Water Governance and Climate Change:
Drought in California as a Lens on Our Climate Future

Prepared by Jacqueline Peel and Janny Choy

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WATER IN THE WEST
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"Thousands have lived without love; not one without water."
W.H. Auden

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About Water in the West

Water in the West is a partnership of the faculty, staff and students of the Stanford Woods Institute for the Environment and The Bill Lane Center for the American West. The mission of Water in the West is to design, articulate, and advance sustainable water management for the people and environment of the American West. Linking ideas to action, we accomplish our mission by engaging in cutting-edge research, creative problem solving, active collaboration with decision-makers and opinion leaders, effective public communications and hands-on education of students.

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1. INTRODUCTION

This report summarizes the insights, lessons and key findings of a workshop hosted by Water in the West on "Water Governance and Climate Change" held at Stanford University on September 25-26, 2014. The report was prepared by Jacqueline Peel, a Visiting Scholar with Water in the West and a law professor at the Melbourne Law School, University of Melbourne, Australia, and Janny Choy, Research Analyst with Water in the West. It contains the authors' analysis of the workshop findings but does not reflect the individual views of any particular participant.

The workshop was held in conjunction with a parallel workshop at Melbourne Law School in Australia. Participants in the two workshops took part in a joint videoconference session to share ideas, lessons and innovations in water governance across the two jurisdictions.

Workshop Participants

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2. DROUGHT IN CALIFORNIA

Summary

- Research shows California can survive big droughts with manageable economic consequences, but this modeling assumes optimized water use.
- We need better tools to optimize our actual use during times of water shortage and to minimize adverse consequences for communities and the environment.

California is in the midst of one of the most severe droughts in its history. Over the past 119 years of record, calendar year 2013 was the lowest year for precipitation on record in California. The drought has only worsened since then: 2014 has been the driest year since 1977 (other than 2013), and bad water conditions have been exacerbated by increased population and water demand. For example, although total water storage in the drought of 1974-1977 fell to 7.8 million acre feet – 5 million acre feet less than the levels in reservoirs today – today's water must supply 14 million more people than was the case 40 years ago. Legally dedicated water for the environment is another more recent constraint on California's water supply. The recently released year-to-date Palmer Drought Severity Index is presently far lower than any previously recorded value for California, including from the Dust Bowl and the droughts of 1976-77 and the early 1990s. As California potentially enters its fourth consecutive year of drought, there is little prospect of relief on the horizon.

Although the current drought in California is severe, droughts (and flooding rains) are a normal part of the Californian climate. Precipitation in California is uniquely variable, with the highest level of year-to-year variability seen anywhere in the United States (Dettinger et al 2011). In the twentieth century, other major periods of drought occurred in the early 1920s and in the mid-1970s. The paleontological record also indicates the occurrence of several past "megadroughts" over the last thousand years in California that lasted more than 100 years (Stine 1994).

Climate change, however, is shifting the baseline in terms of what is "normal" for drought, water availability and temperature in California. In the past 100 years, the state has seen a 0.6°C rise in average temperatures, a 10 percent overall loss in snowpack in the Sierra Nevada, and an average sea level rise of 0.2 meters. In the next 35 years (up to 2050), predictions are for a further 0.6-2.0°C temperature rise, a 25-40 percent reduction in snowpack, 0.2-0.6 meters in sea level rise, and more intense wet and dry periods. The proximate cause of the current drought in California has been a "ridiculously resilient ridge" of concentrated high pressure off the state's coast that blocked moist air from the Pacific Ocean. A recent study has found that the likelihood of such events, although extremely low, is approximately three times as much with global warming (Swain et al 2014). Another recent study suggests that because droughts tend to occur when lower precipitation and warmer temperatures coincide, droughts will become more common, even if precipitation does not change, since increased temperatures are expected with climate change (Diffenbaugh et al 2014, in prep.).

"This is a relatively tame drought compared to what we could face in the future."

Despite the severity of the present drought, the statewide economic consequences are projected to be relatively minor. Estimates are that the current drought will impose direct costs of $1.5 billion on agriculture (approximately 3% of the value of agricultural revenue in California), and overall economic losses to the state of $2.2 billion (Howitt et al 2014). What has helped minimize agricultural economic losses is groundwater – withdrawals (in some cases, overdraft) are making up for the shortfall in surface water deliveries. While the economic losses from the drought are relatively small in comparison to the state's overall economy, the impacts have been locally significant and acute for many in the agricultural sector. Many farmers and smaller rural communities have felt the drought's effects keenly, with water delivery cutbacks, crop losses, fallowing, and high unemployment.

In order to better understand how a severe, prolonged megadrought might affect California's economy, researchers modeled such an event. Results showed that the overall statewide water supply system and economy could function without catastrophe, although agriculture and ecosystems in most areas would contract substantially (Harou et al 2010). However, this modeling assumes optimized water use, and we currently do not have the legal or institutional tools to optimize our actual use during times of shortage. Minimizing economic losses to the extent predicted by the model would require new rules, institutions, data, and infrastructure.

In the real world of water management, we have been far less successful at designing and implementing optimized, flexible systems. Key to how drought affects communities, the economy and the environment in practice is not just science and economics but also institutions and structures of governance. How well we do in drought and in managing water in a future world of climate change – who wins and who loses – will be shaped by the quality of our governance tools. Do we have the tools to adequately plan and prepare for droughts? Do we have the rules, institutions, and infrastructure in place to allocate scarce water optimally? Can we create needed resilience in water supply? How will we ensure equitable outcomes for cities, agricultural communities and the environment, especially as water risks become more extreme under climate change? These questions of governance are the focus of the following sections of the report.

3. DISASTER AS AN IMPETUS FOR REFORM

Summary

- Water users experienced unprecedented cutbacks in water deliveries in 2014.
- Better long term planning and preparation would help managers make difficult decisions and give users better tools to plan for and cope with drought.
- Disasters like severe drought can provide a policy window for major reform efforts.

At the beginning of 2014, with California's rivers and reservoirs falling below record levels, Governor Brown declared a State of Emergency, directing state officials to take all necessary actions to prepare for drought conditions. "We can't make it rain," said Governor Brown, "but we can be much better prepared for the terrible consequences that California's drought now threatens, including dramatically less water for our farms and communities and increased fires in both urban and rural areas." The Governor's declaration paved the way for a coordinated state response to the drought, with agency operations teams organized and coordinated in line with emergency management protocols. State and federal agencies have exerted enormous effort in a scramble to deal with the emergency posed by the drought. Quite obviously, though, managers cannot come up with any additional water during a drought – the state is stuck with the supplies it has once it stops raining. The state's ability to cope with droughts in the short term, however, could be improved by better long-term policies, many of which are highlighted by this year's experience.

Water managers – whether with local, regional, state or federal agencies – have faced difficult decisions about how much to cut back water deliveries to users, and whose deliveries to cut. In the 2013-2014 water year, the Central Valley Project delivered between zero and 40 percent of historical amounts to its customers, representing record low deliveries. Managers have had to make tradeoffs between different users, between cities and agriculture, and between human consumption and the environment. The requirements of different water contracts and water rights, and of environmental laws – most notably those imposed by the Endangered Species Act – often conflict, with an absence of clear rules about how to resolve those conflicts. The allocation of scarce water has not always been governed by principles of the most efficient and best use. Better longer term planning and preparation, along with rules specifically tailored to coping with more severe droughts, would make these decisions by water managers easier and would give water users better tools to plan for drought.

"We had to short people who have never been shorted in their water supply before. These people have no backup plan. They had no groundwater resources and they were not used to doing transfers."

As surface water supplies have become scarce, groundwater pumping has increased in many areas of the state to make up the deficit. For example, in the Kings River Conservation District, which covers portions of the Kings, Tulare and Fresno counties, groundwater has been hit hard as surface water deliveries to growers reduced significantly and urban communities turned to groundwater as a sole source of water supply. The District estimates an overdraft for 2012-2013 of approximately 1 million acre feet, compared with a historical average annual overdraft of 140,000-150,000 acre feet. In the Central Valley, irrigators coped with cutbacks in surface water deliveries of 6.5 million acre-feet by increasing groundwater pumping by 5 million acre-feet. Better long-term management of groundwater would ensure that the resource is available during times of drought.

If there is an upside to disaster like the current severe drought in California, it is that it can provide momentum for reform proposals that would have little chance in normal conditions. In other parts of the United States, this dynamic of disaster as an impetus for policy reform has been evident in the aftermath of other major events such as Superstorm Sandy. In California, increased public and political attention to water issues in the drought seems to be providing a similar window for reform. In its 2014 Statewide Survey of Californians and their Government, the Public Policy Institute of California recorded an unprecedented 24 percent of people naming water and the drought as the state's top issue of concern (in 2012 before the drought set in, this figure sat at 1 percent) (Baldassare et al 2014). In September 2014, Governor Brown signed into law one of the most significant water law reforms in the state's history: the Sustainable Groundwater Management Act. This legislative package will implement a statewide regulatory system for groundwater sources, improving the prospects for sustainability and resilience of supply in the future.

"In the world of public policy, a drought is a terrible thing to waste."

Public concern about drought and climate change is likely to wane when the rains come again. This has been the experience in other drought-prone countries, such as Australia. During Australia's "Millennium drought" that stretched from 1995-2007, the levels of public concern about water issues were very high, but these levels declined with the end of the drought and subsequent floods in many parts of the country. However, over the period of the drought, Australian policymakers were able to lock in major institutional and legal reforms to water allocation systems that have improved their resilience and capacity to cope with future droughts and climate change.

Box 1: Think Big. Australian Water Law Reform During the Millennium Drought

As the driest continent on Earth, Australia is no stranger to drought and water scarcity. Water allocation has been a major policy focus and the subject of ongoing reforms since the 1990s. However, the country's Millennium drought drove home the importance of good water management with the public and policymakers in a way not seen before or since. This megadrought provided the impetus for bold and innovative reforms that brought about a wholesale change in Australia's water management system, which had previously been mostly decentralized, with water rights tied to property rights in land. The reforms implemented during the Millennium drought have strengthened Australia's capacity to weather future droughts, predicted to be more frequent and more severe with climate change.

At the heart of Australia's Millennium drought water reforms are the 2004 National Water Initiative (NWI) and federal legislation, the Commonwealth Water Act 2007. The NWI is an intergovernmental agreement (between federal and state governments) aspiring to the creation of a national market, regulatory and planning based system for all Australia's water resources in order to optimize sustainable outcomes. The NWI has involved significant reforms to the water entitlement system: the introduction of a comprehensive multi-scale water planning framework to govern water allocation and management; and the development of water markets for both temporary and permanent transfer of water, including inter-state transfers. Water entitlements (permanent water rights) have been separated from the land. In addition, these water entitlements are expressed as a share of the available resource rather than as a specified quantity of water. Water is then allocated on a seasonal basis against these entitlements, depending on availability. Allocations made to entitlements in any given water year may vary from 100% to zero. Some states differentiate between high and low water reliability entitlements with the former receiving priority. The reliability of entitlements is not based on type of use or seniority in time, but rather reflects the frequency with which water allocated under an entitlement is able to be supplied in full. On water markets, high reliability entitlements attract higher prices than low reliability entitlements. Both water entitlements and allocations can be traded. Water plans are used to set the over-arching rules for the allocation of water between users and the operation of water markets. These reforms have strengthened the adaptive capacity of the entitlement system to respond to changing water availability and have facilitated efficient and low cost water trading (Tan 2010).

The Water Act adopts a more centralized model for Australia's most important water system: the Murray-Darling Basin. The Act created a federal agency – the Murray-Darling Basin Authority (MDBA) – to develop a Basin Plan that will be implemented by sub-plans at the water management scale. A central feature of the Basin Plan, adopted in late 2012, is the "environmentally sustainable limits" (known as sustainable diversion limits or SDLs) it places on water withdrawals (surface and groundwater) from the Basin overall, and for each individual catchment and aquifer in the Basin. The Basin-wide SDL effectively "caps" the amount of Basin water available for consumptive uses. The Water Act required the SDL to be set at a level that reflected an environmentally sustainable level of take that would not compromise key environmental assets, ecosystem functions, environmental outcomes or the productive base of water resources. In the Basin, water users can trade water either by selling their water allocation for a single year or their water access entitlement.

The significant differences between water management systems in Australia and the United States limit the possibilities for simply transplanting Australian reforms in a U.S. context. However, there are some key lessons from the Australian experience that could inform future reform efforts (Pilz 2011). These include: (1) the value of a shared national vision; (2) treating water not as a matter of "right" but as a shared resource; (3) good processes of intergovernmental cooperation in water management that focus on hydrological not territorial boundaries; (4) better information on water use to support allocation decision-making; (5) tackling the sustainability of current water use using tools that incentivize water efficiency; (6) considering greater development of water markets to optimize water use; and (7) incorporating flexibility in water allocations to reflect changing conditions.

4. IMPORTANCE OF GOOD PLANNING

Summary

- Advance planning, including around extreme event scenarios, can improve water management in wet and dry periods.
- We need to focus not just on making plans but also how and when they are implemented.
- Agencies should think about what steps they can take now to meet future water demands in drought.

In the past, droughts and other disasters have tended to be managed in a reactive fashion with a focus on crisis response and recovery. These practices only treat the impacts of drought rather than addressing underlying policies and practices that can exacerbate the drought's effects. Today there is growing recognition that policies focused on risk reduction, complemented by drought mitigation and preparedness plans at various levels of government, are key to improving the capacity of governments and communities to manage droughts (Wilhite et al 2014).

In the United States, California has been a leader in planning for water management, drought and climate change. Pursuant to the State's seminal climate change law – AB32, the Global Warming Solutions Act – the California Air Resources Board has produced a comprehensive Scoping Plan of measures for climate change mitigation. On the adaptation side, this is supplemented by the California Climate Adaptation Strategy, together with the Adaptation Planning Guide and the Climate Change Handbook for Regional Water Planning (the latter provides step-by-step guidance on vulnerability and impacts assessment for regional water resources). The State also has a comprehensive long-term Water Plan (with a 30-year time horizon) that is updated every five years. State law either mandates or provides funding incentives for a variety of local and regional water plans, including urban water management plans, groundwater management plans, and integrated regional water management plans. In addition to these local and regional plans, large inter-regional water management systems, such as the Central Valley Project, State Water Project, and flood management systems, have their own plans in place. With the passage of the Sustainable Groundwater Management Act, long-term groundwater sustainability plans will also need to be adopted for all high and medium priority groundwater basins in the State.

"It's not that we don't know how to plan. The problem is that we don't know how to use those plans and we don't implement our plans."

While planning has become an accepted part of water and climate change management in California, good planning that is implemented in an effective manner has been more elusive. One problem is that the laws and programs that require preparation of the plan do not always specify a trigger for implementing the plan. Another issue is that the plans are often issue specific and not well coordinated; examples include a groundwater management plan that neglects effects on surface water or water supply plans that fail to factor in water quality or land use considerations. In other cases, implementation of plans, particularly for operations, may be inhibited by a lack of good data. In these circumstances, scenario planning that factors in extreme events can be a useful tool.

"Maybe we need to push planning to the extreme events. If you have a crisis, no plan on the shelf will work. But if you knew a crisis was coming, you could plan for it."

The new groundwater law may change the dynamic as the law requires both the preparation and implementation of sustainable groundwater management plans across the state. Because of the comprehensive nature of these plans, and the law's mandates, the implementation of the law will be an opportunity to see if plans for sustainable management of groundwater can be successfully developed and implemented in wet years and dry. These plans could be an important piece of better drought planning in the state.

Taking steps now to better prepare for the future is an important element of good planning. Those agencies that have used planning effectively to anticipate impacts and manage droughts are ones that have pursued strategies such as diversifying their water portfolio (e.g. through water efficiency, groundwater recharge, water markets, recycled water, stormwater capture, etc.), planning for growth and land use changes through new supply and demand management strategies, and improving water storage. Ultimately, localities in the state need to develop plans that require them to prepare for droughts during wet years, so they have more water during dry years, and can implement cutbacks in a more orderly fashion.

"The deeper the drought, the longer it lasts, the less able we are to muddle through it."

Climate change adds an additional layer of complexity to planning exercises given uncertainties in how water supply will be affected in specific regions and localities. Even so, planning remains important. Agencies should consider what pieces can be put in place now so new water projects can get off the ground quickly if and when they are needed. This might involve preliminary planning or investments in acquiring the necessary land and permits for a project (e.g. water recycling or desalination plants) without proceeding to full implementation.

5. FLEXIBLE DECISION-MAKING PROCESSES

Summary

- Flexibility in interpretation of legal requirements and in the expectations of agencies and water users is key to managing severe drought.
- Californian water management has a lot of built-in inflexibility, but improved planning, data and coordination between state and federal agencies are the basis for developing better, more flexible tools.
- Flexibility needs to be balanced with meaningful and enforceable commitments to achieving valued outcomes (e.g. protecting endangered species).

A theme of much of the literature and practice that has emerged around climate change adaptation and dealing with the associated water risks is that of "adaptive management" (Ruhl 2010, Kundis Craig 2010). The essence of adaptive management is flexible decision-making processes that allow managers to adjust decisions on an ongoing basis in light of new information. In the current drought in California, it seems that flexibility – both in the applicable legal requirements and in the expectations of agencies and water users – has been vital in managing the fast-moving water supply situation.

"We have to plan for the unexpected. We hang our hat onto a couple of sentences in a biological opinion that provided for the preparation of a drought management plan in times of drought."

Water management in California has a great deal of built-in inflexibility. Water is allocated pursuant either to the state's system of appropriative and riparian water rights or contracts with the Central Valley Project or State Water Project. These systems create legal rights (either property rights or contractual rights). Although the legal systems establish broad outlines for prioritizing among rights holders, they do not provide a great deal of detailed clarity about how to prioritize between water users during times of extreme shortage. During the current drought, in many cases, any decision to allocate severely limited water supplies to one user rather than another has resulted in a claim of violated property or contractual rights. Similarly, flow requirements for the protection of endangered species are in many cases categorical, and place water managers in the situation of navigating between claims of violations of water rights or the Endangered Species Act. These conflicts, exacerbated by a lack of planning and good data, make it very difficult for managers to allocate supplies to the highest value human or environmental uses.

One of Australia's responses to drought was a nationwide reconfiguration of its water rights system and how water can be reallocated in times of shortage, including through more robust water markets (see Box 1 above). Although this did not involve major reductions in the amount of water allocated to individual users during normal periods, the changes did alter the system for prioritizing users during times of drought and changes to the terms of water rights to make water rights transactions easier. The reform also created a central fund for purchasing water for the environment, providing protections that are both certain and flexible. It would be very difficult to fundamentally alter the nature of property rights in the American West. However, California has a variety of important legal limitations on the exercise of property rights, including requirements to protect public health and safety, as well as the public trust doctrine. Better planning and better data about water availability during drought could allow the state to use these legal tools to come up with better schemes for allocating water during a drought that protect the highest priority uses, both human and environmental. In addition, greater coordination between the state and federal water projects could allow greater flexibility in managing water flows as part of the drought response.

"We should put a lot more money into gathering data than spending money on lawyers fighting about data we don't have."

Beyond adjustments in agency's interpretations and implementation of regulatory requirements, there is a range of additional tools that can enhance institutional flexibility. For instance, the US Bureau of Reclamation's WaterSmart grants program is designed to leverage funding to increase water management flexibility through measures such as water conservation, reuse and improved efficiency. Economic tools can further enhance flexibility. Water pricing policies can create flexibility in water demand (Scheierling et al. 2006, Olmstead and Stavins 2009) and, over time, incentivize the adoption of water-efficient technologies and practices. Water markets are another available tool for improving flexibility by allowing water to move to the most efficient uses through water trading. In Australia, water trading in the nation's principal water system – the Murray-Darling Basin – has been credited with helping water users better manage uncertainty around seasonal water availability and expanding options to help cope with drought (National Water Commission 2010).

On the flipside, flexibility cannot come at the cost of real protection for aquatic resources. Put another way, there is concern that adaptive management – particularly in a crisis situation – can be an excuse for watering down regulatory requirements, especially those established for environmental protection. Flexibility or – as one participant put it – avoidance of "overnegotiation of details" is important, but there needs to be a balance with more rigid elements that act to preserve valued systems.

"Rigidity is important – some of our environmental laws amount to a pre-commitment that we will do things that will hurt."

Laws like the Endangered Species Act can supply some of that needed rigidity; the challenge for managers is navigating between the formal requirements of such laws and their supporting regulations and the fluid nature of the decision-making scenario that demands flexibility and a preparedness to make tradeoffs.

6. ROLE OF INFRASTRUCTURE

Summary

- Strategic investments in water infrastructure can aid in reducing water demand and increasing resiliency in supply.
- The experience with using desalination as a "drought-proofing" measure is mixed; it is difficult to know with certainty if a drought represents a climate shift justifying new expensive infrastructure.

Severe droughts put the spotlight on existing water infrastructure and its adequacy to meet water needs flexibly and efficiently. With climate change, there is also a need to assess the capacity of infrastructure to cope with impacts such as increased temperatures or more variable precipitation, as well as to undertake long term planning and decision-making about future infrastructure needs (e.g. systems of water reuse, water recycling or desalination plants).

In the present drought in California, local and regional investments in water infrastructure have proved important both in reducing water demand and increasing resiliency in supply. For example, the Metropolitan Water District (MWD) of Southern California, which supplies a population of 19 million in a region that generates a little over half of the state's economic output, has sought to diversify its water portfolio through investing in additional local water storage (e.g. Diamond Valley Reservoir) and firming up reliability of supply from the Colorado River, in part by negotiating long-term water transfers with large irrigation districts. In the past, MWD has relied on the drought water market during times of shortage, but has not done so this year, given that some agricultural users are prepared to pay high prices ($1000-$2000/acre foot) for water to support permanent crops in the Central Valley. Importing water has also proved cheaper than other options that would require new infrastructure such as desalination or recycled water. Under future climate change conditions and increased water stress, however, such options may become more cost-effective.

"It's said that there's no such thing as a shortage of water – only a shortage of cheap water."

Modeling of water supply options in an extreme drought, or "megadrought", situation (100+ years) suggests that some infrastructure investments would be of superior long-term utility than others. For example, in a megadrought, investment in additional storage capacity would be of limited utility as there would be insufficient water across the period of drought for reservoirs to ever fill (Figure 1) (Harou et al, 2010).

By contrast, investments in conveyance infrastructure – creating an enhanced ability to move water around – show high utility in an extreme drought event (Harou et al 2010). Such conveyance capacity would allow more flexibility in allocating water, would promote water markets, and would allow communities to better use local storage options, such as aquifer recharge and local reservoirs.

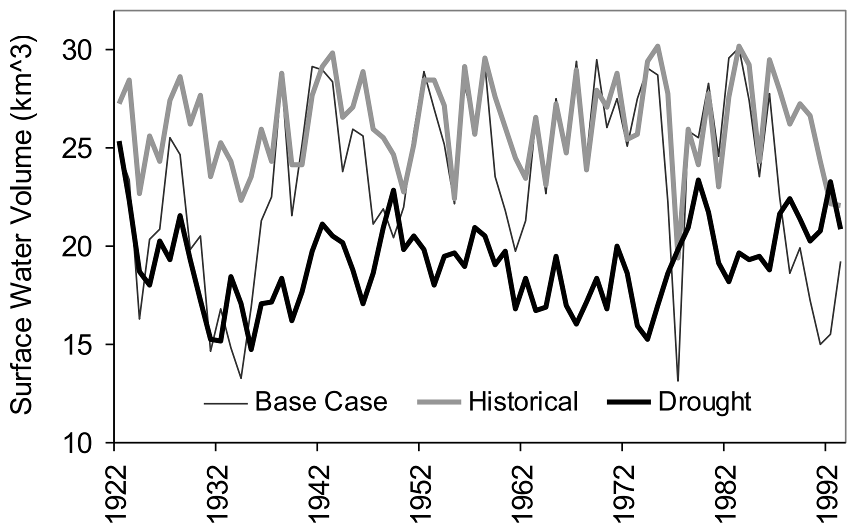

Figure 1. In prolonged extreme drought scenarios, existing reservoirs would never fill. Source: Harou et al, 2010

One of the most difficult questions around infrastructure decision-making for drought resilience is when investments should be made in expensive, “drought-proofing” facilities like desalination plants. The different experiences in various Australian states with desalination plants – all built during the Millennium drought – illustrate a range of scenarios (see Box 2). In the south-eastern state of Victoria, for example, the state’s desalination plant has sat unused since the end of the drought at high cost to Melbourne rate-payers. On the other hand, the desalination plant outside Perth in Western Australia has been “a godsend” in supplementing water supplies and reducing pressure on groundwater resources. Further improvement of technology to reduce the cost of taking desalination plants out of mothballs and restarting them promptly would allow desalination to contribute as a water supply buffer during drought.

“There’s no official statement of regret, but consumers are paying for it. We paid a phenomenal amount of money to drought-proof our urban areas. A lot of it was probably wasted.”

Part of the difficulty with decision-making on large water infrastructure projects lies in doubt about their cost-effectiveness, due to uncertainty about the timing, duration, and intensity of ongoing and future droughts (as illustrated by the Australian experience with desalination). Arguably in conducting any cost-benefit analysis for water supply investments such as desalination, the value of reducing uncertainty should be taken into account given the general risk averseness of the public. This area could benefit from additional research. However, more difficult to gauge in a drought situation is whether the drought is in fact evidence of a climate shift that would strengthen the case for infrastructure like desalination to guard against worse case scenarios (megadroughts). The longer a drought continues the more likely it is that it is evidence of a climate shift.

While there is no doubt infrastructure has played a key role in California, it is important to note that there are other ways to increase water supply resilience. Conservation has been a crucial and cost-effective tool to increase flexibility for water managers over the past few decades. For example, the city of Los Angeles uses the same amount of water today as it did in the 1980s, although it now includes 1 million new residents (Villaraigosa 2008). Demand management is a long-term "no regrets" component that should play a stronger role in California particularly in light of increasing population, more limited water supplies, and more prolonged and extreme droughts expected over time with climate change.

Box 2: Desalination in Australia – A Cautionary but Continuing Tale

In the early 2000s, Australia was in the grip of severe drought with policymakers facing many of the same challenges now confronting California. As water levels in reservoirs fell and concerns grew that the drought might continue unabated, the six state governments around the country commissioned desalination plants. In most states, these decisions have been seen, in hindsight, as economically and environmental disastrous. The desalination plants in eastern Australia were mothballed soon after construction and there is significant uncertainty as to the cost involved and technical feasibility of re-commissioning them when and if they are needed.

The Victorian plant outside Melbourne was the most expensive project and has been the least used. It became fully operational in 2012 just as flooding rains filled up and overwhelmed reservoirs in the State. Contractual arrangements between the Victorian government and the private operator of the plant, however, locked in payments regardless of actual operation of the facility, with consequent astronomical rises in residential water bills in the state.

Desalination has been regarded in a more positive light in other states with drier climates. For instance, desalination plants in South Australia and Western Australia have supplemented water supplies for the capital cities (Adelaide and Perth) in these states. Even so, there have been ongoing environmental concerns associated with high energy demands and saline discharge. The Perth plant, for example, was shut down twice in 2008 because it was causing deoxygenation and ocean die-off in offshore waters.

The debate over desalination in Australia continues. In the media, desalination plants have been lambasted as costly white elephants. However, in some sectors of the scientific and engineering community there remains strong support for desalination as part of longer-term planning for a drier climate.

7. ENVIRONMENTAL FLOWS AND SPECIES PROTECTION

Summary

- Fish species are vulnerable in the current drought and many will face extinction with climate change.
- In drought, environmental flows often "take the hit" despite the best efforts of managers to preserve water for species and ecosystem health.
- There is an urgent need to improve reserves of environmental water and to develop sustainable tools for allocating environmental water to the highest priority ecosystems in dry times.

The ongoing California drought illustrates the difficulty in protecting natural resources during extreme dry periods, even given the protections of the Endangered Species Act (ESA). Experience with the current drought shows that our tools for allocating water to the environment, and optimizing the use of that water, need improvement.

One of the most crucial and most vulnerable water users in drought is the environment. Ecosystem functions and aquatic health – including threatened and endangered species of fishes – depend upon adequate environmental water flows. California has a unique assemblage of native fish with very high levels of species endemism, with 79% of species endemic to the state or region. However, the majority of these fish (75%) are in trouble, with 49% of these extinct or imperiled (Figure 2) (Moyle et al 2011). The declining state of these species is caused in part by the significant alteration of California's waterways by dams and water withdrawals, including large-scale diversions. Most rivers and streams in the state have been physically altered with a great portion of natural flows diverted for human use. Recent research indicates that total water rights granted within California far exceed – at 500% – the total annual streamflow for all the rivers and streams in the state (Grantham and Viers 2014). This indicates the tremendous demand on surface waters to support human uses in the state, even under normal conditions.

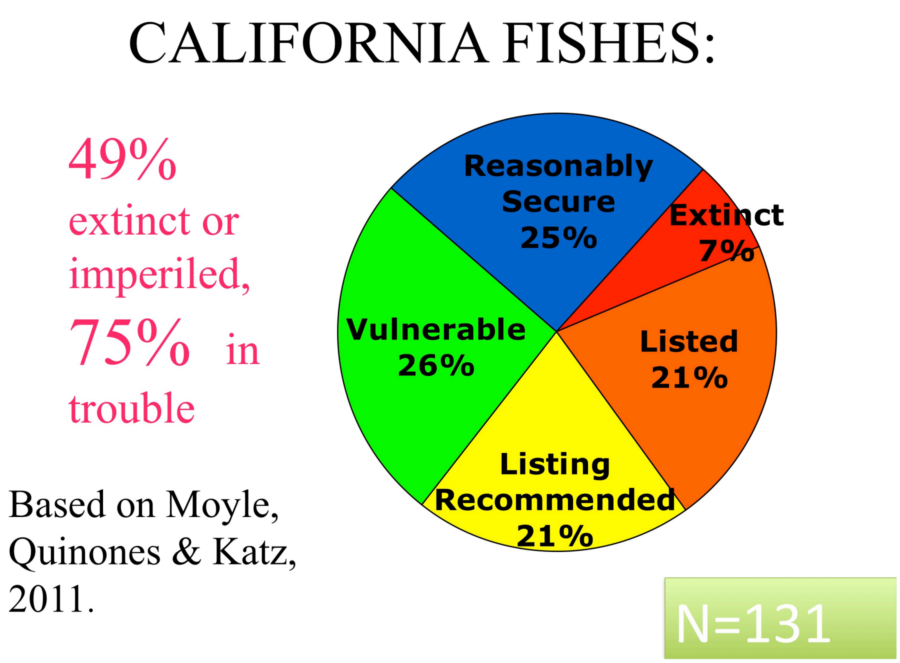

Figure 2. Status of California fishes. Source: Moyle et al. 2011

The current severe drought across most of the state is exacerbating these impacts by extreme low flow conditions and high water temperatures. Some species may not survive this drought. Even if they make it through this drought, conditions are expected to worsen with climate change as droughts are anticipated to become more severe (Swain et al 2014; Figure 3). With future climate change pressures on aquatic ecosystems, it is probable that we will not be able to protect all species; difficult choices about which species to save, and which to let go, loom ahead of us.

When it comes to how water should be used in a drought, short-term interests tend to dominate over long-term considerations, sometimes with unintended consequences. For example, insufficient environmental flows during the 1976-1977 drought severely impacted some native fish, resulting in new ESA listings that now affect exported water for other users, making droughts more difficult to manage by increasing inflexibility within the water system.

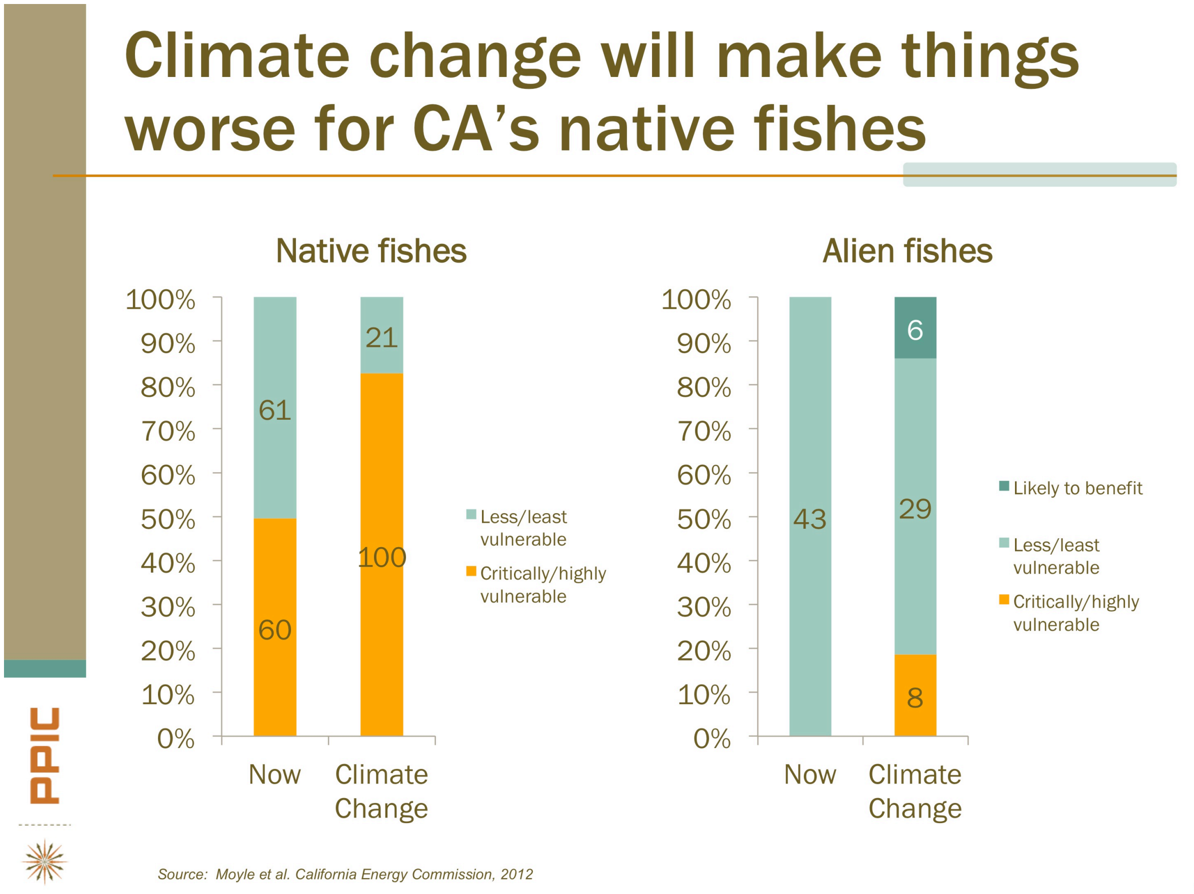

Figure 3. Expected climate change impacts on California's native fish. Source: Hanak, modified from Moyle et al, 2012

"There is a tension between wanting water now and keeping water for later – including for environmental flows. In our last drought we ended up with a lot more endangered species at the end of the drought, which has ended up costing the agricultural community a lot more water ever since."

One of the primary, and certainly the strongest and most controversial, means of limiting withdrawals and protecting environmental flows has been the Endangered Species Act. The last two decades have seen significant conflict between the requirements of the Act and the fairly rigid system of water rights and exchange contracts that institutionalize water management in the state. ESA mandated reductions in water diversions have intensified water politics in the state, and driven a perception that water for the environment comes at the expense of water users.

The most significant arenas for these conflicts have been the State Water Project (SWP) and Central Valley Project (CVP), where biological opinions for the federally listed Delta smelt and Chinook salmon impose a variety of "reasonable and prudent alternatives" (RPAs) to avoid jeopardizing these species. RPAs specify flow levels, water temperature regimes, salinity levels, fish passage, and other conditions or actions that must be taken to meet ESA requirements for each species. These restrictions have caused or exacerbated chronic water service reductions for many agricultural contractors located south of the Delta in both average and above-average water years. In dry years, many project water users receive less than 25% of their stated contract entitlements. For the 2013-2014 water year, which was a critically dry year, most south of the Delta CVP and SWP contractors, including urban and suburban contractors, received no project water.

In addition to ESA requirements, the state has taken several actions on environmental flows. Using authority granted by Governor Brown's 2014 drought relief package, the State Water Resources Control Board curtailed water diversions for several tributaries of the Sacramento River to provide minimum flows to protect listed species, as well as to satisfy water rights and provide for minimum health and safety needs. Previously, the State Water Resources Control Board established principles and guidelines for instream flows in 2010 to protect native fish in northern California coastal streams, although this policy does not establish instream flow requirements for particular rivers or streams. In droughts, environmental flows are particularly vulnerable due to intense competition among users for scarce water. There is great pressure on agencies to relax flow requirements for listed species in order to get water to the agricultural and urban users that desperately need it. Both the Delta smelt and salmon RPAs contain language that accounts for drought conditions, allowing for drought exception procedures (NOAA 2009) or the ability to reinitiate consultation in consecutive drought years (FWS 2008). In addition, required flows under the San Joaquin River restoration agreement go to zero during "critically low" years such as 2014 (San Joaquin River Restoration Program 2013).

Other drought actions affecting environmental flows specified in the California Drought Operations Plan (2014) included increasing exported water during spring pulse flows (with an obligation then to increase pulse flows in a subsequent year), shifting timing of some agricultural diversions to help address water temperatures for fish, installing emergency drought barriers, and modifying salinity standards. All of this flexibility does allow state and federal agencies to get water to more users than could be accommodated otherwise in a time of critical need. But it is important to recognize that it also causes the environment to suffer a double blow – a reduction in mandated water when river flows and wetlands are already severely reduced by drought.

Water in many California streams is literally disappearing in this drought, with few alternatives for the native fish. The harm that aquatic ecosystems and species suffer during this drought is likely to lead to more listings, tighter restrictions, and more conflict in the long run. Emergency drought barriers, trucking salmon, fish "coolers" to maintain suitable water temperatures, and "emergency rooms" for fish are techniques that have been used in the current drought. They are also clear signs that the existing system is not working well for fish or water users in a tightly orchestrated water system that will only continue to face more severe droughts.

The ESA's overriding protections have been critical for protecting listed fish in California, but existing policy tools do not appear up to the task of dealing with climate change and more intense droughts. In particular, this drought has highlighted the need to be able to prioritize the most important habitats and species. We need to analyze which habitats are most important for fish survival during critically dry years, such as cold, spring-fed streams, and put in place policies to protect those habitats over the long-term, so that they are available during drought. We also need to prioritize where we use the limited water available for the environment during drought in order to maximize its benefits for the highest priority ecosystems.

"The present conditions are not an anomaly, they will reoccur. If fish survive this drought, what about the next one?"

We may also need new tools to allow us to make extremely difficult decisions about which species have the best chance of surviving a severe drought and a changing climate, and which species may be impossible to save in specific places due to rapidly changing conditions. Currently, the ESA does not provide good tools for prioritizing among listed species, and it may well be that, in trying to save all endangered species, we fail to save those that have the best chance of surviving. This kind of "species triage" approach would represent a major policy shift, but it may become essential as the pace of climate change accelerates.

There are some useful examples to look to in the search for flexible and effective tools to allocate water to our highest environmental priorities. One example from California's recent efforts to increase flexibility in terms of environmental flows is the Environmental Water Account (EWA), a component of the CALFED Bay-Delta Program. The EWA was intended to help protected fish in the Delta while improving water supply reliability for CVP and SWP customers. EWA had authority to buy water from willing sellers – this, when combined with an ability to curtail pumping out of the Delta when necessary to protect fish, allowed it to (1) replace contract water supplies not diverted from the Delta during pumping curtailments, (2) compensate irrigators who were willing to give up water for a specific period, and (3) enhance instream flows in Delta tributaries. The program took an innovative approach to compensate water users for environmental flows, which made species protection more palatable for many who would otherwise lose in a zero-sum approach. The EWA also had the flexibility to adapt its strategy and spending to prevailing conditions each year.

As in other areas of water management, reforms in Australia to introduce "environmental water holders" provide another potential model. Box 3 below discusses the federal environmental water holder as an example of a more comprehensive system for improving environmental flows.

Finally, farms and other working landscapes must become an essential part of restoring fish and wildlife habitat. There is little pristine land available to protect and restore species, and with our growing population, the need for both urban lands and food production will only grow. There is growing scientific and policy support for an approach called "ecosystem reconciliation" which essentially tries to maximize the ecological potential of both urban and agricultural landscapes. We are already taking important steps down this path. For example, the recently passed California water bond includes a great deal of funding for restoration activities on private land. There are also innovative efforts to maximize the potential of agricultural landscapes for environmental gain. For example, millions of migratory birds depend on aquatic habitats in the Central Valley for resting and feeding each year. The drought has drastically reduced the availability of these wetlands for birds. To address this challenge, The Nature Conservancy (TNC) has created a pilot program to rent "pop-up" wetlands from California rice farmers. TNC is paying these farmers to keep their lands flooded in early fall in strategic places to help migratory birds.

Box 3: Environmental Water Reforms in Australia

Beyond improving water use efficiency and managing for drought, a key element of Australia's water reform agenda has been to redress historical over-allocation and better provide for environmental water needs (see Box 1 above) (Foerster 2011). The federal government has invested in extensive water recovery through a program of water "buy back" and by creating savings through irrigation infrastructure upgrades. There are now considerable volumes of water protected as environmental entitlements across the Murray-Darling Basin and in other major river catchments. There has also been significant institutional innovation, such as the establishment of independent statutory environmental water holders at the federal level and in the states of South Australia, New South Wales and Victoria. The primary role of these organizations is to manage environmental water entitlements to achieve agreed upon environmental outcomes. They have a similar legal status to other water users, with the capacity to manage their entitlement and allocation to best meet objectives and respond to changing conditions. This includes participating in water markets to acquire water to meet environmental needs. This approach gives environmental water managers greater flexibility to match environmental water flows with ecosystem needs, rather than depending on cutbacks on consumptive uses or minimum flow requirements to secure water for the environment (O'Donnell 2012).

At the federal level, the Commonwealth Environmental Water Holder (CEWH) was created by the federal Water Act of 2007 with the purpose of "protecting or restoring the environmental assets of the Murray-Darling Basin." The CEWH holds the federal government's environmental water holdings, which are acquired through a combination of investment in water-saving infrastructure, water purchases (buy backs) and other water recovery measures. Acquisition by the CEWH of water access entitlements has created a reserve of environmental water that is outside of the consumptive pool and available to the environment even in times of severe drought (Connell 2011). As of 31 August 2014, the Commonwealth environmental water holdings totaled 2,183,712 megaliters (or 1.77 million acre-feet) of registered entitlements.

The CEWH's decisions about water use, carryover and trade are made in accordance with an overarching Environmental Watering Plan that forms part of the Murray-Darling Basin Plan implemented under the Water Act. This plan does not stipulate when and where specific sites should be watered. Instead, it establishes a framework for planning and coordination, including objectives, standards and priorities. States are then required to develop environmental watering plans for individual rivers and their catchments. Over shorter timeframes, environmental watering schedules are used to identify annual environmental watering priorities.

Questions over how environmental water holders should best engage with water markets remain a matter of some debate. There are concerns, for instance, that the government entering the market with large amounts of funds to buy back water entitlements creates significant market disruption. Recent research suggests that the environmental and water user benefits are greater when the CEWH actively participates in the annual water allocation market and that such participation enables the CEWH to secure most water when it is needed the most by the environment (Ancev 2014).

8. DROUGHT RESPONSE AND ASSISTANCE

Summary

- Organizing drought response based on an emergency response framework can improve government coordination of efforts to address the social impacts of drought.
- The impacts of the drought have not been felt equally across the state; some communities have suffered much more than others.
- Knowing more about which communities are the most vulnerable to water shortage and its impacts during drought can allow more targeted assistance in future droughts.

The response to the present drought in California has involved adopting an emergency management framework to coordinate the efforts of various agencies in managing water and providing assistance to the hardest hit communities. The Governor's declaration of a State of Emergency in January 2014 called for a range of actions, including directing local water supplies to implement their water shortage contingency plans, directing DWR and the State Water Resources Control Board to accelerate funding for new water supply projects that could break ground in 2014, ordering the Board to put water rights' holders across the state on notice that they may be directed to cease or reduce water diversions based on shortages, and asking the Board to consider modifying requirements for releases of water from reservoirs or diversion limitations so that water may be conserved in reservoirs to protect cold water supplies for salmon, maintain water supplies and improve water quality. At the federal level, emergency response measures have also been invoked for the drought. These include designating counties in California as primary natural disaster areas eligible for emergency agriculture loans, emergency water assistance grants for rural communities experiencing water shortages, and $60 million in food banks for families struggling in the drought.

The adoption of an emergency response framework for the drought – more common for disasters like floods and fires – has brought into play emergency systems and protocols. This appears to have provided a platform for greater coordination of state agency actions – particularly at the operations level. It has also facilitated the use of tools such as "mutual aid", which involves lending assistance and shifting resources across jurisdictional boundaries to wherever they are needed most quickly. This concept is usually employed for disasters like fire where the nearest fire station will supply fire trucks. The application in drought is often more difficult, both because it may not be as easy to move water around and because the lack of familiarity many local water agencies have with emergency management protocols can create a bottleneck in implementation.

While emergency management procedures and measures can help ameliorate some of the worst effects of the drought for affected communities, as the drought continues they cannot stave off the threat of some communities running out of water. As the current drought illustrates, even if economic modeling tells us that the economy and society overall can function adequately with severe water shortages, the lived experience of drought indicates that – like other disasters – there are those who suffer more than others. The story of the present drought in California has highlighted many examples: farmers who have lived for several generations in the Central Valley selling their farms, towns faced with the prospect of going without water, lines for food assistance in rural communities throughout California, and schools having to decide whether to put already limited education funds towards students' schooling needs or dig deeper wells to shore up the school's water supply.

"Disaster stalks the socially vulnerable"

Although, as discussed earlier, with good water management California can minimize the overall economic consequences of drought, the social consequences of drought are becoming more and more stark for some communities. Many communities are in danger of running dry. The California Department of Public Health maintains a list of local drinking water systems that are at greatest risk due to drought. Overlaying maps of the severity of drought risk throughout the state with mapping of social vulnerability data reveals that the pain of the drought is being disproportionately borne by the poorest communities.

The lesson from this experience is one that again points to the value of good planning. Once we are in a severe drought that has not been adequately prepared for, even the best coordination and assistance measures will not get around the fact that, eventually, there may not be enough water to go around. However, if from this experience we can work out which communities are most vulnerable to water shortage, then in the next drought we can better target response and assistance measures to limit the adverse effects for these communities.

9. NEXT STEPS

During the workshop a number of issues were identified as areas for further research, collaboration, academic input. The following are some of the key issues that were raised that could inform a future research agenda:

- **Extreme events** – Do we understand what extreme events we have to plan for? How do we plan for drought while also considering the likelihood of greater variability including floods? How extreme an event do we need to plan for?
- **Do we have the right tools?** How do we manage conflicts and tradeoffs? What barriers are created by existing regulatory mechanisms (e.g. contracts, Central Valley Project, State Water Project arrangements) and how much flexibility is there for reform?
- **Planning** – How can we better plan for and implement our response to extreme events, including scenario planning? How can existing plans be better integrated to address water supply and demand along with important factors like land use changes?
- **Values** – How can we optimize the use of water without sacrificing important societal values? How do we make difficult value judgments about whose land gets fallowed, and who goes out of business in drought? If we move water around how does that impact endangered species?
- **Innovation** – Are there technological tools that could lessen the economic impact of climate change, lower the cost of certain sources of water and improve decision-making or make it easier?
- **Cost-benefit analyses** – What is the value of reducing uncertainty when considering different water supplies? More research into the value of having a more reliable supply (e.g. desalination or water recycling) as part of cost-benefit analysis could make water supply investment decisions easier for many communities.
- **Local solutions and local successes** – Localities, groundwater basins, irrigation districts, and other water entities have been confronted by local water crises at different scales and have done a lot of good things to solve them. A lot of this involves flexibility and making compromises between agriculture and environmental values. How can we better share these stories?
- **Environmental water tools** – What new tools can we develop to protect environmental water users in extreme events such as droughts? How do we allocate environmental water in difficult times? What does good advanced planning look like and how do we make sure we do not just take the easiest path at the time we are confronted by these decisions?

- **Behavior in ordinary years** – How do we ensure that what we do in "ordinary" years will set ourselves up for the next drought? How much water do we set aside in a wet year for a dry year? When we have water how should we behave to ensure we have a buffer for species?

Ultimately, climate change governance is all about managing transitions. We can let circumstances take control and determine who the winners and losers are. Or we can do the hard thinking now to develop the institutions and rules to ensure that the difficult choices that we make reflect our common goals as a society and minimize the economic and ecological disruption that occurs when we have more severe droughts.

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