The overwhelming majority (85%) of water withdrawals in the semi-arid Intermountain West (IW) are used for agricultural irrigation. However, the region is rapidly changing. Population doubled between 1970-2010 and is expected to double again by mid-century. Most urban growth has occurred on formerly irrigated farmland. New economic sectors have also emerged and farming has diminished as a major source of income or employment (Power & Barrett, 2001).
While the pace and scale of change in the IW is almost unparalleled in the U.S., the impacts of urbanization and economic diversification on water use patterns is less clear. On the one hand, it would make sense to assume that water formerly used for irrigating crops would become available to provide drinking water for new residents. However, a number of legal and social factors constrain the free movement of water between different types of users.

Water law in the region allocates water for specific designated uses on a “first in time, first in right” basis. As a result, most water rights are still controlled by people whose ancestors originally laid claim to water over 100 years ago and its use is generally restricted to farming. Converting agricultural water rights to urban uses can be difficult, though there are efforts to develop institutional mechanisms to facilitate these transfers (Squillace, 2013).

Growing competition from other users and concerns about diminishing water availability due to a changing climate have prompted farmers to invest in new technology to improve the efficiency of their irrigation systems (Schaible & Aillery, 2012). The most common approach has been to replace “ditch-flood” irrigation with new sprinkler systems that are capable of applying water more evenly and accurately to farm fields. Between 1985 and 2010, the proportion of irrigated farmland using sprinklers in the IW rose from 33% to 48%.

There is surprisingly little published research on the impacts of these demographic, economic, and technological changes on water use in the IW region. Moreover, the common assumption that trends in water use in the farm sector are directly related to growth in urban populations has rarely been tested empirically. To inform discussions about water policy and planning in the region, we used county- and state-level data to assess trends in water use across different economic sectors over the last 20-30 years.

**FINDINGS**

**Urban Trends**

Population in the IW region grew by 3.6 million people (over 50%) between 1985-2010. During this time, total withdrawals for public water supplies grew by 25%, with per capita water use rates declining 14% (from 211 to 182 gallons/per capita/day). There are important differences across the five states in the region. Per capita water use is notably higher in Utah and Idaho (218 and 193 gpcd, respectively) and lowest in Montana and Colorado (151 and 164 gpcd). Improvements in per capita water use efficiency over the last 20 years were highest in Idaho (-20%), and lowest in Montana and Wyoming (-8 and -9% respectively).

**METHODS**

For our analysis, we included five states in our definition of the "Intermountain West" region: Colorado, Idaho, Montana, Utah, and Wyoming. Data came from four publicly available datasets. County population trends were measured using the decennial U.S. Census of Population and intercensal estimates between 1980 and 2010 (US Census Bureau, 2017). Agricultural trends were captured using results from the U.S. Census of Agriculture, conducted every five years between 1982 and 2012 (USDA, 2017).

Our most important source of data was the national county water use database maintained by the U.S. Geological Survey (Maupin et al., 2014; U.S. Geological Survey, 2017). The USGS data provides estimates of total water withdrawals by sector every five years. Combining data on water use, irrigated acreage, and population allowed us to estimate per acre and per capita water use rates.

Finally, we disaggregate IW counties based on their metropolitan status and whether or not they are agriculturally important (AI), an indicator that provides a "direct measure of the relative size and intensity of farming across diverse U.S. counties" (Jackson-Smith & Jensen, 2009, p. 37).
Agricultural Trends
Rapid population growth and competition for water is widely perceived to be an existential threat to farming in the region. In reality, while acres in farming may have declined slightly, farm output actually grew over the last 30 years, with both gross farm sales and farm numbers increasing by roughly 20% between 1982-2012 (USDA, 2017).

Water use in agriculture is determined by the amount of irrigated farmland and the rate at which water is applied. Overall, roughly 11 million acres of farmland are irrigated in the region. Total irrigated acres declined by 1.4 million acres (about 11%) between the mid-1980s and late 2000s. Per acre application rates declined by 7%, from 4.15 Mgal/acre in 1985/90 to 3.86 Mgal/acre in 2005/10. Interestingly, states where use of sprinkler irrigation grew most rapidly (Utah and Colorado) did not see notable gains in application efficiency.

Overall, use of water for agricultural irrigation in the IW region declined by nearly 15% over this time period. Interestingly, these trends vary widely by state (see Figure 1). In Utah, irrigated acreage actually expanded, while application rates declined by a less than average 5%, leading to an overall increase in agricultural water use of 1%. Meanwhile, Idaho removed 190,750 acres from irrigation and reduced per acre application rates by 18%, resulting in a decline in agricultural water use of over 22%. Colorado’s irrigated farmland acres dropped 8%, but saw almost no change in per-acre application rate. Wyoming witnessed the most dramatic swings with irrigated acreage down nearly 44%, application rates up 17%, and a net decline in agricultural water use of roughly 35%.

County Level Trends
While regional and state trends provide important insights into overall trends in water use by sector, most water is obtained and used within relatively concentrated geographic areas. For example, we might expect that urbanized counties would see more rapid increases in water use for public water supplies and more dramatic declines in agricultural water use. Similarly, not all rural counties have significant agricultural sectors because of the predominance of public lands or a harsher climate.

Figure 2 shows the locations of four types of counties in the five-state region: those that are either agriculturally important/non-important and those classified as metropolitan/non-metropolitan (Jackson-Smith & Jensen, 2009). Out of 215 counties in the region, more than half (146) are considered to be both non-metropolitan and not agriculturally important. Interestingly, 13 of the 38 agriculturally important counties in the region are located in metropolitan counties (and likely experience more competition between urban growth and farming).

Figure 3 illustrates differences in trends in population and water use by sector for the region overall and...
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by county type. Given all the attention to growing competition for water in the region, it is striking that the total amount of water withdrawn for all types of uses actually declined between 1985-2010 across the region as a whole and in each of the four county types. Most of the decline is due to reduced levels of water use for agricultural irrigation. In addition, the places where most of the decline occurred (non-metropolitan counties) are not the same counties where population growth and urban water use increases are concentrated (metropolitan counties).

Overall, it is clear that increases in water use for public water systems can account for only a small fraction of the net drop in water use in agriculture. Rather, internal dynamics within the farm sector (changes in commodity prices and technology) and competition from nonfarm commercial activities in rural areas (e.g. aquaculture and self-supplied industrial development) account for most of the changes in water withdrawals for irrigation.

Interestingly, most of the net declines in agricultural water use in the region occurred in counties that have a less commercially important farm sector (e.g., are not considered agriculturally important). Particularly in rural or nonmetropolitan areas where agriculture is economically vibrant, farms are more likely to maintain levels of water use. However, in metropolitan areas, the reverse is true. In the face of urban pressure, counties with agriculturally important farm sectors were more likely to experience rapid reductions in irrigation withdrawals.

CONCLUSION
These findings suggest that despite rapid population growth and economic diversification, overall water withdrawals actually decreased in the Intermountain West over the past twenty years. This pattern is driven mainly by significant declines in water use on irrigated agricultural fields, and is accounted for more by a drop in irrigated acres than by improvements in the efficiency of irrigation systems. Moreover, declines in agricultural water use have not been associated with a decrease in the gross value of agricultural output or farm numbers. Meanwhile, urban water use does not appear to be the main driver of changes in agricultural water use. Partly because of improvements in per capita water use, overall regional increases in withdrawals for public water systems is much smaller than the size of the net decline in irrigation water use. In addition, the vast majority of the declines in agricultural water use occurred in counties that are not experiencing significant population increases.*