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ENVIRONMENT AMERICA
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Via Electronic Submission to:
http://regulations.gov

Mr. Bryan Berringer
U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Building Technologies Office, EE-5B
1000 Independence Avenue, SW
Washington, DC 20585

Dear Mr. Berringer:

We urge the Department of Energy ("DOE") not to adopt the proposed rule it published on August 13, 2020. The proposal is disturbing and deeply flawed. Showerhead manufacturers, the plumbing industry, and consumers have managed the existing definition of "showerhead" for nearly a decade. For DOE to reverse course now is unnecessary, unlawful, and arbitrary and capricious.

I. BACKGROUND

The Energy Policy Act of 1992 ("EPAct 1992") added several new products to the coverage of the Energy Policy and Conservation Act ("EPCA"). Pub. L. 102-486, § 123, 106 Stat. 2776. The new covered products included "showerheads," which Congress defined as "any showerhead (including a handheld showerhead), except a safety shower showerhead." As usual when Congress adds to the list of covered products, it specified an initial standard: a maximum flow of 2.5 gallons per minute ("gpm"), plus a design standard with respect to any flow control insert used in a showerhead. *Id.*

Nearly a decade ago, DOE clarified that the 2.5 gpm standard applies to a complete showerhead, no matter how many nozzles it has.[1] Multi-nozzle showerheads remain on the market,[2] but compliant with the 2.5 gpm standard. The use of water in showers has decreased over time as

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[1] DOE, Showerhead Enforcement Guidance, at 2 (Mar. 4, 2011).

[2] The proposed rule notes that about 3% of models in DOE's certification database have multiple nozzles. 85 Fed. Reg. 49,293.

households replace older showerheads with lower-flow fixtures.[3] The 2.5 gpm standard has been broadly successful. And consumers are comfortable with it. Indeed, many utilities report that consumers are satisfied with even lower-flow showerheads qualifying for the EPA WaterSense label (2.0 gpm and below).[4]

Now, DOE proposes to revise the definition of "showerhead" in its regulations. The textual change, on its face, would not make a difference. But DOE says it interprets the new proposed definition to mean that for a multi-nozzle showerhead, each nozzle can use 2.5 gpm. That reinterpretation and revision of the showerhead standard is a radical departure from what Congress intended and from DOE's historical implementation of EPCA. DOE would be revising the standard to restore high-flow products that have been gone from the market for nearly 10 years.

II. A THING THAT CONNECTS TO THE PLUMBING SYSTEM AND SPRAYS WATER ONTO A BATHER IS A SHOWERHEAD.

DOE's 2011 interpretation sensibly concluded that a showerhead is a showerhead. It may have multiple nozzles, as in the figures included in the 2011 guidance and reproduced in the NPRM, but it is still one showerhead.

That is the ordinary English usage of the term. When you take a shower, you expect water to come out through the showerhead. Not through the showerheads, plural. If you were building a house and the plumber's invoice included a line for five showerheads, you would be surprised to learn they were all being installed in the same shower. You might sometimes have two showerheads for a single shower—one overhead, and one handheld. Still, you would be even more surprised if you found out your plumber bought *eight* showerheads for a single shower, as DOE's new interpretation of its Figure 1, 85 Fed. Reg. 49,290, suggests could happen.

Taking Figure 1 to represent one showerhead is also the interpretation most consistent with the structure of EPCA, both at the time of EPAct 1992 and it has evolved over the years. The primary policy goal of EPCA is to reduce energy and water usage by progressively tightening, over time, the minimum standards allowable for products in distribution in the United States. The primary balance that the statute strikes is to avoid imposing excessive economic costs for those improvements—both in the form of higher costs and prices for manufacturing a given product, and in terms of eliminating useful product functions.

EPAct 1992 added a conservation standard for showerheads because Congress was concerned about the volume of water use in showers. The standard is simple. A shower cannot consume more than 2.5 gallons per minute; eventual spread of showerheads compliant with that standard would reduce water consumption. Thus, the concept of a showerhead in the statute surely matches the functional use of the object: Congress limited the water consumption of a showerhead in order to limit the amount of water a person uses in a shower. The Congress that enacted the 2.5

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[3] *See* 2019 U.S. WaterSense Market Penetration, GMP Research Inc., at 31-36 (July 2019), *available at* https://www.safeplumbing.org/files/safeplumbing.org/documents/misc/7-1-19-WaterSense-2019-Report.pdf.

[4] *See* Exhibit A, City of Durham Department of Water Management, Comments on Docket ID No. EPA-HQ-OW-2020-0026 Request for Information on the WaterSense Program (July 21, 2020).

gpm standard would be startled to learn that DOE thinks a person should be able to take a shower using 5, 10, or more gallons per minute so long as the water comes out of several nozzles.

DOE's new interpretation is contrary to those standards and goals. Certainly, it will permit higher water usage. DOE has said plainly that the new interpretation will mean a three-nozzle showerhead counts, for purposes of the water conservation standard, as three showerheads, each permitted to emit 2.5 gpm of water flow. The new interpretation enables easy circumvention. Indeed, a manufacturer that finds itself limited by the 2.5 gpm standard would be missing a step. The company could just redesign its products to have two nozzles, and magically double its permissible water flow. In fact, DOE's interpretation would eviscerate the 2.5 gpm standard, because the water flow available in a shower would be simply a matter of choice, between manufacturer and consumer, about how many nozzles to use. The "octopus" model depicted in Figure 1 would be allowed to consume 20 gpm (2.5 gpm per nozzle times 8 nozzles). That would be far above what showers typically used even before EPAct 1992, and thus the conservation standard would have no impact on actual water usage for such a product. Congress cannot have intended this conservation standard to be so illusory.

Meanwhile, DOE's new interpretation does not serve the goals of economic efficiency that are the main counterbalancing concern in EPCA. Consider a showerhead like DOE's Figure 1, with three nozzles. DOE has not identified any way that showerhead would be less costly to manufacture than a simple one-nozzle showerhead. It certainly looks like it would be more costly. DOE has not identified any technological advancement that would be necessary to make and use single-nozzle showerheads. After all, single-nozzle heads have been commonplace for decades, and single nozzles with 2.5 gpm flow have been the norm since DOE announced its current interpretation in 2011. DOE does not suggest the three-nozzle showerhead in Figure 1 has a distinctive functionality, or a value as a product category that DOE's 2011 interpretation would have eliminated. The three-nozzle head might spray water over a large area, but a single-nozzle head could do that too.[5] If the standard is interpreted to apply only at the level of nozzles, then the sole functional difference is that the three-nozzle head lets you exceed the statutory maximum of 2.5 gpm. Presumably DOE believes—though it has not said so and has offered no evidence on this point—that consumers will value being able to get additional water flow from multiple nozzles. But that functionality—enabling increased water use beyond the maximum standard set by Congress—is not one that can justify a regulatory decision under EPCA. Indeed, it is precisely the functionality that EPCA forbids.

The NPRM barely grapples with these issues. DOE's past rules on this topic (in 2011 and in 2013) had clearly taken account of the primary EPCA goal of decreased water use. In the NPRM, DOE does not so much as mention the fact that its new interpretation will lead to increased water use, much less try to balance that concern against some other value.

DOE suggests its past interpretation was contrary to the principle that EPCA standards should not eliminate product categories. This argument is puzzling. Nothing prohibits multiple-

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[5] Modern "rain" showerheads achieve a broad spray while complying with the 2.5 gpm standard as currently understood. *See* Justin Ball, "Different Types Of Shower Heads: What To Know Before You Buy," The Showerhead Store (last accessed Oct. 14, 2020), at https://www.theshowerheadstore.com/blogs/news/types-of-shower-heads.

nozzle showerheads, and they remain on the market today even under DOE's current standards.[6] Congress simply imposed a 2.5 gpm maximum for water use across all nozzles. That is not a category-destroying standard except if the category is high-flow showerheads, and certainly Congress explicitly eliminated those. Similarly, the 2011 guidance did not suggest it was giving a grace period for the sale of *any* multiple-nozzle showerhead because *all* would be unlawful. DOE allowed a sell-off period for multiple-nozzle showerheads that exceeded the 2.5 gpm standard. Multiple-nozzle showerheads below that flow limit remained lawful, and remain on the market.

DOE's supposed justification is that Congress preferred DOE to align with voluntary industry standards. 85 Fed. Reg. 49,287 & n.5. Therefore, DOE says, it must adopt a definition of "showerhead" that mimics the one in ASME's current standard. These argument are not proper rationalizations for interpreting what Congress meant by a "showerhead," as discussed below. But more fundamentally, they don't help DOE anyway. Each of the items in Figure 1 is a single showerhead under the ASME definition too.

DOE's current regulations define a "showerhead" as "[a] component or set of components distributed in commerce for attachment to a single supply fitting, for spraying water onto a bather, typically from an overhead position, including hand-held showerheads, but excluding safety shower showerheads." 10 C.F.R. § 430.2. The ASME definition is "an accessory to a supply fitting for spraying water onto a bather, typically from an overhead position." 85 Fed. Reg. 49,286. Leaving aside the inclusion of hand-held showerheads and the exclusion of safety shower showerheads (of which more below), the key difference is between the word "accessory" and the phrase "component or set of components . . . for attachment." That change in wording is irrelevant for the question whether an object with multiple nozzles is a showerhead. ASME defines an "accessory" to be "a component that can, at the discretion of the user, be readily added, removed, or replaced, and that, when removed, will not prevent the fitting from fulfilling its primary function." ASME, "Plumbing Supply Fittings," Std. No. A112.18.1-2018/CSA B125.1-18, p.24 (Oct. 2018) ("ASME Standard"). So: ASME says a showerhead is an accessory to a fitting, and an accessory is a component to be attached to a fitting; DOE has said a showerhead is a component for attachment to a supply fitting. Not a big difference.

The real consequence of the shift from "accessory" to "component" is that an "accessory," under the ASME standards, can be "readily added, removed, or replaced." DOE used the word "component" because it wanted to be able to cover sprayers that cannot so easily be removed—namely, body sprays. Contrary to the assertion in the NPRM, 85 Fed. Reg. 49,289, DOE explained

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[6] To pick just a few examples, Delta's model "Pendant Raincan" includes three flexible nozzles that can be individually aimed, all with a collective flow rate of 2.5 gpm. The Pendent Raincan is listed in DOE's Compliance Certification Database as models 57140****25, 57190****25, and others. Brizo offers a similar Pendant Raincan product with three flexible nozzles that can be individually aimed, with a collective flow rate of 1.75 gpm. Brizo's Pendant Raincan model is listed in DOE's Compliance Certification Database as model 81335********. Waterpik's DualSpray 2-in-1 Adjustable Drencher Rain Shower Head includes two nozzles that can be independently directed onto the bather, with a collective flow rate of 2.5 gpm. Waterpik's DualSpray model is listed in DOE's Compliance Certification Database as model AAD-773E. Delta likewise offers a HydroRain 2-in-1 product with two independently pivoting nozzles and a collective flow rate of 2.5 gpm. This model is listed in DOE's Compliance Certification Database as model 58580********25*******. https://www.regulations.doe.gov/certification-data/CCMS-4-Showerheads.html#q=Product_Group_s%3A%22Showerheads%22.

this strategy during the rulemaking. DOE's original proposed definition used the word "accessory," but then explicitly included body sprays. Commenters said body sprays are not accessories because they are not removable; so DOE issued a supplemental proposal to switch from "accessory" to the word "component" precisely to eliminate removability as a criterion.

None of this, however, bears on whether the complete object in Figure 1 is a showerhead. The answer to that question is simple. Is the whole unit a "component"? Yes. Does it get attached to a supply fitting? Yes. Can it be readily removed from the fitting and replaced? Yes. Can it be removed without blocking the primary function of that fitting? Yes. So the complete unit is an "accessory" to a "supply fitting"—and, of course, one intended for spraying water onto a bather—and is therefore a showerhead, just as much under the ASME definition as under DOE's.

Yet DOE apparently thinks the complete assemblies in Figure 1 are not themselves showerheads under the ASME definition. Given the structure of the ASME definition, DOE's conclusion would only be possible if the thing to which these assemblies attach is not a supply fitting. But of course it is. What one attaches the complete unit to is a pipe existing in the wall, which is in turn connected to a shower valve. The pipe is a fitting, and so is the valve. A "supply fitting," according to ASME's definition, is a "device that controls and guides the flow of water in a supply system." The pipe and the valve both control and guide the flow of water in the supply system.

DOE might contemplate that removal of any of the Figure 1 objects would leave the fitting dysfunctional, because then turning on the water would make water shoot out of the pipe without forming a spray. That cannot be a correct understanding of the ASME definitions. The pipe would still be doing its job of delivering water to the point where the showerhead should be connected. Confirming that understanding, the ASME definition surely treats a single-nozzle showerhead as a "showerhead." If you remove that showerhead from the pipe, you get a jet of water out of the pipe, same as if you remove any of the Figure 1 assemblies. The multiple-nozzle showerhead satisfies the ASME definitions in exactly the same way as a single-nozzle showerhead.

Moreover, DOE's use of the ASME definition does not even rationally support the distinction that DOE wants. If you remove one nozzle from any of the Figure 1 assemblies, you get an uncontrolled jet of water from the empty port. Yet DOE considers that nozzle to be an accessory to a supply fitting. If it is, then so is the complete assembly, which can also be removed from the supply pipe.

In truth, any interpretation of the ASME definition that would support DOE's notion that the complete assembly is not a showerhead would lead unavoidably to the conclusion that nothing is a showerhead. Every showerhead and every showerhead nozzle is attached at the end of a pipe or manifold of some sort. The pipe or manifold is a supply fitting that controls and guides the water up to the showerhead, and the showerhead—whether a single nozzle or a multi-nozzle assembly—is a replaceable component that distributes the water as a spray. If the single nozzle within an assembly is a showerhead, so is the assembly.

In fact, DOE already articulated views like this in the 2012-2013 rulemaking. Initially, DOE proposed to use the "accessory" term from the ASME standard, and a definition of "fitting" identical to the ASME definition. And DOE then explained that this definition makes the complete unit a single "showerhead." 77 Fed. Reg. at 31,747 ("All components that are defined as an "accessory" (or a combined set of accessories) to a supply fitting represent a single covered product that must meet the DOE standard."). "[A] system of spraying components that is packaged and/or distributed in commerce as a single 'accessory' or a single set of 'accessories,' designed to be attached to a single fitting, would be defined as a single showerhead." *Id.* at 31,748. DOE now proposes to switch from the word "component" to the word "accessory," and it says that change will have the opposite meaning, without even acknowledging this view from the 2012 proposal.

The NPRM is a transparent attempt to exploit an apparent discrepancy between DOE and ASME definitions of "showerhead" as an excuse to redefine the showerheads conservation standard. To do that, DOE has focused on whether an individual nozzle is a "showerhead" under the ASME definition. But none of DOE's wordsmithing changes the fact that the whole unit is a showerhead anyway.

III. THE SCOPE AND MEANING OF THE 1992 SHOWERHEADS CONSERVATION STANDARD CANNOT DEPEND ON HOW ASME DEFINED "SHOWERHEAD" 20 YEARS LATER.

EPAct 1992 makes two things unmistakably clear: (1) Congress enacted its own definition of "showerhead"—it did not farm that task out to ASME; and (2) Congress established its own substantive standard that a showerhead cannot use more than 2.5 gpm of water. Pub. L. 102-486, § 123, 106 Stat. 2820, 26. An industry document adopted two decades later cannot alter the meaning of the standard enacted in 1992.

DOE's supposed reason for following the ASME definition of "showerhead" is not consistent with EPCA or with EPAct 1992. The key point, according to DOE, is that EPAct 1992 "relied on the ASME standard for measuring the water use of showerheads," and "included references to ASME and the ASME standard" in the Act's definition section, energy conservation standard, and labeling requirements. 85 Fed. Reg. at 49,289-90 (citing 42 U.S.C. §§ 6291(31), 6293(b)(7), 6294(a)(2)(E), and 6295(j)). From these references, DOE infers that Congress intended the meaning of "showerhead" to match ASME's as it might change over time.

Multiple signals in the text show that inference to be incorrect. First, Congress actually didn't refer the "showerhead" definition back to the ASME standards. The definition of "showerhead" just says "any showerhead (including a handheld showerhead), except a safety shower showerhead," no mention of ASME. 42 U.S.C. § 6291(31)(D). Meanwhile, the very same paragraph in the statute does say that certain other terms—"water closet", "urinal", "blowout", "flushometer tank", "low consumption", and "flushometer valve"—have "the meaning given such term in ASME A112.19.2M-1990 . . . ." *Id.* at (31)(F)-(H). These provisions all came from the same pages in EPAct 1992. The contrast shows exactly the opposite of what DOE supposes. Congress intended the "showerhead" definition *not* to be based on ASME standards.

Second, none of DOE's justifications provide any reasonable basis for changing the *definition* of showerhead so as to allow more than 2.5 gpm cumulatively from a single fitting. DOE says EPAct 1992 "relied on the ASME standard for measuring the water use of showerheads." 85 Fed. Reg. at 29,290 (citing 42 U.S.C. § 6293(b)(7)). But the cited section states only that "[t]est procedures for showerheads . . . shall be the test procedures specified in ASME A112.18.1M-1989." 42 U.S.C. § 6293(b)(7). Test procedures, in the case of showerheads, simply measure water use—the rate of water flow through a fitting and through a nozzle (or multiple nozzles). 42 U.S.C.

§ 6293(b)(3).[7] That statutory section says nothing about what constitutes a showerhead in the first place, or how much water should be allowed to flow through a nozzle.

Making the test procedures depend on ASME's methods certainly does not suggest that ASME documents should determine those broader questions of showerhead definition and cumulative flow. To the contrary, all test procedures are subject to section 6293(e), which says that if a change in test procedure alters the measurement of water use, the standards regulation has to be revised accordingly so that actual water use does not increase. If DOE believes that following ASME standards means each nozzle of a showerhead should be tested separately for water flow, then it has to revise the showerheads standard so that each nozzle is allowed only a proportionate share within the 2.5 gpm total.

Similarly, DOE says it should match definitions of showerhead with ASME because EPAct 1992 "included references to ASME and the ASME standard" in EPAct 1992's definition section, energy conservation standard, and labeling requirements. 85 Fed. Reg. at 29,290. None of the "references" to ASME in those sections have anything to do with what constitutes and does not constitute a showerhead, or the amount of water that should flow through one. The ASME references in section 6291(31) define only "ASME" ("the American Society of Mechanical Engineers") and the terms "water closet", "urinal", "blowout", "flushometer tank", "low consumption", and "flushometer valve". 42 U.S.C. §§ 6291(31)(B), (F)-(H). They say nothing about the definition of showerhead. Likewise, the ASME references in the energy conservation standard discuss that group's design requirements in relation to EPAct 1992's 2.5 gpm maximum flow rate; it does not purport to define showerhead. 42 U.S.C. § 6295(j). And section 6294(a)(2)(E) requires the FTC to prescribe labeling rules for showerheads consistent with ASME A112.18.1M-1989. Nothing in that section shines any light on the definition of showerhead.

As DOE acknowledges, "Congress did not specifically direct DOE to define showerhead according to the ASME standard." 85 Fed. Reg. at 49,289. Indeed. Congress's use of ASME standards in EPAct 1992 was surgically precise. The statute tells DOE to follow the standards on specific points, in particular ways. For example, EPAct 1992 distinguishes between the substantive water use standard and the test procedures to determine compliance with the substantive standards. *See* 42 U.S.C. § 6295(j) & 6293(b)(7). As another example, Congress did not follow ASME for the water flow standard; Congress wrote its own; while Congress did follow ASME for the design standard of an 8 lbs. pull force for removing a flow restrictor. *Id.* § 6295(j) (citing A112.18.1M-1989, 7.4.3(a)). Given these contrasts, ordinary principles of statutory interpretation suggest that where Congress did not explicitly cite ASME standards, it did not want DOE to rely on them. For DOE to treat Congress's careful, specific uses of ASME standards as a generalized instruction to follow ASME on everything is irrational.

Moreover, each of those uses in the statute is explicit to the applicable ASME standard that existed in 1992. *See* 42 U.S.C. § 6291(31) (citing 1990 version of definitions); *id.* § 6293(b)(7) (citing 1989 test procedures); *id.* § 6295(j)(1) (citing 1989 standard). None of them can justify using a 2011 amendment to the standards as a free-range interpretive source for what "showerheads" means. Further, Congress understood that the ASME standards would be revised, and it explained exactly

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[7] The test procedures also measure characteristics such as spray force and distribution that are not regulated by the conservation standard.

what DOE should do in response. For test procedures, Congress directs DOE to follow the ASME test procedures for showerheads unless the test procedures do a poor (or unduly burdensome) job of measuring water use. 42 U.S.C. §§ 6293(b)(3) & (7). Thus, before simply following ASME, DOE is supposed to conduct its own assessment, based on its own understanding of what the conservation standard is, and evaluate whether the ASME test procedure appropriately measures water use against the standard. That is the opposite of what DOE proposes to do here, namely using the ASME test procedure to define the standard. Meanwhile, for the substantive water use standard, DOE may update the maximum flow rate requirements in response to an ASME revision *only* if the revision decreases the maximum allowable water use. *Id.* at § 6295(j)(3)(A). ASME's 2011 definition of showerhead, which DOE contends allows a maximum flow of 2.5 gpm per nozzle rather than cumulatively from a fitting, obviously does not meet 6295(j)'s requirement for revision under EPAct 1992.

Nor can DOE rely on the National Technology Transfer and Advancement Act ("NTTAA") or OMB Circular A-119 to justify matching the definition of showerhead to the ASME standard. *See* 85 Fed. Reg. at 49,287 & n.5, 49289. NTTAA does not require or even encourage DOE's proposal here. That statute says agencies should use voluntary technical standards "as a means to carry out policy objectives or activities determined by the agencies and departments." Pub. L. 104-113, § 12(d), 110 Stat. 775, 783. The 2.5 gpm showerhead maximum flow rate was not a policy objective determined by DOE; it was a water conservation standard determined by Congress. NTTAA does not instruct DOE to base its interpretation of Congress's policy by referring to industry standards. Even if it did, NTTAA itself states that an agency should not follow an industry standard where that is "inconsistent with applicable law." *Id.* For all the reasons discussed in this comment letter, DOE's proposal *is* inconsistent with EPAct 1992, and thus NTTAA provides no safe harbor. And as discussed, EPAct 1992 described in detail how the showerheads program should interact with ASME standards—NTTAA does not repeal or amend those directives.

DOE's reliance on OMB Circular A-119 is misplaced for the same reasons. To state the obvious, Circular A-119 cannot trump the statute. Nor does it try to. Like the NTTAA, Circular A-119 does not instruct an agency to follow industry standards where doing so would be "inconsistent with applicable law." 85 Fed. Reg. at 49,287 n.5. In particular, Congress specified the policy goals that DOE must consider when it makes rules under EPCA. Circular A-119 cannot supplant those policy goals with an extra-statutory mandate.

IV. MAKING A MULTIPLE-NOZZLE SHOWERHEAD INTO MULTIPLE SHOWERHEADS WOULD VIOLATE THE ANTI-BACKSLIDING RULE.

DOE's proposal, which would increase the maximum allowable water use of certain showerheads, is contrary to law. In eliminating the requirement that certain showerheads comply with the 2.5 gpm standard, the proposal runs afoul of EPCA's provision that explicitly prohibits backsliding. EPCA's anti-backsliding provision states, "The Secretary may not prescribe any amended standard which increases the maximum allowable . . . water use . . . of a covered product." 42 U.S.C. 6295(o)(1); *see also id.* § 6293(e)(2) (if an amended test procedure would lead to increased water use, DOE must amend the standard correspondingly to avoid backsliding).

Take, as an example, the product on the left in Figure 1. Under EPCA and DOE's longstanding regulatory approach, the maximum amount of water allowed to flow through that product is 2.5 gpm. 42 U.S.C. § 6295(j); DOE, Showerhead Enforcement Guidance, at 2 (Mar. 4, 2011). Under the proposed rule, the maximum amount of water allowed to flow through that same product would increase to 7.5 gpm. Such an increase in the maximum allowable water use of the covered product is a clear violation of EPCA's anti-backsliding provision.

The proposal does not mention or address this issue, so we cannot tell why DOE thinks it could possibly be lawful to revise the standard this way. But we note that in recent briefing on the standards for general service lamps ("GSLs"), DOE asserted that it could undo or revise a prior standard, despite the anti-backsliding rule, if the previous standard was incorrect. The Second Circuit has already rejected that proposition with respect to EPCA itself, *NRDC v. Abraham*, 355 F.3d 179 (2d Cir. 2004); and the D.C. Circuit rejected a comparable notion under the Clean Air Act in *New Jersey v. EPA*, 517 F.3d 574 (D.C. 2008). Besides, DOE has not even suggested that its existing interpretation of "showerhead" is incorrect. The proposed rule says the term is ambiguous in the statute and that DOE thinks the proposed interpretation would be more appropriate. A shift in policy preference like that is certainly not an exception to the anti-backsliding rule. Nor can an error in the reasoning for a prior regulation, if there was one, exempt it from the anti-backsliding provision. The D.C. Circuit, in *New Jersey v. EPA*, rejected that argument too. 517 F.3d at 583 ("EPA's disbelief that it would be prevented from correcting its own listing 'errors' . . . cannot overcome the plain text enacted by Congress.").

DOE also argued in the GSLs case that the anti-backsliding rule does not apply if the pre-amendment rule was not a standard set by DOE. That is contrary to the text of the statute. The anti-backsliding provision does not turn on whether DOE had previously established a standard. The anti-backsliding principle states that a new rule—like what DOE now proposes—cannot "prescribe any amended standard which increases the allowable . . . water use . . . of a covered product." DOE cannot deny that each product shown in Figures 1 and 2, and many others like them, are currently only permitted to consume 2.5 gpm; and it cannot deny that its proposed rule would permit such products to use more than 2.5 gpm—indeed, the "octopus" model depicted in Figure 1 would be allowed to consume *eight times* the current 2.5 gpm standard. The anti-backsliding rule applies even though the *status quo* is a standard set by Congress and interpreted by DOE, rather than a standard established by DOE from scratch.

Thus, the anti-backsliding provision must be interpreted to apply not only to actions that amend standards themselves but also to actions that alter the scope of a standard by changing the interpretations of definitions set forth in test procedures. An interpretation that effectively allows certain types of covered showerheads to use more water than they did previously "prescribe[s] . . . [an] amended standard which increases the maximum allowable . . . water use . . . of a covered product." EPCA's anti-backsliding provision must be interpreted in light of "the appliance program's goal of steadily increasing the energy efficiency of covered products" and Congress' intent to provide a "sense of certainty on the part of manufacturers as to the required energy efficiency standards." *Abraham*, 355 F.3d at 197. It is irrational to think that Congress would have prohibited DOE from weakening the standards themselves while at the same time permitting DOE to weaken standards applicable to certain products by simply reinterpreting a definition in a test procedure. Such a result would run directly counter to EPCA's "goal of steadily increasing the energy efficiency of covered products" and would "completely undermine any sense of certainty on the part of manufacturers as to the required energy efficiency standards" for covered products. *Abraham*, 355 F.3d at 197. In addition, reading EPCA this way would "effectively render" the anti-backsliding provision "inoperative" or a "nullity." *Abraham*, 355 F.3d at 197.

Finally, we note that DOE purports to frame its revision as part of a test procedure, rather than part of a standard. In fact, the regulatory definition at issue applies across the showerhead regulations—to the standard as well as to the test procedures. 10 C.F.R. § 430.2. Moreover, even if DOE were only amending a test procedure, it would still be engaged in impermissible backsliding. To amend a test procedure, DOE must assess whether the change will alter the measured water use of any product, and if it does, then DOE must revise the standard to account for that shift. 42 U.S.C. § 6293(e). DOE is apparently changing the testing procedure to permit testing of the flow from just one nozzle among several that can spray simultaneously. Obviously, the total flow from all the nozzles will be greater, by how many nozzles there are. In other words, if DOE wants to define "showerhead" to mean each nozzle, it has to revise the standard so that the permissible flow from a multi-nozzle assembly is 2.5 gpm divided by the number of nozzles. That is what section 6293(e) requires.

Not that DOE can take any of those steps at this point. It has not even proposed the assessment required by section 6293(e), and it cannot rely on this comment letter to raise the issue.

V. DOE IS IGNORING THE SUBSTANTIAL COSTS OF ITS PROPOSAL

Reinterpreting the showerheads standard to apply only on a per-nozzle basis will lead to increased use of hot water. DOE has not offered any estimate of how much water use will increase—how many consumers will switch to the new nozzles, how many homebuilders and plumbers will put them into new construction, or even how many companies might introduce models taking advantage of DOE's new high-flow loophole. Without estimates like these, neither DOE nor commenters can fully assess the consequences of the proposal. But the costs will probably be significant.

Showering accounts for 17% of residential water use.[8] As of 2016, according to the landmark Residential End Uses of Water study, showering consumed an average of 11.1 gallons per day per person in 2016.[9] At that time 80% of homes had EPCA-compliant showerheads, representing an increase of 5% from 1999.[10] Suppose that 5% increase is reversed because of DOE's new high-flow loophole—an increase that would likely take place over about a decade as people replace showerheads.[11] And suppose the new showerheads have only two nozzles, probably an underestimate, allowing 5 gpm of flow. For that 5%, each shower will cost an extra 2.5 gpm. The average shower lasts approximately eight minutes.[12] Given the current population of the

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[8] 2019 U.S. WaterSense Market Penetration at 31.

[9] Residential End Uses of Water Executive Report, Version 2 ("REU Study") at 8 (Apr. 2016), *available at* https://www.waterrf.org/research/projects/residential-end-uses-water-version-2.

[10] *Id.* at 10.

[11] 2019 U.S. WaterSense Market Penetration at 4, 17, 33.

[12] REU Study at 9.

country,[13] the extra water usage amounts to an additional ***120 billion gallons of water a year***. That's enough water to supply Los Angeles for more than a year.[14]

The increased water use will have at least three direct costs: the cost of the water used, the cost of the energy to heat it for shower use, and the cost of sewerage to drain it. Water prices vary, but on average residential customers pay about 0.6 cents per gallon.[15] The extra 120 billion gallons a year will cost them $800 million a year. The water in a shower is hot. Heating that 120 billion gallons from will require an extra 1 billion therms of energy,[16] costing $1.3 billion per year.[17] Sewerage charges vary widely around the country, but in the range of 0.3 cents to 1.2 cents per gallon; the additional cost of draining DOE's new high-flow showers would be around another $1 billion a year.[18] These amounts represent just what consumers will pay. The societal costs will be even greater. Water services (supply and sewerage) have historically been underpriced; outside subsidies will be needed to support the additional usage of 120 billion gallons a year. Extra energy consumption—both to heat the water and to generate the water—means additional carbon dioxide generation, which carries costs that DOE must account for.[19]

Against those costs, DOE presumably would say that consumers benefit from the opportunity to take showers with higher water flow. But that benefit is uncertain, and almost certain to be smaller than the costs. For one thing, not all increased water use will be intentional. While some consumers might switch to multi-nozzle showerheads because they want higher flow, some might switch because they like the multiple nozzles for unrelated reason, for example because they like the look of an octopus showerhead. Many may not notice that a multi-nozzle showerhead—in DOE's new regime—may have higher water flow. These consumers will be using extra water, without gaining any conscious benefit from doing so. But they will incur extra costs all the same,

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[13] About 330 million. *See* U.S. Population Clock, https://www.census.gov/popclock/ (last accessed Oct. 14, 2020).

[14] The average indoor water consumption in 2016 was 58.6 gallons per day per person. REU Study at 8. At that average, the residential use of Los Angeles (2019 population about 4.0 million, https://www.census.gov/quickfacts/losangelescitycalifornia) is 85 billion gallons per year.

[15] https://www.circleofblue.org/2019/world/2019-price-of-water/.

[16] DOE has estimated that an Energy Star rated heater producing 20,075 gallons of hot water per year uses 165 therms per year. https://www.energy.gov/eere/femp/purchasing-energy-efficient-residential-gas-storage-water-heaters.

[17] According to EIA, the high and low prices of gas in the past year were $17.57 and $9.12 per thousand cubic feet, on a national average. https://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PRS_DMcf_m.htm. The annual average is roughly $1.30 per therm.

[18] https://www.circleofblue.org/2010/world/the-price-of-wastewater-a-comparison-of-sewer-rates-in-30-u-s-cities/. Sewerage fees are not necessarily calculated on a per-gallon basis of actual usage, but the average charge of sewerage per gallon is a rough estimate of the cost of the drainage.

[19] The most reasonable available estimate of the social cost of carbon for 2020 is that produced by the interagency working group in 2016 of $42 per metric ton of carbon dioxide (based on 3% discount rate), https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf, but at a minimum DOE would need to recognize the smaller cost of $7 per metric ton of carbon dioxide (3% discount rate) estimated by U.S. EPA in its August 2018 Regulatory Impact Analysis for the Proposed Emission Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Generating Units; Revisions to Emission Guideline Implementing Regulations; Revisions to New Source Review Program, https://www.epa.gov/sites/production/files/2018-08/documents/utilities_ria_proposed_ace_2018-08.pdf.

and their additional water use will impose costs on society as well. DOE has not offered any estimate of how many consumers will switch intentionally and how many unintentionally. Still, it seems unavoidable that the new high-flow loophole must have negative costs for this reason alone.

That negative effect is the direct consequences of DOE's perverse plan to reduce conservation standards. After decades of the EPCA regime of progressively increasing conservation standards, consumers are used to the dynamic that if you replace a household appliance, what's available on the market today will be at least as efficient as the old one you had. But for showerheads, the reality will be reversed. A consumer buying a showerhead after DOE's rule will be able to get a multi-nozzle showerhead that unexpectedly uses much more water than the showerhead that was already in place. Many consumers will not recognize the costs of buying a multi-nozzle showerhead.

Showerheads are used in commercial settings too, and DOE has not offered any estimate of the costs or the benefits of high-flow multi-nozzle showerheads in those contexts.

Beyond the costs caused by people's buying and using the new high-flow showerheads, the rule will be costly to domestic manufacturers and their workers. Today, a manufacturer in the United States is prohibited from making a showerhead that uses more than 2.5 gpm, no matter how many nozzles. That prohibition is not in force in all countries, so foreign manufacturers presumably have models already in production that would fit DOE's relaxed standard. So when the rule comes into force, the first high-flow products on the market will be imported, and domestic manufacturers of showerheads will have to catch up. This cost, too, scales with any benefit the proposal might conceivably provide. The more consumers switch to the high-flow showerheads, the more market share will shift to those imports.

This unfortunate impact on American manufacturing is also the direct consequence of DOE's backsliding. A decade after DOE clarified the meaning of the showerhead standard, American manufacturers have no doubt fully incorporated the standard into their product designs and manufacturing. The public, including companies that make showerheads, have relied on the stable regulatory program of EPCA. The proposed rule, going backwards on what the showerheads standard has been for many years now, would upend those expectations.

In many standards rulemakings, a key cost-benefit consideration is the technical feasibility of a proposed standard—the amount of investment that will be needed for manufacturers to achieve a given improvement in efficiency, and how much more a product will have to cost because of components, materials, or design features that increase efficiency. No such concerns are present here. There is no doubt that 2.5-gpm multi-nozzle showerheads are technologically feasible, because that has been the standard for many years. No research or development is needed to maintain the tighter water conservation standard; compliant multi-nozzle products have long been on the market. In fact, the research and development costs run the opposite direction. Manufacturers will need to design new high-flow products to compete with imports allowed by DOE's relaxation of the standard. Meanwhile, there is no particular reason to think the current, compliant products have more costly components or materials that make them more expensive than the high-flow products will be. In short, with respect to technical feasibility as with other economic concerns, DOE's proposed relaxation of conservation standards will cause additional costs.

DOE is obligated to consider all these costs. EPCA itself requires DOE to consider whether an amended standard is economically justified. Among other factors, DOE must consider the economic impact of the standard on manufacturers and on consumers; the savings in operating costs of the product; the projected change in water usage; and the need for water conservation. 42 U.S.C. § 6295(o). DOE's Process Rule also requires DOE to assess whether a proposed standard will result in "significant savings" of energy or water. 10 C.F.R. part 430, subpart C, app. A.[20] The proposed backsliding on the showerhead standard will obviously not result in significant savings. DOE appears not to be considering any of these issues.

Even if the proposal were solely a revision to test procedures, DOE has not undertaken key assessments. It is required to evaluate whether the change in test procedures will change the measured water usage of products. 42 U.S.C. § 6293(3), (7)(B); 10 C.F.R. part 430, subpart C, app. A. The proposed rule contained no such assessment.

And even if DOE could characterize the proposal as merely an interpretation, and not a change to the standard or even to the test procedure, it would still have to consider the costs outlined above. DOE asserts that the definition of "showerhead" is ambiguous, and it follows that DOE's choice among possible meanings must be based on the goals, policies, and mandate of EPCA. The costs described above are central concerns under the statute. The point of conservation standards is to reduce the societal costs of energy and water consumption. The costs of extra water usage are particularly significant in areas like the Southwest and California, where water has always been scarce, the population is growing, and climate change is causing a long-term decline in water supplies.[21] These regions are redoubling their efforts to conserve water, and the last thing they need is for DOE to authorize new models of showerheads that use significantly more water. DOE cannot lawfully or rationally ignore all these issues while purporting to interpret a term that determines the effect of the congressionally mandated 2.5-gpm standard.

VI. DOE HAS NOT PROVIDED ADEQUATE NOTICE AND COMMENT.

The proposal falls far short of what the Administrative Procedure Act requires for such a substantial change, and it is also inconsistent with DOE's own Process Rule. As just a few examples of information that DOE has not shared with the public:

- What products exist currently with multiple nozzles?
- How popular will high-flow showerheads be? What amount of market shift does DOE anticipate?
- How much additional water will showers consume if DOE creates its high-flow loophole? How much energy will that cost?
- How long will it take manufacturers to design, and retool to make, the high-flow products? How much will that cost?

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[20] We object to DOE's treatment of the Process Rule as binding, and are contesting the Process Rule in court. But if DOE is going to consider the Process Rule to be binding, it has to apply when DOE relaxes standards too.

[21] Exhibit B, Glen M. MacDonald, *Water, climate change, and sustainability in the southwest*, Proceedings of the National Academy of Sciences, Vol. 107, No. 50, 21256–21262 (Dec. 14, 2010), *available at* https://www.pnas.org/content/107/50/21256.

In addition, under the Process Rule, DOE was obligated to provide a more extensive and more expansive comment process than the APA requires. DOE has committed to providing public notice of either a potential standard or a potential test procedure amendment, and taking public feedback, before it even issues a notice of proposed rulemaking. It did not meet that commitment here. DOE also promised that the comment period on a proposed rule would be at least 75 days. Here, DOE originally allowed just 30 days; it extended the comment period to 60 days after multiple commenters pleaded for an extension; and it has refused to allow the full 75 days. These process violations, contrary to DOE's own regulations, will be fatal defects in the final rule.

VII. CONCLUSION

DOE's proposal to reinterpret "showerhead" so that each nozzle is permitted to use 2.5 gpm is fundamentally flawed. DOE should abandon this notion and adhere to its sensible existing standards.

Respectfully submitted,

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Environment America Research and Policy Center
Environment Arizona Research and Policy Center
Environment California Research and Policy Center
Environment Colorado Research and Policy Center
Environment Florida Research and Policy Center
Environment Georgia Research and Policy Center
Environment Illinois Research and Education Center
Environment Maryland Research and Policy Center
Environment Massachusetts Research and Policy Center
Environment Michigan Research and Policy Center
Environment New Jersey Research and Policy Center
Environment New Mexico Research and Policy Center
Environment North Carolina Research and Policy Center
Environment Ohio Research and Policy Center
Environment Oregon Research and Policy Center
Environment Texas Research and Policy Center
Environment Washington Research and Policy Center

EXHIBIT A

WATER MANAGEMENT
CITY OF DURHAM

July 21, 2020

Mr. Andrew Wheeler
Administrator
US Environmental Protection Agency
Washington, DC

RE: Comments on Docket ID No. EPA-HQ-OW-2020-0026
Request for Information on the WaterSense® Program

Dear Administrator Wheeler:

The City of Durham Department of Water Management (DWM) respectfully submits the following comments in response to the *Notice of Recent Specifications Review and Request for Information on the WaterSense Program* published on April 10, 2020 in the Federal Register as Docket ID: EPA-HQ-OW-2020-0026.

In Durham, we regularly utilize the tools, technical assistance, research, and data provided by the WaterSense program. The City of Durham has been a promotional partner in the EPA's WaterSense Program since 2007, and it has become absolutely essential to our ongoing efforts to provide quality services and programming to our residents and customers. Our Toilet Rebate program and our Water Efficiency Kit program rely the WaterSense product labeling system.

In 2019 alone, we estimate that Durham's WaterSense-related programming, such as our toilet rebate program and showerhead program, saved over 4.5 million gallons. Durham's experience has been that customers and retailers are very satisfied with products that have received the WaterSense label. In the 12 years that we have been WaterSense promotional partners, we have not received any complaints regarding the performance of their fixtures from participants in our programs.

Nationally, the program has saved trillions of gallons of water and has provided customers with confidence in their purchasing choices of water-efficient fixtures. By focusing on both water-savings and performance, the WaterSense program has a successful history of working with relevant manufacturers and interested parties to craft fair, science-based methods to evaluate the efficacy of products.

As such, DWM believes that customer satisfaction criteria should not be included as part of WaterSense product specifications. Incorporating customer satisfaction criteria into WaterSense specifications would introduce uncertainty and bias into an otherwise fair and scientific process.

DWM supports the EPA's decision not to revise any product specifications at this time; however, we do suggest that the EPA continue to regularly review WaterSense product performance criteria. As technology changes, periodic review of product performance and specifications will allow WaterSense to ensure product specifications continually advance.

Thank you for the opportunity to provide input on the WaterSense Program. Durham remains committed to partnering with EPA WaterSense program and will continue to support the program's goals for water efficiency. We value and appreciate the EPA's continued efforts to support and ensure the continuity of this essential and effective program.

Sincerely,

Donald F. Greeley, P.E., P.L.S.
Director

EXHIBIT B

Water, climate change, and sustainability in the southwest

Glen M. MacDonald

Institute of the Environment and Department of Geography, University of California, Los Angeles, CA 90095-1496

Edited by B. L. Turner, Arizona State University, Tempe, AZ, and approved October 26, 2010 (received for review August 29, 2010)

The current Southwest drought is exceptional for its high temperatures and arguably the most severe in history. Coincidentally, there has been an increase in forest and woodland mortality due to fires and pathogenic outbreaks. Although the high temperatures and aridity are consistent with projected impacts of greenhouse warming, it is unclear whether the drought can be attributed to increased greenhouse gasses or is a product of natural climatic variability. Climate models indicate that the 21st century will be increasingly arid and droughts more severe and prolonged. Forest and woodland mortality due to fires and pathogens will increase. Demography and food security dictate that water demand in the Southwest will remain appreciable. If projected population growth is twinned with suburb-centered development, domestic demands will intensify. Meeting domestic demands through transference from agriculture presents concerns for rural sustainability and food security. Environmental concerns will limit additional transference from rivers. It is unlikely that traditional supply-side solutions such as more dams will securely meet demands at current per-capita levels. Significant savings in domestic usage can be realized through decreased applications of potable water to landscaping, but this is a small fraction of total regional water use, which is dominated by agriculture. Technical innovations, policy measures, and market-based solutions that increase supply and decrease water demand are all needed. Meeting 21st-century sustainability challenges in the Southwest will also require planning, cooperation, and integration that surpass 20th-century efforts in terms of geographic scope, jurisdictional breadth, multisectoral engagement, and the length of planning timelines.

From prehistoric pueblos to today's burgeoning suburbs, water scarcity has posed sustainability challenges for the people of the Southwest. In the 21st century, these challenges are becoming acute. Since 2001, large portions of the arid Southwest (defined here as California, Nevada, Utah, Arizona, and New Mexico) have experienced prolonged drought. Particularly widespread drought occurred in 2002, 2003, 2007, and 2009 (1). During these years, the region's precipitation averaged as much as 22–25% below the 20th-century mean, with local deficits being greater. In 2002 and 2009, annual precipitation in Arizona was ~40% below normal (2). The effects of low precipitation have been exacerbated by high temperatures, increased evapotranspiration, and decreased runoff. The average annual temperature for 2001–2009 was 0.8 °C warmer than the 20th-century mean (2).

The Colorado River is a critical conduit of water in the Southwest and is apportioned to supply 20,400 million m^3 (16.5 million acre feet; MAF) of water to the basin states and Mexico (3). Of that, about 12,400 million m^3 (10.0 MAF) are allocated to the arid Southwest. This represents approximately one sixth of the annual water use for irrigation, domestic needs, and industry (4). In Nevada, the river mainly supports the domestic and industrial demands of the Las Vegas region, whereas in southern California about 70% is used for agriculture. The allocation of Colorado River water was based upon an early 20th-century average annual flow of around 20,970 million m^3 (17.0 MAF) at Lees Ferry, Arizona. For 2001–2006, the estimated natural annual flow at Lees Ferry averaged 13,814 million m^3 (~11.2 MAF), dropping as low as 7,647 million m^3 (~6.2 MAF) in 2002 (3).

Higher temperatures, earlier spring warming, and decreased surface water contribute to an increase in wildfires. In California, the 2 largest wildfires on record and 11 of the 20 largest recorded fires occurred in the past decade (5). Outbreaks of forest pathogens such as bark beetles are also promoted by higher temperatures and drought. According to the US Forest Service, "the current outbreaks, occurring simultaneously across western North America, are the largest and most severe in recorded history" (6).

The purpose of this special issue is to assess current and future drought and chronic water-related challenges in the Southwest and consider the problems and prescriptions for 21st-century sustainability. A particular focus is placed on the potential impact of greenhouse warming on current and future hydroclimatology. This issue cannot address all aspects of the water resource questions facing the Southwest. Nor is it intended to present exhaustive reviews of earlier work. In this paper, I will set the spatial, temporal, and sustainability context for the Early 21st-Century Drought. I will draw upon the other papers in this issue to further explore the nature of the current drought. I will examine the possibility that arid conditions will persist and intensify due to climate warming and consider some of the sustainability challenges and solutions related to an arid 21st century.

Geography and Trajectory of the Southwest Sustainability Challenge

The spatial and temporal contexts of the Early 21st-Century Drought can be clearly demarcated relative to the climate of the last century (1895–2000 mean values from ref. 2). From 2001 through 2009, many regions of the conterminous United States experienced elevated annual temperatures (Fig. 1*A*), but temperatures in the Southwest have been exceptionally high (>1 to >2 SD above 20th-century means). The difference in annual precipitation between the early 21st century and the 20th century shows a strong geographic contrast between West and East. Many areas of eastern North America experienced precipitation >0.15 SD above the 1895–2000 mean. In contrast, much of the West experienced lower than average precipitation (Fig. 1*B*). The net result of the enhanced temperatures and decreased precipitation has been the development of persistent aridity (measured in terms of the Palmer Drought Severity Index; PDSI) in the Southwest and adjacent intermountain West—including the headwaters of the Colorado River (Fig. 1*C*). Although much of the conterminous United States experienced increased temperatures in the early 21st century, we are a nation divided in terms of changes in precipitation and resulting water resource challenges.

Annual values and 5-y running means for temperature (Fig. 2*A*) indicate that in the late 20th and early 21st centuries the Southwest has experienced an unprecedented period of sustained high tem-

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Author contributions: G.M.M. designed research, performed research, analyzed data, and wrote the paper.

The author declares no conflict of interest.

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peratures relative to the 20th century. There has been a general, but episodic, decline in regional precipitation (Fig. 2*B*). During the 21st century, the regional PDSI for the Southwest reached its lowest level during the period of record (Fig. 2*C*). It is the high temperatures, rather than unprecedentedly low precipitation, that appear largely responsible for the exceptionally low regional PDSI values (Fig. 2 *A*–*C*). The Colorado River has also experienced the lowest 5-y mean flows on record (Fig. 2*D*). Other periods of region-wide aridity and coincidental declines in Colorado flow have occurred over the 20th century (1900–1904, 1924–1936, 1953–1964, and 1988–1991). These "perfect droughts" of widespread persistent aridity have also been associated with warmer regional temperatures (Fig. 2 *A*–*C*). However, the amount of warming during the Early 21st-Century Drought is exceptional.

Although meteoric and extraregional supplies of water may have diminished, the human demand for water remains considerable. Over the 20th century, the population of the Southwest has increased from about 2,100,000 to over 50,000,000 people (7) (Fig. 2*E*). More than 36 million of those people live in California. Initially, the amount of irrigated acreage increased in tandem with population and reached over 4.8 million ha (~12 million acres) in the 1970s (Fig. 2*F*) (8, 9). The vast majority of that land is in California. Since then, there have been a flattening and decreases in irrigated farm acreage (Fig. 2*F*). Factors at play include the full development of most practically farmable lands by the 1970s, fallowing of land during the 1987–1991 drought and the conversion of some farms to suburbs and cities. Between 1990 and 2004, more than 200,000 ha (500,000 acres) of California farmland were converted to urban and suburban land uses (10). This trend is widespread, with the conversion of 809,000 ha (1,999,082 acres) in the seven states of the Colorado River Basin between 1997 and 2007 (8).

To support the growing population, water withdrawals for domestic use in the Southwest increased to over 12,334 million m^3 (10 MAF) annually (4) and continue on an upward trajectory (Fig. 3*C*). However, the largest use of water is for agriculture. Industrial uses are relatively negligible in comparison with agriculture and have declined in recent decades (Fig. 3*C*). Roughly 80% of all water withdrawals are used for agricultural purposes. Agricultural water use in the Southwest rose to over 700,000 million m^3 by the 1970s and then flattened and declined. This is contemporaneous with, but not wholly attributable to, the accelerated withdrawal of irrigated farm lands for other uses

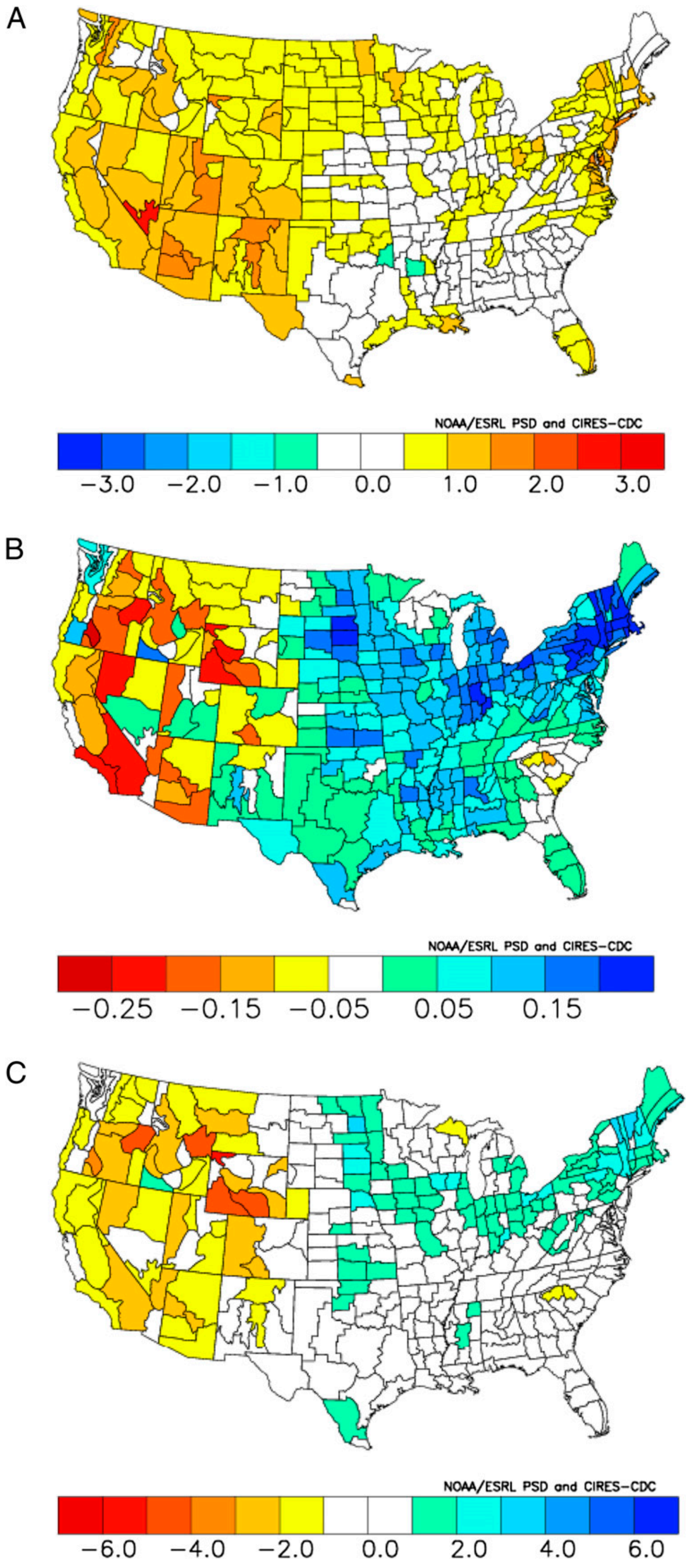

Fig. 1. (*A*) Composite standardized temperature anomalies for 2001–2009 relative to 1895–2000. (*B*) Composite standardized precipitation anomalies for 2001–2009 relative to 1895–2000. (*C*) Mean PDSI values for the period 2001–2009. Data are from ref. 2 and mapped by state climate divisions.

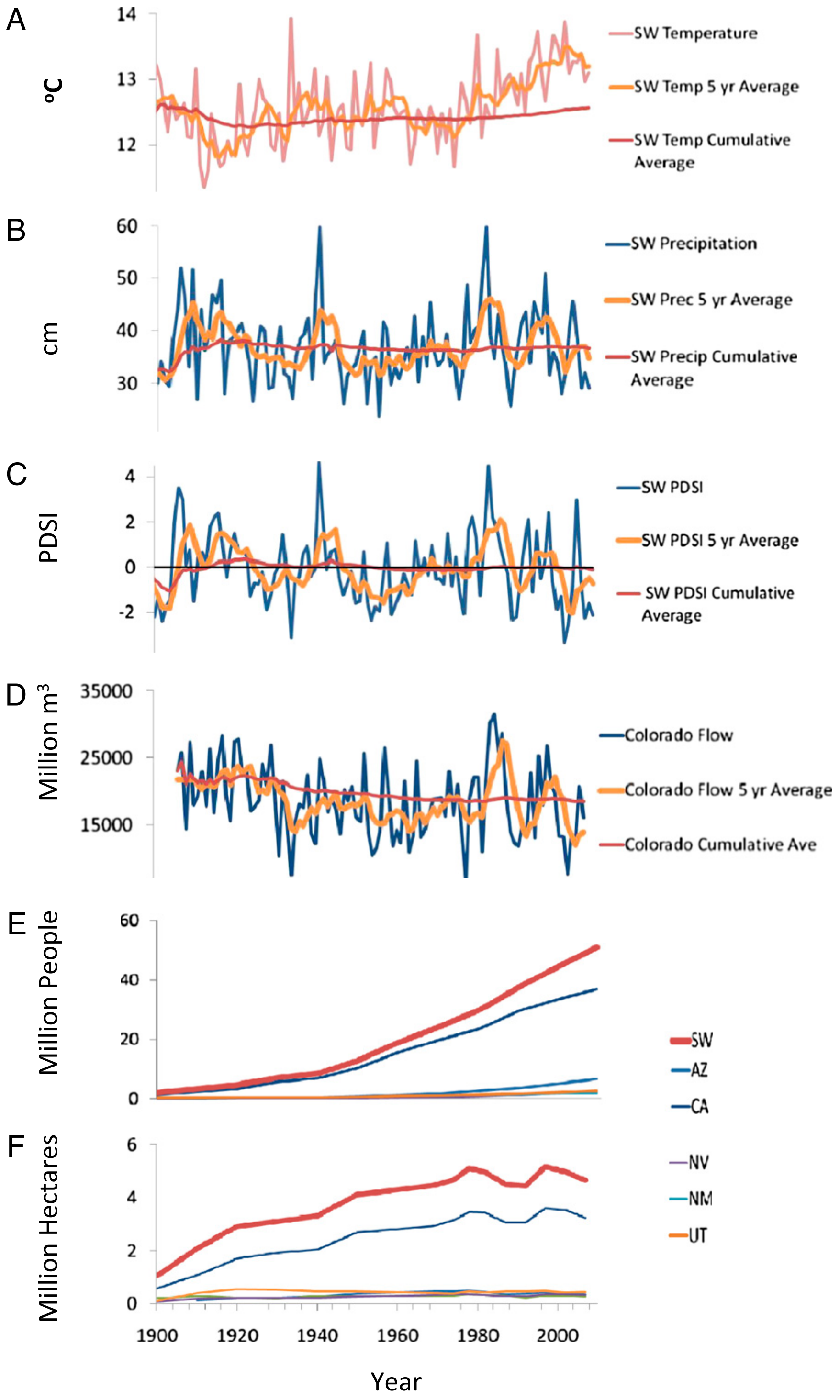

Fig. 2. (*A*) Southwest (California, Nevada, Arizona, New Mexico, Utah) average annual temperature (2). (*B*) Southwest average annual precipitation (2). (*C*) Southwest average annual Palmer Drought Severity Index (2). (*D*) Naturalized discharge of the Colorado River at Lees Ferry, AZ (3). (*E*) Southwest population size (7). (*F*) Southwest irrigated agricultural land area (8, 9).

(Fig. 3*C*). There were also declines in water use during the 1987–1991 drought. Agricultural water use stood at about 61,859 million m^3 (∼50 MAF) by the end of the 20th century. Although domestic use has steadily increased, declines in agricultural and industrial withdrawals produced a decrease in overall water use in the 1980s followed by a gradual increase over the 1990s in which increasing domestic consumption has played a significant (33%) role (Fig. 3*C*).

The net result of increasing population, agriculture, and industry over the 20th century is water use in the Southwest estimated to have totaled 77,425 million m^3 (∼62.7 MAF) in 2000 (4). This is a decline from a peak of 88,218 million m^3 in 1980. However, through this period, net domestic consumption continued to rise.

Some Sustainability Challenges

Is the increasing aridity in the Southwest capable of posing significant challenges to socioeconomic and environmental sustainability as we move further into the 21st century? The paper by Sabo et al. (11) tackles the current water sustainability challenges in the broader West by focusing upon the concerns raised by the late Marc Reisner in his book *Cadillac Desert—The American West and Its Disappearing Water.* Sabo et al. calculate that humans now appropriate the equivalent of 76% of the West's streamflow for agriculture, domestic use, and other purposes.

It is not anticipated that population growth in the Southwest will abate over the long term. The US Census estimates that by 2030 over 67 million people will live in the region (12). California would add the greatest number and reach a population size of over 46 million. Nevada, Arizona, and Utah would be among the top 5 states in the nation in terms of percentage of population increase. Arizona is projected to add over 5 million people to become one of the 10 most populous states in the United States. Not only are populations increasing but the geographic distribution of the population is changing in an important fashion. Since 1950, there has been a strong increase in the proportional growth of suburban populations. In 2000, suburbanites accounted for 50% of the population (7). Southwestern suburban developments, in which 70% or more of the water is often used for landscaping (13), amplify the water demands exerted by the increasing population. Sabo et al. estimate that per-capita virtual water footprints are seven times higher for cities in the arid West than in the East. They suggest that with a doubling of population, the West would require the equivalent of more than 86% of its total streamflow to meet human use at current per-capita levels.

Agriculture remains an important sector of the Southwest's economy. California's farm receipts totaled $36.1 billion in 2008 (14). Aside from a fundamental role in domestic consumption and food security, its exports contributed some $13.6 billion (14) to the nation's international trade balance. Changes in the agricultural productivity of the Southwest in response to water shortages and/or reallocation will have direct implications for food supply and security. Aside from the negative

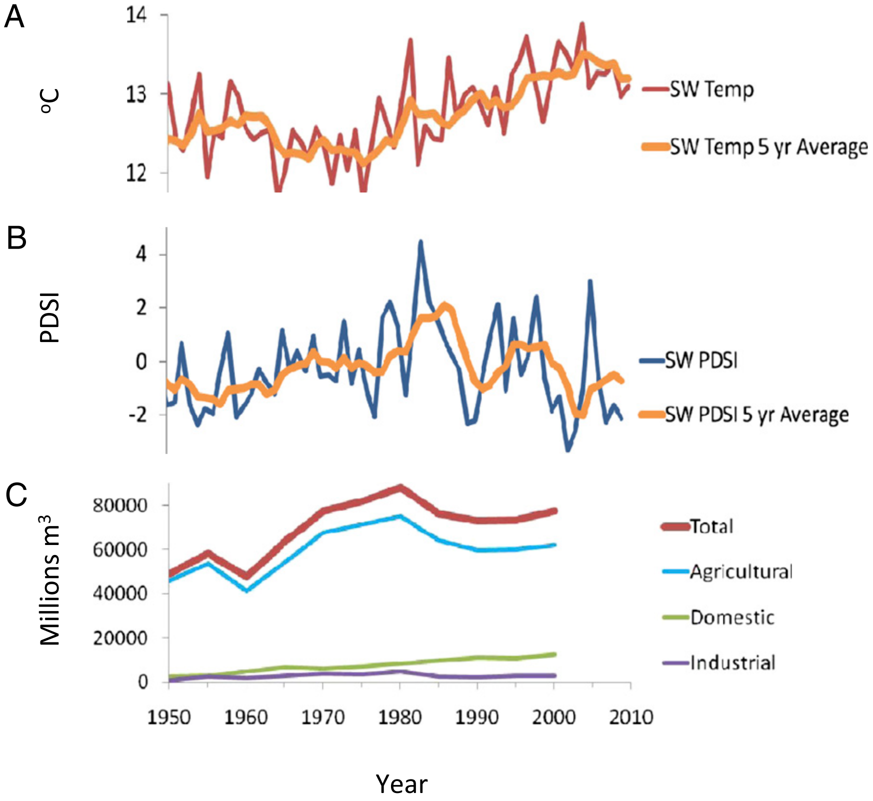

Fig. 3. (*A*) Southwest average annual temperature (2). (*B*) Southwest average annual PDSI (2). (*C*) Southwest water withdrawals by usage sector (4).

impacts of discrete droughts, chronic salt accumulation in soils promoted by hot and arid climate can also produce agricultural losses. In the West today these losses are already on the order of $2.5 billon/y (11). Avoiding salt accumulation places additional restrictions on agricultural water management in the Southwest.

The reservoir system on the Colorado River is one of the most important buffers against drought in the Southwest. Although significant loss of reservoir capacity due to sedimentation may not be imminent (11), water supply and demand challenges for the reservoir system are clearly acute today. The Colorado system has seen storage levels decline precipitously, and they stood at 40,766 million m^3 (33.05 MAF) or 55.6% of capacity as of October 1, 2010 (3). The level of Lake Mead has now fallen more than 40 m below capacity level. A further decline of a few meters will trigger a level 1 water shortage declaration. At the extreme end of the spectrum, a recent study suggests that Lake Mead and Lake Powell have a 50% chance of receding to inoperable status by the 2020s (15). Loss of reservoir storage also produces loss of hydroelectric production and decreases energy supplies.

The recent drought has prompted emergency restrictions on outdoor water use by residents in cities such as Las Vegas, Tucson, Albuquerque, Los Angeles, and San Diego. The Metropolitan Water District of Southern California serves ~17 million people and in April 2009 voted to cut deliveries in its largely urban and suburban service area by 10%. Although urban water restrictions may be inconvenient, drought conditions have an appreciable financial impact on agriculture. In 2008, California alone experienced at least $308 million in lost agricultural revenue due to drought (16).

The increasing temperatures and aridity of the early 21st century also pose challenges for wildlands and land management. For example, experimental studies have found that a 4 °C warming produces a 30% increase in piñon pine mortality among drought-stressed trees (17). Earlier spring warming and decreased surface water appear to contribute to a recent increase in fires (18). The annual cost of wildland fire suppression in California alone now typically exceeds $200 million (5). In 2007, over 3,000 structures were destroyed and total suppression costs plus damages was almost $780 million (5). Total costs of bark beetle damage are difficult to calculate, but during the 5-y period of 2005–2009, over $75 million of federal, state, and local funds were spent on prevention, suppression, and restoration. That produced treatment of only about 200,000 ha (500,000 acres) throughout the West—a fraction of the more than 8 million hectares (22 million acres) of forest and woodland area under threat (19).

The 21st Century

The remaining papers in this issue look at the Early 21st-Century Drought and the remainder of the century. The studies tackle various aspects of water sustainability with an array of approaches that include analysis of current meteorological, socioeconomic, and ecological data, paleoenvironmental data analysis, model simulations, and policy analysis. From the papers presented here, several important insights emerge—often possessing particular weight because they arise from more than one research approach. These insights can be organized around four critical questions.

1. Is the Early 21st-Century Drought Exceptional Compared with Earlier Droughts and Is This Attributable to Increasing Greenhouse Gasses?

Cayan et al. (20) examine the Early 21st-Century Drought relative to historical droughts of the 20th century. They conclude that for the Colorado River Basin, the Early 21st-Century Drought has been the most extreme in over a century, and might occur in any given century with a probability of about 60%. They point out that 3 of the 11 driest years experienced over the past 100 y have occurred in the past decade (2002, 2007, and 2008). Only the 1930s experienced a comparable run of dry years. Similarly, Seager and Vecchi (21) conclude that the Southwest has been experiencing a general drought that is at least as severe as any in the past 100 y. They also note that the drought appears to be part of a longer-term trend of strong drying that began around 1979 (Figs. 2 and 3). Woodhouse et al. (22) use paleohydrological reconstructions to show that although the 21st-Century Drought is severe by standards of the past 100–200 y, it "pales" in terms of spatial extent and duration compared with the prehistoric drought of the 12th century. As bad as things might seem, they have the demonstrated potential to become worse.

Both Cayan et al. and Woodhouse et al. point out that warmer temperatures are typically associated with prolonged droughts in the Southwest. Cayan et al. find that summer temperature anomalies during past Southwest droughts have ranged from +0.5 °C to +1 °C. Similar to the present drought, this warming in the Southwest occurred in concert with widespread warming over the conterminous United States. Although the current drought is consistent with the observed relationship between extreme droughts and high temperatures, the magnitude and prolonged nature of the high temperatures of the Early 21st-Century Drought have no analog in the 20th century (Fig. 2*A*). Woodhouse et al. use paleoclimatic records to show that the current warming in the Southwest may exceed any other warming episode experienced over the past 1,200 y. Cayan et al. and Seager and Vecchi also note the influence of warm temperatures in the impact of the current drought on decreased snowpack, earlier timing of snowmelt, and greater evaporation rates and transpiration demands. The current drought is therefore exceptional in terms of the magnitude of warming and additional evapotranspiration stresses.

The studies by Cayan et al. and Seager and Vecchi suggest that the recent warming is consistent with the Intergovernmental Panel on Climate Change Assessment Report 4 (IPCC AR4) projections of anthropogenic climate change (23). However, both studies conclude that it is not possible to definitively attribute the Early 21st-Century Drought to increased greenhouse gasses. Cayan et al. conclude that the Early 21st-Century Drought, although severe, is not outside the realm of natural variability in the Southwest. Seager and Vecchi argue that the great North American droughts of the past 200 y were caused by very small sea surface temperature (SST) anomalies. They note that there has been a general cooling trend in the eastern Pacific following 1979 and that such cooling typically is associated with drought in the Southwest. The drivers of such SST anomalies remain poorly understood, as does the potential impact of increasing greenhouse gasses on Pacific SSTs. Seager and Vecchi conclude that the general drying in recent decades and the 21st-Century Drought could be a result of natural decadal variability in Pacific SSTs.

2. Is It Likely That the Southwest Will Experience a More Arid Climate Due to Global Climate Change Driven by Increasing Greenhouse Gasses? The climate model estimates analyzed by Cayan et al. and Seager and Vecchi all indicate that continued warming could produce increased aridity, overprinted by more severe droughts. Analysis of the results of 15 and 24 different general circulation models lead Seager and Vecchi to argue that increasing aridity in the Southwest would be an expected outcome that results from a poleward expansion of the subtropical dry zones as the planet warms. Southwest drying is mainly being driven by a decline in winter precipitation associated with increased moisture divergence due to changes in mean atmospheric flow and reduced moisture convergence via transient eddies. The drying of the Southwest and similar subtropical regions is a highly robust result from the model simulations. Seager and Vecchi anticipate that anthropogenic aridity will be as large in magnitude as the droughts caused by natural decadal variability in climate by around 2050. They also conclude that it is unlikely that the Southwest will see a return of any prolonged periods of moist conditions similar to the long wet spells experienced in the 20th century. The analysis by Cayan et al. similarly indicates that the Southwest is likely to become drier and experience more severe droughts than witnessed over the 20th century. Drought activity is likely to increase toward the end of the 21st century, particularly in the Colorado River Basin. Drought episodes typified by continuous soil moisture depletion will increase from 4–10 y to periods of 12 y or more.

The paleohydrological analysis of Woodhouse et al. provides evidence in support of the potential for prolonged aridity and greater droughts if warm temperatures persist in the 21st century. The driest and most widespread interval of drought documented in the paleorecords occurred in the mid-12th century and is coincidental with the period of greatest prolonged temperature increase. The 12th century, typified by warm temperatures produced by increased insolation, decreased volcanic activity, a coincidental cooling of the eastern Pacific Ocean, and widespread, prolonged, and intense drought in southwestern North America, has been used as a comparison for the current drought (24). During the decade of 1146–1155, the flow of the Colorado River averaged about 78% of its 20th-century mean. The portion of the Southwest experiencing drought in any given year averaged 65.5% of the total land area. The paleorecords also show a general consistency between warmer temperatures and prolonged drought, and indicate that the observed droughts of the 20th century do not capture the full potential severity and duration of droughts exacerbated by warm conditions. Even in the absence of manmade climate change, the region is prone to periods of prolonged warming and exceptional drought that should be considered in planning efforts for a sustainable Southwest.

3. What Are the Potential Impacts of Increasing Aridity on Wildland and Urban/Suburban Systems? Williams et al. (25) examine correlations between climate and the radial growth of trees across North America. They show that conifer trees in the Southwest are particularly sensitive to temperature and aridity relative to other regions. They use climate–tree growth relations calculated for the past 100 y, combined with IPCC climate model estimates for the 21st century, to predict the likely fate of important Southwest tree species such as piñon pine (*Pinus edulis*), ponderosa pine (*Pinus ponderosa*), and Douglas fir (*Pseudotsuga menziesii*). Williams et al. conclude that woodlands and forests will experience substantially reduced growth rates and increased mortality at many Southwest sites as the century progresses.

Based on analysis of satellite data and aerial photographs, Williams et al. demonstrate that Southwest forests and woodlands have been experiencing significant impacts from wildfires and bark beetles in recent decades. Climate warming and drought promote forest flammability and can increase lightning ignition. Southwest forests are hosts to three important species of bark beetle—spruce beetle (*Dendroctonus rufipennis*), pine beetle (*Dendroctonus ponderosae*), and piñon ips beetle (*Ips* spp.), the last being the most widespread in the region (26). Climate warming allows for greater beetle reproduction and expansion of beetles' ranges to higher and cooler elevations. Drought weakens the resistance of trees to beetle infestations and promotes greater susceptibility and mortality when infestations occur. Dying trees can increase forest fuel loads and promote fires. Williams et al. estimate that from 1984 to 2006 some 2.7–3.0% (6,420 km^2) of the total area of southwestern forest and woodland has experienced mortality due to stand-clearing wildfires. A staggering 7.6–11.3% (18,177 km^2) of woodland and forest has experienced mortality due to bark beetles between 1997 and 2008. What is most disturbing is the high rate of forest loss. They estimate that 14–18% of the Southwest's forests have been impacted by fires or bark beetles in the period 1984–2008. There has also been a steady rise in the annual area burned by severe fires. It is likely that bark-beetle- and fire-related mortality will increase should 21st-century climate warming continue, and this will pose a significant challenge for conservation and resource management across the Southwest.

Gober and Kirkwood (27) look at Phoenix as an example of the water challenges facing cities in the Southwest. Phoenix displays and amplifies many of the attributes typical of the Southwest including increasing population, large suburban development, limited water supply, and shifting agricultural to urban land and water use. They use the WaterSim model to simulate conditions in the year 2030. Future climate scenarios from IPCC AR4 were used to develop a range of scenarios for the flows of the Salt/Verde and Colorado River systems. These two systems supply much of the city's water. Groundwater conditions were also estimated. The water demand estimates were based upon extrapolated population-size and land-use projections. Many of the scenarios indicated that achieving sustainability would require decreases in per-capita urban water use to slightly less than current indoor use. This suggests a dramatic curtailment of almost all usage for landscaping and pools in Phoenix. Even restricting population growth by 50% would not allow current per-capita water usage to be sustained under many water-supply scenarios. Increased groundwater reliance does not effectively mitigate the concerns. Under worse-case simulations, groundwater drawdowns range from 6 billion to 14 billion m^3. Gober and Kirkwood conclude that policy action to limit groundwater use will be necessary even without climate change to contend with. Limiting growth to 50% of projected levels and eliminating most irrigated outdoor landscaping and private backyard pools may be needed to achieve groundwater sustainability even under normal river flow conditions. The simulations suggest that with or without climate change, the Phoenix area faces clear sustainability challenges in the opening decades of the 21st century.

4. What Policy Prescriptions and Other Strategies Might Help Us to Develop Water-Use Sustainability in the Southwest? Water sustainability can be maintained through two basic variables: (*i*) increased supply or (*ii*) decreased demand. As is pointed out by Gleick (28), the preferred response to water challenges over the 20th century was based on engineered solutions on the supply side: "Build large-scale, centralized, federally subsidized infrastructure to move water in both space and time to meet current and projected demands." Such dependence upon extralocal water and engineering approaches predate the past century (29). Archeological evidence and early historical accounts tell us that peoples such as the Hopi, Zuni, Rio Grande Pueblo, and Pecos Pueblo built large villages and practiced irrigated agriculture along rivers including the Little Colorado, the Rio Grande, and the Pecos. Indeed, native peoples engineered small check dams and irrigation canals beginning about 2,000 y ago. In the 18th century, Spanish missions and settlements in California were typically established near rivers and developed masonry dams >3 m thick and stone aqueducts that ran for more than 10 km. In the 20th century, large infrastructure projects such as the Hoover Dam, which incorporates 2,600,000 m^3 of concrete, and the California Aqueduct, which is 1,151 km long, were built. After 2,000 y of application, there is certainly still a role for additional storage and transference capability; however, the engineering of water reservoir and transference systems as a comprehensive solution to Southwest water sustainability has run its course. Some of the limiting factors include the huge size of the current population, the importance and water demands of its agriculture, the limitations of meteoric and groundwater supply, the potential for decadal-length drought, and the challenges of global warming in terms of decreased precipitation and increased evapotranspiration. To these limitations should be added environmental concerns over the preservation of the ecosystems and species in places such as the Sacramento Delta, the riparian systems along the Colorado River, and the waterfowl habitat of the Salton Sea. In cases such as the Sacramento Delta, transference has already been significantly curtailed due to environmental concerns and resulting judicial restrictions. If the now-desiccated Colorado River Delta lay in the United States rather than a few kilometers over the border in Mexico, similar environmental concerns would likely be placing additional constraints on the usage of Colorado River water.

Aquifer drawdown and saltwater intrusion limit further extraction of groundwater (27, 29). Enhanced water harvesting, particularly stormwater capture, can augment supplies. In California, the Stormwater Resource Planning Act allows municipalities to access funds for projects that capture stormwater for reuse or to recharge groundwater. The City of Los Angeles estimates that during rainy days as much as 37,854,117 m^3 (~10 billion gallons) may flow through the stormwater system. However, such water still requires considerable treatment depending upon intended use (30). Sabo et al. call for increased urban desalination plants. Large-scale desalination, although technically feasible, requires significant energy and remains expensive (31). Treating brackish water is less expensive, and Gleick outlines how desalination of brackish groundwater is significantly augmenting municipal water supplies in El Paso. Improvements in technology and particularly the use of solar energy could help offset the energy and cost restrictions of desalination (32). Gray water recycling and use in landscaping is already being applied (33). This holds much promise given the prominent role of suburban lawns and gardens in Southwest water demand. Potable reuse of some recycled wastewater is possible, but faces economic and community acceptance challenges.

Despite the innovations outlined above, increased supply will likely not provide the complete answer for the Southwest in the near future. Although there remains relatively greater uncertainties in projections of precipitation than temperature, the consensus is that global climate change due to increased greenhouse gasses will exacerbate surface water deficiencies in the Southwest (20, 21, 23). Much of the increase in demand is and will be driven by cities and their suburbs. Water could be transferred from farms to maintain urban growth. For example, a recent modeling study by Tanaka et al. (34) concludes "California's water system can adapt to the fairly severe representations of population growth and climate warming. This adaptation will be costly in absolute terms and include transaction, institutional, and fixed costs not quantified in the model, but, if properly managed, should not threaten the fundamental prosperity of California's economy or society, although it can have major effects on the agricultural and environmental sectors." As discussed above, environmental concerns are already curtailing water transference and it is unlikely such policies will be significantly reversed. However, significant transfers of water from agriculture to satisfy the domestic demands of a growing suburban population also raise a plethora of important concerns including loss of agricultural sector sustainability, rural socioeconomic decline, increased food prices, decreased food choice, decreased food security, increased carbon footprint for imported food, and decreased foreign trade balance. Thus, as pointed out by Gleick, Gober and Kirkwood, and Sabo et al., innovations and policies that decrease overall demand must figure prominently in planning for water sustainability. Sabo et al. estimate that to completely eliminate freshwater stress would require decreased water use to an appropriation of only 60% of the total streamflow in the region. They argue for a compromise target of a 15% decrease. Gleick suggests that increased efficiencies are to be found in domestic and industrial water uses. He notes that some 50% of agricultural water use in California is for "inefficient flood-irrigation." Sabo et al. also suggest greater water-use efficiencies can be implemented in the agricultural sector. Gober and Kirkwood articulate a three-pronged strategy of implementing policies in urban areas that will slow population growth, focus remaining growth in high-density developments, and alter outdoor consumption by encouraging xerophytic landscaping and decreasing private swimming pools. It is encouraging that even more modest policy prescriptions, such as public information campaigns, water-efficient building requirements, and limited restrictions, can have significant results. Water deliveries by the Metropolitan Water District of Southern California peaked in 1990 at about 3,207 million m^3 (2.6 MAF) and by 2008 had fallen to about 2,466 million m^3 (2 MAF), despite a population increase of 2 million people. In response to drought, the City of Los Angeles was able to reduce total water usage by 17% over the 1-y period of 2008–2009. Sabo et al. suggest that market-based pricing of water and the restriction of government subsidies to only those uses that fulfill basic human needs should also be used. In a region where the majority of water use is often for exterior landscaping, decreasing per-capita demand does not have to mean fundamental hardships in terms of drinking water and cleanliness. Efficiencies clearly remain to be realized in the Southwest in urban and suburban water use. For example, per-capita water use in Tucson is half that in Phoenix despite similarities in climate for the two cities (27).

In view of the broad scope of the problem, Gleick and Sabo et al. highlight the need for comprehensive, multisectoral, and transregional policies to formulate water strategies for Southwest sustainability. As Gleick demonstrates, these efforts must foster communication, planning, and implementation among a plethora of agencies and jurisdictions. In addition, as the climate models and paleoclimatic studies indicate, the region could become more arid and droughts could extend over decades. Typical 3- to 5-y drought plans are insufficient to address climate change and decadal-to-multidecadal droughts.

Discussion of sustainability must also incorporate consideration of ecosystem services and protection of endangered species. Williams et al. point out that the vegetation of the Southwest is likely undergoing profound changes. Management of forests, woodlands, streams, deltas, and other habitat to preserve ecosystem functioning and conserve biodiversity will be extremely challenging and at times come at an appreciable cost in terms of water-supply options for other demands. Sabo et al. point out the threats posed to native fish species should care not be taken in water-infrastructure projects.

Cooperation and strategic integration that surpass 20th-century efforts in terms of geographic scope, jurisdictional breadth, multisectoral engagement, and planning timelines are required to develop Southwest water sustainability. Given the impacts of the current drought on water supplies and infrastructure, those efforts should be undertaken with expediency.

However, with greenhouse gas concentrations at their current levels, we likely will not escape significant warming and resulting increased aridity over the 21st century (20, 21, 23). Coupled with the demographic projections, the climatic estimates for the next decades compel us to develop water resource strategies that adapt to these changing conditions and promote sustainability in the face of increasing general aridity as well as more severe episodic droughts. Finally, the proximal economic costs of reducing greenhouse gas emissions are often cited as a rationale for inaction on emissions reduction. Because climate warming will exacerbate water sustainability problems, the Southwest is likely to experience some of the highest economic expenses and environmental losses related to climate change. As the papers in this issue illustrate, the ultimate costs of inaction in curbing greenhouse gas emissions will be particularly high for the Southwest.

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