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Irrigation Organizations:

Water Inflows and Outflows

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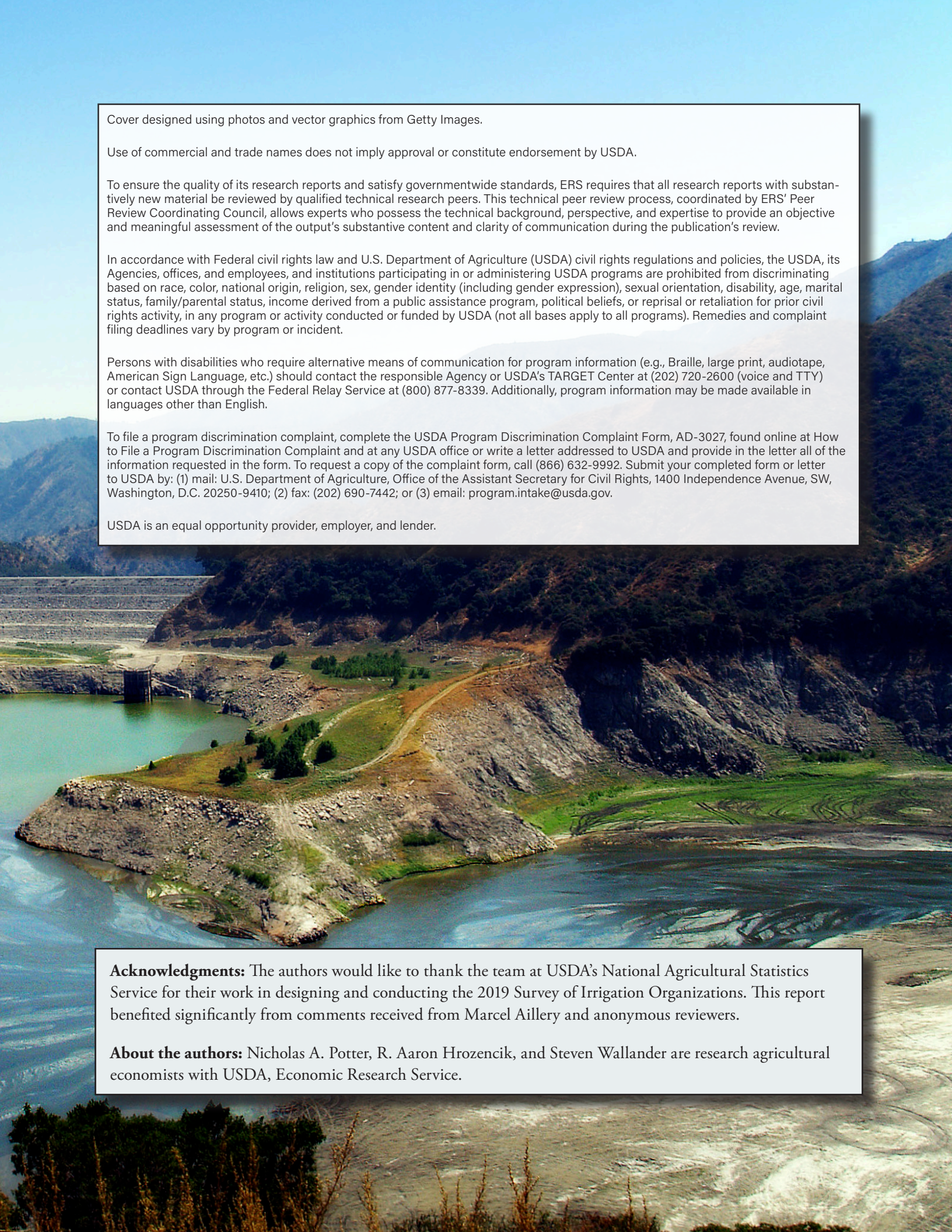
Abstract

The USDA's 2019 Survey of Irrigation Organizations provides information on the quantities of water supplied to and delivered by irrigation water delivery organizations. This report examines these delivery organizations inflows and outflows and the extent of water transfers both within and across delivery organizations. Inflows to irrigation water delivery organizations make up nearly half of the average surface freshwater withdrawals in the United States and are especially important in more arid western regions. Much of the water flowing into delivery organizations' systems comes from Federal water projects or is directly withdrawn from natural surface water bodies. Most water delivered by organizations goes to farms and ranches, with the remainder going to municipalities and domestic or other users. Among those organizations engaging in water transfers in 2019, transfers between water users within an organization were more common than external transfers (leases) between delivery organizations and other organizations or entities. However, since external transfers tend to be large quantities of water, the total amount of water transferred by users within organizations was smaller than the total water leased by organizations.



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Summary

Irrigation water delivery organizations play a key role in conveying water for use on farms and ranches and nonagricultural uses in the United States. However, little information is available about the origins and destinations of water that flows through irrigation water delivery organization systems. Increasing water demands and declining groundwater aquifers have intensified stress on available surface water supplies, particularly in dry years when surface flows are most limited. Climate change is projected to increase the frequency and severity of droughts, as well as reduce snowpack and change the timing of runoff (Musselman et al., 2021), further increasing stress on water resources. An accounting of the quantities of water flowing into and out of delivery organization systems is important for responding to increasing water stress and understanding its implications for irrigated agriculture, ecosystem services, and other water uses.

Irrigation plays a substantial role in crop production in the United States. Nationally, about 6 percent of agricultural land and 17 percent of harvested cropland is irrigated. However, fully irrigated farms account for 30 percent of all crop sales, and farms with at least some irrigation account for 54 percent (USDA, National Agricultural Statistics Service, 2018). Irrigation water delivery organizations provide water for much of this production, serving about 260,000 farms of which 240,000 received water in 2019. Delivery organizations provide water for 19 million irrigable acres, or approximately a third of all irrigated harvested cropland in the United States.

Estimates of water used for agricultural irrigation can vary due to differences in the year of collection, the data source (e.g., estimation from irrigated area, surveyed farm, or surveyed irrigation organization), the location of measurement (e.g., water applied on-farm or water diverted from a stream or lake), and variation in survey response and estimation methods. To summarize key differences in the inflows and outflows water delivery organizations manage at the regional scale—which affect estimates of water used for irrigation—the report addresses some basic questions:

- How much water is received and delivered by irrigation water delivery organizations, and how does that relate to water withdrawals as a whole and for irrigation specifically?
- Where does the water used by delivery organizations come from, and how does that vary by region and size of the organizations?
- Where does water delivered by these organizations go, and how much water exits these delivery systems?
- To what extent do delivery organizations engage in water marketing through leasing water into or out of their systems?
- How much water is transferred between users within an organization?

Key findings from this report include:

- In the western United States (the Northwest, Pacific, Southwest, and Eastern Rockies regions), more than 80 percent of fresh surface water withdrawals are managed by irrigation delivery organizations.
- In the central and southeastern United States (the High Plains and Southeast regions), where more irrigation water comes from on-farm groundwater wells or surface water sources, irrigation organizations deliver about a third of all water used for irrigation on farms and ranches.
- In every U. S. region except the Southeast, direct diversions of surface water or water contracted from Federal sources make up more than 60 percent of water inflows to delivery organizations.
- Large delivery organizations (serving at least 10,000 agricultural acres) receive about half of their water supply from Federal water project storage facilities, while small delivery organizations (serving less than 1,000 acres) and medium-size delivery organizations (serving 1,000 to 10,000 acres) rely more on direct diversions from natural water bodies.
- Water marketing (leasing of rights to water by delivery organizations or between users within a delivery organization) accounts for a relatively small share of total water inflows.
- Water marketing is most common in the Pacific Region, where 17 percent of irrigation organizations engage in leasing for water that accounts for 9 percent of total regional inflows.
- In western regions other than the Pacific, transfers between users served by an irrigation delivery organization occur in about 10 percent of organizations.

This report is fourth in a series of economic bulletins that draws on data from the USDA's 2019 Survey of Irrigation Organizations (SIO) to provide basic statistics on key topics related to irrigation organizations and irrigated agriculture in the United States. For additional information, this report uses the U.S. Geological Survey's (USGS) National Water Use Information Program reports (2005, 2010, 2015), and USDA's 2018 Irrigation and Water Management Survey (IWMS).

Overview of Delivery Organizations' Inflows and Outflows

Nearly a third of all water withdrawn for irrigation is managed by irrigation water delivery organizations. These delivery organizations serve as intermediaries that deliver water from water sources to farms, ranches, and other users, coordinating investment in conveyance infrastructure and managing limited water supplies during drought (Bretsen & Hill 2006; Libecap, 2011; Ostrom, 2011).

The USDA's 2019 Survey of Irrigation Organizations (SIO) collected novel information on the quantities of water supplied to and delivered by irrigation water delivery organizations, providing previously unavailable information on the water resources these organizations convey (see the "2019 Survey of Irrigation Organizations" text box for more information). This report—the fourth of a series of economic briefs that summarize information from the SIO—provides an accounting of water flows into and out of delivery organizations, as well as how these flows relate to water withdrawals for all uses and water used for irrigation from all sources.

This report focuses on those irrigation organizations that indicated having inflows and outflows that were greater than zero in 2019 and were not pass-through organizations (which store and deliver water to irrigation organizations but not directly to farms and ranches; see the "2019 Survey of Irrigation Organizations") or primarily hydroelectricity organizations.[1] This excludes organizations that are engaged only in groundwater management. Although groundwater makes up half of all water used for irrigation (USDA, National Agricultural Statistics Service, 2019), water inflows to delivery organizations are almost entirely drawn from surface freshwater sources.[2]

Historically, little information has been available on water flows conveyed by irrigation organizations in the United States, despite the importance of the flows' role in water-supply management and allocation. Information on irrigation organizations was collected as part of the U.S. Census of Irrigation Organizations until 1978, but the Federal Government did not collect further information on delivery organizations until the 2019 SIO. An additional source of irrigation water use data is the Irrigation and Water Management Survey[3] (IWMS), a follow-on sample survey of farms reporting irrigation in the Census of Agriculture. The IWMS, conducted roughly every 5 years since 1978, surveys farms and ranches on their irrigation water use and water management practices. The 2018 IWMS includes information on the quantity of applied irrigation water on a field that is sourced from off-farm providers but does not ask about water lost during on-farm conveyance or water received at the farmgate. In contrast, the SIO provides information on the sources of inflows to delivery organizations and the destinations of outflows to water users, providing an estimate of water delivered to the farmgate.

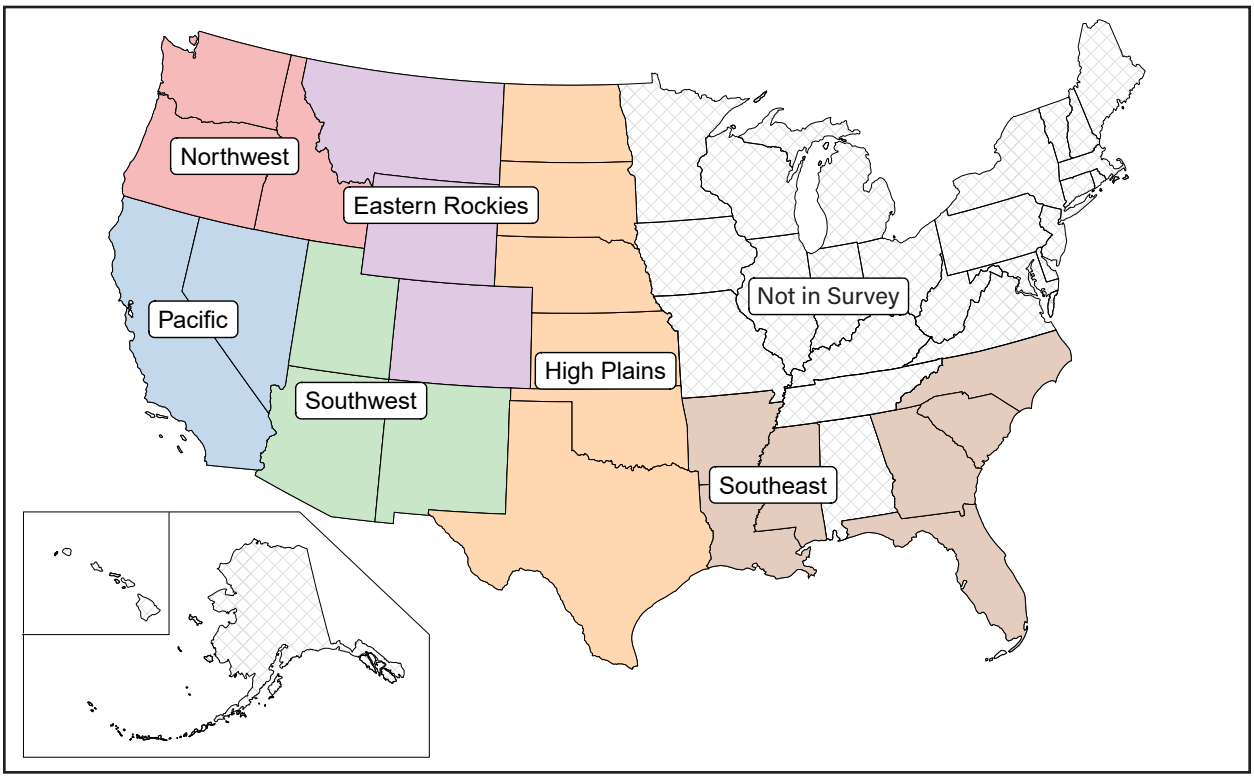
Throughout this report, delivery organizations are often grouped by region, organization type, or organization size. Regional definitions match those used in USDA, NASS (2020) and are shown in figure 1. Organization size reflects the number of irrigable acres to which the organization could have supplied water—small (supplies water to less than 1,000 acres), medium (1,000 to 10,000 acres), and large (to more than 10,000 acres). Irrigable acreage is the amount of land that could have received irrigation water from the organization in 2019.

[1] Organizations were determined to be primarily hydroelectricity organizations if the organizations had hydroelectricity sales and deliveries to farms and ranches that were smaller than outflows for all other uses combined (which includes electricity generation).

[2] 1.7 percent of all water inflows to irrigation water delivery organizations is from groundwater.

[3] Prior to 2018, the Irrigation and Water Management Survey was previously named the Farm and Ranch Irrigation Survey (FRIS).

Figure 1
Survey of Irrigation Organization Regions



Note: USDA, National Agricultural Statistics Service (NASS) SIO regions are as follows: Eastern Rockies (Colorado, Montana, and Wyoming); High Plains (Kansas, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas); Northwestern (Idaho, Oregon, and Washington); Pacific (California and Nevada); Southeastern (Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, and South Carolina) and Southwestern (Arizona, New Mexico, and Utah). All remaining States were not part of the SIO, as organizations that deliver water to farms or influence on-farm groundwater use are rare or nonexistent in those States.

Source: USDA, Economic Research Service using data from the USDA, NASS' *Irrigation Organizations* publication (USDA, NASS, 2020).

USDA 2019 Survey of Irrigation Organizations

The USDA's 2019 Survey of Irrigation Organizations (SIO) collected data on irrigation organizations in 24 States[1] within the western, southeastern, and Mississippi Delta regions of the United States, where these organizations are most common (see figure 1 for States that are included in the survey). The SIO was a collaboration between the U.S. Department of Agriculture's Economic Research Service (ERS), National Agricultural Statistics Service (NASS), and the Office of the Chief Economist (OCE). The SIO was funded through a congressional budget initiative aiming to expand research and data on agricultural drought resilience.

The SIO defined an irrigation organization as an entity that either delivers water to farms and ranches or influences on-farm groundwater use. Irrigation organizations are structured differently across the United States according to State water law and regional water resource development history. Examples of irrigation organizations that deliver water include irrigation districts, canal/ditch companies, acequias [communal irrigation ditches; see Hutchins (1928) for more information], and irrigation mutuals. Organizations that influence on-farm groundwater use include groundwater management districts, natural resource districts, and groundwater sustainability agencies (depending on State-enabling legislation). Some irrigation organizations engage in both on-farm groundwater management and water delivery.

The 2019 SIO was the first nationally representative Federal data collection of irrigation organizations since the U.S. Bureau of the Census conducted the 1978 Census of Irrigation Organizations (CIO). The 1978 CIO did not collect information on organizations that influence groundwater use, as these types of organizations largely did not exist in 1978. Additionally, the 1978 CIO collected information on "pass-through" entities, which are organizations that store and deliver water to irrigation organizations but do not deliver water directly to farms and ranches. The 2019 SIO did not collect information on "pass-through" organizations. For a summary of selected survey findings and additional information on survey design, see USDA, NASS' *Irrigation Organizations* publication (USDA, National Agricultural Statistics Service, 2020).

[1] California, Colorado, Montana, Wyoming, Kansas, Nebraska, North Dakota, Oklahoma, South Dakota, Texas, Idaho, Oregon, Washington, Nevada, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Arizona, New Mexico, and Utah.

Water Rights

The legal institutions defining the rights of water use differ across States.[1] In the eastern United States, the ownership of surface water follows the riparian doctrine that assigns water rights based on the ownership of land adjacent to streams and rivers. Generally, in the western United States, the ownership of surface water is based on the doctrine of prior appropriation, where water rights are granted based on historical beneficial use of water rather than the ownership of riparian land (Haar & Gordon, 1958; Huffaker et al., 2000).

Under prior appropriations, water is allocated on a "first in time, first in right" basis—in which older, more "senior" water rights claims have priority in times of water scarcity. Water withdrawals for newer, more "junior" rights are curtailed first. Under prior appropriations, the junior rights holders are the most likely to face water supply shortages during times of scarcity. When regions using the riparian doctrine face water scarcity, an individual's water use is limited to an amount of water that does not materially injure downstream users' access. Thus, the riparian doctrine proportionally allocates water curtailments in times of drought and water scarcity.

Where prior appropriation applies, water rights may be held by either individuals or private irrigation organizations (e.g., ditch companies or mutual irrigation companies) and often specify an allowed location of use. When an organization holds the rights, irrigators with access to the canals and ditches can buy shares in the organization, which entitles the owner to a percentage of the organization's total water supply each year (Rice & White, 1987). In many basins, particularly those with fully adjudicated and well-defined water-use property rights, the rights are transferrable and active markets have developed for irrigation organization shares and individual water rights (Goodman & Howe, 1997).

In some cases, irrigators and irrigation organizations hold long-term "contract entitlements" rather than "rights" to water (Hanak & Stryjewski, 2012). In these arrangements, local public irrigation organizations purchase their water under terms specified in contracts with State or Federal agencies (such as the U.S. Department of the Interior, Bureau of Reclamation) that operate large-scale water conveyance and storage infrastructure. Since some irrigators held prior appropriation rights that were established before the development of these large irrigation projects, the terms of their agreements for water delivery are set under adjudicated "settlements" rather than the standard contracts, which effectively create a tier of seniority within these projects.

[1] See Richardson & Aloi (2017) for a comprehensive review of State-level laws regarding surface and groundwater.

Delivery Organization Water Inflows

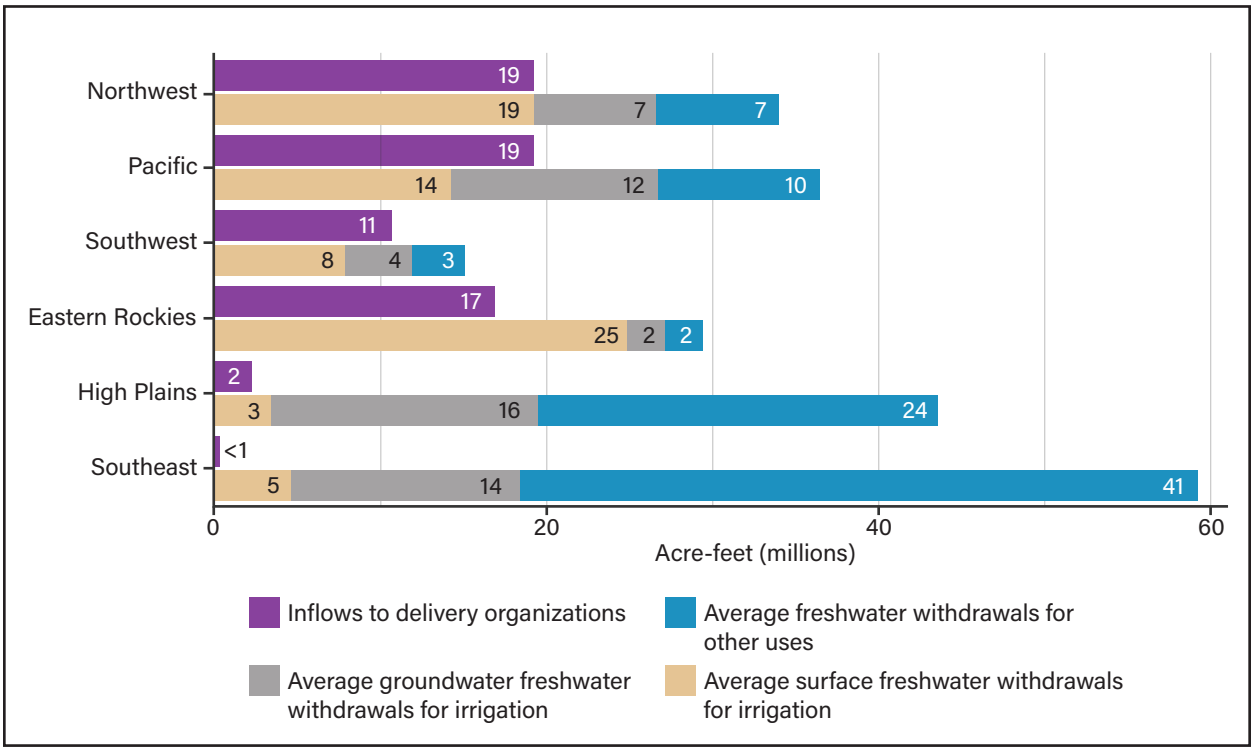
Inflows to irrigation water delivery organizations are primarily drawn from renewable surface water resources. The SIO distinguishes between inflows that are contracted from water providers, such as Federal and State water storage facilities and inflows directly diverted from surface water bodies, such as rivers and lakes. Generally, contracted water sources come from Federal, State, or local water supply entities that a delivery organization contracts with for water. Contracted water may also come from private and municipal providers, though Federal and State water projects provide most contracted water. In contrast to contracted sources, direct water sources refer to water that the organization diverts from natural bodies of water using the organization's own infrastructure. Direct sources include surface water, groundwater, and drainage from other delivery organizations. See figure 2 for regional total inflows to delivery organizations in comparison to water withdrawals for all uses in the United States. Figures 3 and 4 show the composition of water inflows by region and organization size respectively.

Water sources for delivery organizations reflect the historical conditions in which irrigation developed in the United States. Irrigation water delivery organizations arose to coordinate irrigation water management among groups of farmers (Libecap, 2011). In the eastern United States, precipitation enables significant dryland agriculture, making the need for large-scale coordination to deliver water to farmland largely unnecessary. But precipitation west of the 100th meridian is generally less than 20 inches per year (Seager et al., 2018), making irrigation necessary for the cultivation of most crops. Large-scale Federal and State water projects were developed in the West to collect, store, and transport water for the irrigated agricultural sector and other uses (Ostrom, 2011). Much of the surface water delivered by organizations in the West derives from snowpack, which is particularly susceptible to the impact of climate change, as higher temperatures and variable precipitation patterns reduce snowpack and alter the timing of spring runoff (Qin et al., 2020).

Irrigation water delivery organizations convey a substantial portion of average annual water withdrawals in western U.S. regions

- Inflows to delivery organizations make up between 45 and 76 percent of all freshwater withdrawals in the Northwest, Pacific, Southwest, and Eastern Rockies regions.
- In the High Plains and the Southeast, inflows to delivery organizations make up only a small portion of all freshwater withdrawals. Irrigation in these regions is largely sourced from groundwater, which few irrigation water delivery organizations rely on as a source for water deliveries.

Figure 2
Water inflows to delivery organizations in 2019 and average annual water withdrawals for irrigation and other uses by region



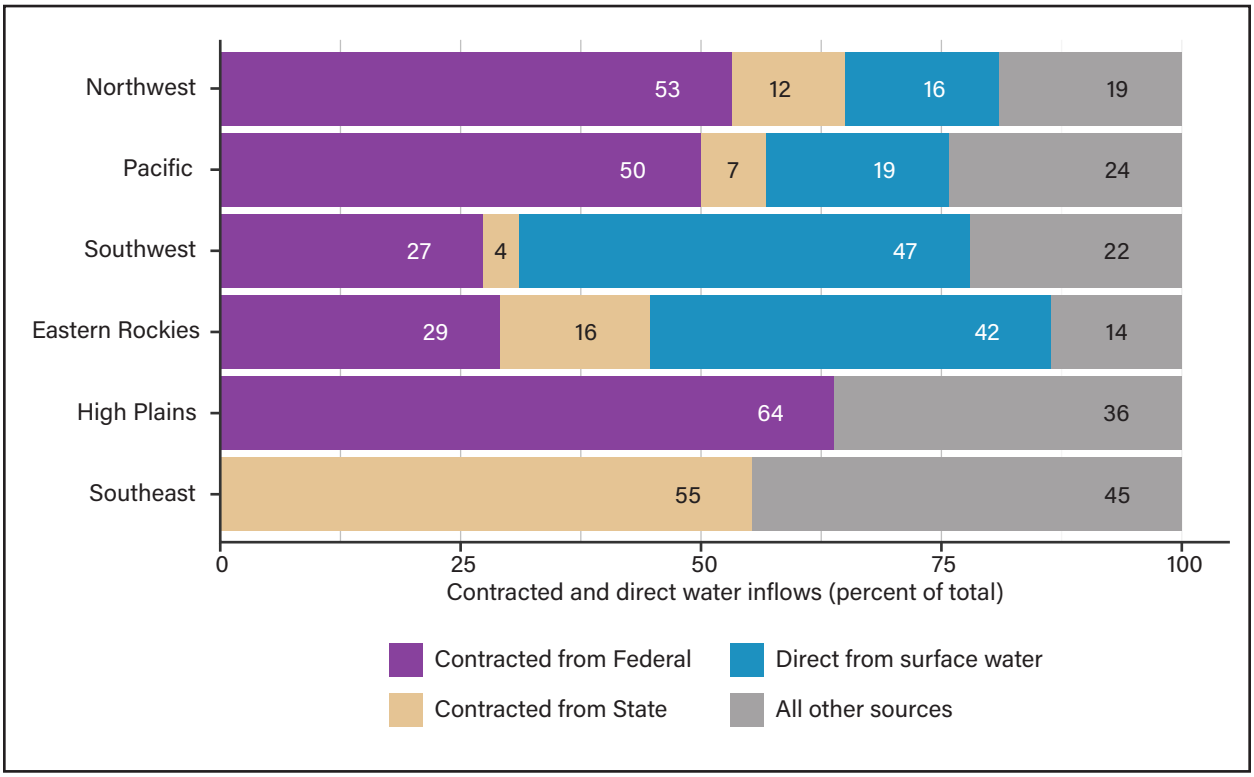
Note: *Inflows to delivery organizations* are total inflows to delivery organizations from surface and groundwater sources in 2019, and do not include withdrawals by farmers not in delivery organizations or by domestic, commercial, industrial, or other water users. *Average withdrawals* are the average of the 2005, 2010, and 2015 total estimated freshwater withdrawals from groundwater for irrigation, from surface water for irrigation, and from all sources for all other uses (Dieter et al., 2018).

Source: USDA, Economic Research Service analysis using data from the USDA 2019 Survey of Irrigation Organizations. Water withdrawals data are from the 2005, 2010, and 2015 U.S. Geological Survey Water Data for the Nation (Kenny et al., 2009; Maupin et al., 2014; Dieter et al., 2018).

Water contracted from Federal projects and water directly diverted from surface water bodies are the main sources of inflows to irrigation water delivery organizations

- Together, Federal water projects and direct surface water diversions account for between 64 and 75 percent of all inflows to delivery organizations in all U.S. regions except the Southeast. In the Northwest, Pacific, and High Plains regions—Federal water projects provide most inflows to delivery organizations, while surface water provides the largest share of inflows in the Southwest and the Eastern Rockies regions.
- In the Southeast, Federal involvement in agricultural water supply development is substantially more limited. The majority of water (55 percent) is contracted from State water projects.

Figure 3
Water inflows to irrigation water delivery organizations by region



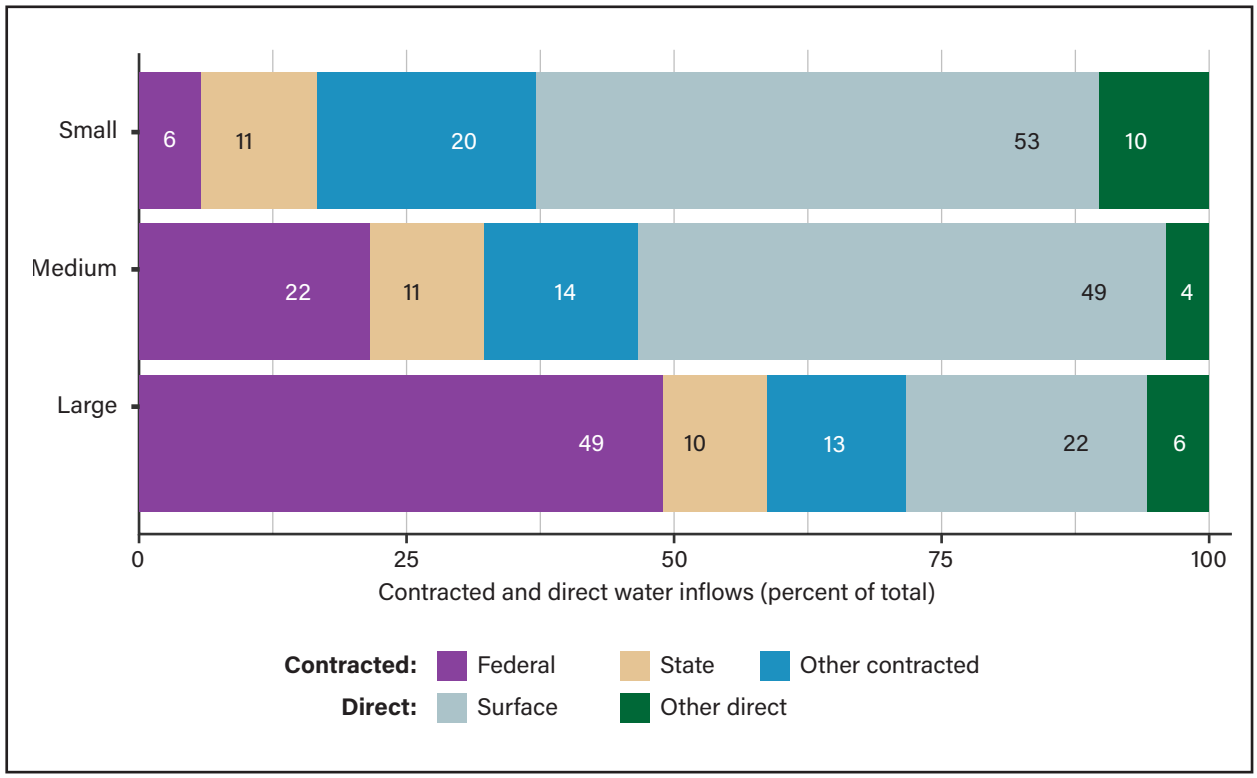
Note: *Contracted from Federal* refers to water that delivery organizations contract from Federal water projects. *Contracted from State* refers to water contracted from State water projects. In many cases, water from Federal and State water projects is drawn from reservoirs. *Direct from surface water* refers to direct diversions from surface water bodies. *All other sources* includes all categories in a region that are not delineated, including those that do not meet disclosure requirements. In some cases, organizations may have water rights allowing for direct withdrawal of water resources, while in other cases water rights may belong to the organization's constituents.

Source: USDA, Economic Research Service analysis using data from the USDA 2019 Survey of Irrigation Organizations.

Large delivery organizations draw water predominantly from Federal water projects, while inflows to smaller organizations largely come from direct surface water body diversions

- There is substantial variation in water sources across organizations of different sizes. More than half of water inflows to small organizations come from direct surface water diversions, while only 6 percent of inflows come from Federal sources.
- In contrast, about half of water inflows to large organizations come from Federal sources, while less than a quarter of inflows come from direct surface water diversions.
- Water contracted from State and private sources is also a significant source of water inflows, though differences between organizations of different sizes are less stark. About 30 percent of water inflows to small organizations come from other contracted or other direct diversions, while about 20 percent of inflows to medium and large organizations come from these other sources.
- Organizations of all sizes receive a similar share of water inflows (about 10 percent) from State water projects.

Figure 4
Source of water inflows as a share of total deliveries by organization size



Note: Small organizations service less than 1,000 irrigable acres, medium organizations service 1,000–10,000 irrigable acres, and large organizations service greater than 10,000 acres. *Contracted* water refers to water that delivery organizations receive from a Federal, State, private, municipal, or other water supply entity. In many cases, these water supplies originate from reservoirs. *Surface* water refers to water that organizations directly withdraw from a natural body of water or reservoir. *Other contracted* refers to water contracted from private, municipal and local, and other sources. *Other direct* refers to other water inflows directly sourced from other reservoirs, groundwater, and drainage from other organizations. In some cases, organizations may have water rights allowing for direct withdrawal of water resources, while in other cases, water rights may belong to the organization's constituents.

Source: USDA, Economic Research Service analysis using data from the USDA 2019 Survey of Irrigation Organizations.

Delivery Organization Water Outflows

In 2019, irrigation water delivery organizations reported total outflows of almost 65 million acre-feet, with 64 percent of outflows going to farms and ranches. These outflows to farms and ranches serviced 32 percent of U.S. irrigated acres[4] and comprised 50 percent of all water applied for irrigation in 2018.[5] In the western United States—where irrigation organizations play a substantial role in the delivery of water for irrigation—delivery organizations serviced about 60 percent of all acres that were irrigated, and water delivered by organizations constituted about 67 percent of all water used for irrigation by farms and ranches in 2018.

The SIO distinguishes between water outflows delivered to different types of water users and water that exits the delivery organization system in other ways. While most outflows from delivery organizations flow to farms and ranches, water is also delivered to industrial and municipal users, domestic users, and other delivery organizations. The second-largest outflow from delivery organizations is water lost during conveyance. Other exits include return flows,[6] flows used for groundwater recharge, or other unspecified exits. Figure 5 shows irrigated land and water delivered by delivery organizations in comparison to irrigated land and water from all sources applied for irrigation by farmers.

Figure 6 shows the regional composition of these deliveries, a portion of which is conveyance losses. Conveyance losses in the SIO are defined as water lost from the delivery organization's water system due to seepage, evaporation, or other means during conveyance or temporary storage between the water source and the farmgate. Although these losses are unavailable to the delivery organization, the losses may benefit other water users within the water basin—as water returns to stream flows, recharges groundwater resources, or otherwise remains part of the larger hydrological system (Knapp et al., 2003). As competition for increasingly scarce water supplies during drought increases pressure on water systems, reducing conveyance losses may help to meet the water demands of delivery organization constituents, though potential downstream effects are important to consider. Conveyance losses may be reduced by using piped conveyance or lining conveyance canals (Hrozencik et al., 2022). While the Environmental Quality Incentives Program (EQIP) (administered by the USDA, Natural Resources Conservation Service (NRCS)) generally focuses on farm-level investments for water conservation, the 2018 Farm Bill made funding available for conveyance infrastructure improvements by delivery organizations (Fischer & Willis, 2020).

Some irrigators can supplement with groundwater when surface water supplies are insufficient. Droughts have increased the rate of groundwater extraction and altered the water management functions of delivery organizations (Wallander et al., 2022; Scanlon et al., 2012). About 4 percent of delivery organizations report using excess surface water to intentionally replenish groundwater stocks, in a process known as Managed Aquifer Recharge. The volume of water going to groundwater recharge was less than 2 percent of all outflows from delivery organizations. However, this process may increase as managed aquifer recharge is increasingly implemented, especially in regions with significant groundwater and surface water resources. In this report, these outflows are listed as a component of "other outflows" due to data confidentiality concerns.

[4] The Irrigation and Water Management Survey reports that there were 55.9 million acres of irrigated cropland in 2018 (USDA, National Agricultural Statistics Service, 2019). The SIO reports that irrigation water delivery organizations served 17.8 million acres in 2019.

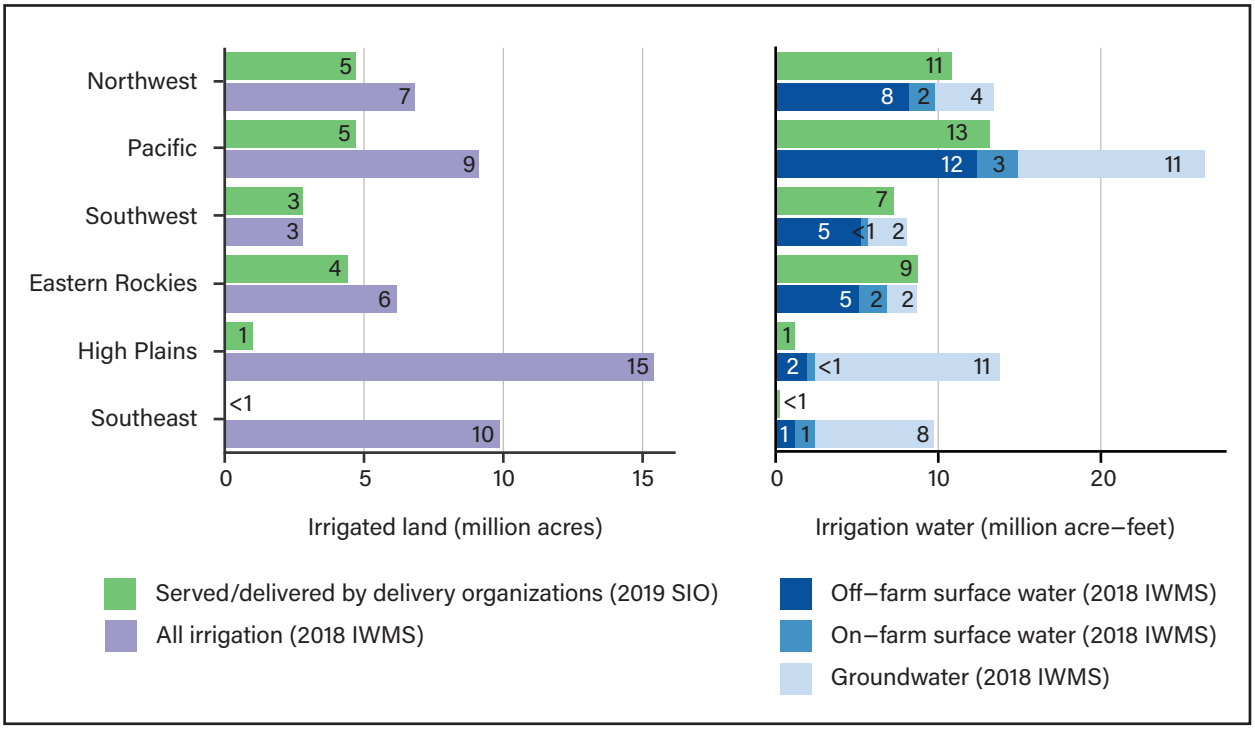
[5] The Irrigation and Water Management Survey reports that a total of 83.4 million acre-feet of water were applied for irrigation in 2018 (USDA, National Agricultural Statistics Service, 2019). The SIO reports that (in 2019) deliveries to farms by irrigation water delivery organizations totaled 41.4 million acre-feet (USDA, National Agricultural Statistics Service, 2020).

[6] Water that is applied for irrigation moves through the water cycle as evaporation or transpiration or replenishes water resources directly through the recharge of groundwater or return flows to surface water bodies.

Irrigation water delivery organizations serve most of the irrigated acres and deliver substantial portions of all water used for irrigation in western U.S. regions

- Delivery organizations are particularly important in the Northwest, Southwest, and Eastern Rockies regions—where the organizations supply more than 75 percent of the irrigated acres and deliver more than 80 percent of the irrigation water used in these regions.
- In the Pacific region, delivery organizations serve more than 50 percent of the irrigated land and deliver more than 50 percent of water used for irrigation. The region includes extensive irrigation from groundwater and on-farm surface water, which is not generally managed by delivery organizations.
- In the High Plains and Southeast regions, delivery organizations serve less than 5 percent of irrigated land and deliver less than 5 percent of water used for irrigation.

Figure 5
Farmland and water delivered to farms by delivery organizations compared with other irrigation water sources, by region



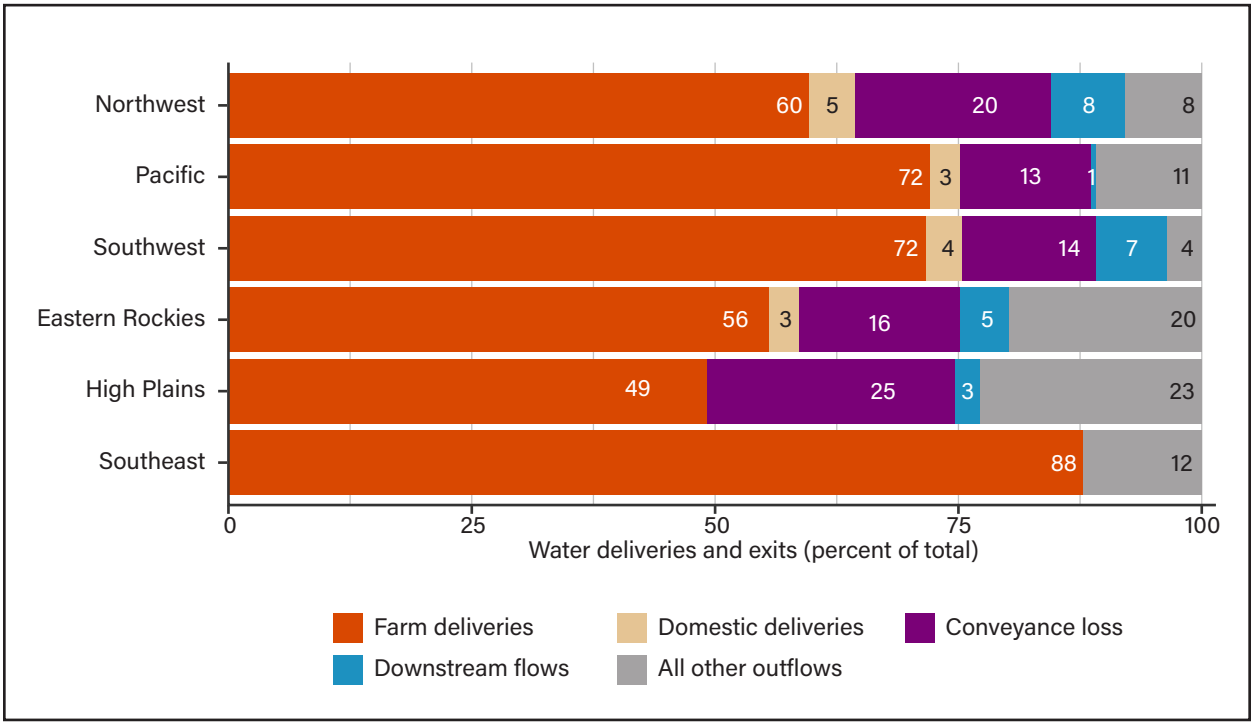
Note: The chart shows acres served and acre-feet of water delivered to farms by delivery organizations (2019 SIO) and all acres and water used for irrigation (2018 IWMS). *Groundwater* refers to water pumped and applied by farms. *Off-Farm surface water* refers to water delivered to farms primarily from delivery organizations. *On-Farm surface water* comes from local surface water sources on individual farms.

Source: USDA, Economic Research Service analysis using data from the USDA 2019 Survey of Irrigation Organizations. Additional data are from the USDA's 2018 Irrigation and Water Management Survey.

Farms and ranches are the primary receivers of outflows from delivery organizations, but conveyance losses are also a significant outflow

- In all regions, between about 50 and 88 percent of outflows from delivery organizations go to farms and ranches.
- Conveyance losses are the second largest outflow in most of the United States, accounting for between 13 and 25 percent of outflows in all regions except the Southeast.
- "All other outflows" are highest in the High Plains, reflecting delivery organizations that are engaged primarily in hydroelectricity generation but have some farm deliveries as well.

Figure 6
Water outflows from irrigation water delivery organizations by region



Note: *Farm deliveries* refers to outflows to farms and ranches. *Domestic deliveries* refers to deliveries to municipalities and domestic households. *Conveyance loss* refers to water lost during conveyance to the farmgate due to evaporation, soil seepage, and other factors. *Downstream flows* refers to releases for downstream users—which may include other irrigation organizations, domestic users, or other users. *All other outflows* refers to all other outflows and includes deliveries for industrial and municipal use or to other irrigation organizations—as well as exits for environmental requirements, groundwater recharge, or other releases. All other outflows includes all categories in a region that are not delineated, including those that do not meet disclosure requirements and may vary from region to region.

Source: USDA, Economic Research Service analysis using data from the USDA 2019 Survey of Irrigation Organizations.

Delivery Organization Water Transfers

In some water governance systems, particularly in western States that govern water use under the prior appropriations doctrine (see the "Water Rights" text box), water rights can be leased or bought and sold independently of land (Anderson & Hill, 1975). These markets (where feasible) can facilitate voluntary water transactions to meet the needs of users, particularly in years with low water supply (Young & Brozovic, 2019). The 2019 water year had above-average precipitation in most irrigated regions. Water transfers reported by delivery organizations in the 2019 SIO may reflect lower demand for such transfers, even though more water was available to be transferred.[7] Water transfers are often physically constrained within a watershed due to legal restrictions and the cost of moving over a watershed boundary.[8] Water markets can also face substantial barriers in the form of high transaction costs and administrative difficulties (Loch et al., 2021). Some efforts are being made to reduce water market transaction costs, which may be lowered as water marketing activity increases. For example, the U.S. Department of the Interior, Bureau of Reclamation's WaterSMART program provides assistance to States, Tribes, and local entities to facilitate the development of water markets (Garrick & Aylward, 2012; U.S. Bureau of Reclamation, 2016). The USDA, NRCS's Environmental Quality Incentives Program (EQIP) works in conjunction with the WaterSMART initiative, providing funding to farmers to make improvements that increase water conservation (USDA, Natural Resources Conservation Service, 2021). The USDA's Regional Conservation Partnership Program (RCPP) is a partner-driven approach to conservation that funds solutions to natural resource challenges on agricultural land, including funding for water transfer markets that facilitate the voluntary reallocation of water supplies during drought.

The 2019 SIO distinguishes between transfers that are both external and internal to the irrigation organization. External transfers are transfers of water rights between delivery organizations and other entities. This report focuses on external leases rather than permanent transfers since less than 2 percent of all delivery organizations report engaging in the purchase or sale of a water right in the 5 years from 2015–2019. Internal transfers are transfers of water rights between water users within an organization delivery system. While external transfers have the capacity to be significantly larger in volume, the transfers can also face more significant transaction costs and legal barriers. In contrast, transfers between water users within a delivery organization system (where permitted) can often be done informally with relatively low transaction costs (Xinde & Cobourn, 2018). In 2019, relatively few organizations reported engaging in external water leases, while more organizations reported water transfers between their constituent users. Figures 7 and 8 show the extent of participation in external water markets by region and organization size, respectively.

Internal transfers (where allowed by a delivery organization) can help to address water shortages or otherwise provide flexibility to producers if the transfers have excess water or would benefit from having access to more water. These types of transfers generally face lower transaction costs due to reduced concern about third-party harms and the presence of existing conveyance infrastructure within an organization that would facilitate water reallocation. Internal transfers between users within a delivery organization are more than twice as common as external leases, occurring in 8 percent of delivery organizations in 2019. Figure 9 compares these internal transfers with external leases.

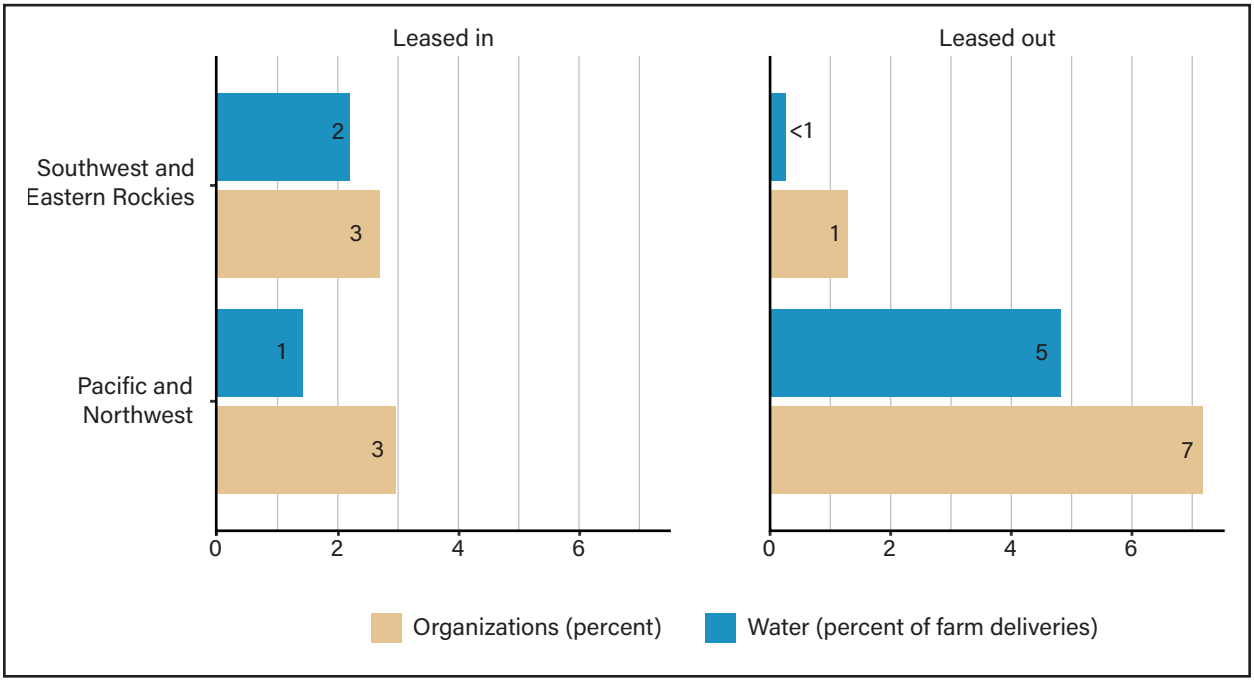
[7] Average precipitation in the western United States was 22.2 inches in the 2019 water year (October–September) versus a 30-year average of 20.8 inches and 18.9 inches in 2018 (estimated using PRISM climate data). The percentage of the United States that was classified as abnormally dry or in drought in the first full week of June was 13 percent in 2019 versus 36 percent in 2020, 59 percent in 2021, and 58 percent in 2022 (U.S. Drought Monitor, 2022).

[8] There are some cases of large-scale infrastructure investments that have shifted water between basins, for example, the Moffat Tunnel Collection System in California and the Big Thompson Project in Colorado.

External leases made up only a small fraction of all inflows in 2019

- In the combined Southwest and Eastern Rockies regions and the Pacific and Northwest regions, about 3 percent of delivery organizations leased water into the organization water system, accounting for accounting for between 1 and 2 percent of water deliveries to farms.
- More delivery organizations (about 7 percent) leased water out in the Pacific and Northwest regions. Water leases were about 5 percent of the total water deliveries to farms. In contrast, in the Southwest and Eastern Rockies regions, only about 1 percent of organizations leased water out, and that water was just a quarter of 1 percent of water deliveries to farms.

Figure 7
External leasing organizations and externally leased water, 2019



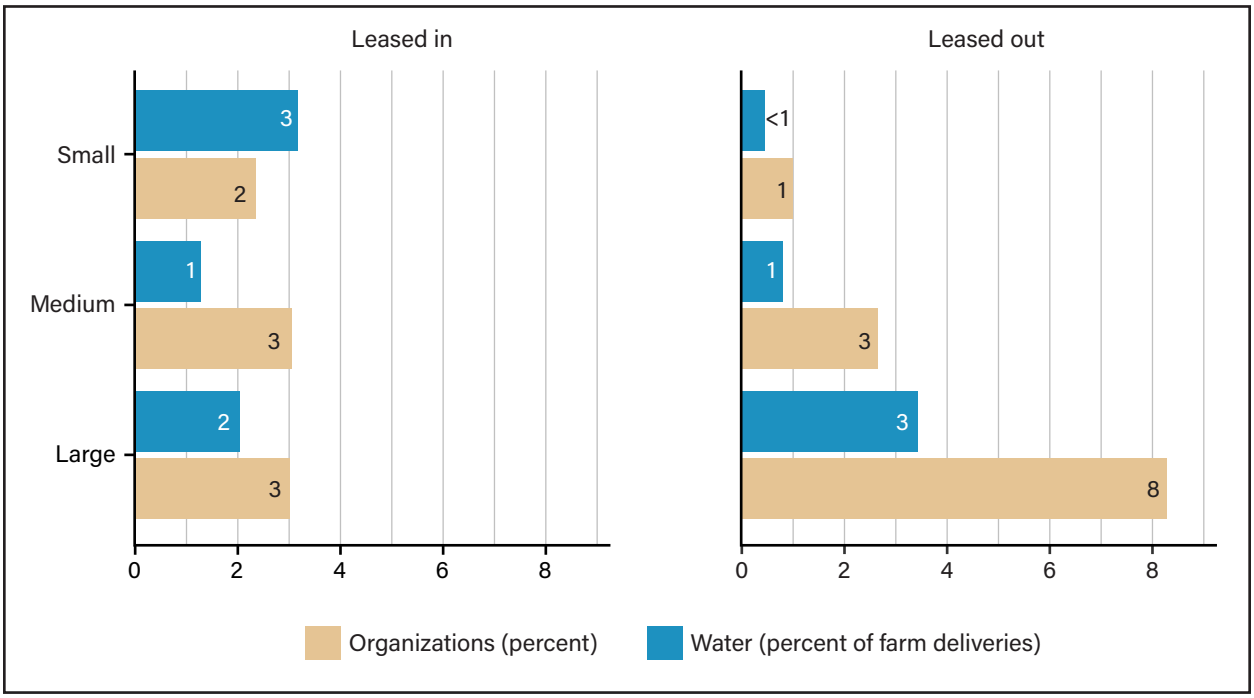
Note: *Organizations* refers to the percentage of delivery organizations in each region that engage in external transfers of water. *Water* refers to the volume of external leases as the percent of total farm deliveries. Leases in refers to the purchase of water in a lease agreement. Leases out refers to the sale of water in a lease agreement. The High Plains and Southeast regions are omitted to avoid disclosure.

Source: USDA, Economic Research Service analysis using data from the USDA 2019 Survey of Irrigation Organizations.

In 2019, a small fraction of delivery organizations of all sizes leased water in, but large delivery organizations externally leased out a significant share of deliveries

- While about 3 percent of delivery organizations of all sizes leased water into their system, 8 percent of large organizations leased water out, and 3 and 1 percent of medium and small organizations (respectively) leased water out.
- In terms of the water volume, external leases in or out of delivery organization systems accounted for about 3 percent or less of total farm deliveries for organizations of all sizes. Small and medium-sized organizations lease in more water (between 1 and 3 percent of farm deliveries) than the organizations lease out (1 percent or less of farm deliveries).

Figure 8
Externally leased water by organization size, 2019



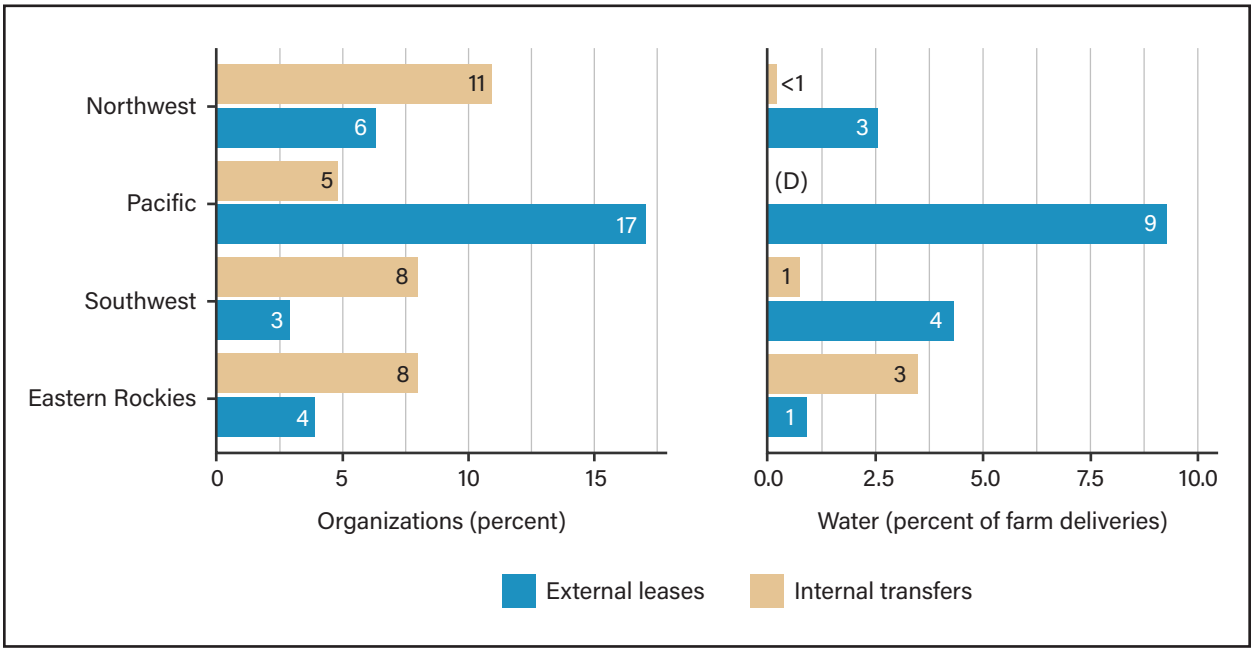
Note: *Organizations* refers to the percentage of delivery organizations in each region that engage in external transfers of water. *Water* refers to the volume of external transfers as the percent of total farm deliveries. Leases in refers to the purchase of water in a lease agreement. Leases out refers to the sale of water in a lease agreement. Small, medium, and large organizations are those serving less than 1,000, between 1,000 and 10,000, and more than 10,000 irrigable acres, respectively.

Source: USDA, Economic Research Service analysis using data from the USDA 2019 Survey of Irrigation Organizations.

In 2019 (outside of the Pacific region), internal water transfers are more common, but the amount of water transferred is smaller than the amount of water in external leases

- In most regions of the western United States, internal water transfers occur in more organizations than organizations that engage in external leases. However, in the Pacific region—where 17 percent of delivery organizations engage in external leasing—only 5 percent have users engage in water transfers within that organization.
- The amount of water involved in external leases is substantially higher than the amount involved in internal transfers. The share of water involved in internal transfers is 1 percent or less in all regions except the Eastern Rockies region, while the share of water involved in external leases is between 1 and 9 percent of total farm deliveries.

Figure 9
Internal transfers and external leases by region, 2019



Note: *External leases* refers to leases of water into or out of a delivery organization system. *Internal transfers* refers to transfers between water users within a delivery organization. *Organizations* refers to the percentage of delivery organizations in each region that engage in external transfers of water. *Water* refers to the volume of external transfers as the percent of total farm deliveries. The percentage of water involved in internal transfers in the Pacific region is omitted to avoid disclosure.

Source: USDA, Economic Research Service analysis using data from the USDA 2019 Survey of Irrigation Organizations.

Conclusion

Irrigation water delivery organizations receive about 50 percent of average water withdrawals for irrigation in the United States (70 percent in the western United States). These organizations serve as intermediaries between water resources and water users, managing the infrastructure used for water conveyance to farms and ranches as well as to domestic and other users. Because of the role of delivery organizations in managing irrigation water, an accounting of water sources, destinations, and conveyance losses in delivery organization systems is important for managing water resources in a changing climate, especially as reduced snowpack affects available surface water supplies.

The pattern of water inflows and outflows for irrigation water delivery organizations reflects the historical development of irrigation across the United States. Federal water storage and conveyance infrastructure projects constructed throughout the western United States enabled the distribution of water across large arid regions of land, providing most of the water to large delivery organizations that were formally organized as irrigation districts. In contrast, small mutuals and irrigation districts serve the collective function of building localized diversion works and irrigation infrastructure that directly source surface water. Irrigation in the more central and eastern regions of the High Plains and the Southeast is less dependent on Federal projects, instead sourcing water from groundwater resources, direct surface diversions, and more recent State irrigation projects.

In the western United States, snowpack serves as a natural storage of water for use during the growing season. In the Western regions, the two largest irrigation water sources (Federal water projects and surface water resources) are highly dependent on snowpack for irrigation water. Declining snowpack results in reduced water availability during periods of peak water demand (Mote et al., 2018). Coupled with increased water demand for domestic use, water stress in the western United States is likely to intensify (Qin et al., 2020). Understanding the extent and disposition of these supplies and how delivery organizations manage allocations will be important in achieving optimal water use under increasing water scarcity during the higher-demand growing season. Given the extent of conveyance losses before the farmgate, investments in conveyance infrastructure may increase the amount of water effectively available for irrigation (Hrozencik et al., 2021).

Regions with an active water transfer market may also help to mitigate the economic costs of water scarcity. Economists emphasize the importance of water markets in allowing users the flexibility to buy and sell temporary or permanent rights to water while also recognizing limitations imposed by high transaction costs (Garrick & Aylward, 2012; Womble & Hanemann, 2020). Increased participation in water markets may help to partially mitigate negative impacts from drought and reduced snowpack, but the extent to which this reallocation is feasible varies greatly and depends on both legislative and geographic limitations. Increased trade between users within an organization may be more feasible, but the capacity for mitigation of losses during drought may also be more limited.

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Irrigation Organizations:
Infrastructure

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Irrigation Organizations:
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