Wyoming's Water Issue: Planning for Water Scarcity or Ignoring It?

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Abstract:

The state of Wyoming contains the headwaters for the Colorado River, a river that supplies billions of people their water throughout the Western United States. Water is a vital resource that all life needs to survive. As climate change is predicted to change the known water regime and timing in snowpack melt, the state must plan for changes in water availability. In 2015, Wyoming's Governor Matthew Mead released *Wyoming's Water Strategy* to address and plan for future water scarcity. Within his plan, the governor laid out plans for 10 new water storage projects in ten years. Three years after the plan was published, no projects have been completed and only two have been started.

The goal of this project was to understand the necessity and accuracy for Governor Mead's plan. This was accomplished by observing and interviewing people throughout the state of Wyoming who would be affected by the Governor's plan. This project also offers different projects or solutions the state would benefit from considering the uncertainty in the future of water.

Introduction:

In 2015, Governor Matthew Mead released his Water Strategy Plan, which laid out his objectives to plan for water scarcity in the future. This plan includes four initiative themes: management, development, conservation, and restoration. Within each theme, there are multiple objectives the Governor wants to accomplish for water within the state.

In the management initiative, the three objectives aim to improve stream flow data throughout the state, develop a plan for groundwater use in the Laramie County, and obtain a greater understanding of the state's weather and climate variability and groundwater regime. These three objectives are reasonable; all objectives aim to better understand Wyoming's water system. Climate and weather impact all water users, and having a greater understanding of the weather's impact on streams would help all Wyomingites to plan for their water uses and their timing of water use.

In the development initiative, the Governor's objectives relate to infrastructure for water storage. This includes expanding and completing the Fontenelle Dam, obtaining a larger water right from the Army Corps of Engineers in the Glendo Reservoir, and building ten new water projects in ten years. In this sense, a water project is a new dam and reservoir. The ten in ten project is lofty and expensive. The state has started five of the ten projects within the last three years, but has yet to start building any (Labonde 2018). The state legislature has appropriated money for the projects to start, but the state must go through the National Environmental Protection Act (NEPA) process before building any structure. The state legislature has voiced concerns with many of the projects and has been hesitant to appropriate all the money the projects have been predicted to need. Building just one project, the Dam on the West Fork of Battle Creek, is estimated to cost the state around 40-million-dollars in hopes that the Federal

government would cover the other 40 million. The development initiatives are where the Governor's plan becomes controversial for many people. Is building new dams the best use of the state's money?

In the conservation initiatives, the one objective revolves around obtaining better water quality data and improving credible data collection.

The governor's recreation initiative aims to build fish passages and restore rivers throughout the state. Both of these objectives would benefit fish and wildlife throughout the state, but are expensive projects.

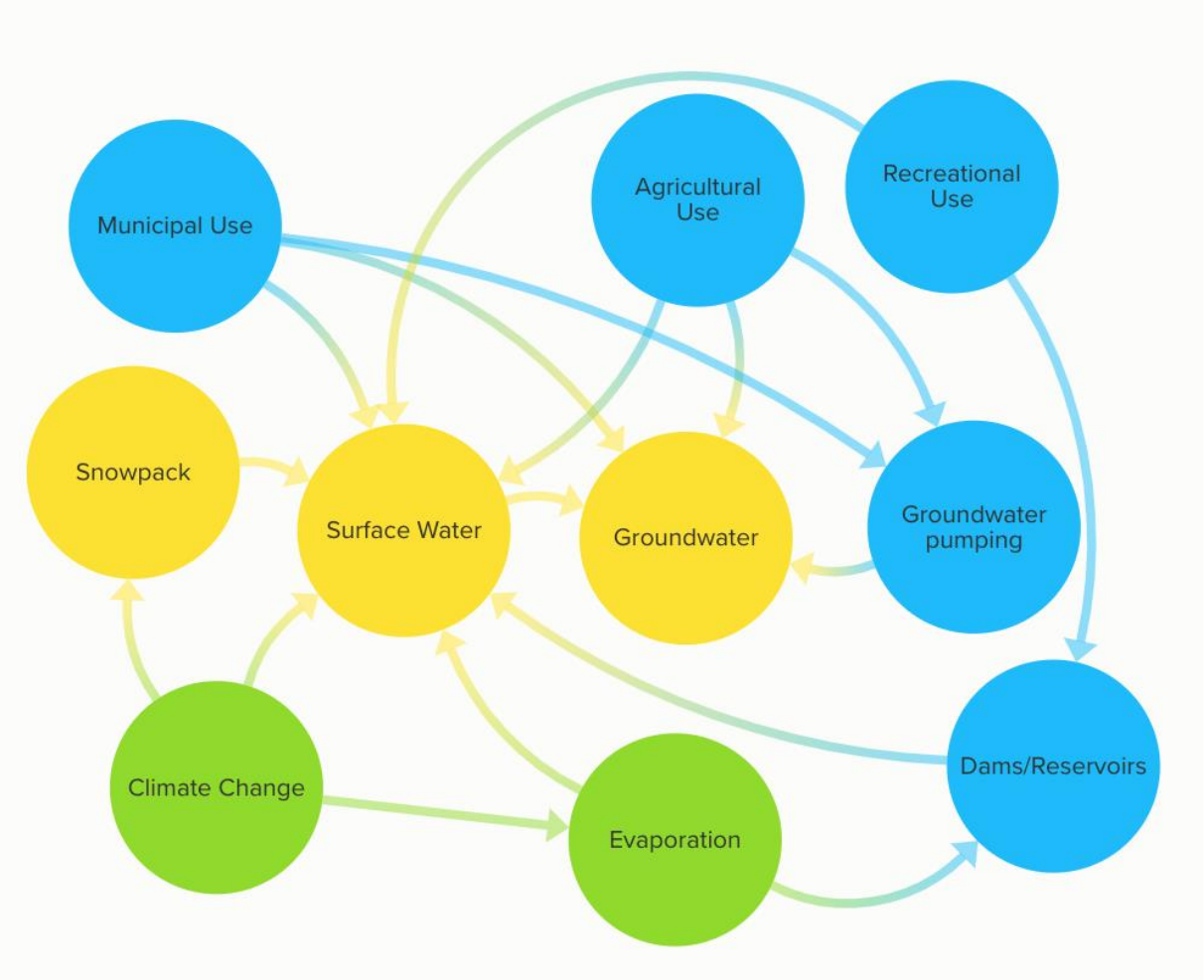
Through and through, the Governor's plan captures the state's culture and outlook. He makes claims throughout the plan that assume the state has total control over the water that runs throughout it, and no new weather or climate pattern was going to get in the way of Wyoming irrigating the dry land. The Governor shows his metaphorical firm grip on water in this plan without mentioning Wyoming's obligation to give other states water and the Federal agencies that regulate so much of the state's water in dams and reservoirs, but rather talks of these parties as threatening.

> "As a state, we have seen recent challenges to our water resources and our rights to manage them. In the last year alone, federal agencies have sought greater control of surface water, groundwater, and even our watersheds. We have also faced challenges from neighboring states who would like a greater portion of our water. We have and will continue to challenge these actions. We owe it to those that came before us and those who will come after us."

This project set out to understand the Governor's plan, how it could better fit the needs of Wyoming, and ultimately what was missing from the plan entirely. Given the uncertainty of the future water need and resources, how can Wyoming collaborate with different stakeholders to balance different uses including management, development, conservation and restoration? To do

this, one needs to understand the history of water in Wyoming including water laws, how people and agencies are connected to the water, and the wants and needs of the stakeholders throughout the state.

Figure 1: Below is an example situation map of Wyoming's water resource

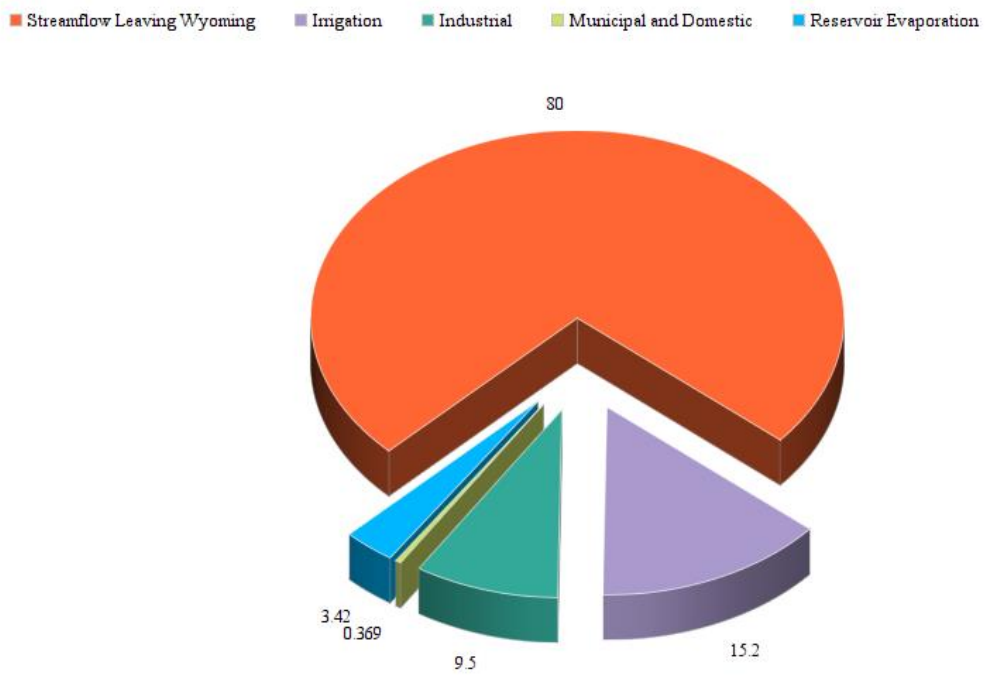


Color Key:
Yellow: Water within Wyoming
Green: Forces limiting/changing water
Blue: Uses of water

Figure 1 shows the relationships between users and the water available within the state, along with the larger forces impacting water available in Wyoming. The arrows point from an element to what it is impacting, for example, climate change will impact snowpack melt earlier

in each calendar year, will increase evaporation rates with increasing temperatures and will decrease surface water later in the season due to earlier snowpack melts.

Figure 2: Below is a pie chart displaying where Wyoming's surface water goes, percentage wise.



(Hansen et al. 2015)

This figure displays Wyoming's surface water uses. With 80 percent of the surface water leaving the state. It is difficult to believe the state has a current issue with water shortage. Although there may not be an urgent need to save the state's water in reservoirs, conserving and using water without waste is environmentally forward-thinking. Just examining the state's uses without including streamflow leaving the state, 17 percent of the use is from reservoir evaporation. For this reason alone, and with the firm grip mindset of this resource, the state needs to figure how to better use and store the water available.

Background:

When the Homestead Act of 1862 was established, Wyoming was just beginning to be established and settled. The Homestead Act gave 60 acres of federal land in the Western United States to anyone who could irrigate it and use for the next five years (Campbell 2002). The settlers claimed their water using prior appropriation, meaning "first in time, first in right" (Campbell 2002). In prior appropriation, the first water user obtains their first right and is then the senior right holder; everyone to follow the senior right holder is referred to as a junior water right holder. Within the next 40 years, many pioneers tried to farm and failed largely due to the lack of available water and the harsh conditions of the American West.

In 1902, the Newlands Reclamation Act established for 95% of the funds derived from the sale of public lands (federal lands) in the Western states would be used for irrigation projects to attract more settlers (Campbell 2002). Under the Newlands Reclamation Act, the Department of the Interior created the United States Reclamation Service. Within the first five years after the act was in place, the Reclamation Service started 30 irrigation projects in the West. At the time, the term "irrigation project" largely meant the creation of a dam and reservoir. Building dams and reservoirs allowed settlers to successfully irrigate the Western lands and have created the American West we know today. Before these reclamation projects, settlers were being forced to move back to the East because of the lack of water in the West. The states did not have the money or resources to build dams without federal intervention (Campbell 2002). With the Newlands Reclamation Act, the Western United States operated and was built with cooperative federalism.

Over the next century, the Reclamation Service became the expert agency in building dams, building Hoover Dam, Glen Canyon Dam, and hundreds of others throughout the West.

All most all of the major dam creation was before the United States had created the National Environmental Policy Act of 1970, which requires every federal agency proposing a major federal action to conduct an analysis of how the proposed action would effect the environment. The state of Wyoming has depended on the Federal government to fund their dams and reservoirs for over 100 years because of the large extensive cost these project. The Newlands Reclamation Act provided a way for the federal government to fund irrigation projects and help farmers stay in the West, even before the country was starting to feel the large impacts of climate change. Today, it is known that dams create sediment build-up in rivers, warm waters, increase evaporation therefore increasing salinity, block fish migrations, and alter riverbeds (Grace 171). Dams negatively impact the surrounding environment but the primary reason the West was able to become settled.

The state of Wyoming and all other western states still operate under prior appropriation today to distribute water. In Wyoming, the water rights are given and approved by the State Engineer (Hansen et al. 2015). With prior appropriation, if the user does not use all the water given in their water permit, they can lose their water right. Since the start of prior appropriation, this rule of "use it or lose it" has arguably caused users to waste water rather than losing it. Water rights are connected to the land, meaning that the water right remains in tact with the land even if the land is sold. A parcel of land does not have to be in close proximity to a body of water to obtain a large water right. In years where there is a call on the river, the senior water right holder gets to fulfill their entire water right before any other junior right holder gets any water. Since prior appropriation arose with the Homestead Act, there are right holders in the state of Wyoming with a right date going back to 1862; that being said, with prior appropriation ruling the land, water is not equally distributed among people in the state. The state also operates under

Beneficial Use, which is a list of uses that a right holder can use their water for in Wyoming (Toll 2011). Traditionally, beneficial uses were limited mining and agricultural uses in Wyoming and all other western states, ingraining the western culture of mining and farming into the law. Over time, the list of beneficial uses has expanded, but the state still contains a preferred use list. Preferable uses can determine who can obtain a water right in the state, and who can use their right in a drought. In Wyoming, if a junior water right holder contains a more preferred use than the senior water right holder, the junior right holder can obtain their right before the senior right holder. When the laws of preferred uses arose in 1868, the first priority and preferred use was for municipalities (Cooper 2004). Since then, the priority of preferred uses have altered through time to follow the values of the era. Today, preferred uses in order from most preferred are (1) drinking water for both humans and livestock, (2) water for municipal purposes, (3) water for steam engine and general railway use; water for cooking, laundering, bathing; water for steam and hot-water heating plants, steam power plants, (4) water for industrial purposes (Cooper 2004). All other uses other than those listed are considered non-preferred uses.

Currently climate change is altering the known water regime in the Western United States. Mountain snow melt is the source of water for the West during the summer season, but as the Earth warms, the mountains retain less and less snow, and more snow melts earlier in the season, leaving less water for the driest months of the year (Grace 173). With a changing water regime, the state of Wyoming needs to find ways to conserve water for the later summer season and conserve water throughout the year.

Wyoming is the headwaters state for the Colorado River Basin, with the Green River being the largest river in the entire system. This being said, Wyoming has compacts with other states and has an obligation to give water to those states. In the Upper Colorado River Compact

of 1948, Wyoming was allotted 14 percent of the water in Colorado River Basin throughout the Upper Basin States (Wyoming, Utah, Colorado, and New Mexico). With this compact, the water that appears in Wyoming, is not solely the state's property despite the fact that the state has declared to own all the water within its borders (Cooper 2004).

The firm grip that Governor Mead perceived to have on the state's water is not so firm at all. Most recently, Montana and Wyoming battled over the Yellowstone River in the Supreme Court of the United States. In the final decision on February 20th, 2018, the Supreme Court decided against Wyoming in favor of Montana, where Wyoming was taking too much water from the Tongue and Yellowstone River at the state line and has to pay Montana $67,270 for this violation (583 U.S.__ 2018). This is only one of the many examples where Wyoming has ended up in court to deal with water rights issues. Rather than focusing on holding on the water, the state should ensure that they are providing the cleanest and safest water to its citizens.

Stakeholders:

Figure 3: Below is a map of stakeholders revolving around Wyoming's water.

Color Key:
Orange: Central element
Green: Federal Agencies/Involvement within Wyoming
Yellow: State agencies
Blue: Water users and stakeholders
Red: Permits Wyoming's water within state

The arrows show relationships between stakeholders and water. This figure portrays the complicated nature of water in the state, and how many differing agencies and people are dependent on the resource. For example, as seen in figure 1, municipalities must obtain a water permit from the state engineer to provide water to Wyomingites, and they rely on the Department of Environmental Quality and County Conservation Districts to provide clean, safe drinking water.

Investigation:

With climate change, the state needs to plan for its water uses and availability. The Governor's water strategy plan attempts to do this, but deliberately leaves out climate change from the entire plan, never once acknowledging the seriousness of this and how it will impact water availability. Uses will be prioritized within the state in the future, and planning for what should be done is critical. This investigation, aimed to hear from all opinions and academia on what they though Wyoming should do with its water, from conservationists to the dam builders themselves, in order to obtain a fully informed report on what Wyomingites want to see with their water in the future, what the state should do and how they think climate change will impact them. Below is a list of stakeholders interviewed throughout this investigation.

- Harry Labonde, State Engineer, Wyoming Water Development Commission
- Scott Miller, University of Wyoming, Ecosystems Science and Management, Watershed Hydrology
- Tony Hoch, Albany County Conservation District
- Jason Robinson, University of Wyoming Law School
- Kristi Hansen, University of Wyoming, Department of Agriculture, Water Resource Economics
- Brett Moline, Wyoming Farmer's Bureau
- Mary Throne, 2018 Wyoming Governor Candidate

This investigation was used to uncover what has been missing from the Governor's water strategy plan and what could be added in the future. The stakeholders were chosen based on their knowledge of water within the state and their careers in water resources in Wyoming.

Throughout this investigation, the West Fork of Battle Creek Dam was being discussed at the state legislature as one of the Governor's 10 in 10 dams. This dam is the fifth of the ten dams to be proposed within the state as part of the Governor's development initiatives. During January and February of 2018, the Wyoming Water Development Commission (WWDC) wanted the state to appropriate 40 million dollars for this dam, in order to start construction. The overall cost

of this dam is predicted to be 80 million dollars, is estimated to hold 10,000 acre-feet of water, and would be used by under 10 Wyomingites for irrigation purposes. The WWDC is depending on the Federal Government to provide the other 40 million dollars. With resistance from many in the state legislature, in February the project was appropriated 4.7 million dollars to continue the project. The Wyoming state legislature has required Colorado to contribute to this project moving forward, if Wyoming is to build this dam since the reservoir would be built so close to the Colorado-Wyoming state line arguably more Coloradans could benefit from this project than Wyomingites.

Results and Suggestions:

Throughout discussing water resources and the Governor's plan with stakeholders throughout the state, solutions suites and themes became reoccurring in discussion and evident. The themes through which all solution suites, those proposed by the Governor and in this report, must be looked through the lenses of climate change and resource economics. Solutions must move away from the culture of the state and what has been done traditionally since climate change is an active force on the state's resources. The following solutions are suggestions for additions or things to change moving forward with the Strategy Plan. For example, if the next Governor elected in the Fall of 2018 were to create a water strategy plan, these following solutions should be considered in such.

Suggestion 1

The first suggestion is to scratch a state-wide water strategy. With the state of Wyoming differing in geology and hydrology from county to county, having a uniform strategy for the state is more political than scientific. A large theme felt throughout the Plan, is that Wyoming has a firm grip on it's resources state-wide, when in reality the state's firm grip is held in each individual water right in each county and town, not by the Governor. The quality and quantity of water is dealt with at a county level, other than the application for a water permit, and therefore should be planned for by the County Commissioner and County Conservation District. For the Governor to create a plan that encompasses the needs of all Wyoming water uses, a plan should be locally based with sponsorship, and support from the Governor.

There are several counties left out in the Strategy Plan, for example Albany County has no projects included in the Plan, when the county could greatly benefit from quality control. All water quality in Albany County in monitored and logged by the Albany County Conservation

District, which is funded by the federal government. When speaking with Tony Hoch from the Albany County Conservation District, he led on that the Little Laramie River will be listed next year as "Impaired" under the Clean Water Act because of sediment and E-coli. The Little Laramie River is one of the major water sources for the city of Laramie and once it is listed as "impaired" the city will be entirely depended on the Casper Aquifer. Albany County would greatly benefit from an initiative promoting water quality but this issue is entirely left out of the Plan because it is not a state-wide issue.

One of the issues that these smaller plans would run into, is that there could be less funds appropriated in a county than is being used right now. For example, in Bighorn Basin of Wyoming, there are two dams being rebuilt. These two projects cost about 65 million dollars (Thuermer 2015). Without this centralized plan with the 10 in 10 initiative in the development portion of the Plan, the Bighorn Basin would have likely had a more difficult time getting all of the funds required for these two dam projects. Since the state sees such urgency to save water within the limits of Wyoming and has been water projects like these for many years, it is still likely that dams would be built even without a state-wide plan.

Suggestion 2

The second suggestion is to include Native American Reservations in the conversation on water in Wyoming. The Wind River Reservation is not mentioned once throughout the Governor's Plan, and yet they hold a large water right within the state. Not only do they hold a large water right, but the majority of their water on the Reservation is leached with uranium from old uranium mines. Since water law does not exclude the Wind River Reservation, the Native Americans should be represented in court and in the state's discussions on water. The water right of the Wind River Reservation dates back farther than most rights in the state of Wyoming, back

to 1864; this senior water right holder should hold weight in the water discussion (Robinson 2018).

The in the latest water litigation, Wyoming v. Montana, the use of the Yellowstone River was fought over. Multiple tribes in Montana use this water, along with the Wind River Reservation, and municipals in Montana and Wyoming. Throughout all the case, Montana had representatives from the the Crow Tribe and the Cheyenne Tribe (583 U.S.__ 2018). Wyoming included no representative from the Wind River Reservation (Robinson 2018).

The Wind River Reservation deserves representation in the water discussion since their nation lays within the state of Wyoming and is directly affected by the decisions made by the state (Robinson 2018). The Plan was created by a team in the State Engineer's Office who traveled throughout the state to gather a sense of what the public wanted to happen throughout the state, but the minority is not included in this plan (Labonde 2018). With no mention of the Wind River Reservation, this plan does not capture the entire voice of the state, just those with the loudest, largest voice. The state of Wyoming does an injustice to the Wind River Reservation by not including them in this discussion on water, and is a clear example of what environmental justice looks like throughout the country.

Suggestion 3

In the Plan, the majority of the conversation is surrounding obtaining a greater quantity of water, rather than a higher quality of water. The state of Wyoming does not take primary in the Safe Drinking Water Act, meaning that state municipalities and water treatment facilities do not clean water to the Safe Drinking Water Act (SDWA) standard. This allows the federal government to regulate the drinking water and take initiative on regulation within the state. By not taking primary in the SDWA, the state is not consistent in their "firm grip" mentality, and

removes themselves from the responsibility of regulating water. This is not consistent with the rest of the state's position on water. Wyoming rather spend money on creating more water storage than actually provide clean, safe water to their citizens.

With 80 percent of the water within Wyoming leaving the state, there is less of an urgency with having enough water, compared to having clean water (Hansen et al. 2015). If the state invested as much money in obtaining a higher water quality as they have in building new water storage facilities (130 million in the last three years), Wyoming would arguably have the cleanest and safest drinking water in the nation. There is a need to regulate the water people are drinking, as it directly impacts the health of people.

Suggestion 4

In the conservation initiatives in the Plan, the only initiative is surrounding collecting water quality data in the state, and improve data credibility. Conservation is much more than just improving water quality data, and this theme can be largely expanded throughout the state. Fundamentally, conservation is an expression of human values; what do we want to save and continue to use in the future? Conserving the quality of water is important, and so it the resource itself. Conservation efforts done by one user can save water to be transferred as another user's water source. This is where the Governor's Plan should meet New Conservation Science and plan for climate change (Kareiva et al. 2012). Wyoming should plan on using water within the state based on the changing water regime, adapting to how seasons and water cycles are changing with climate change, instead of holding onto to past water uses and laws set up when the West had more water.

With 80 percent of the water use in Wyoming being irrigation, the state should focus on how to use water in irrigation more efficiently. The percentage of water going towards irrigation

shows how large of a value and priority irrigation and agriculture is in Wyoming. For this reason, efforts should be focusing on how to efficiently irrigate lands so that it can be continued in the future. The majority of Albany County farmers use flood irrigation methods. By switching to center pivoting systems, irrigators can save around four hours per acre foot per year, causing less fertilizer to run off into streams and lakes, and allowing greater instream flows and water for other users (Brown 2008). Center pivot systems allow the soil to retain nutrients and ensure soil for future farmers. In the state of Wyoming, water rights can be leased to other users, meaning that if an irrigator has water left over, they can lease that water to a municipality or other irrigator. By cutting down on a water right and finding smarter ways to use water, the state might not feel the need to spend as much money on building water storage facilities.

There can be downsides to using center pivoting systems depending on the type of soil one is irrigating, and the the winds must be lower than 10 mph on average to accurately water crops with center pivot systems. But center-pivot systems is not the only application of conservation. Cities can xeriscape to save water and use it more efficiently. Rather than having grass yards, individual home owners could xeriscape and save thousands of gallons of water (Hoch 2018). By water not going towards grass, there would be more water in the summer when water is needed for irrigation, and the city would have more water available and less need for new storage facilities.

Conservation can be the small actions individuals take to save water, but with the influence and campaign of the state and Governor to save water, efforts could spread and widen throughout the state. Using water efficiently is a goal that all water users should strive for, and this is completely missing in the Plan.

Suggestion 5

Groundwater is linked to surface water. In the entire Plan, there is one initiative that discusses groundwater; other than that one objective, the plan does not address groundwater. The majority of aquifers in Wyoming are alluvial, meaning that they are shallow deposits recharged by running water, streams and rivers (Hansen et al. 2015). There are little to no laws surrounding groundwater use in Wyoming, and a user does not need a permit to use groundwater once they obtain their own well. The majority of wells in the state do not have meters, so users do not know how much water they are using (Hansen 2018). Wyoming should implement groundwater meters and create plans for groundwater use that link the usage to surface water.

To plan for climate change and changing water regime, groundwater users must be aware that their water supply will deplete as climate change accelerates. Water that percolates today is essentially excess water to the above ground system. When there is enough in the rivers and streams, water is able to percolate into the ground. Less water will percolate into the ground in the future because there will be less water overall.

The single initiative that involves groundwater is in Laramie County, surrounding the Ogallala aquifer. The farmers in Southern Laramie County have been using this groundwater source for their farms and wells throughout the settlement of the West, and have never been required to meter or measure their use (Hansen 2018). In 2015, the State Engineer met with the Laramie County groundwater stakeholders to decide on what to do moving forward with the Ogallala aquifer. The stakeholders have the choice to decide if they want to recharge the aquifer to before-today-levels, maintain current levels, or just deplete the aquifer completely—all on the state's dime. Although this is a plan that accommodate stakeholder wants, this is not a smart conservation plan and does not plan for the future of groundwater use. Since the state has no laws surrounding groundwater, their authority over groundwater is so small that they are almost

forced to allow the stakeholders to choose what they want to do with the aquifer. Other states that use the Ogallala, like Nebraska, Kansas, Oklahoma, have laws and rules surrounding groundwater use and Wyoming should do the same.

The Nebraska Department of Natural Resources (NDNR) regulates groundwater by water basin. Each well owner must register each well they drill with the NDNR, and the well owner must track how much water they use from the well (Nebraska Department of Resources 2016). Each basin in Nebraska has a water management plan that includes surface and groundwater initiatives; this way the NDNR is fully aware of the groundwater and surface water situation everywhere in the state. Well users in Nebraska are allowed to use as much water as they need, unless there it is a "Call Year," meaning a dry year. In a dry year, the well users are limited based on their use (Nebraska Department of Resources 2016). Call years are based on surface water, but since groundwater and surface water are connected, the lawmakers in Nebraska know that the low levels of surface will affect the amount of available groundwater.

If Wyoming managed water by basins like Nebraska, the State Engineer's Office could create six management plans, including groundwater. Wyoming should also implement Nebraska's rule of limiting groundwater use in dry years. Not only would this localize management, but would be inclusive of all water in Wyoming, not ignoring groundwater. With groundwater initiatives and implementing groundwater laws, the Plan would be strengthened and more inclusive of all of Wyoming's water.

Conclusion

The Governor's Water Strategy Plan was based on stakeholder wants and needs throughout the state. From a natural resource management and conflict management point of view, this plan is inclusive and made by the people and keeps everyone happy. But, in a state that largely does not accept climate change and believes that it will not be affected by it—this plan is ineffective. Snowpack melt is the major source for Wyoming's water and snowpack will change and is changing the state's water regime.

Government exists to look out for its people and protect them. By the state and the Governor not addressing climate change and this concern of the changing water regime in Wyoming, the state is not looking out for the public's best interest. The state wants to address scarcity, but blatantly leaves out climate change in the discussion on water scarcity. The Governor plans for scarcity with dams and reservoirs, but with 17 percent of the state's water going towards evaporation, increasing reservoirs will only increase the contribution to evaporation in Wyoming (Hansen et al. 2015). The Plan does not include measures to address climate change in the Wyoming climate with resource economics included. Wyoming cannot afford to continue to build dams and reservoirs as climate change intensifies throughout the state, considering that the Wyoming Water Development Commission has already used up 160 million dollars in less than three years. The state must find reasonable measures to ensure water in Wyoming in the late summer season without causing further harm to the environment—dams and reservoirs do not accomplish this.

Throughout time and generations, people change and values change. What we use water for today may seem nonsensical in the future. As governments today create structures and enact laws that encapsulate the culture of our time, will we disadvantage future generations by not

including climate change in these laws and structures? The idea that Wyoming owns the water that flows across its landscape is nothing more than an esteemed claim. Wyoming must let go of the idea that the state owns all resources with a firm grip; water flows where it likes, and over time the course a river takes can change.

The Earth has reached a point where warming in inevitable for at least the next 60 years. Lawmakers and citizens today must be proactive for the fate of these future generations that will live in Wyoming and all across the Western United States.

Resources

Brown, Paul. 2008. “Flood vs. Pivot Irrigation for forage crops: what are eh advantages and disadvantages” *University California Davis.*

Campbell, Robert. 2002. "Newlands, Old Lands: Native American Labor, Agrarian Ideology, and the Progressive-Era State in the Making of the Newlands Reclamation Project, 1902-1926" *Pacific Historical Review*. Vol. 71, No. 2, pg. 203-238.

Cole, Nephie. 2018. Personal Communication

Cooper, Craig. “A History of Water Law, Water Rights, and Water Development in Wyoming 1868-2002” *Wyoming Water Development Commission and State Engineer’s Office*, June 2004.

Grace, Stephen. “Dam Nation: How water shaped the west and will determine its future” *Globe Pequot,* 2012.

Hansen, Kristi., et al. “Wyoming’s Water: Resources and Management” *University of Wyoming Extension* November 2015.

Hansen, Kristi. 2018. Personal Communication

Hoch, Tony. 2018. Personal Communication

Kareiva, Peter., and Marvier, Michelle. November 2012. “What is Conservation Science?” *BioScience*, Vol. 62, Issue 11, pp. 962-969.

Labonde, Harry. 2018. Personal Communication

Mead, Matthew. 2015. “Leading the Charge: Wyoming Water Strategy”

Miller, Scott. 2018. Personal Communication

Moline, Brett. 2018. Personal Communication

Nebraska Department of Natural Resources. 2016. “Integrated Management Plan”
Robinson, Jason. 2018. Personal Communication

Toll, Michael. 2011. "Reimagining Western Water Law: Time-Limited Water Right Permits Based on a Comprehensive Beneficial Use Doctrine" University of Colorado. Rev. 595-640

Throne, Mary. 2018. Personal Communication.

Thuermer, Angus. “$72 Million in dam projects advance” *Wyofile.* August 25, 2015. https://www.wyofile.com/70-million-in-dam-projects-advance/

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