Unsustainable Use of the High Plains Aquifer

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*Farming and Fish Communities Left High and Dry**

Kansas legislators are meeting this week to discuss the future of groundwater use in the western part of the state. This discussion was motivated in part by the continued declines in the High Plains Aquifer and appeals from conservation agents warning of the negative impacts of groundwater depletion for endangered wildlife using streams in the region.

The High Plains Aquifer is the largest source of groundwater in the United States (450,000 km^2), extending from South Dakota to Texas across the Great Plains (Figure 1). The aquifer provides nearly a third of the groundwater for irrigating crops in the country, but unsustainable pumping has exceeded recharge rate leading to water shortages and stream drying.

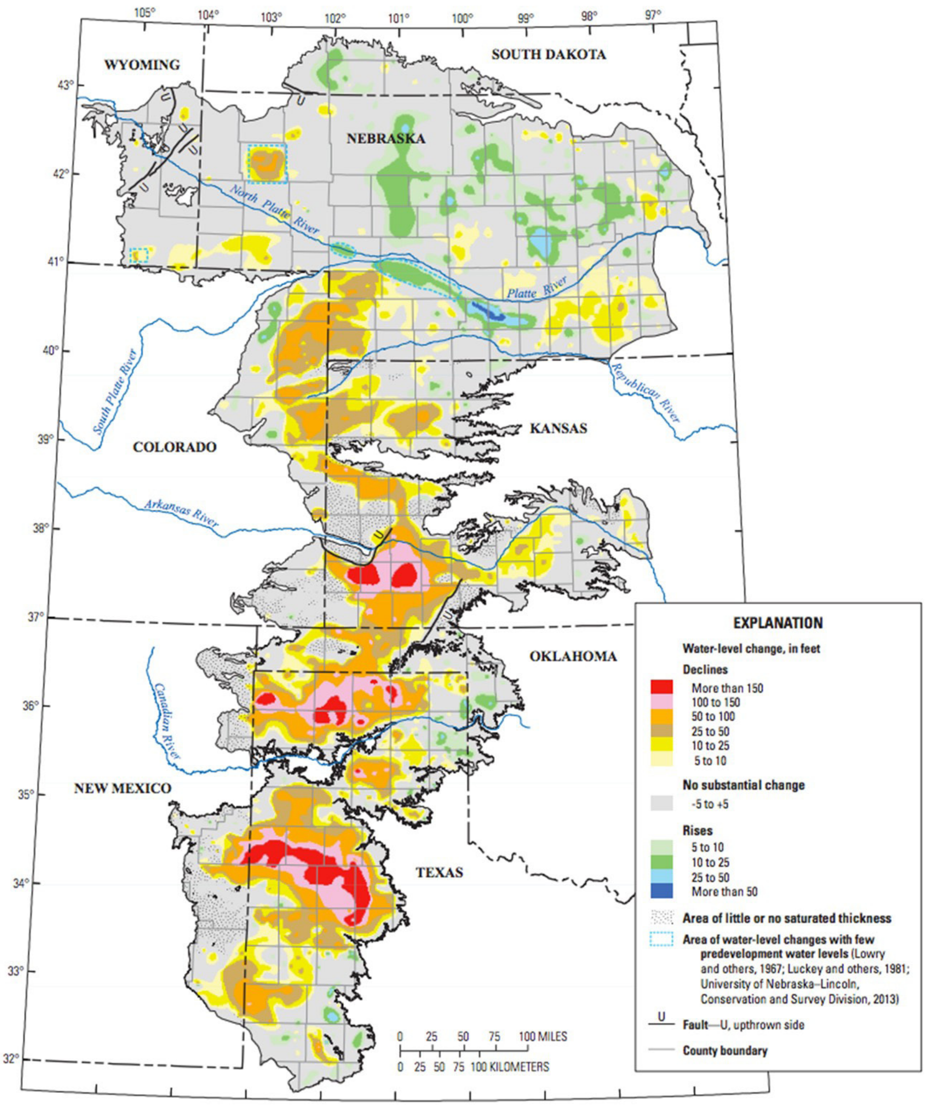


Figure 1: Water level changes across the High Plains Aquifer from ~1950–2013 (McGuire, 2014; USGS).

* The following case study is written in the style of a "news report." It is a work of fiction; although the data presented are authentic and the general situation described is based in fact, the named persons and quotations are not real, but are intended to be representative of the current state of affairs in western Kansas as of 2018.

In 2007, agriculture production supported by the High Plains Aquifer yielded a market value of $35 billion (12% of United States total; Scanlon *et al.,* 2012). Average water table decline is 7 m in Kansas from groundwater pumping. Professor Scanlon of the Bureau of Economic Geology at the University of Texas at Austin predicted that if the depletion rate from 1997–2007 were to remain unchanged over the next 30 years, irrigation would not be possible in the southern portions of the aquifer (i.e., Kansas, Oklahoma, and Texas).

Irrigation pumping of the aquifer by farmers has exceeded the natural recharge rate (~10 mm/y) by 12 to 40 times (NRC, 1996). In Kansas, this is bad news for farmers that rely on irrigation for crop production. Governor Sam Brownback of Kansas supports a proposition to build an aqueduct, or a water pipeline, to take water from the Missouri River and recharge the High Plains Aquifer in parts of Southwestern Kansas where water is needed most. The logic behind this strategy is that pumping water back into the aquifer would help speed up the recharge rate. However, groundwater recharge comes at a cost.

According to the Corps of Engineers, the aqueduct would cost Kansans $400 million annually and the project could take up to twenty years. Additionally, it's not clear what a water pipeline would do without simultaneously putting restrictions on further irrigation. Upon hearing the proposal, Missouri governor Jay Nixon was quoted saying that a water pipeline was a "harebrained idea" because of the long-term cost and concerns that an aqueduct would impose on Missouri's water quantity and quality.

This is certainly not the first water-dispute case among states. Water use laws differ across state lines that overlie the aquifer, and Kansas has faced previous legal battles with states upstream such as Nebraska and Colorado. These cases centered on groundwater over-pumping in the headwaters and were reviewed in the U.S. Supreme Court. One example of a settlement occurred in April, 2005, when Kansas was awarded $34 million in damages and $1 million in legal costs for disputes over water rights with Colorado.

Current water distribution laws in Kansas proceed in accordance with the rule of "first in time, first in right." Water right applications must be submitted to the Division of Water Resources and water usage reports are filed to keep track of pumping and water redistribution. As the aquifer becomes increasingly depleted, neighboring farms are worried about disputes between water rights holders. "It's clear that the Ogallala [part of the High Plains Aquifer] isn't recharging at the rate we're pumping," noted Betsy Dryland, a concerned citizen. "We need to find a solution before we've pitted neighbor against neighbor, farm against farm."

In an effort to conserve threatened fish communities, land managers have pushed water reform policies to legislators across Great Plains states. Land managers and other conservation proponents argue that increased damming of rivers and unsustainable ground water pumping has caused habitat loss for stream dwelling fishes, which has changed fish communities and led some species to become threatened or endangered (Figures 2–4).

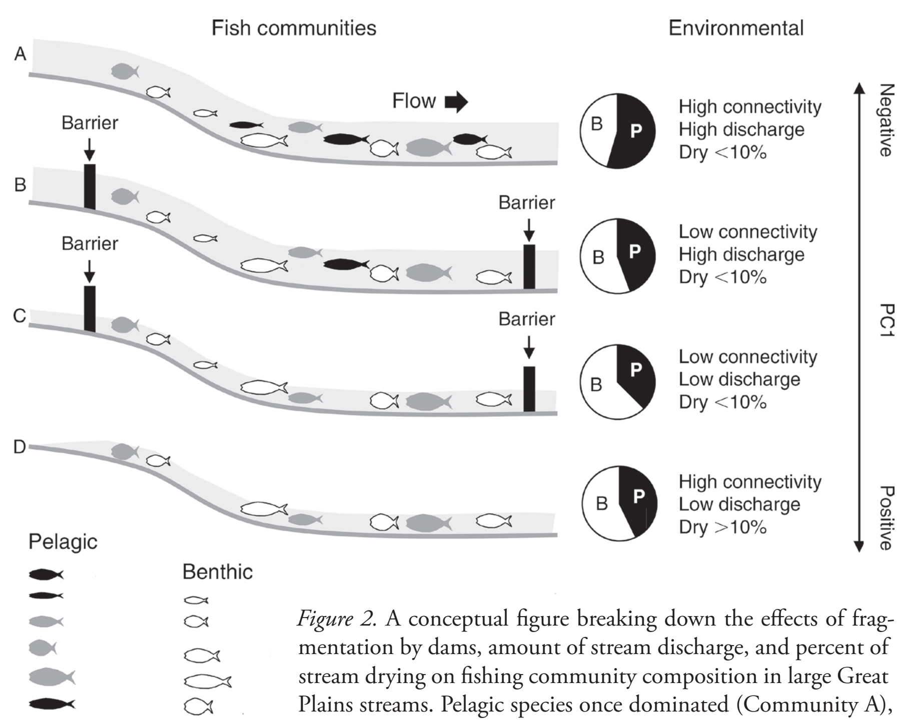


Figure 2. A conceptual figure breaking down the effects of fragmentation by dams, amount of stream discharge, and percent of stream drying on fishing community composition in large Great Plains streams. Pelagic species once dominated (Community A), but as water development has increased benthic species have taken over.

Figure 3. Proportion of benthic and pelagic species occurrences within river fragments differing in degrees of fragment length, mean annual discharge, and stream drying. The x-axis is the first axis from a principal components analysis and represents the variation in environmental factors mentioned. This plot tells us that the proportion of pelagic spawning species occurrence decreases as a function of decreasing fragment length, decreasing discharge, and increasing stream drying.

Credit: Figures 2 and 3 are modified and used with permission from Perkin, J.S., K.B. Gido, A.R. Cooper, T.F. Turner, M.J. Osborne, E.R. Johnson, and K.B. Mayes. 2015. Fragmentation and dewatering transform Great Plains stream fish communities. *Ecological Monographs* 85(1): 73–92. <https://doi.org/10.1890/14-0121.1>.

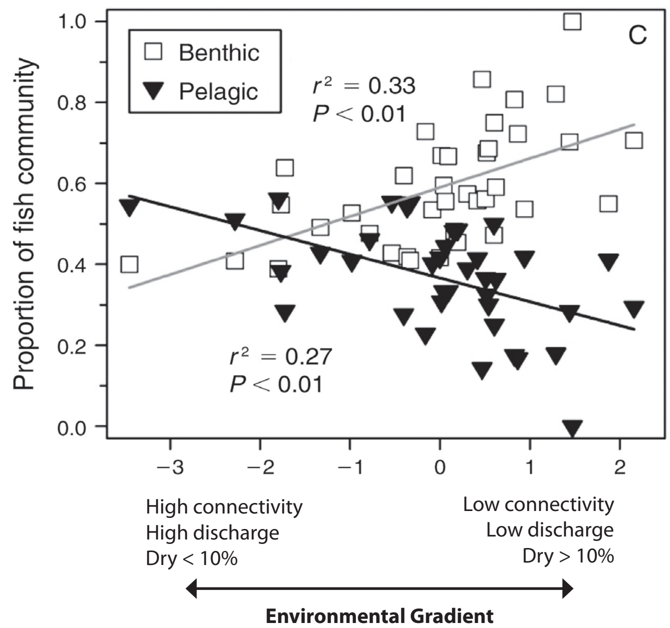


Figure 4. Pelagic-spawning minnows release and fertilize eggs in the water column. This group has suffered population declines due to fragmentation and habitat loss across the Great Plains. *Credit:* Figure modified and used with permission from Platania, S.P., and C.S. Altenbach. 1998. Reproductive strategies and egg types of seven Rio Grande Basin cyprinids. *Copeia* 1998(3): 559–69. <https://doi.org/10.2307/1447786>.

Several species endemic to the region have experienced population declines and are considered threatened or endangered in several states (Figure 5). The pelagic-spawning minnows, a unique group in the Great Plains, are highly susceptible to the effects of fragmentation and habitat loss. They require long intact river reaches to complete their life-history. The concern held by conservation agents and ecologists is that continued ground water extraction will lead to further range contractions as the amount of flowing surface water, which is linked to aquifer levels, continues to decline.

Figure 5. Three species of pelagic-spawning minnows endemic to the Great Plains. *Left:* Peppered chub *Macrhybopsis tetranema*. *Middle:* Plains minnow *Hybognathus placitus*. *Right:* Arkansas River shiner *Notropis girardi*.

One species is federally threatened, the Arkansas River shiner (*Notropis girardi*). As more species become increasingly threatened across the region, state wildlife managers have warned more species may be considered for federal protection under the Endangered Species Act. While federal regulations are often helpful for protecting species, federal regulatory action can have negative implications for communities that rely on groundwater pumping for irrigation.

It's difficult to put a price on biodiversity, and conservationists in Kansas understand that agriculture is an economic empire. However, these small fish are an important part of stream ecosystems. They provide food for larger game fish, such as bass and catfish. Furthermore, these small fishes may serve as a "canary in a coal mine."

"Fish are an indication of the health of the environment," Dr. Heath Kiddo of Kansas State University explained in a recent interview. "A while back there was a sewage leak in the Arkansas River and it was the dead fish that helped identify the problem. Children play and swim in that water, so it's important that we have a good understanding of water quality."

World Wildlife Fund reported that the rate of global biodiversity loss is between 1,000 and 10,000 times the normal extinction rate. It's difficult to know how many endemic species can be threatened or lost before an ecosystem becomes unstable. What is known is that once these small stream fishes are lost, there's no way to bring them back.

Land owners share mixed feelings about changing ground water use. While many farmers are concerned about fish communities and conservation in Kansas, they're also concerned about how water reform might impact their business.

The conversion from irrigated to dryland farming is a potential option for reducing the burden on the aquifer; it might be the only environmentally sustainable option. However, it can be costly for farmers and farming communities. Estimates of annual economic impacts in Kansas following conversion from irrigation to dryland farming predict a loss of over 17,000 jobs and just under $8 million in total income. For families that rely on farm income, this reduction in yield could have serious financial consequences.

Part of the controversy surrounding aquifer depletion relates to how the government subsidizes crops. Corn is king across the Great Plains, and farmers receive cash benefits for growing corn that is ultimately used for human consumption, ethanol production and animal feed. However, corn is also one of the most water intensive crops, as irrigated corn produces eight times more crop yield per acre according to the United States Department of Agriculture (Figure 6).

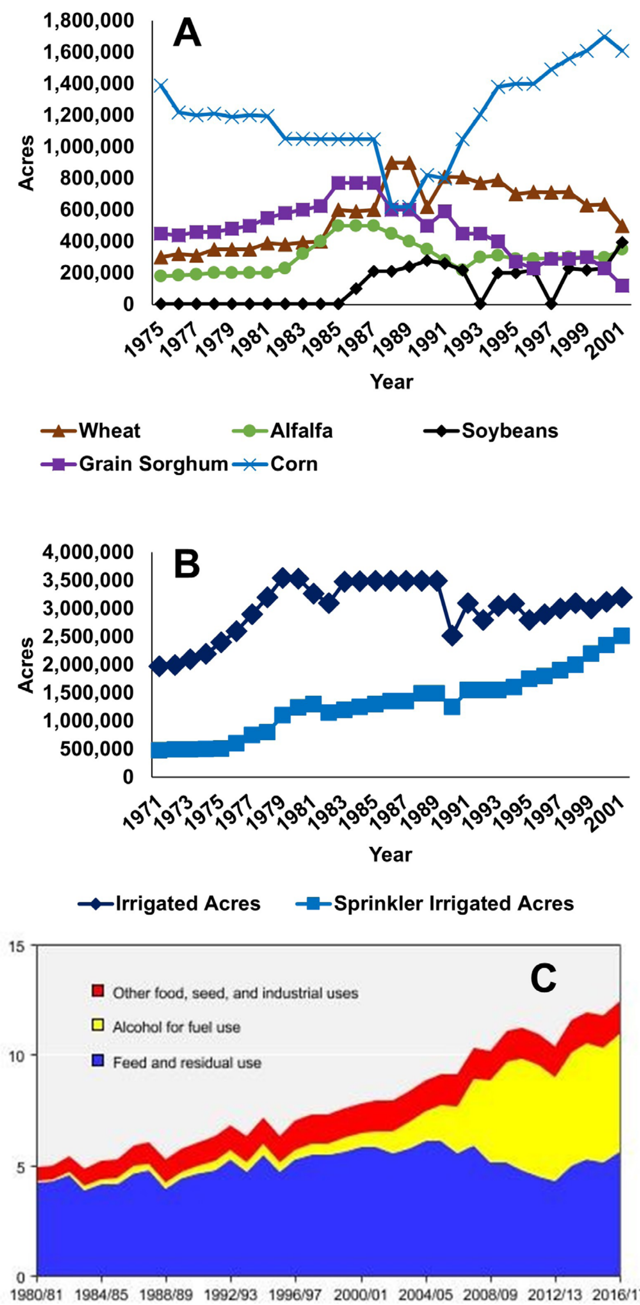


Figure 6. Trends in water use in Kansas: (A) indicates changes in irrigated crops grown in Kansas from 1975–2001, (B) indicates how water use and depletion have changed from 1971–2001, (C) indicates how corn use has changed from 1980–2017 (in billions of bushels) (Source: USDA 2017).

While limiting irrigation comes with a financial burden, some farmers are beginning to self-regulate in hopes of building a sustainable water-use plan. For example, farmers in Hoxie, Kansas self-implemented a 20% reduction in irrigation. These farmers recognize that short-term economic losses may be key to saving water for future generations and improving long-term economic outlooks. Thus far, water laws in Kansas have not changed and while some landowners are self-regulating, their neighbors continue pumping.

Many have a stake in these policy decisions, and it's clear that a sustainable solution for conserving this finite resource must be negotiated. As Kansas legislators plan to meet, the future proponents of Kansas agriculture and ecology alike hope to have their voices heard.

Questions

Set A – Neutral Perspective

1. Given that the High Plains Aquifer overlaps so many states, how might water use in one state affect water use in another state? How could this further complicate water policy decisions?
2. How is water use correlated with crop production and the types of crops produced (Figure 6)?
3. Think about potential consequences to the transformation of fish communities across the region. Considering that fish species are indicators of ecosystem health, what can the decline of pelagic-spawning minnows tell us about the status of Great Plains rivers?
4. What other natural communities might be altered because of decreased stream flow?
5. What are some potential ways to make fish communities more resilient to change?
6. What is the intrinsic cost of a species and/or biodiversity loss? For more information, see the *Living Planet Report 20016* from the World Wildlife Fund on the state of planetary biodiversity: <http://wwf.panda.org/about_our_earth/all_publications/lpr_2016/>.

Set B – Stakeholder Perspective

The following questions should be answered from the perspective you have been assigned. Use the Venn diagram below to help you organize your thoughts.

7. Should the water policies in Kansas be changed? Why or why not?

8. What is at stake for land managers who support water use reform? Will conditions improve for the ecosystems that they study if water reform is approved?

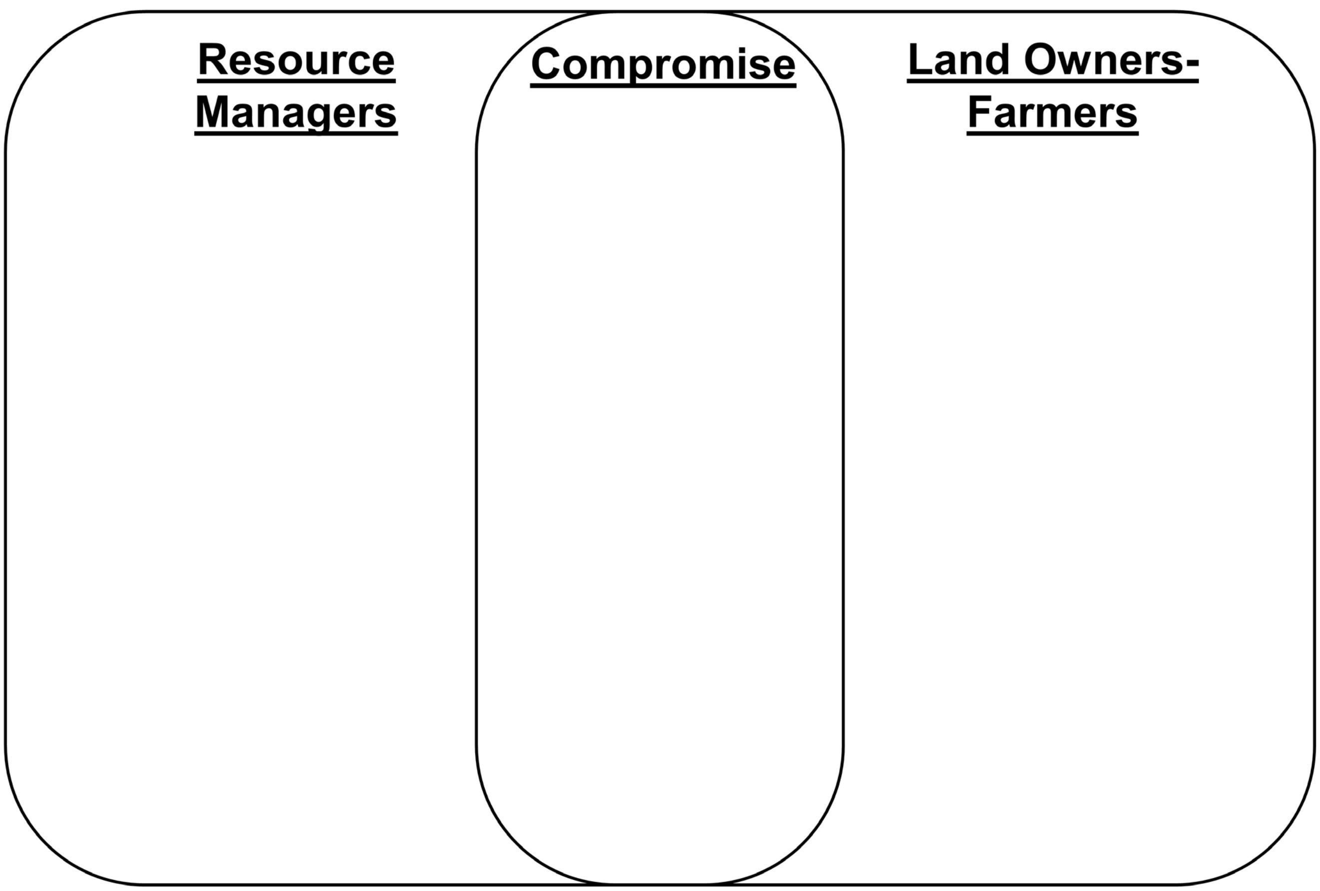
9. Why are the landowners concerned about water use changes? What is at stake for landowners and their farm businesses?

10. What are some possible compromises between landowners and land managers?

11. How have farming practices changed over the past 100 years in the High Plains? How could these changes positively and negatively impact aquifer use?

12. How has water use and development around the High Plains Aquifer altered fish communities? What does this mean for managers at the state level that are tasked with the conservation of these species?

A simple way to use this Venn diagram to organize your thoughts is to make a list of pros and cons within each side of the diagram and then use those to come up with some compromises.



Assignment

Maintaining your group's originally assigned perspective (farmer or conservation agent), write a letter to policy makers in the state congress using the data presented in this case study and that you found during your own research to support or oppose water use reform. Come up with some practical compromises, and brainstorm other consequences to the region should the High Plains Aquifer continue to be depleted.

Remember: Persuasive letters are effective when they display an understanding of an opposing position and use contrasting evidence to find fallacies in the opposing viewpoint's logic.

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