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The four articles that follow are case studies of how the laws designed to protect the aquatic environment functioned during California's 2012-2016 drought.[1] This recent drought was especially severe, as it included the driest four-year period in California since recordkeeping began in 1895,[2] as well as the two warmest years in state history.[3] The combination of extended warm and dry weather triggered numerous unhappy milestones in California. The snowpack in the Sierra Nevada all but disappeared for the first time in the state's history.[4] Surface water deliveries from the Central Valley Project and State Water Project fell to historic lows, with most CVP south-of-Delta agricultural contractors receiving no project water in 2014 and 2105.[5]

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2. Jeffrey Mount, Caitrin Chappelle, Brian Gray, Ellen Hanak, Richard Howitt, Jay Lund, Richard Frank, Greg Gartrell, Ted Grantham, Josué Medellín-Azuara, Peter Moyle, Barton "Buzz" Thompson, and Joshua Viers. (2016). *California's Water: Managing Droughts*. Public Policy Institute of California, Water Policy Center.

3. Alvar Escriva-Bou, Brian Gray, Ellen Hanak, Jeffrey Mount. 2017. *California's Future: Climate Change*. Public Policy Institute of California.

4. Craig Miller, Governor Orders Water Cuts Amid Record Low Snowpack, KQED Drought Watch, Mar. 31, 2015. https://ww2.kqed.org/science/2015/03/31/record-low-sierra-snowpack-will-drive-home-drought-impacts/.

5. U.S. Bureau of Reclamation. 2016. Summary of Water Supply Operations. U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region; Metropolitan Water District of Southern California. 2016. MWD Water Sales and State Water Project Water Conditions: 1990 to 2015.

Reservoirs also declined, in some places exposing towns that had been underwater for decades.[6] And the State Water Resources Control Board curtailed surface water diversions for junior appropriators in many watersheds for the first time since the 1976-1977 drought.[7]

One of the few benefits of suffering through a drought this extreme is the opportunity to learn from it. Compared to many other natural disasters, the timing, severity, and length of any given drought are maddeningly difficult to predict in advance. We know the next drought is coming, but we do not know when. We never know if a dry spell will bloom into a full-fledged, multi-year drought until we are well into it. It is telling that Governor Jerry Brown did not declare the drought to be a state of emergency until February of 2014, half-way through what turned out to be a five-year drought. [8] The state will miss a great opportunity if it does not take a hard look at water management during the drought, squeeze every lesson that it can out of the experience, and put in place policy measures to better prepare California for the next drought. This is especially important because, as California's climate continues to warm, it is likely to incur more frequent and severe droughts.[9] The state at all levels needs to treat the recently concluded drought as a portent of droughts to come.

In some respects, California showed remarkable resiliency during the 2012-2016 drought, implementing several key policy reforms that should improve water management for the next drought. For example, most urban areas were able to meet or exceed the state's water conservation regulations, which required average reductions in municipal water use of 25 percent across the state.[10] The State Water Board has kept some water efficiency measures

6. Natalie Crofts, 3 underwater ghost towns uncovered by drought, KSL.com. Aug. 11, 2015. http://www.ksl.com/?sid=35922070&nid=148.

7. Gray, Brian, Ellen Hanak, Richard Frank, Richard Howitt, Jay Lund, Leon Szeptycki, Barton ("Buzz") Thompson. 2015. *Allocating California's Water*. Public Policy Institute of California.

8. *Governor Brown Declares Drought State of Emergency*, https://www.gov.ca.gov/news.php?id=18368. In the Sacramento River basin, the largest source of California's developed surface water, the years 2011-12 through 2015-16 were below normal, dry, critically dry, critically dry, and below normal, respectively. Although 2010-11 was a wet year, it was preceded by a four-year drought. The years 2006-07 through 2009-10 were dry, critically dry, dry, and below normal. California Data Exchange Center, Chronological Reconstructed Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices. California Department of Water Resources, Mar. 21, 2017. http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST.

9. Ellen Hanak, Jeffrey Mount, Caitrin Phillips-Chappelle, Jay Lund, Josue Medellin-Azuara, Peter Moyle, and Nathaniel Seavy (2015), *What If California's Drought Continues*? Public Policy Institute of California, Water Policy Center.

10. Water conservation data and press releases can be accessed at http://www.waterboards.ca.gov/water_issues/programs/conservation_portal/conservation_reporting.shtml. *See* David Mitchell, Ellen Hanak, Ken Baerenklau, Alvar Escriva-Bou, Henry McCann, Maria Perez-Urdiales, and Kurt Schwabe. 2017. Building Drought Resilience

in place, and hopefully cities can keep their water use lower between droughts and conserve water earlier in the next drought.[11] Agriculture also lost surface water supplies during the drought, but adapted by improving water use efficiency, shifting to higher value crops, and (most significantly) increasing its extraction of groundwater.[12] The first two measures should put irrigators in a better position for the next drought. High levels of groundwater overdraft, although certainly not sustainable, did prompt the California legislature to pass the Sustainable Groundwater Management Act in 2014,[13] which has the potential improve groundwater management and make groundwater a more sustainable resource for future droughts.[14]

These four case studies are part of a broader effort by the Public Policy Institute of California's Water Policy Center and its research partners to evaluate the environmental effects of the 2012-2016 drought. The drought presented a potential calamity for California's aquatic ecosystems—and the fish and other species that inhabit them—in part because those ecosystems were strained to begin with. The massive human re-engineering of the state's hydrology has transformed the physical environment for the state's aquatic species, with grim consequences. As of 2010, on the eve of the drought, 82 percent of California's native fish were either extinct (5 percent), listed as endangered (24 percent) or classified by biologists as vulnerable (53 percent).[15]

The California Legislature and Congress have enacted a panoply of laws to protect water quality, stream flows, fish and wildlife, and other *in* situ uses of the state's rivers, estuaries, and wetlands. These include limits on water rights to protect instream beneficial uses, water quality and flow standards under the federal Clean Water Act and the California Porter-Cologne Act, minimum release requirements from dams to support downstream fish, and a variety of operational requirements on water project operations under the

in California's Cities and Suburbs. Public Policy Institute of California, Water Policy Center (forthcoming).

11. California State Water Resources Control Board, State Water Board Continues Water Conservation Regulations, Prohibitions Against Wasting Water, Feb. 8, 2017, http://drought.ca.gov/topstory/top-story-69.html.

12. Howitt, Richard, Josué Medellín-Azuara, Duncan MacEwan, Jay R. Lund, and Daniel A. Sumner. 2014. Economic Analysis of the 2014 Drought for California Agriculture. Center for Watershed Sciences, University of California, Davis; Howitt, Richard, Duncan MacEwan, Josué Medellín-Azuara, Jay R. Lund, and Daniel A. Sumner. 2015. Economic Analysis of the 2015 Drought for California Agriculture. Center for Watershed Sciences, University of California, Davis.

13. California Water Code §§ 10720-10737.8.

14. Tara Moran and Amanda Cravens, California's Sustainable Groundwater Management Act of 2014: Recommendations for Preventing and Resolving Groundwater Conflicts. Stanford University, Water in the West (2015). http://waterinthewest.stanford.edu/sites/default/files/SGMA_RecommendationsforGWConflicts_2.pdf.

15. Moyle PB, Katz JV, Quiñones RM (2011) Rapid decline of California's native inland fishes: a status assessment. Biological Conservation 144:2414-2423.

state and federal endangered species acts.[16] These legal protections can spark considerable controversy when they limit the impoundment and diversion of water for municipal and agricultural uses, even under circumstances far less taxing than the worst drought in the state's history. As starkly demonstrated by the fish species numbers cited above, this collection of legal requirements and restrictions has not achieved a particularly stellar level of success.

These four case studies arose out of a desire to understand how the various legal rules functioned during the extreme water shortages created by the five-year drought. Our goal was to look at several critical questions. These included: how well regulators and water mangers incorporated the legal requirements into their drought planning and response; how they made difficult allocation decisions when there was insufficient water to supply all beneficial uses; and whether water quality standards, endangered species mandates, and other environmental criteria were modified or violated. Most importantly, our goal was to determine how state and federal regulators, water managers, and local communities both succeeded and failed in providing water to meet vital environmental needs, and how California can improve its water management for future droughts.

For this part of the larger project, we deliberately chose not to look at environmental standards for Bay-Delta water quality and outflows and limits on Delta exports to protect endangered and threatened species. Because, so much of the public debate had focused on the Delta, we chose instead to evaluate several smaller watersheds—the Russian River, the Stanislaus River, the Yuba River, and Deer, Mill, and Antelope Creeks (in a single case study)—because they presented a mix of water rights, regulatory regimes, and water management challenges.

These case studies provide a remarkable set of lessons. In each setting, water managers, water users, and regulatory agencies were faced with the reality that there was simply not enough water to go around. Yet, the case studies provide a surprising (given the severity of the drought) number of examples where the parties were able to provide water for the environment while also serving water supply objectives.

Their successes and failures illustrate a number of crucial lessons, including (but by no means limited to) the following:

- Advance planning for drought, including setting achievable flow targets for drought conditions, makes a significant difference in protecting water quality, stream flows, temperature, and aquatic habitat. All of the case studies illustrate this to some extent, but perhaps the best example is the advance planning on the Yuba River,

16. Brian Gray, Barton "Buzz" Thompson, Ellen Hanak, Jay Lund, Jeffrey Mount. 2013. Integrated Management of Delta Stressors Institutional and Legal Options. *What If California's Drought Continues*? Public Policy Institute of California, Water Policy Center. http://www.ppic.org/content/pubs/report/R_413BGR.pdf.

compared with the relative scramble for water that took place on both the Stanislaus and Russian rivers.

- Clear flow targets can produce conflict, but they can also set the stage for collaborative deal making. On the Yuba River, as well as Deer and Mill creeks, flow targets mandated by the State Water Board initially triggered conflict, but ultimately provided clear boundaries that enabled a collaborative settlement.

- Good data on flows and water usage is vitally important. In particular, the lack of specific and reliable data on water use in the Russian River watershed triggered a rush to collect information and hampered decision-making.

- Water transfers have considerable potential to enhance stream flows and to assist water users during drought. On both the Stanislaus and Yuba rivers, water transfers to downstream users helped to supplement downstream supplies, provide revenue to upstream water users, and augment stream flows.

The case studies illustrate these lessons and numerous others in specific contexts, but their lessons are of broad applicability. We hope that each of them will inform better planning and decision-making during the next drought.