that went into developing the report that the Bureau of Reclamation has done. We thank you all for coming and participating in the hearing.

Let me indicate that we will be glad to accept statements for the record that we will include in the committee record of this hearing. They can be submitted to our committee, which—the same website, what, energy dot Senate dot gov through the 11th of May.

So I thank everyone for participating, thanks for coming. We will stop the hearing at this point.

[Whereupon, at 3:10 p.m., the hearing was adjourned.]

APPENDIX

ADDITIONAL MATERIAL SUBMITTED FOR THE RECORD

STATEMENT OF CHRISTINE REIMER, GOVERNMENT AFFAIRS DIRECTOR, ON BEHALF OF NATIONAL GROUND WATER ASSOCIATION, WESTERVILLE, OH

The National Ground Water Association (NGWA) appreciates the opportunity to provide testimony for this hearing. NGWA is the world's largest association of groundwater professionals, representing public and private sector engineers, scientists, water well contractors, manufacturers, and suppliers of groundwater related products and services. NGWA's comments will focus on groundwater's role during droughts and the scientific understanding of impacts of climate change on groundwater resources.

Groundwater, the nation's subsurface reservoir, will be relied on more in the future, to help balance the larger swings in precipitation and associated increased demands caused by heat and drought. Groundwater will also be used to increase water supply reliability through periods of climate fluctuations and may serve as future repositories for CO2 emissions. There will be more emphasis on conjunctive use, which involves the coordinated and planned operation of both surface and groundwater resources for conservation and optimal use. There will be an increased focus on efforts to manage aquifer recharge, and there should be a greater emphasis on protecting our valuable groundwater supplies.

Groundwater has and continues to take on an expanding and pivotal role in water resource planning. The expanding emphasis on the need and usage of groundwater resources will require policy tools based on sound science to provide the nation with safe, reliable water supplies.

While groundwater management decision making is most effective when done at the state and local level where site-specific considerations can be taken into account, the federal government is currently playing and must continue to play a leadership role. Federal leadership is needed to help ensure these water professionals have the tools they need to promote the long-term sustainable use of our groundwater resources, including addressing the potential impacts of climate change.

In particular, NGWA calls on the federal government to provide federal funding to the U.S. Geological Survey's Ground Water Resources Program to begin implementation of a systematic nationwide groundwater level and quality monitoring network and data management system. Currently, there is no systematic nationwide groundwater level or quality monitoring network.

Congress authorized a national groundwater monitoring network with passage of Public Law 111-11 (Omnibus Public Land Management Act) in 2009. In 2010, six states[1] voluntarily pilot tested concepts for a national groundwater monitoring network as developed by the federal Advisory Committee on Water Information's (ACWI) Subcommittee on Ground Water (SOGW). If this effort moves forward, consistent, comparable nationwide data would become accessible through a web portal for federal, state, local government and private sector users. In these tight fiscal times, the proposed network would build on existing state and federal investments, maximizing their usefulness and leveraging current dollars to build toward systematic nationwide monitoring of the groundwater resource.

Groundwater provides 40% of the nation's drinking water supply. For a small investment, the nation can begin finally to put in place adequate monitoring of this irreplaceable resource.

Thank you.

---

[1] The six pilot states were Illinois, Indiana, Minnesota, Montana, New Jersey, and Texas. Additionally, Idaho, North Carolina, South Carolina, Washington and Wyoming volunteered as pilots but were not included given limited oversight resources.

STATEMENT OF THE WILDERNESS SOCIETY

Thank you Chairman Bingaman and Ranking Member Murkowski for this opportunity to address the issue of water and climate in New Mexico.

The Wilderness Society[1] shares your concern for maintaining the viability of community water supplies in the face of global warming. America's public lands—some 635 million acres of land and 150,000 square miles of protected waters—are a legacy we hold in trust for generations to come. Global warming poses an unprecedented threat to the nation's iconic landscapes—our national parks, forests, wilderness areas, desert lands managed by the Bureau of Land Management, and wildlife refuges. At the same time, our country's parks and other public lands offer one of our best hopes for sustaining the plants, animals, birds, clean water and air, and recreational opportunities that are important to our heritage. They store water and carbon and provide large core protected areas that will be essential in adapting to a changing climate. These lands also provide critical services for our communities, including filtering the air we breathe and the water we drink and rely on for food production. Protecting these natural places is more important now than ever.

The Wilderness Society appreciates the leadership of this Committee in undertaking a review of water supplies in the West, both through understanding climate impacts on reclamation[2] and data collection relevant to monitoring hydrologic conditions. To supplement these reports, we are submitting a set of case histories below so that the Committee may consider examples of water protection initiatives that have relied extensively on the maintenance of natural ecosystems. The health of our nation's public lands—particularly its forests—are critical to maintaining the viability of thousands of communities across America. Just as a car won't start if the battery is low, economic activity weakens and dies if our natural water systems—acting as a battery for sustainable water supplies from season to season—run dry.

In fact, forests supply drinking water to more than 180 million people and over sixty million people rely on a national forests for their water.[3] Climate change threatens both the health of our forests as well as the water resources they provide. Protecting forests today, and keeping them resilient in a warming world by investing in climate-smart conservation, is a cost-effective strategy to mitigate future climate impacts and ensure our wildlands and communities have the water they need in years to come.

Restoring and protecting forests for their water resources is not a new concept. In fact, many of America's forests were originally established for this exact reason—and we benefit today from this foresight. The case studies below highlight this legacy, and we hope inspire a renewed commitment to keeping our forests resilient as we face changing climates.

CASE HISTORIES

1. The Tolt River Watershed is smaller area of land, but similar to the Cedar River Watershed in its contribution of fresh water to the Seattle area. The entire watershed is 63,800 acres, although only 8,400 acres is owned by the City of Seattle. This forestland is located at the foot of the breathtaking Cascade Mountains and produces up to 100 million gallons of clean drinking water per day. The City of Seattle recognized the importance of this watershed and traded Weyerhaeuser Timber Company for the land, which now belongs solely to the city. Today, the Tolt River Watershed supplies 30% of fresh drinking water to the 1.3 million people in the greater Seattle area. Earth Economics estimates that the entire watershed has a present value of between $5.6 and $20.9 billion at a 7% discount rate, using a 3.5% discount rate (used for renewable and self sustaining ecosystem services,) that number would be between $10.9 and $40.3 billion.

"Tolt River Watershed." Seattle.Gov: Seattle Public Utilities. Seattle Public Utilities, 2011. Web. 30 Mar 2011. <http://www.seattle.gov/util/About__SPU/Water__System/Water__Sources__&__Treatment/Tolt__River__Watershed/index.asp>.

---

[1] The Wilderness Society was established 75 years ago to protect wilderness and inspire Americans to care for our wild places. Our mission is to maintain the integrity of America's wilderness and public lands and ensure that land management practices are sustainable and based on sound science. With more than half a million members and supporters nation-wide, TWS represents a diverse range of citizen support for wise stewardship of our network of wild natural areas.

[2] See reports generated in response to the SECURE Water ACT: http://www.usbr.gov/climate/SECURE/docs/SECUREWaterReport.pdf and http://acwi.gov/Rpt.Congress3.18.11.pdf.)

[3] http://www.fs.usda.gov/Internet/FSE__DOCUMENTSstelprdb5107789.pdf

Batker, David K. "Supplemental Ecological Services: Tolt River Watershed Asset Management Plan." Earth Economics. Earth Economics, December 16, 2005. Web. 31 Mar 2011. <http://www.eartheconomics.org/FileLibrary/file/Reports/Puget%20Sound%20and%20Watersheds/Tolt__River__Ecological__Service__Study.pdf>.

2. The Cedar River Watershed is 90,638 acres of forestland that has been regulated by the City of Seattle since 1899. The watershed continued to be logged until erosion, forest degradation and forest fires lead the City to take the first steps in protecting this forestland. An extensive watershed assessment was done, which resulted in the creation of more sustainable logging practices and the replanting of local species. Today, 17% of old growth remains in the Cedar River Watershed and this watershed currently provides clean drinking water to 1.4 million people in the Seattle area. If the Cedar River Watershed was not there to filter the water being used by the city, the City of Seattle would have to pay over $250 million for a water filtration plant like other cities in the U.S.

"Cedar River Watershed." Seattle.Gov: Seattle Public Utilities. Seattle Public Utilities, 2011. Web. 30 Mar 2011. <http://www.seattle.gov/util/About__SPU/Water__System/Water__Sources__&__Treatment/Cedar__River__Watershed/index.asp>.

"Flood Protection and Ecosystem Services in the Chehalis River Basin." Earth Economics. Earth Economics, May 2010. Web. 1 Apr 2011. <http://www.eartheconomics.org/FileLibrary/file/Reports/Chehalis/Chehalis__Executive__Summary.pdf>.

3. The Bull Run Watershed is within the larger Sandy River Watershed, in the Mt. Hood National Forest. The City of Portland successfully lobbied President Harrison in 1892 to make Bull Run a national forest Reserve. In recognition of the paramount importance of this watershed, the US Congress passed amendments to the 1977 Bull Run Act in 1996 that limited activities and increased protection in the Bull Run Watershed. Bull Run has is the primary source of drinking water for almost one-fourth of the population of Oregon, around 787,000 people. Bull Run watershed, along with the Mt. Hood National Forest, serves as emergency water sources during summer droughts.

"The Bull Run Watershed." City of Portland: Portland Water Bureau. Portland Water Bureau, 2011. Web. 31 Mar 2011. <http://www.portlandonline.com/water/index.cfm?c=29784>.

Hopper, Kim, and Caryn Ernst. "Source Protection Handbook: Using Land Conservation to Protect Drinking Water Supplies." Trust for Public Land. (2005): Print.

4. The Upper Neuse River basin in North Carolina is a huge watershed in the central part of the state. The basin covers 770 square miles and is managed by multiple agencies, all of which have different management objectives ranging from water quality monitoring and conservation to wastewater treatment and storm water management. The Upper Neuse River Basin Association is a regional collective of local governments who have jurisdiction in different regions of the Upper Neuse. The association is an attempt to aid cooperative management between agencies. The whole basin supplies more than .5 million people in North Carolina with fresh drinking water.

Terziotti, Silvia. "The Upper Neuse Watershed Evaluation Tool." USGS. USGS, 2006. Web. 31 Mar 2011. <http://nc.water.usgs.gov/reports/abstracts/Ter06Upp__full.html>.

NOTE: for the Snohomish and Nisqually—both estimates are low, because these are estimated values of natural systems, they technically should be treated differently than other economic assets and so their value over, say, 100 years is actually huge because they would receive 0% discount rates.

5. The Snohomish Basin provides multiple ecosystem services to Western Washington including providing fresh water, buffering against flooding, supporting fisheries and agriculture, and providing waste treatment. These combined services are estimated to be providing between $383.1 million-$5.2 billion every year. These ecosystem services have a present value of between $13.2 billion and $180.1 billion, (using a 2.7% discount rate). If we fail to protect this important watershed and allow natural systems in the Snohomish to become degraded, we could face huge economic value losses.

Batker, David, Rowan Schmidt, Jennifer Harrison-Cox, and Briana Lovell. "The Whole Economy of the Snohomish Basin." Earth Economics. Earth Economics, No-

vember, 2010. Web. 31 Mar 2011. <http://www.eartheconomics.org/FileLibrary/file/Reports/Snohomish/Earth__Economics__Snohomish__Basin__Report__LQ.pdf>.

6. The Nisqually Watershed links the glaciers of Mount Rainier to the Puget Sound and crosses multiple municipalities, but it is unique in that it's headwaters are in a National Park and its delta is in a National Wildlife Refuge. In 1985, the Washington State Department of Ecology created a management plan and council for the protection of the watershed. The Nisqually River Task Force was created and includes representatives from federal, state, and local governments, agencies, and organizations as well as members of the Nisqually Indian Tribe. Earth Economics did an assessment of the economic benefits that this watershed provides people living in the Pierce County area and have estimated that the value of just 12 of the 23 ecosystem services that this watershed offers is between $287,600,000 and $4,165,990,000 in yearly benefits. If the watershed was viewed as an economic asset, its asset value would be between $9.5 billion and $138 billion.

Batker, David, Isabel de la Torre, Maya Kocian, and Briana Lovell. "The Natural Economy of the Nisqually Watershed." Earth Economics. Earth Economics, 2009. Web. 31 Mar 2011. <http://www.eartheconomics.org/FileLibrary/file/Reports/Natural__Economy__of__Nisqually__Watershed__7__2009.pdf>.

"The Nisqually Watershed Stewardship Plan." Nisqually River Council. Nisqually River Council, 2009. Web. 31 Mar 2011. <http://nisquallyriver.org/who-we-are/the-nisqually-river-management-plan/>.

"Nisqually Land Trust Facts." Nisqually Land Trust. Nisqually Land Trust, 2006. Web. 31 Mar 2011. <http://www.nisquallylandtrust.org/land.php>. µ

7. Puget Sound is in the western part of the state of Washington and is made up of interconnected estuarine systems and waterways. The basin is home to 4.3 million people and one of the largest cities on the West Coast, Seattle. The basin provides drinking water, recreation, fish , flood and storm protection, and erosion control, just to name a few. As a whole, the ecosystem services within the basin provide between $7.4 and $61.7 billion in benefits to human communities every year. If viewed as an economic asset, the basin is worth at least between $243 billion and $2.1 trillion.

Batker, David, Paula Sweeden, Robert Costanza, Isabel de la Torre, and Roelof Boumans. "A New View of the Puget Sound Economy ." Earth Economics. Earth Economics, n.d. Web. 1 Apr 2011. http://www.eartheconomics.org/FileLibrary/file/Reports/A__New__View__of__the__Puget__Sound__Economy.pdf

8. The Skokomish River is in the Southeast part of Washington's Olympic Peninsula and is one of the US Forest Service's focus points in terms of restoring damaged watersheds. The Skokomish watershed was overcut in the early 1950's and continued until the 1980's. By this point, 60% of the Skokomish had been clearcut and hundreds of miles of logging roads had been built, causing erosion. Sediment and gravel were deposited in the River and created buildup, which lead to flooding in Skokomish Tribeland. Since the 1990's, the Forest Service has been working on restoring the watershed and decommissioning old logging roads. In 2006 by the Wilderness Society, the Olympic Forest Coalition and others organized the Skokomish Watershed Action Team (SWAT) to help restore the watershed. The Skokomish watershed is economically valuable because it is the main source of fresh water for the Hood Canal in Puget Sound.

Anderson, Mike. "Washington's Skokomish Watershed: Exemplar of the Legacy Roads and Trails Initiative." Wilderness CPR. Wildlands CPR, 2010. Web. 13 Apr 2011. <http://www.scribd.com/full/39748952?access__key=key-2a553fp1puuc85pry87u>.

9. The Upper Little Tallapoosa Watershed is a 95 square mile area about an hour west of Atlanta. This land has historically been used for traditional farming and forestry, but over the past few decades it has begun to be developed into large scale residential communities and commercial buildings. This watershed provides drinking water for 30,000 people, mostly in Carrollton and in Carol Country, Georgia. In 1987, there was an outbreak of Cryptosporidum, an intestinal parasite that made residents in Carol County very sick and resulted in an increased awareness of water quality in the region. In 2003, the citizens of Carroll County voted to raise sales taxes to generate almost $85 million over five years to fund quality of life projects, $19 million went toward land conservation to protect drinking water.

"Source Water Stewardship: Upper Little Tallapoosa River, Georgia." The Trust for Public Land. The Trust for Public Land, 2003. Web. 12 Apr 2011. <http://www.tpl.org/content__documents/TallapoosaGA__ConVisCaseStudy.pdf>.

10. Two primary watersheds are responsible for providing fresh, clean water for the Boston area: the Wachusett Reservoir and the Quabbin Reservoir. The Wachusett Reservoir can be dated back to the late 19th century, when Boston was experiencing a period of rapid growth and was beginning to require large quantities of water not just for drinking, but also for plumbing. City planners decided that an additional water source was needed, and in 1897 the Wachusett dam was built on the Nashua River. Construction was finished in 1905, and the reservoir started to be regularly used in 1908. The Quabbin Reservoir was constructed a few years later, in 1926. The Division of Water Supply Protection and the Department of Conservation and Recreation oversee management of these two watersheds. Because they are both unfiltered supplies they rely on forest bio-filtration to maintain drinking water standards, so the Division also manages 100,000 acres of forests surrounding the watersheds. The Wachusett and Quabbin Reservoirs provide drinking water for almost 2.2 million people and 5,500 city industrial users and are essential water sources for the city of Boston.

"The Water System." Water Resources Authority. State of Massachusetts, April 2011. Web. 19 Apr 2011. <http://www.mwra.state.ma.us/04water/html/wat.htm>.

"Office of Water Management." Department of Conservation and Recreation. State of Massachusetts, 2011. Web. 19 Apr 2011. <http://www.mass.gov/dcr/watersupply/watershed/water.htm>.

11. The Kenai Watershed is about 1.4 million acres and the majority of the water in this watershed is the result of glacier melt, which gives the River a light turquoise color. The Kenai Watershed is a drastically important watershed to fish species and has a very high economic value. The local Alaskan commercial salmon fishing industry generates between $75 and $175 million every year, Over 40% of this number can be attributed to the Kenai River. The Kenai River Watershed is owned by different parties. The lower 50 miles of the Watershed are owned by private entities and are already being developed. This development affects water quality and fish livelihood. The headwaters of the watershed are in the Chugach National Forest.

"Living and Playing in the Kenai River Watershed." Kenai Watershed Forum. Kenai Watershed Forum, n.d. Web. 22 Apr 2011. <http://web.acsalaska.net/?kenaiwatershed.forum/Living__and__Playing__KRW.pdf>.

The Wilderness Society thanks the Committee for its attention to the critical connections between water, climate and community health. It is our hope that the case histories set forth in this testimony will improve public understanding of successful, cost effective strategies for water management and can give direction to adaptation strategies needed to meet the challenge of climate change in the years ahead.

STATEMENT OF MEREDITH R. MACHEN, PRESIDENT, LEAGUE OF WOMEN VOTERS, SANTA FE COUNTY

WATER (*adopted 2010)*

The League of Women Voters of New Mexico believes that consumptive use of water in New Mexico must be in balance with renewable supply. Healthy ecosystems naturally perform services that benefit both people and nature, such as cleaning water, reducing floods, and creating fish and wildlife habitat. To secure the benefits of functioning ecosystems and to conserve New Mexico's biodiversity, sufficient water must be budgeted for environmental flows. The creation and adherence to comprehensive water budgets is essential to preserve public lands, water, and open space, and to ensure that there will be enough water for future generations of New Mexicans. The state, water regions, and local governments must

1. monitor and measure all water resources and uses, and publish this information;
2. use a public process to create and follow water budgets;
3. educate citizens on their responsibilities as well as their rights;
4. promote strategies to reduce demand;
5. minimize water contamination in order to promote the health and safety of all life;
6. preserve and restore rivers and watersheds.

Conservation of water and efficiency of use must be encouraged to enable New Mexico to meet its interstate compact obligations, to help balance use with supply, to relieve stress on the physical system, and to reduce net depletion.

Regional Water Planning

The League supports continued funding for regional planning. Using a public process, regional planning should

1. gather and publish data on supply and demand, and provide regular updates;
2. create a balanced water budget;
3. identify critical and emerging issues.

Local land use plans should be required to be consistent with applicable regional water plans.

The public welfare statements of a regional water plan should be considered by the State Engineer when reviewing applications for transfer of water rights.

Land Use and Water

Land use and development must be tied to water availability. To encourage this:

1. Compliance with water availability determinations by the Office of the State Engineer (OSE) under the Subdivision Act should be mandatory.
2. Review of subdivision applications pursuant to the Subdivision Act should be expanded to encompass all divisions of land.
3. Long-term cumulative impacts as well as short-term water requirements of development should be taken into consideration by the local permitting authority.
4. The applicant must be required to acquire water rights before development can proceed.
5. The impact of any transfer of water rights on the area of origin must be assessed.
6. The permitting authority should evaluate the impact of proposed developments on "public welfare" as defined by the applicable regional water plan and be able to demonstrate that the proposed development is consistent with the plan.
7. New residential and commercial developments should be water-efficient.
8. Growth should not be permitted where water is not available.

Local zoning and subdivision statutes should be updated. State and local governments should collaborate in addressing the problem of antiquated subdivisions in order to facilitate planning and to make the water budget process meaningful.

Role of Government

State government and the legal process must work to reconcile the many claims on New Mexico water in a manner that is open and as fair as possible. Among other considerations:

1. Communal as well as private interests must be respected in applying water law;
2. Maintenance of in-stream flow and general ecological health must be recognized as a "beneficial use" of water.

The Office of the State Engineer should be adequately funded to execute its functions. In addition:

1. The OSE must be given more authority to regulate domestic well permits. Improved regulation and monitoring of domestic wells and septic systems is essential to protect groundwater supplies and should be adequately funded.
2. The effort to gather data must be coordinated and adequately funded by the state, which should establish consistent protocols, accounting methods, and terminology.
3. The state should also help implement the regional water plans and provide coordination among planning activities at the different levels of government and across river basins.

Government should support research on water-related issues including

1. methods to manage and store water that lose less to evaporation,
2. best agricultural practices that optimize the use of water for both farmers and downstream users, while sustaining the natural flow;
3. urban systems that maximize water re-use;
4. health of the state's rivers and watersheds.

Governments at every level must educate citizens by developing and disseminating data about water resources. Local governments must promulgate and enforce regulations promoting conservation, including positive incentives and rate structures.

○