U.S. Water Policy: Trends and Future Directions

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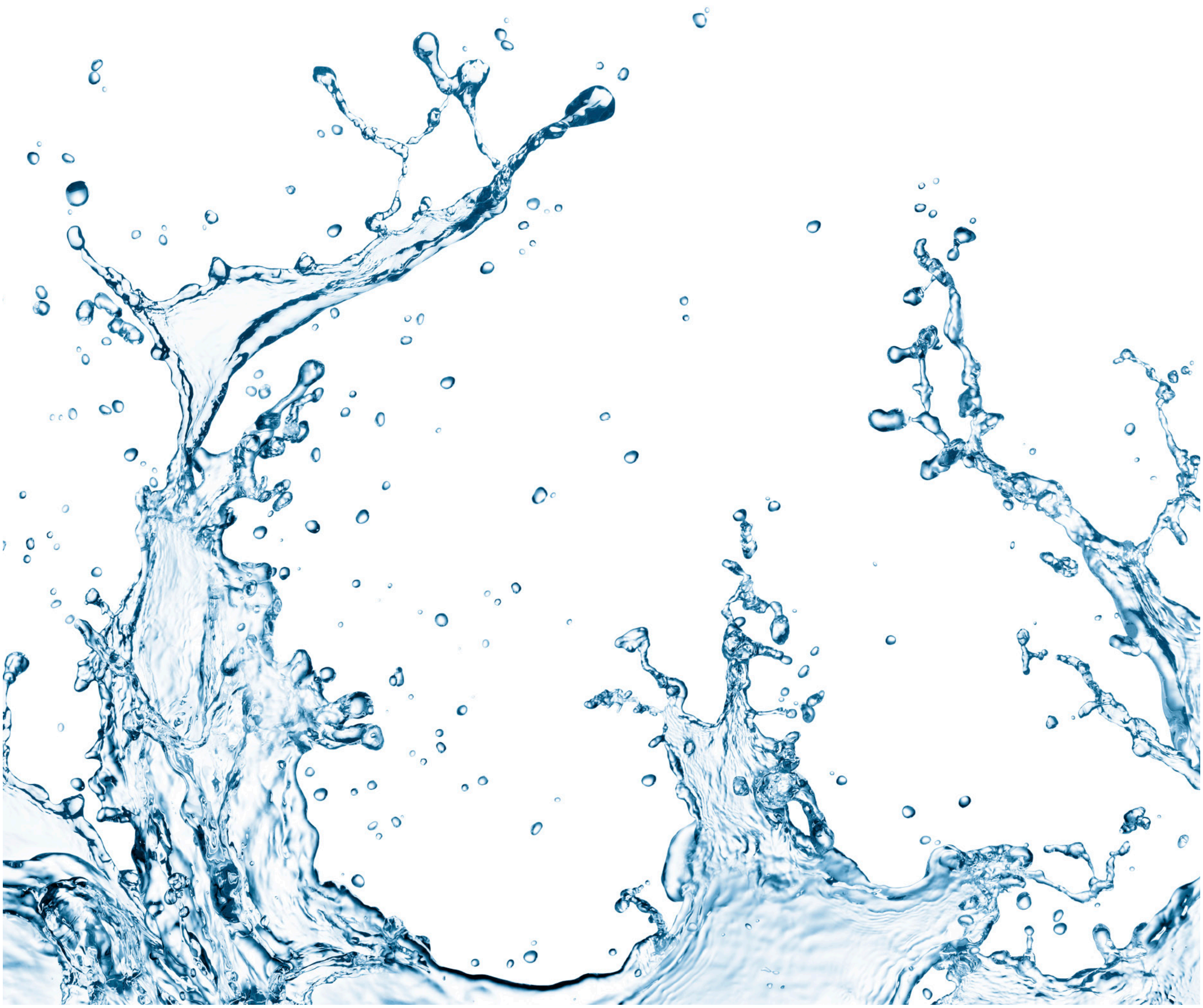

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Abstract

Water resources in the U.S. are dynamic and diverse but national water policy is fragmented and continually evolving. Numerous federal laws and agencies oversee various aspects of water policy, including both water supply and water quality. The federal government maintains and operates many water supply and storage systems for public and private use, particularly in the western states. The federal government has implemented a number of laws and programs aimed at improving water quality nationally, often in cooperation with states. States and local governments also maintain control over various aspects of water policy, particularly allocation of water rights. Increasingly, water resources are managed for a wide range of purposes, including municipal drinking water supplies, irrigation, recreation, and water quality. Water agencies have increased focus on managing water resources collaboratively in cross-agency efforts that include involvement from nongovernmental organizations and private citizens. River basins and watersheds provide useful biophysical units of action, but challenges arise in coordinating efforts across political boundaries. Population growth and increased water use create concerns about sustainability, particularly in groundwater systems. There is increased attention to water efficiency, especially at the state and local level. For water resources to be managed effectively in the future, agencies will need to work more closely together and incorporate adaptive management principles to meet dynamic and difficult challenges, including climate change. Ecological principles and ecosystem restoration are potential tools for providing sustainable supplies of water while protecting ecosystem services, including flood control, water quality, and habitat.

Introduction

Water resources in the U.S. are dynamic and diverse. Water policy follows this biophysical trend; the U.S. lacks one cohesive national water policy but instead has a number of governance and policy structures at the federal, state, and local levels. The current array of water policies is the result of a history characterized by increasing interest in the range of benefits water provides, as well as increasing strain on the nation's water resources. The fragmented nature of water governance is also deeply rooted in the U.S. system of federalism. The water policy realm is indicative in many ways of the evolution of federal power since the founding of the country and the complexity of environmental, economic, and social problems facing the nation in the coming decades.

This paper outlines the current water policy system, with a focus primarily on federal policy. I discuss the history of governance in this area, describing the major federal laws governing water, and offer some analysis of the directions future policy might take. Two major umbrellas describe water policy: supply and quality. While these generic areas overlap with each other in many ways, and are increasingly interrelated, policy has traditionally dealt with each separately.

History of U.S. Water Policy

This section gives a brief overview of policy in this area rather than a comprehensive overview. From a national perspective, water policy has largely followed the development of policy and governance in other areas. In the 19th century, water policy was largely the dominion of states, with the federal government largely focused on territorial expansion and development (Gerlak, 2006; Getches, 2001). For much of the early history of the U.S., the federal government controlled large portions of the country, particularly in the West. The focus of federal resource policy was on encouraging settlement and development of these new portions of the county. As a critical resource for human settlement and many economic activities, including mining and agriculture, water allocation was the primary concern. During this phase of the nation's history, the federal government largely deferred to state and territorial governments in determining water allocation (Getches, 2001). Federal policy was primarily reserved for ensuring flows of waterways and their usability for economic and domestic purposes (Holmes, 1972; Getches, 2001).

Guide to Water Acronyms

BMP: *Best Management Practice*

CALFED: *California-Federal Bay-Delta Program*

CWA: *Clean Water Act*

CWSRF: *Clean Water State Revolving Fund*

DWSRF: *Drinking Water State Revolving Fund*

EPA: *Environmental Protection Agency*

ESA: *Endangered Species Act*

NEP: *National Estuary Program*

NEPA: *National Environmental Policy Act*

NPDES: *National Pollution Discharge Elimination System*

NPS: *Non-point source*

SDWA: *Safe Drinking Water Act*

TMDL: *Total Maximum Daily Load*

USACE: *U.S. Army Corps of Engineers*

USDA: *U.S. Department of Agriculture*

Much of the federal policy established in the 19th and early 20th centuries focused on maintaining the navigability of major river systems and harbors (Gerlak, 2006). The U.S. Army Corps of Engineers (USACE) was established early on as the primary federal agency responsible for water issues, primarily due to their expertise in the types of large-scale projects required to maintain working waterways, including canals (Hays, 1959; Holmes, 1972). The 19th century could be characterized as an era of federal construction projects, including canals, improved natural waterways, and levees to facilitate economic growth around major river systems, once called the "public highways" of the country (Holmes, 1972). While the federal government focused on waterways, the allocation of water was left largely to states (allocation policies will be discussed in more length later in this paper).

The turn of the 20th century marked a dramatic shift in both the balance of federal-state power in water policy as well as the focus of federal attention. The Roosevelt administration ushered in a new Progressive era of federal policy and a renewed focus on development and conservation of natural resources (Hays, 1959). Federal authority over waterways expanded through new legislation and the creation or expansion of federal resource agencies (Hays, 1959; Holmes, 1972). Developing waterways for multiple uses, including transportation, flood control, irrigation, and power generation became additional goals. While some of these areas had been the traditional purview of the federal government, planning and implementation capacity expanded dramatically (Holmes, 1972). The Reclamation Act of 1902, and creation of the federal Reclamation Service (which later became the Bureau of Reclamation), increased the national government's responsibility to plan and construct irrigation works in the western U.S. (McCool, 2005). The expansion policies of the 19th century increased the population of the west, creating a pressing need to develop water infrastructure in the region (Holmes, 1972; McCool, 2005; Tarlock, 2001). While allocation of water was still largely left to state control, the federal government invested substantial resources into the creation of dams, water storage facilities (such as reservoirs), and water transport systems (Allin, 2008; Getches, 2001). This infrastructure facilitated further settlement and economic development, especially in agriculture (Dowd et al., 2008; Gerlak, 2006; McCool, 2005; Tarlock, 2001).

Figure 1. The Hoover Dam, on the border of Arizona and Nevada. This Bureau of Reclamation project was built in the 1930s to provide flood control, hydroelectric power, and a source of irrigation water for the region.

Increasing concerns with deteriorating water quality in the 1950s, especially in the industrial Northeast, and the growth of the national environmental movement in the 1960s resulted in another phase of water policy and perhaps the greatest expansion of federal authority yet (Gerlak, 2006). Prior to this, water quality and conservation concerns were limited primarily to their impacts on other water goals, including navigation and irrigation. Major environmental legislation, particularly the Clean Water Act (CWA) in 1972, expanded authority to cover water quality explicitly, tasking new federal agencies such as the Environmental Protection Agency (EPA) with reducing pollution and improving uses of water for wildlife and fish habitat and recreation. As Gerlak (2006, pg. 236) says: “Environmental legislation of the 1960s and 1970s institutionalized environmental values in federal resource management, including water management.”

Figure 2. The Bureau of Reclamation's Central Valley Project in California, which supplies hydroelectric power as well as water for irrigation and consumption.

In addition to increasing the interests of federal water policy, the 1960s and 70s ushered in a new federalism balance. Where previously the federal government had carved out areas of authority, leaving states the areas that remained, the growth of environmental policy required cooperative (or coercive) arrangements between federal and state governments (Elazar, 1990; Gerlak, 2006). Under these policies, which included the CWA and the Safe Drinking Water Act (SDWA), the federal level sets standards while states are largely in charge of establishing plans and policies for meeting those standards. These policies are viewed by some as a mechanism for subverting what have traditionally been states’ rights and expanding federal control (Benson, 2006; Getches, 2001). These new environmental laws placed burdens on state and local governments and threatened total loss of state regulatory power if they failed to meet federal standards (Gerlak, 2006).

The growth of environmentalism and water quality policy also contributed to the decline in the era of big construction projects. The era of construction largely ended by the 1980s as water quality concerns continued to gain emphasis over power generation, flood control, and water supply concerns. Hydroelectric power had expanded throughout much of the country, particularly the west, but dams were increasingly seen as destructive to the environment and prohibitive of other uses of water (Getches, 2001). The National Environmental Policy Act (NEPA) formalized a federal policy in which environmental impacts must be assessed for proposed government projects. This process increased public involvement and concerns with environmental quality and recreational benefits, changing the overarching emphasis of federal water policy (Gerlak, 2006). Regional planning bodies gained renewed emphasis during this time, primarily organized around river basins. These commissions were a more cooperative form of federalism, where the federal government sought to share power over water with state and local governments (Gerlak, 2006).

By the late 1980s a new era of state and federal water agency experimentation embraced collaborative and voluntary approaches, particularly in water quality (Hoornbeek, 2004). The Reagan administration moved decision-making from federal to state control (Gerlak, 2006; Hoornbeek, 2004). A tight budgetary environment and an ideological emphasis on limited federal government contributed to a de-emphasis on federally-led infrastructure projects, as well as a withdrawal from regional river basin planning efforts. States became the primary creator of new water policies. Under increasing pressure to meet federal water quality standards, states initiated intrastate and federal-state compacts and coordinating bodies. State governments spearheaded cross-border collaborative efforts in the Chesapeake Bay region and Colorado River basin as a renewed structure for coordinating action (Gerlak, 2006). The watershed approach to management and policy (where the area draining into a particular water body served as the management unit as much as the water body itself) also became increasingly prevalent throughout the 1980s and 90s. Watershed-based approaches often required cross-border and cross-agency coordination and collaboration (Adler and Straube, 2000; Gerlak, 2006). Federal policies increasingly relied on partnerships with state and local governments, as well as private entities, to achieve management goals, especially around water quality (Lubell, 2004a; Mandarano et al., 2008).

The increasing emphasis on state and collaborative action transitioned to the current era of water policy, which is characterized by restoration and collaboration (Gerlak, 2006). During the 1990s and 2000s, the emphasis of federal policy continued to shift toward environmental and water conservation values and away from older economic and utilitarian policy models. States dramatically increased their capacity in terms of water policy through the latter half of the 20th century. Policy measures such as the National Pollutant Discharge Elimination System (NPDES) through the CWA had forced the states to become better equipped to tackle water quality and conservation issues on their own. In the 1980s, the Bureau of Reclamation ceased construction of new water projects, shifting to a management and maintenance role (Getches, 2001). The emphasis for other agencies shifted as well; by the 1999 Water Resources Development Act, much of USACE's flood control efforts moved from large water projects to more local ones, including environmental mitigation, restoration, and stormwater retention (Gerlak, 2006). States were increasingly charged with implementing and maintaining smaller scale, local flood control, pollution control, and water conservation measures. Recognition of long term water quality and flooding problems (caused by ecosystem modification) increased throughout the latter half of the 20th century, leading to increased focus on ecological restoration. Emphasis in water quality had shifted from one primarily focused on point-source polluters (such as factories and municipal facilities) to non-point source pollutants (Allin, 2008; Gerlak, 2006).

Major Federal Laws and Water Agencies

The evolution of water policy led to a diverse and fragmented agency structure at the federal level. Federal water policy is set through several important mechanisms, including Congress and federal agencies. A wide range of federal agencies play at least a minor role in managing or regulation water resources (more than 25 according to Allin, 2008), including the Department of Commerce and Department of Defense. Several agencies play a larger role in water policy, particularly those with a historical role in water management, such as USACE and Bureau of Reclamation. Congressional oversight and interest in water is similarly as varied. More than 40 Congressional committees and subcommittees deal with various aspects of water policy, resulting in fragmentation and overlap (Allin, 2008).

The USACE still has influence on federal water policy, primarily through creating and managing water infrastructure projects. USACE is a large organization, with over 37,000 civilian employees. The agency manages over 600 dams, 12,000 miles of navigable inland waterways, and over 300 million acre-feet of water storage capacity (USACE,

Major Water Laws

Clean Water Act (CWA): The most important law concerning environmental aspects of water, the CWA sets national standards for water quality, with the goal of making most waters of the U.S. swimmable, fishable, and drinkable. Requires states to set classify water bodies by intended use and regulate entities that emit into water bodies through the National Pollution Discharge Elimination System (NPDES) permitting structure.

Safe Drinking Water Act (SDWA): The primary law regulating drinking water standards, this law sets national standards for all public drinking water sources.

National Environmental Policy Act (NEPA): This law requires federal agencies to assess the environmental impacts of proposed actions, including projects and new regulations, through environmental impact assessments (EIAs).

Endangered Species Act (ESA): This law identifies and protects endangered animals and plants. ESA impacts water policy by prohibiting federal or private actions that harm endangered species or their habitat. Federal projects are required to have permits issued by the Fish and Wildlife Service determining the impact on species.

Wild and Scenic Rivers Act (WSRA): This legislation designates certain waterways as protected to maintain their natural, free-flowing condition. Congress can designate rivers or states can recommend rivers for designation.

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2013). While the era of massive construction projects (such as the Hoover Dam) is largely over, USACE still conducts a large number of building projects each year, particularly to manage existing water resource projects. USACE maintains the navigability of waterways, conducting maintenance projects such as dredging channel management, maintains flood control structures such as levees, and operates locks and dams on navigable waterways (Allin, 2008). The Corps is also a key player in power generation, managing roughly a quarter of the nation's hydroelectric capacity. In addition, the agency provides leadership and expertise to other federal agencies in construction projects and increasingly in environmental restoration. For example, USACE manages wetland restoration and mitigation projects on federal lands (USACE, 2013).

The Bureau of Reclamation maintains a key role in managing water resources in the western U.S. Today the agency primarily maintains existing water infrastructure, primarily water supply and hydroelectric power projects. The agency maintains over 50 hydroelectric dams and is the largest wholesaler of water in the country (Bureau of Reclamation, 2013a). The impoundments and reservoirs managed by the agency provide considerable recreational benefits; a number of project sites are designated as National Recreation Areas managed by the National Park Service or U.S. Forest Service (Bureau of Reclamation, 2013b). As with the USACE, Bureau of Reclamation is

Major Water Laws

Federal Power Act (FPA): Requires federal licensing of all private hydroelectric facilities. Administered by the Federal Energy Regulation Commission, private entities must go through a licensing process that ensures facilities meet federal regulations, including the CWA and ESA, as well as state water quality and hydroelectric policies.

Water Resources Development Act (WRDA): This name has been given to Congressional legislation passed periodically since 1974, replacing the older River and Harbor Acts of the 1800s and early 1900s. This legislation serves as the primary authorizing law for the USACE and governs most federal actions on navigation, flood control, and maintenance of water infrastructure. The last WRDA was passed in 2007.

Treaties: A number of international treaties govern certain aspects of water policy, including the **North American Free Trade Agreement**, which places restrictions on some aspects of water commercialization, and the **International Boundary Waters Treaty of 1944**, which oversees usage of the Colorado River between the U.S. and Mexico.

increasingly focused on environmental restoration of project sites, though the agency is focused primarily on managing water and hydroelectric sources and providing irrigation water to customers in the western states (Gerlak, 2008).

The U.S. Environmental Protection Agency (EPA) is the primary federal agency in charge of water quality, administering many of the regulations authorized by the CWA and Safe Drinking Water Act (SDWA) (see box "Major Water Laws"). The CWA is a far-reaching piece of legislation, imposing on states water quality standards and a robust process of regulation and permitting. The EPA manages the federal side of these regulations, working with states to establish specific use categorizations for water bodies and operating the NPDES permitting system. States are required to establish technology standards and discharge limits for permitted entities to achieve broad federal water quality standards. If states fail to meet these requirements, EPA is authorized to take over for the state. In addition to regulating point source emitters (sources regulated under the NPDES permit system), EPA increasingly focuses on addressing nonpoint source pollution. Nonpoint sources (NPS) are not regulated under the CWA but are responsible for a large portion of the nation's water pollution (Brown and Froemke, 2012). EPA leads federal policy on NPS pollution by providing technical assistance and funding to states to implement programs aimed at reducing NPS pollution (Allin, 2008).

The purpose of the CWA is specifically to restore all of the nation's waterways to fishable and swimmable. Passed in its current form in 1972, the CWA, along with the 1973 Endangered Species Act (ESA), did more to extend federal authority over water than any previous legislation (Benson, 2006). By tasking the federal government to "restore and maintain the chemical, physical, and biological integrity of the nation's waters" (CWA, s. 101, in Allin, 2008), the CWA provided a legal basis for the federal government to regulate and control both water quality and water supply, an area that was previously the purview of the states. The ESA is administered by the U.S. Fish and Wildlife Service and places limits on federal, state, and private actions that threaten endangered species. This includes projects or actions in regards to water that would damage endangered fish or wildlife habitat. Along with the CWA, this law extends federal authority over water to include environmental quality, through regulation of both water quality and structural habitat (Allin, 2008). Through these two laws, the ability of the federal government to restrict state, local, or private development of water bodies is quite strong (Allin, 2008; Benson 2006).

Water Supply and Infrastructure Policy

Water Use in the U.S.

Water is used a wide variety of ways in the U.S. and these uses vary across geographic regions. Total usage in 2005[1] was over 410,000 million gallons of water per day. Some states use far more water than others, with populous states such as California, Texas, and Florida consuming large amounts of surface and groundwater. Nationally, most water (80 percent) is from surface sources, with groundwater making up the balance (Barber, 2009). The largest use sectors are power generation and agriculture, which together take up more than 80 percent of total usage, with power generation alone accounting for nearly half of the total (Table 1). Electricity production uses large amounts of water to operate electric turbines (mostly electricity, especially that produced by fossil fuel sources, uses turbines that are powered by steam generated by burning a fuel source). Generally, electricity production accounts for a higher percentage of total water usage in the eastern U.S. (Barber, 2009).

[1] The U.S. Geological Survey assesses water usage every five years. The 2010 assessment was delayed and the report is not expected to be released until 2014. 2005 then is the last federal government estimate available.

Agriculture uses most of the water directly through irrigation, which is highly concentrated in the western U.S. Nearly 85 percent of irrigation water is used in the 17 western conterminous states (the same states served by the Bureau of Reclamation). Compared to overall water usage, much of the irrigation water is drawn from groundwater sources (42 percent, Barber, 2009). Unlike power generation, which generally recaptures the water used during generation and recycles it, irrigation water is considered a consumptive use because it is not recycled. Irrigation accounts for nearly 90 percent of total U.S. consumptive use (Schaible and Aillery, 2012). Grain and cotton farming use the most water within the agriculture sector, with sugar cane and beets, tree nuts, fruits, and vegetables accounting for most of the remainder (Blackhurst et al., 2010). Livestock and aquaculture generally use much less water than irrigated cropping systems.

Table 1. U.S. Water Usage by Sector

Sector	Percentage of Total U.S. Usage
Power Generation	49%
Agriculture	31%
Non-domestic Public Supply	11%
Industrial	4%
Livestock and Aquaculture	3%
Mining	1%
Domestic Use	1%

The industrial category in Table 1 represents industrial users who supply their own water, so this excludes industrial users whose water comes from a public supply like a municipal facility (this category make up a fairly small amount of total industrial use). Industrial uses of water include food processing, paper production, chemical manufacturing and petroleum refining, wood products, and metal production. Most self-supplied industrial water comes from surface water sources (over 80 percent; Barber, 2010).

Public supply and self-supplied domestic water account for about 12 percent of total water usage. These sources are primarily used for commercial and residential purposes, including home drinking water and sanitation. Public supplies include both municipal drinking water and sewerage systems and are primarily drawn from surface water sources, though groundwater accounts for a third of withdrawals. Self-supplied domestic accounts for a sizable portion of the rural U.S. population; over 40 million people in 2005 (14 percent of the U.S. population) primarily draw their residential water from private groundwater systems. The proportion of Americans who rely on self-supplied groundwater gradually declined since the 1950s, though total self-supplied domestic water use increased slightly due to offsetting increases in per capita water use. Public water systems are usually maintained by states and municipalities, often in public-private partnerships or contracting arrangements with private utilities (Arnold, 2005a; Perard, 2009). In the western U.S., public water systems often draw their water from federal wholesale sources, especially the Bureau of Reclamation, though the systems themselves are maintained by the local authority (Allin, 2008).

Surface Water Supply Policy

Public supply is largely controlled by state and municipal authorities, though they must abide by federal rules under the SDWA (including drinking water quality standards and public disclosure requirements) and CWA (including effluent standards and NPDES permitting requirements for sewage treatment facilities). Congress created several funding mechanisms to assist state and local governments in meeting federal mandates. The EPA operates the Clean Water State Revolving Fund (CWSRF) and Drinking Water State Revolving Fund (DWSRF), which offer matching loans to municipalities to meet CWA and SDWA requirements, respectively. These funds require a state or municipal match and federal approval of the project, and then the recipient is required to pay back the loan, which goes back into the fund for use by other entities (Allin, 2008; Travis et al., 2004). These loan programs can be used to fund a wide range of projects, including upgrading or creating new public water supplies, upgrading or creating new sewage treatment facilities, combined sewer overflow projects that address surface runoff, NPS projects, and environmental remediation (Travis et al., 2004). Despite the existence of these programs for a number of years[2], there is still a need for overhaul of water supply infrastructure. In 2011, EPA assessed the total national infrastructure needs for just drinking water systems at over $380 billion. Much of this need is for upgrading or replacing transmission and distribution systems, though there is also need associated with treatment facilities, storage capacity, and source development (EPA, 2013).

The area of water supply, including how water resources are allocated among users, has traditionally been the province of states. Allocation policies vary between states; Getches (2001) describes the case that there are 50 different water supply policies in the country. Generally these policies fall into three broad categories: 1) ***riparian rights*** dominate in the eastern U.S., largely due to abundant water resources; 2) ***prior appropriation*** in the western states; and 3) ***hybrid systems***, primarily in the Great Plains and Pacific coast states that combine elements of both riparian and prior appropriation systems (Allin, 2008; Getches, 2001).

Riparian rights reflect English common law principles that date to colonial times, in which landowners bordering a waterway (also known as a riparian area) have the right to use water from that source. In this system, water is treated as a component of the larger set of rights associated with owning a property. Use (or non-use) of the water is largely unregulated by the state in these systems, in that individuals may put the water to which have rights to any particular purpose they wish, as well as start

[2] The CWSRF was created in 1987, the DWSRF in 1996 (Travis et al., 2004)

or stop new uses at any particular time. In times of scarcity, all users of a particular water body are required to reduce use proportionally (Sax et al., 2006). ***Prior appropriation*** developed in the western U.S. during the expansion and settlement era of the 19th century (Tarlock, 2001). Under this system, water is allocated on a first-come, first-served basis. The allocation is treated as a property right that the individual owns. This allocation can be mortgaged, transferred or sold, and even taxed in some states (Allin, 2008). This allocation system typically requires that the water be used for a beneficial use and maintaining the water right relies on continuing to put the water to a beneficial use (Sax et al. 2006). This contrasts with riparian rights, where water rights are tied to the land property and the water right itself is not tied to the use of that water (Allin, 2008). ***Hybrid systems*** combine these two approaches, where most allocations are made through prior appropriation but riparian landowners are granted water rights similar to those in riparian rights states. In these states, uses of water by riparian landowners can be generated at any time, though with some restrictions on quantity, and they are not transferrable like the first-in-time rights given to other users in the state (Allin, 2008).

Groundwater Policy

Groundwater rights are typically treated under a different system from surface water rights, though the larger national trend is the same (Allin, 2008). Typically, eastern states allow landowners to use groundwater from underlying aquifers and western states appropriate groundwater to users in a way similar to surface water (Sax et al., 2006). Groundwater allocation is becoming increasingly complex as states face growing concerns with depletion of aquifers (Allin, 2008). Groundwater is primarily a western issue, as two thirds of groundwater use occurs in the 17 conterminous western states. As pointed out above, groundwater usage is primarily driven by irrigation for agriculture (Barber, 2013).

Groundwater is inherently different from surface water in ways that impact use, management, and institutional structures to regulate or guard resources. For example, surface water is easily seen and the impacts of individual users on the amount of resource available are relatively easy to surmise. Groundwater impacts on the other hand are harder to gauge. Groundwater resources tended to be developed later than surface water resources due to technology limitations in the first half of the 20th century and federal government investment in developing abundant surface water capacity. After technology made well-digging cheaper and more efficient, developing new groundwater sources was easier for landowners than developing surface water. Just as federal-level institutions and policies developed alongside government investment in major surface water projects in the early 20th century, state-level water allocation policies were largely arranged before most groundwater resources came into use (Schlager, 2006). Many states attempted to use similar policies with groundwater as they had established for surface water (i.e. prior appropriation), despite the inherent differences in technical capacity for individuals to install groundwater pumping systems and the difficulties in regulating and monitoring use (Getches, 2001; Schlager, 2006).

Groundwater can generally be divided into two categories based on biophysical properties: 1) non-tributary basins, where there is no hydrological connection to surface waters; and 2) tributary basins, which are connected to surface waters. Western states in general do not manage these sources separately, despite the clear connection in the case of tributary groundwater basins with existing surface water rights. Whereas western states quickly established surface water allocation systems early in their existence (many even have prior appropriation enshrined in their state constitutions), they were slower to identify how they would manage groundwater. Early on, most states relied on a simple doctrine of “reasonable use”. Under this system, any landowner could develop and use groundwater resources that they could reasonably use (“reasonable” being an undefined term). New Mexico was the first western state to replace this with a more robust framework of prior appropriation in the 1920s. Arizona was the last state, waiting until 1980 to implement a groundwater law (Schlager, 2006). Nebraska is the only western state that has since modified their water laws to treat groundwater and surface water rights under the same system. In other states, the connections are still largely ignored and treated differently. Generally, wells are treated on a prior appropriation basis; landowners with existing wells at the initial time of regulation are given priority and new potential users are required to obtain permits from the state. Under this system, junior landowners may be denied a permit or be required to stop pumping if state agencies determine the aquifer is overdrawn. In the case of tributary basins, groundwater rights are nearly always junior to the surface right, so during shortages, groundwater users are generally required to cut back. Those with groundwater rights on non-tributary basins are generally unaffected by seasonal fluctuations; however, these aquifers generally have slow recharge times and are more suspect in terms of their sustainability (Schlager, 2006).

Prior appropriation systems generally developed due to water scarcity, where early pioneers, who assumed great risks in establishing themselves in an arid environment, benefit from certainty of access to water. However, this system has been criticized for encouraging development and use of water and discouraging conservation. A key tenet of prior appropriation is beneficial use, which is essentially a “use it or lose it” system. Water appropriators are incentivized to maximize their allocation or risk losing that right in the future (Getches, 2001). Under this system, relatively inefficient uses are socially and legally institutionalized, including irrigation systems subject to evaporation and inefficiency (Alley 2006; Schaible and Aillery, 2012), as well as rapid growth in urban areas serviced by subsidized water sources (Schlager, 2006; Tarlock, 2001). This resulted in increasing pressure on western water resources, both surface and subsurface; many sources are over-allocated creating concerns about the future of major aquifers (Alley, 2006).

Water Scarcity and Efficiency Policy

Water use increased throughout the 20th century, peaking in the 1970s and 80s before declining slightly thereafter. Water usage increased over 200 percent between 1950 and 2000, driven by but outpacing population growth (population increased 90 percent over the same period) as standards of living and increases in electricity usage and irrigated agriculture led to increasing withdrawals (Allin, 2008). The decline in water withdrawals after 1980 was primarily driven by increasing efficiency in the electricity and agriculture sectors; the nation uses less water for irrigation now than in the 1970s, despite irrigating more acreage overall (Barber, 2009). Growing domestic and public uses of water led to concerns, especially in the fast growing southwestern states (which also happen to be the most arid), with the sustainability of current supplies. These concerns drive policies at the federal, state, and local levels to increase efficiency and conservation of water (Getches, 2001). As with other aspects of water supply policy, this is primarily addressed through state policies, with federal leadership and funding to support state actions (Allin, 2008).

A number of states adopted initiatives and programs aimed at increasing efficiency and decreasing overall use. Western states in particular led the charge in efficiency efforts as population growth, especially in urban areas, stretches existing supplies. State efforts to increase efficiency include (adapted from Allin, 2008):

- Water loss management policies to repair water transport infrastructure and reduce losses to leaks and waste
- Water reuse and recycling programs to improve use efficiency in domestic and urban settings
- Market mechanisms to incentivize use efficiency and conservation
- Cooperative water management to improve collection and transport at the regional level
- Conjunctive land use and water planning

Many of these efforts are aimed at fixing problems perceived by some to be driving inefficient use, including water pricing and fragmented decision-making. Water pricing in the U.S. has been described as subsidized; especially in the western U.S., public water supplies largely come from government public works, which results in taxpayer subsidized infrastructure and artificially low prices. This increases use over market-efficient levels and decreases the incentive to target waste and inefficiency (McCool, 2005). Water management decisions are made at a variety of levels, with municipalities, industrial users, and irrigators often competing for the same existing resources (Hayes, 2003). Increased scale and collaboration increase institutional capacity to deal with water scarcity and improve system efficiencies (Abbott and Cohen, 2009; Gerlak, 2008). In addition, integrating land use decisions (especially development and green space planning) can have beneficial impacts on water supplies, including improved efficiency for transportation and storage infrastructure and improved recharge of ground and surface water (Arnold, 2005b; Makar, 2010).

At the federal level, policies concerning efficiency and conservation developed slowly and focus primarily on reporting and leadership. Federal agencies, including the U.S. Department of Agriculture and EPA, report low levels of efficiency in water systems compared with other countries, outlining the areas where states can improve (Allin, 2008; O'Neill and Dobrowolski, 2005). The Department of the Interior started a program in 2003 focused on addressing water shortages, called Water 2025. This program offers federal consultation to states, local governments, and tribal entities on water supply issues and conflict resolution. In addition, the program offers a grant program to fund small projects aimed at improving efficiency and water markets. The EPA operates a WaterSense program aimed at establishing public-private partnerships around efficiency labeling of appliances and education of water consumers. Despite interest from administrative agencies on water supply and scarcity issues, Congress in the 2000s was less focused on these issues, focusing instead on water quality (Allin, 2008).

As in all areas of water policy, collaborative governance arrangements are becoming more common to address water scarcity. At the state level, California has been a leader in encouraging conservation and efficiency in water supply systems, and leads a collaborative initiative known as the California-Federal Bay-Delta Program (CALFED). This effort is designed to better coordinate management actions by agencies at the state and federal level in central California and has 23 agencies collaborating on "a single, comprehensive plan for the entire region" (Gerlak, 2006). The California Department of Water Resources is a key agency in this collaborative process, emphasizing water scarcity and conservation through their California Water Plan, currently undergoing an update in 2013 (Department of Water Resources 2013). This plan addresses a wide range of state priorities, including developing new and non-traditional supplies (including desalination), conjunctive land and water development, and especially efficiency. In the 2005 plan, use efficiency was the top state priority. The collaborative CALFED body also focuses on improving efficiency at all levels of water management in California (Allin, 2008).

Water Quality and Ecosystem Policy

Evolution from Point Source to Nonpoint Source Pollution Control

Despite the existence of strong national policies concerning water pollution (over 40 years in the case of CWA), water quality is still a major national concern, though the threats have shifted somewhat over time (Hoornbeek, 2004). In the 1970s, national attention was focused primarily on water pollution from point sources; pollutants of concern included heavy metals, petrochemicals, toxic chemicals such as polychlorinated biphenyls (PCBs), and bacteria from sewerage systems (Gerlak, 2006; Zellmer, 2009). Industrial pollutants in particular were the initial impetus for passage of the CWA in 1972 (Hoornbeek, 2004). The primary mechanisms in this law, particularly the focus on technology standards and permitting through NPDES, were designed to deal with point source pollution. These provisions in policy required regulators to have good information about the sources of pollution and be able to identify the responsible parties (Hoornbeek, 2004). Since the 1970s, industrial pollution problems have been reduced substantially (Brown and Froemke, 2012). The focus on industrial facilities required rethinking of the purpose of waterways. Once seen as a way primarily to remove waste from an area, whether from a factory or municipal sewer system, the increased focus on environmental quality required facilities to pay attention to the pollutants in both effluents and receiving waters (Zellmer, 2009). Other laws, including the SDWA and ESA, attached other public health and environmental benefits to water, encouraging government regulators and private entities to consider the holistic benefits of the waters they discharged into (Gerlak, 2008).

Policy reflecting the increased concern with holistic environmental management was codified in the 1992 amendments to the CWA with the creation of the Total Maximum Daily Load (TMDL) process. The TMDL system classifies waterways based on their intended uses, and identifies whether the water quality is sufficient to allow that intended use. These uses can range from supporting fisheries and aquatic communities, to recreation and drinking water, to industrial and agricultural uses. Waterways are classified as fully supporting or impaired based on water quality. A water body is considered impaired if the quality is insufficient for that water body to be used for its intended use (Hoornbeek, 2004). After classification, EPA, working with state and local authorities, can begin a TMDL process, which identifies that amount of pollution that water body can take while still meeting quality standards. These quantities are then allocated among different users, including point sources through the NPDES system and voluntary reductions targets for nonpoint sources. Whereas the permitting system and early CWA provisions focused primarily on effluent standards and reducing or eliminating pollutants, the

TMDL process places the focus on the receiving water. By incorporating both water quality standards (such as would allow for human consumption) and fish and wildlife concerns into one governance structure, the TMDL process attempts to move all of the nation's waterways into full environmental compliance (Boyd, 2000). In addition, the process focuses on watershed-scale problems that cut across traditional governance boundaries and attempts to involve a variety of stakeholders in the identification, allocation, and implementation stages (Boyd, 2000; Dowd et al., 2008). Despite the emphasis on collaboration and stakeholder input, the TMDL process has been subject to conflict and controversy. Scientific assessment of pollution problems has not necessarily decreased uncertainty among agency personnel and stakeholders, leading to conflicts over pollutant load allocation and waterway classification (Caudill and Curley, 2008).

While the initial mechanisms in the CWA were particularly effective for decreasing industrial pollutants, they did little to curb the impacts of NPS pollution, which is currently the leading source of water quality impairment in the U.S. (Brown and Froemke, 2012; Dowd et al., 2008). NPS source pollutants include excess nutrients (especially nitrogen and phosphorus) from agricultural and residential use of fertilizers, pesticides and other chemicals from agriculture, petrochemicals from roadways, and sediment (Dowd et al., 2008). Excessive nitrogen in particular is a major and growing problem in the agricultural Midwest, contributing to impairment of waters throughout the Great Lakes and Mississippi River basins and hypoxia (low dissolved oxygen) in the Gulf of Mexico (Davidson et al., 2012). These pollutants come from numerous and diffuse sources; while in the past it was seen as impossible to identify the sources of these pollutants, improved monitoring and modeling have increased the information available to regulators, scientists, and the public (Dowd et al., 2008). This has generally resulted in greater public concern with water quality (Gerlak, 2008), though there is a tendency for segments of society to place the blame on other groups, such as suburban residents blaming agriculture for nutrient runoff when lawn fertilizers contribute to the problem as well (Larson et al., 2009).

It was not until the 1987 amendments to the CWA that one of the primary mechanisms for addressing NPS pollution was created. Known as the 319 program after the section of the act authorizing it, this program offers planning and implementation grants to watershed-based organizations focused on addressing runoff from urban areas, roadways, agricultural fields, and other sources (Dowd et al., 2008; Hoornbeek, 2004). Congress has chosen to limit direct regulation of nonpoint sources, specifically exempting groups like farmers from regulatory efforts like NPDES permits (with the exception of large confined animal operations). Decreasing NPS pollution relies primarily on voluntary efforts by individual actors, supported by government programs. Typically government policies rely on providing financial incentives, either through tax breaks or payments, technical assistance, and education to individuals to change behaviors (Dowd et al., 2008). In the agricultural sector, there has been increased focus on providing financial incentives and technical assistance to farmers in exchange for adoption of best management practices (BMPs). The federal government operates a variety of programs, including the Conservation Reserve Program and Environmental Quality Incentives Program, which have water quality goals among others. These programs offer rental payments, cost share payments, and technical assistance to incentivize adoption of BMPs to protect water quality (Napier, 2009; Reimer, 2012). In addition to the 319 program, EPA operates a variety of education programs aimed at educating farmers, landowners, and urban residents about water quality, the impacts of various behaviors, and methods for reducing pollution (Hoornbeek, 2004).

Watershed Management and Market Mechanisms

Figure 3. An example of a watershed approach to water management in Georgia.

The 319 program has enabled more local and grassroots efforts to lead voluntary and community-based efforts to reduce pollution (Lubell, 2004a; Weber 2003). Within the water quality realm, federal, state, and local policies are increasingly focused on the watershed scale, which inherently ties water quality to land use and NPS issues. Watershed-scale projects focus on building local capacity, improving awareness and promoting adoption of new behaviors to effect improvements in water quality, and monitoring long-term impacts (Dowd et al., 2008; Weber, 2003). The federal government largely supports these efforts through funding and technical assistance, both through the 319 program and National Estuary Program (NEP), as well as other grant programs, including an environmental education grant program (Dowd et al., 2008). Federal efforts also focus on coordinating action among various agencies, for example coordinating USDA cost-share programs aimed at agricultural producers and EPA 319 programs (Lubell, 2004a). Partnerships between state and federal agencies typically center on multi-goal water efforts, and increasingly include grassroots citizen involvement. To address more diffuse sources of water quality impairment, it was increasingly seen as necessary to engage broad audiences in voluntary actions (Lubell, 2004a; Weber, 2003). Citizen involvement in water policy is also described as a way to avoid conflicts that had dominated coordination efforts in the 1970s and 80s (Gerlak, 2006). Community-based collaborative watershed-scale projects show some great promise in achieving water quality improvements (Adler and Straube, 2000; Mawhorter, 2010; Weber, 2003), while also being criticized for being piecemeal and more focused on achieving social goals, such as building community capacity and social capital, than actual environmental improvements (Lubell, 2004b; Raymond, 2006).

There is increased interest in bringing market mechanisms to bear on water quality (Shabman and Stephenson, 2007). Market mechanism champions argue they provide a way to bridge regulation of point sources with voluntary actions to reduce NPS pollution (Woodward and Kaiser, 2002). Under discharge permit trading schemes, regulated point sources with discharge limits through the NDPES system are allowed to "trade" reductions with nonpoint sources. Long a focus of academic work, a number of trading programs have proliferated; the EPA reports that 25 programs are in some stage of development and implementation. These programs take a number of forms, including:

- *exchanges*, where permits are traded in an open market;
- *bilateral negotiations*, where trades are worked out between buyer and seller;
- *water-quality clearinghouses*, where government agencies serve as an intermediary, buying pollution reductions and then selling those reductions as variances; and
- *sole source offsets*, where polluters are allowed to reduce pollution somewhere else in exchange for variances in their normal waste stream (Woodward and Kaiser, 2002).

Most programs to this point have followed a bilateral negotiation form due to a large diversity in buyers and sellers and high variability in the goods involved (in this case the "good" is pollution abatement) (Malik et al. 1993; Woodward and Kaiser 2002). More stringent point source pollution abatement is often expensive, particularly since the least expensive point source abatements are already in place. In many cases additional pollution reductions can be made at lower cost by nonpoint sources than by point sources. To facilitate this, market programs allocate pollution permits under the TMDL structure and then allow those permits to be traded between point and nonpoint sources. Abatement is then carried out by the lowest cost abaters in a trading region. These trading regions are typically established at a relatively small scale such as a regional watershed to reduce transaction costs and facilitate trades (Hoag and Hughes-Popp, 1997; Malik et al., 1993; Shabman and Stephenson, 2007).

Policy Devolution and Adaptive Management

Water pollution policy is a devolved system, where mandates and standards are set by the federal government but technical implementation of programs is done by states. In the early era of federal pollution control policy (prior to 1990), when the focus was primarily on point sources, the focus at the state level was on agency capacity building and compliance with federal standards. There was little variation between states in implementation of policies under the CWA and SDWA (Hoornbeek, 2004). As concerns shift to NPS control, there is more variation in state action, with some states more aggressively creating and implementing programs than others (Mawhorter, 2010). States appear to respond to a complex set of political, economic, and governance factors rather than a simple analysis of public concern and identifiable problems. The federal focus on grant-based programs to incentivize individual actions as well as state-level policies has not necessarily resulted in more aggressive actions by all states. Rather, a few states act as policy innovators, with new policy approaches trickling out more slowly to other states, largely based on variations in state-level agency capacity (Hoornbeek, 2005). Institutional culture and capacity are barriers to policy change at all levels and across policy arenas, but given the highly fragmented nature of water governance, differences in cultures can hinder both policy adaptation and collaboration between agencies (Mawhorter, 2010). These barriers can hinder the ability of policies to deal particularly with large-scale problems with diffuse sources, potentially requiring more flexible agencies and policies that emphasize adaptation and collaboration (Adler and Straube, 2000; Dowd et al., 2008; Gerlak, 2008).

Despite the institutional fragmentation and existing obstacles to collaborative management, increased collaboration among water and environmental management agencies is driven by pragmatic concerns, particularly the connections between water quality and supply/management (Gerlak, 2008). Many water quality concerns, especially those stemming from NPS, are driven by land use policies or past management decisions, including damming and modification of stream courses, lack of effective barriers to keep runoff out of waterways, and disorganized urban growth that stretches water resources and promotes inefficiencies (Adler and Straube, 2000; Gerlak, 2008). Increasingly policies look beyond the traditional areas of control, such as state water rights policies and federal pollution control laws, to emphasize collaborative, ecological management of water resources (Richter et al., 2003). The emphasis in these systems is on integrated, results-oriented policies that incorporate adaptive management principles (Mawhorter, 2010). Adaptive management encourages agencies to establish policy "experiments", where efforts are implemented on a trial basis, information collected, and strategies revised as lessons are learned by the agencies involved. Adaptive management relies heavily on ongoing monitoring as well as an open, communicative policy process that includes input from stakeholders, scientists, and agency personnel (Gerlak, 2008).

The emphasis on holistic environmental management led to increased emphasis on ecological restoration, focused on restoring natural systems where possible to both improve water quality and increase water availability (Mawhorter, 2010; Gerlak, 2008; Richter et al., 2003). By 2000, there was a push to invest meaningfully in landscape-scale restoration efforts around water systems. Among the most noteworthy examples of this shift was Congress' inclusion of the Comprehensive Everglades Restoration Plan (CERP) in the 2000 Water Resources Development Act. Headed by USACE and the South Florida Water Management District, the goal of CERP is to coordinate agency actions and increase investment in ecological restoration in south Florida and involves a wide range of federal, state, and local partners. The plan is intended to result in improved water storage capacity, water quality, and distribution among different users (Perry, 2004). A variety of other existing programs, including CALFED, Colorado River management, and the Chesapeake Bay Program, now incorporate ecological restoration as a major management goal. Adaptive management has been a heavy emphasis in the Florida Everglades restoration as well as other efforts, which is a massive project expected to take decades and billions of dollars of investment. Many of the early efforts in the Everglades use an experimental approach, with a heavy emphasis on data collection and institutional learning (Gerlak, 2008). These types of projects are indicative of where water policy has evolved: large, landscape-scale efforts relying on active partnerships between federal, state, local, and private entities to achieve a range of goals, including water quality, quantity, supply, and distribution (Adler and Straube, 2000).

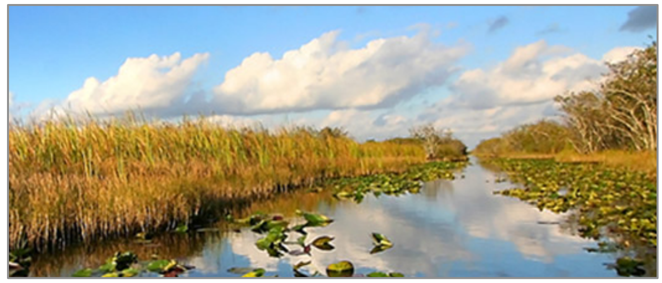

Figure 4. The Florida Everglades restoration effort is an example of devolved, cooperative management of water resources. The CERP effort is a collaborative arrangement involving a number of agencies, including the USACE and Florida water management agencies.

Analysis and Conclusions

Water policy in the U.S. evolved dramatically from the founding of the country through the 21st century, and is now a complex, diverse, and fragmented system. Under the current water policy regime, a multitude of agencies control of various aspects of water policy, from local and municipal governments managing drinking water and sewer systems, to state governments operating complex and varied water allocation rubrics, to federal agencies managing hundreds of water supply projects geared toward meeting multiple goals. This complex system is a result in part of federalism in the U.S.; many scholars use water policy to elucidate trends in federalism over the past 250 years (Benson, 2006; Gerlak, 2006; Gerlak, 2008; Getches, 2001; Hoornbeek, 2008; McCool, 2005). In part the fragmented nature is a result of changing conceptions and values of water in American society. The evolution of water policy can be viewed as reactive and problem-based, with the perceived problems changing greatly over the course of American history.

In the early stages of the nation's development, water was a plentiful resource. Settlement occurred from east to west, generally following the gradient in water availability (Holmes, 1972; Zellmer, 2009). Low population densities and levels of industrialization meant early Americans had little concerns with water quality. Rivers and streams could effectively be used to remove waste with little impact on intended uses (Zellmer, 2009). In the 19th century, the major water concerns were related to overabundance. The largely agricultural economy required extensive clearing of land for farming, including draining wetlands and controlling seasonal flooding. Waterways also made for effective transportation avenues. These concerns were reflected in the original mission of the oldest and largest water management agency at the federal level, USACE (Gerlak, 2006).

As settlement moved west, the concerns shifted to water scarcity. In the eastern states little thought or attention was needed in establishing water rights; water allocation policies were simply adopted from the British colonial rules. As settlers moved into more water-scarce regions, there was a need to develop new systems of allocation. Establishing industry and habitation in a water scarce area is risky and new states and territories respected the original risk-takers by guaranteeing their water rights, leading to the prior appropriation rules that dominate the western states (Allin, 2008; Getches, 2001). Additionally, the federal government invested substantial resources in developing large water supplies, damming rivers and tapping groundwater resources to enable large-scale agriculture and development in the western states (Gerlak, 2006; Holmes, 1972). Population growth and industrialization took their toll on water quality throughout the 20th century and by mid-century there was growing emphasis on protection the environment. This was not just a reaction to the biophysical realities but also driven by social and economic changes to the country; the environmental movement of the 1960s largely drove the major changes to water pollution policies in the 1970s (Gerlak, 2006; Zellmer, 2009).

Improvements in science and changing environmental values continued to push water policy at all levels in the last decades of the 20th century towards more integrated and multi-goal management of water resources. By this time however the existing institutional and governance capacity and infrastructure was already long established. Agencies such as USACE and the Bureau of Reclamation have largely shifted their missions, incorporating more environmental and planning capacity (Gerlak, 2006). Despite this, the perceived challenges in water policy confound the existing structure of management. Shifts towards more collaborative, integrated management are a necessary and pragmatic step but that does not mean can be accomplished easily (Mawhorter, 2010). Cross-boundary and cross-agency collaborations such as CALFED and Colorado River management experience conflict and institutional inertia. Calls by academics and agency professionals for improved management based on ecological principles, including greater emphasis on conjunctive land and water planning and watershed based approaches (Adler and Straube, 2000; Arnold, 2005b; Mandarano et al., 2008; McCool, 2005) are easier said than implemented (Hoornbeek, 2005; Mawhorter, 2010).

The fragmentation of water policy and infrastructure will continue to pose challenges for the U.S. as the nation faces a variety of water problems. These include growing scarcity concerns (O'Neill and Dobrowolski, 2005; Makar, 2006), the sustainability of surface and groundwater sources (Alley, 2006; Schlager, 2006), diffuse and insidious NPS pollution (Davidson et al., 2013), and the ecological sustainability of water ecosystems (Gerlak, 2008; McCool, 2005). These challenges have persisted for decades and will continue to be challenges in the future even with the relative consistency in water availability that characterize the past century. Climate change however throws that consistency out the window; climate change threatens to dramatically change the distribution and availability of water resources throughout the country (Adler, 2010).

Climate change is projected to increase both the annual and seasonal variability in precipitation, decreasing overall quantities of water in several regions of the country, including the already water-scarce southwest (Adler, 2010; Makar, 2010). Climate change is expected to negatively impact agriculture especially. Annual variations in temperature and precipitation are vital concerns for agricultural producers in particular. While some production agriculture zones may benefit from certain aspects of climate change, such as longer growing seasons and increased yields from CO_2 fertilization, other aspects of production are likely to be negatively impacted (Hatfield, 2012; Redden et al., 2011; Southworth et al., 2000; Wuebbles and Hayhoe, 2004). Climate change-induced water variability is of particular concern (O'Neill and Dobrowolski, 2011). Climate change is likely to lead to changes in precipitation patterns in many regions, including increases in winter and spring precipitation and decreases in summer precipitation, both of which may have negative impacts on agriculture (Winkler et al., 2012; Wuebbles and Hayhoe, 2004). Increases in temperature and summer evapotranspiration may decrease yields in warmer, drier regions through heat stress (Southworth et al., 2000). Increased pest damage is also possible under future climate change scenarios (Simberloff, 2000; Wuebbles and Hayhoe, 2004). Furthermore, extreme weather events associated with climate change, including droughts, floods, and storm events, can cause disruptions to agriculture (Hatfield, 2012; Rosenzweig et al., 2001). Increased need for irrigation systems, already a major use of water in the west, could lead to increase strain on water supplies in these states (O'Neill and Dobrowolski, 2005).

Increased water demand and decreased supply is likely to change how states allocate water rights to users (Adler, 2010), as well as how states and the federal government manage water supplies (Arnold, 2005b; Makar, 2010). Western state water allocation policies are already in flux, with court decisions eroding the traditional view of "first in time, first right" (Benson, 2006; Getches, 2001). Substantial gains can be made in water use efficiency, in urban settings (Allin, 2008; Makar, 2010) and in agriculture (O'Neill and Dobrowolski, 2005). Efficiency alone will not be sufficient to ensure sustainable water supplies however; with growing populations and increased economic activity, reductions in overall use are the ultimate goal (Allin, 2008). Thus far state governments are leading the charge on water efficiency. The federal government will likely need to increase activity in this area to ensure the viability of water resources in coming decades. In an era of strained state budgets, federal capacity will also be needed to assist states and municipalities deal with eroding infrastructure (Allin, 2008).

The fragmented structure of water policy and water agencies poses challenges to management but it can also be an asset. Future variability in water resources due to climate change will require greater flexibility and adaptation in both policy and the institutions that operate them (Adler, 2010; Mawhorter, 2010). Federal agencies have shown the ability to adapt and change in the past; their ability to do so in the future will be crucial to the long-term management of water resources. Emphasis on local, grassroots action in the NPS pollution arena can be a valuable structure in the holistic management of water resources (Weber, 2003), as long as those efforts are supported by a robust federal and state structure (Gerlak, 2008; Mawhorter, 2010). The goals of water policy in the future will need to emphasize these aspects of flexibility and resilience that will allow institutions to shift emphasis as needed to react to problems as they develop. U.S. water policy has been largely reactive in the past but too often has waited until problems are full blown before addressing them (as in water pollution policy). Improved information and monitoring are assets that water agencies have started to utilize through adaptive management principles. Collaboration and information-sharing between agencies at all levels have characterized water policy over the past 20 years (Gerlak, 2008). The challenge will be to use the collaborative capacity built up in recent decades to build resilience into the system to ensure sustainability of water resources in the future.

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