UPPER YELLOWSTONE WATERSHED WORKSHOP

Water Planning Efforts To Date, Land Use and Economics, Ground Water Supply, Surface Water Supply & Quality, Water Use, Climate Trends

Abstracts

Topic: Water Planning Efforts To-Date

Presentations:

The Governor's Upper Yellowstone River Task Force (1997-2003)

Presenter: Andy Dana, PMD Ranch

Yellowstone River Cumulative Effects Analysis (2000 – 2015)

Presenter: Karin Boyd, Applied Geomorphology

Yellowstone River Basin Water Planning (2013 – 2015)

Presenter: Barb Beck, Montana Fish, Wildlife & Parks

Goal of this workshop section: To better understand the major scientific studies and planning processes that have focused on the Upper Yellowstone River Basin over the last three decades. These efforts each produced a wealth of data in addition to stakeholder-led, science-based management recommendations that can inform current, local efforts to improve the health of the Upper Yellowstone River watershed.

The Governor's Upper Yellowstone River Task Force (1997-2003)

Presenter: Andy Dana, PMD Ranch

Background:

Two 100-year floods in 1996 and 1997 significantly impacted the Upper Yellowstone River's morphology, ecology, private property and more. To address these issues, Governor Marc Racicot appointed the multi-stakeholder Upper Yellowstone River Task Force in 1997 to address these issues.

Goal of the Task Force: Provide a diverse stakeholder forum to address issues, competing values and uses that impact the Upper Yellowstone River in the wake of back-to-back major flood years. Ultimately, the effort focused on conducting an interdisciplinary, six-year study of the river and its physical, biological and cultural attributes.

Membership: Twelve voting members represented a broad spectrum of the community; ex officio advisors included agencies such as the Montana Department of Natural Resources and Conservation, Department of Transportation, Department of Environmental Quality, Department of Fish, Wildlife & Parks, and the U.S. Army Corps of Engineers). The Task Force operated by consensus.

Process: The Task Force operated by consensus and held monthly meetings and educational activities that sought to involve the community. They focused on acquiring a common science-based knowledge of the Yellowstone River and spent six years studying, compiling, debating, and discussing information about the river.

Outcome: In addition to various studies, assessments, and reports, the Task Force generated **43 consensus-based final recommendations** which they presented to Governor Judy Martz in 2003. Recommendations fall into the following categories: bank stabilization, bridges, financial incentives, fish and fisheries, floodplain development, future science/monitoring/research, new stakeholder group, Ninth Street Island, noxious/invasive plants, permitting/regulatory/management decisions, and public structures.

Gaps: The Task Force effort did not anticipate – or address – challenges such as rapidly increasing recreational use, land use changes (i.e. subdivision), and climate change.

Online Resources:
Montana State Library -
http://geoinfo.msl.mt.gov/data/yellowstone_river/upper_yellowstone_river_task_force

The Yellowstone River Cumulative Effects Analysis (CEA) (2000 – 2015)

Presenter: Karin Boyd, Applied Geomorphology

Background: After the floods of 1996-1997, bank stabilization (rip-rapping) along the Yellowstone River increased markedly. The Army Corps of Engineers, as the permitting agency, was sued by several conservation groups for allowing this development to occur without understanding the cumulative impacts on the Yellowstone River. In response, the Army Corps was directed to "conduct a comprehensive study of the Yellowstone River from Gardiner, Montana to the confluence of the Missouri River to determine the hydrologic, biological and socioeconomic cumulative impacts on the river." Cumulative effects are to the total of individual human activities impacting the river that, when combined, can significantly alter an ecosystem. This study was authorized and funded by the 1999 Water Resources Development (WRDA) Act.

Goal of the CEA: Evaluate the cumulative hydrologic, biological and socioeconomic impacts of human activity on the Yellowstone River. Develop recommended management practices to improve river health.

Membership: The state of Montana, to ensure robust local leadership and participation in the study, formed a Council to lead the effort and represent local interests. At the time it formed, the Council comprised 12 representatives from each of the conservation districts along the length of the Yellowstone River from Park County, MT to Mackenzie County, ND. A Technical Advisory Committee (TAC) consisting of agencies, universities and individual consultants met bi-monthly to advise the Council and ensure sufficient progress. A Resource Advisory Council (RAC) consisting of diverse stakeholders in the basin provided local input for the duration of the effort.

Process: The effort first involved generating several strategic scopes of work as well as implementation and funding strategies for each. The Council met regularly over the length of the study and led several educational and outreach events, tours, and discussions. Primary research components included: hydrology, hydraulics, geomorphology, riparian systems, wetlands, water quality, avian life, fisheries, land use and socioeconomics.

Outcome: **The Yellowstone River Cumulative Effects Analysis**: A 433-page scientific study and a web-based clearinghouse of information hosted by the Montana State Library. **Science-based recommended management practices related to**: floodplain restoration, bank armoring, side channel blockage removal, riparian/wetland management, invasive woody plant control, noxious weed control, nutrient reduction, solid waste removal, irrigation water management. **Position statements related to**: oil/gas/brine pipeline crossings, altered flows, channel migration zone maps, fish passage and entrainment, watercraft safety.

Current Efforts: The Yellowstone River Conservation District Council is still going strong and has formed two working groups to implement recommended practices related to invasive woody species control and irrigation water management. The Council is focused on soliciting, prioritizing and funding on-the-ground projects. Contact Dan Rostad, Council Coordinator at 930-0594 for more information.

Online Resources:
Montana State Library's Yellowstone River Corridor Clearinghouse:
http://geoinfo.msl.mt.gov/data/yellowstone_river/about

The Yellowstone River Conservation District Council: http://yellowstonerivercouncil.org/

Yellowstone River Cumulative Effects Analysis:
http://ftp.geoinfo.msl.mt.gov/Documents/Projects/Yellowstone_River_Clearinghouse/Yellowstone-River-Cumulative-Effects-Study.pdf

Yellowstone River Recommended Practices:
http://ftp.geoinfo.msl.mt.gov/Documents/Projects/Yellowstone_River_Clearinghouse/Yellowstone_River_YRRPs_Final03_01_2016.pdf

Yellowstone River Basin Water Planning (2013 – 2015)

Presenter: Barb Beck, Montana Fish, Wildlife & Parks

Background: In 2013, Montana launched a planning process to update the State Water Plan under DNRC's statutory water planning authority. The State Water Plan consisted of water resource information and recommendations developed by four regional Basin Advisory Councils (BACs) in Montana's four major river basins - the Upper Missouri, Lower Missouri, Clark Fork/Kootenai and Yellowstone. The State Water Plan is a guide for the use and conservation of the state's water resources.

Goal of Yellowstone Basin Water Planning: To document the status of the Yellowstone River's water resources and propose management recommendations to protect the Yellowstone River's water for the benefit of current and future generations.

Membership: The Yellowstone River Basin Advisory Council comprised 20 members representing agriculture, recreation, instream flow, municipal water use, industry, energy development, the Crow Tribe, and protected federal lands.

Process: In 2013, the effort began with forming the BAC, public scoping and determination of priority issues. The BAC then engaged with a variety of experts through technical presentations and discussions to better understand priority issues identified by the public. The BAC then developed management recommendations based on public information and the best available science.

Outcome: The effort resulted in the Yellowstone River Basin Water Plan - a compilation of natural resource information and resultant management recommendations. **Recommendation categories include**: Drought readiness, water information, integrated water quality and quantity management, water administration and beneficial use, watershed planning, groundwater/surface water nexus, instream flow maintenance, water storage and funding.

Barb Beck's Thoughts on Moving Forward: Build on the water plan, engage all stakeholders collaboratively, use the best science and make it available to all, monitor drought and water quality transparently, celebrate successes and good practices, continue to learn.

Online Resources:

Yellowstone River Basin Water Plan: http://dnrc.mt.gov/divisions/water/management/docs/state-water-plan/yellowstone/river-basin-plan/yellowstone_river_basin_report_final.pdf

Topic: Land Use & Economics

Presentations:

Land use trends in Paradise Valley

Presenter: Lawson Moorman, Park County Planning Department

Economic Profile of Park County

Presenter: Larry Swanson, PhD Economist, University of Montana

Goal of this workshop section: To better understand the projected future trends of land use and economic development in Park County and its impact to the watershed.

Key Land Use Trends:

- Population in Park County grew by 4,285 residents between 1970 and 2010.
- Livingston added only 117 residents in that timeframe, amounting to an additional 4,168 living out in the county.
- 4,553 undeveloped parcel in Park County as of 2018
- Influx of more intensive and diverse uses (e.g. Sage Lodge and Yellowstone Hot Springs)
- Fewer subdivisions
- 21 new lots created through subdivision exemptions from 2017 – Present
- Major increase in short-term rentals from AirBnB, VRBO, Homeway, etc (e.g. 363 short-term rentals listed in Paradise Valley on VRBO)

Key Economic Trends:

- The combination of high area natural amenities, high levels of creative occupation employment, and strong entrepreneurial cultures are referred to by ERS economists as the "trifecta" in terms of underly attributes for economic growth

PARK COUNTY BY THE NUMBERS

- **$196 MILLION** in non-resident tourism revenues in 2014.
- **ONE** and only year-round driving entrance to Yellowstone Nat. Park.
- **20** different economic sectors fuel a diverse economy.
- **2,800 square miles**, just over half being National Forest Land
- **TOP 6%** - non-metropolitan nationwide – in possessing a thriving "creative class."
- **$70 MILLION** a year in direct spending from fishing industry alone.
- **4.1 MILLION** visitors to Yellowstone National Park in record-breaking 2015; a **13% INCREASE** since 2010.
- **564** farms and ranches.
- **22%** of all labor income fueled by travel, tourism, and recreation.

and vitality. Park county is one of only several hundred rural counties across the US that appears to possess all three attributes.

- Income on a per-person basis in 1990 was $20,980. By 2000 this had grown to $28,156 and more recently in 2014 had reached an all-time high of $40,614. Park County per capita income was less than the statewide level in 2001 – $29,890 vs. $31,870 for the state as a whole. But the 2014 Park County per capita income level exceeds the state level -- $40,614 vs. $39,903.

- Proprietor or self-employment represents a significant portion of all employment in Park County, accounting for **39%** of all jobs in 2014. This has grown over the last decade from about one-third of all jobs before 2000 and this growth has been entirely among non-farm proprietors. Statewide in Montana proprietors accounted for **27%** of all jobs in 2014, up only slightly from 26% in 2000.

- The poverty rate in Park County also is lower than statewide with poverty in Park at 12.3% versus 15.2% statewide.

- **Tourism Trends**: In 2017, **residents** spent nearly $2.87 billion on trips 50 miles or more away from home but still in Montana. In comparison, 12.5 million **non-resident travelers** came to Montana and spent $2.8 billion supporting 39,000 jobs and indirectly contributed an additional $1.9 billion and a total of 53,000 jobs. Total travel industry spending in Montana is $6.23 billion dollars; 54 percent contributed by nonresidents and 46 percent by resident travel within the state.

    - Park County ranks #1 in Montana in non-resident traveler expenditures among major destination counties (per capita).

    - Angling spending amounted to $70 million a year during these fishing trips, compared to the estimated $5 to $6 million a year spent by hunters while hunting in Park County area hunting districts.

    - The Montana Bed Tax alone, in Park County, generated $1.7m in tax revenue to the state and local tourism boards in 2017.

- **Agriculture Trends**: In 2012, there were 774,000 acres of land in farms, with an ave size farm of 1,372 acres and total of 564 farms. The market value of products sold was $38M with an average of $68k per farm. This represents a growth of over 30% in value from the 2007 census.

- **Housing and Part-Time Resident Trends**:

    - Park County is a net importer of labor income. A significant and growing number of county residents work outside of the county, but choose to live in Park County and not in the county where their workplace is located.

    - “Total assessed value” of taxable property in Park County was $1,536,517,157 (roughly $1.54 bil). Of this total “Residential property” excluding “Residential Low Income” homes and “Mobile Homes” accounted for 57.3 percent of this total assessed value in Park County, or $879,923,187 ($880 mil.). This percentage compares with 47.1 percent statewide, indicating the above average dependency of Park County on this type of property within the county’s overall tax base. (During the 2000 to 2010 housing units increased significantly in spite of little change in the resident population. This indicates that there are a growing number of part-time residents who are building and buying homes in the county.)

- Homes valued between $500 thousand to one million dollars are 11.1% of Park County houses versus 5% of homes statewide and 8.2% nationally. Park County also has a larger percentage of homes $300-to-$500 thousand in value than statewide and nationally.

County Tools Used to Manage Growth

- Subdivision Regulations: Evaluates a wide spectrum of potential impacts as part of the review process but with over 4,500 undeveloped parcels we are not seeing a lot of subdivisions.
- Floodplain Regulations:
  - Jurisdictional authority is only within the FEMA designated Special Flood Hazard Area.
  - Primary concern is protection of life and property for insurance purposes, not environmental protections or growth management.
  - National program is not very flexible to adapt to local needs.
- Buildings for Lease or Rent Regulation
  - Reviews for a variety of impacts.
  - Only covers parcels with 4 or more rental units.
  - Wide variety of exemptions means that we have only reviewed one property under these regulations since they were adopted in 2013.
- Zoning
  - Can help manage growth through tools like density standards, setting allowable land uses, and setbacks.
  - Not widely used in Park County.
- Growth Policy

Topic: Groundwater Supply and Quality

Goal: To better understand the basic hydro-geological framework (aquifers), patterns of groundwater development, storage and recharge trends, and groundwater quality, as well as understanding of how our groundwater is being monitored.

Presenter: John LaFave, Montana Bureau of Mines and Geology, Groundwater Assessment Program

Presentation Abstract:
The challenges of groundwater assessment and management are aptly captured in the observation of hydrologist Harold E. Thomas: "The science of hydrology would be relatively simple if water were unable to penetrate below the earth's surface." Of course water does seep into the ground, and its hydrology is hidden from casual view.

John's presentation provided an overview of the Upper Yellowstone Basin, including its geology (which has profound effects on the nature and extent of groundwater), and trends for groundwater development. The presentation detailed growth and location of water wells, how groundwater is used (e.g., 67 percent for public water supply, 12 percent for domestic), and how aquifers are recharged through precipitation, stream loss, canal seepage, and the like.

Some take-home observations from presentation and resulting discussions among participants included:

- 90% of all water resources are below ground.
- Groundwater is stored and transmitted through 1) basin-fill and 2) fractured rock aquifers.
- Groundwater supplies all drinking water in the basin.
- Groundwater withdrawals small relative to "incidental" recharge, which has implications for land use and climate changes.
- At this time, monitoring does not indicate any depletion trend in groundwater availability in the basin.
- Irrigation systems can help manage our ground water levels – they have become part of our hydrology. Example spring creeks gain in late season from return flows throughout the upper basin.
- Irrigation systems have also influenced our ecology and habitat in the valley – the creation and maintenance of riparian, wetlands etc.
- Important to understand the balance of irrigation and groundwater levels. The conversion to sprinkler irrigation increases water efficiency (i.e. delivery of water to crops) but also effects the amount and location of groundwater recharge. Simply stated, efficiency does not always mean savings though there are numerous other temporal factors to consider as well (e.g., spring runoff, precipitation).
- Socioeconomic impact of flood irrigation, takes a lot of labor vs. sprinkler irrigation with greater efficiency but tradeoffs with how much recharge happens. This tradeoff was largely not recognized years ago when society encouraged conversion from irrigation to pivots. Irrigation also impacts social relationships – increasing efficiency can reduce conflicts over irrigation water availability.

Research/Management Questions

1. If we have a critical base flow (e.g., 1,000 cfs) can we model and predict if ground water recharge will sustain river surface flows in low-water years?
2. How does the timing of precipitation change and effect recharge and ground water levels?
3. What happens if we retain early flows and runoff in the basin longer, spread it out and maximize recharge?
4. Going forward, aquifer monitoring is vital to understanding trends and potential impacts.

Presentation:
John's full presentation, JohnLaFave_GroundwaterConditions [hyperlinked] is available at: [website] in both PowerPoint and PDF format.

Contact:
John LaFave, Groundwater Assessment Program, Montana Bureau of Mines and Geology, Butte, MT
406-496-4306; jlafave@mtech.edu

On-line Resources:
Ground-Water Information Center: http://mbmggwic.mtech.edu/
Montana Bureau of Mines and Geology: http://www.mbmg.mtech.edu/

TOPIC: SURFACE WATER SUPPLY

Fluvial geomorphology, hydrology/geology of the basin, streamflow and trends, stream gaging

Chuck Dalby, DNRC

The Upper Yellowstone River Basin faces several existing and future water management challenges. Currently a variety of uses compete for water and in periods of extended low flow, for example 2000 to 2006, water shortages affect all uses. Existing challenges or stresses, such as rural subdivision development, availability of water for competing interests like irrigation and instream flow, increasing recreational pressure, stream channel alteration and stabilization, invasive species (PKD), timber harvest, and forest fires will be magnified by effects of global warming on climate. Global warming puts more energy in the climate system and the resulting effects on water supply are highly variable from year to year but follow a general trend in the Northern Rocky Mountains--reduced snowpack, earlier runoff, late season declines in river flows. Review of scientific literature and analysis of streamflow and snowpack records in the Upper Yellowstone Watershed shows that:

- Snowpack (peak snow-water equivalent) has declined by about 30% over the period 1955-2016;
- Runoff is beginning about 10 to 15 days earlier;
- Peak river flows are occurring about 2 to 3 weeks earlier;
- Late season (August) base flow has declined 25 to 35 %;
- Annual volume of water shows a declining trend or not, depending on the period of record analyzed.

What does all this mean for upper Yellowstone physical, biological, and human ecosystems? Increased variability in snowpack, length of growing season and runoff will make running a farm/ranch operation economically even more difficult. Planning many recreational activities that involve fishing or floating will be increasingly challenging and there will be increased stress on aquatic life and habitat. In general, competition for water will increase. Cooperation among all water users will be increasingly important to stretch scarce water supplies; an effective Drought Management Plan provides a framework for accomplishing this.

TOPIC: WATER USE IN THE UPPER YELLOWSTONE

Presenter: Kerri Strasheim, Montana DNRC

Goal: To understand how water in the Upper Yellowstone River is used.

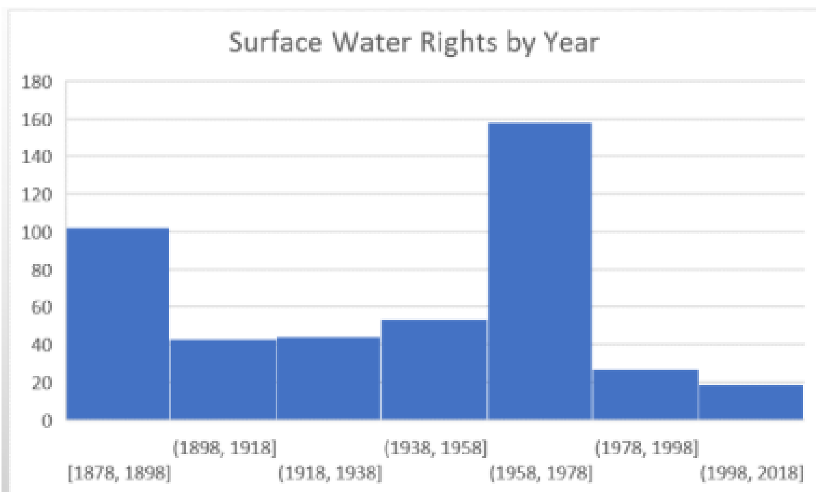
Three take-home points:

1) **The water is mostly all spoken for.**
2) **Development impacts the hydrologic system (past, present, and future).**
3) **The future will bring change and begs the question: How will water users adapt and remain resilient?**

1) The water is mostly all spoken for:

In Montana, as in most of the arid West, the water rights system is based on the **Prior Appropriation Doctrine.** This means "first in time is first in right." Water rights are prioritized by date, not by purpose of use. So, in late season, water shortages are common and junior water right holders with more recent priority dates are impacted first.

Surface water development in the Upper Yellowstone began in 1878 – the earliest priority date. There was an increase in water right claims from 1958 – 1978, likely coinciding with the Montana Water Use Act.



Water rights on file sometimes exceed instream flow rights during parts of the year.

Closed vs. Open Basins

In a closed basin**:**

- All surface water has generally already been appropriated
- Groundwater is connected to surface water, so groundwater appropriations are mostly unavailable
  - Exempt wells are still allowed in closed basin
- Permitting a new water use must involve mitigation

- The permitting process is lengthy

In an open basin**:**

- Same process for determining water availability
- Groundwater analysis is the same
- Because some water is available, mitigation isn't required for full consumption
- **The Upper Yellowstone has months where water is not available, so partial mitigation for new large groundwater uses is now required.**

What is the water in the Upper Yellowstone used for?

Top 3 water uses with the highest number of associated water rights (not volume)

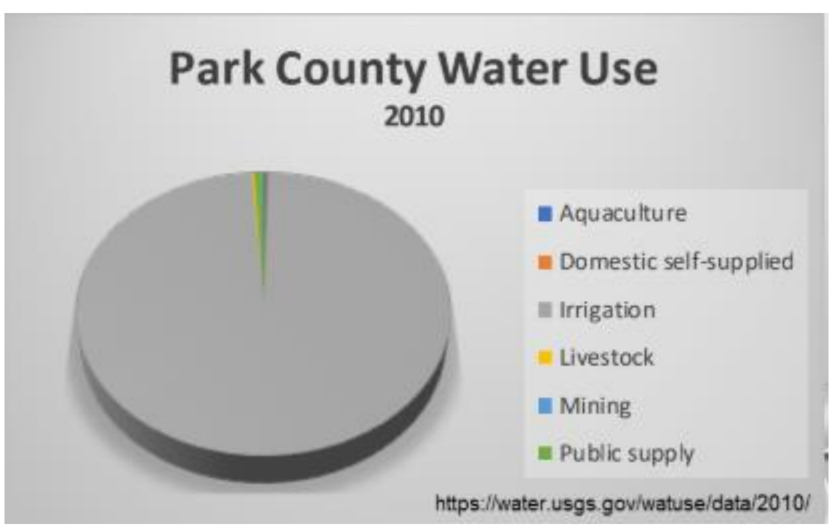
1) Stock (1202 water rights)
2) Irrigation (1190 water rights)
3) Domestic (379)

Water rights by volume of diverted use
(using 2010 water use values from the USGS)

Irrigation (mostly surface water) 273,800,000 gallons per day (gpd)
Public supply (groundwater) 2,400,000 gpd
Aquaculture (surface water) 1,000,000 gpd
Self-supplied domestic (groundwater) 430,000 gpd
Mining: 40,000 gpd
Industrial: 29,000 gpd
Total water use: 278,530,000

--

Residents served by public supply: 10,154
Residents served by domestic wells: 5,482
Irrigated acreage: 61,459 acres (2007, DNRC); 45,870 acres (2010, USGS) *Note that irrigated acreage varies yearly based on factors such as water availability, market prices, etc.



Flow rates

- Flow rates for all diversionary water rights = 2228.18 cfs
- Flow rates for all irrigation water rights total 2152.4 cfs (96.6%)
- Unperfected reserved conservation district irrigation water rights = 433.9 cfs (up to 62,538.6 AF)

A "rough" illustration of flow diverted vs. mean monthly instream flow:

	Median of the Mean Monthly Gage Flow at Livingston (CFS)	Maximum Diversion Amount (CFS)	Possible Maximum Full Flow (CFS) (70% Efficiency Factor)	**ROUGH** Percentage of Flow Diverted (CFS)
May	7518	2228.2	9077.7	**25%**
June	12125	2228.2	13684.7	**16%**
July	5800	2228.2	7359.7	**30%**
August	2981	2228.2	4540.7	**49%**
September	2221	2228.2	3780.7	**59%**

2) Development Impacts the System (past, present and future)

Irrigation systems:

- Complex network of ditches, flood irrigated fields causes water to spread over the land, delaying return flow to the river and supplementing the aquifer and late season flows
- Changing irrigation systems since the 1970s mean ditches getting put into pipelines, lined and consolidated, more sprinkler/pivot irrigation, less water diverted and returned to the river resulting in less aquifer supplementation

Current water use trends in the Upper Yellowstone:

- Emphasis on instream flow to support Yellowstone cutthroat trout and other species
- Increase in ponds
- Clean-up of irrigation water rights to reflect changes in the place of use – generally resulting from conversion from flood to pivot irrigation
- Domestic development (individual house wells)

3) The Future will Bring Change:

Who manages Upper Yellowstone water?

- DNRC Water Resources Division and the Montana Water Court provide the legal framework for use of water (water rights and adjudication)
- Water users and landowners are managing water on the ground
- Other states and federal agencies are involved (e.g. interstate compacts, National Park Service, EPA, etc.)
- DNRC Water Resources also manages compacts and treaties, dam safety, floodplain development
- Conservation Districts have a regulatory role (310 law) and, in addition to watershed groups, lead local conservation efforts

- Mountain valley systems are seeing earlier runoff, changes in rain patterns, changes in aquifer levels, changes in land use

Planning is helpful:

Planning is beneficial to address challenges – recognition of a shared resource, collaborative effort, mutually-agreed-upon plan in place when not all water uses can be satisfied, can present a unified front, can have a process in place for conflict resolution, can trigger public awareness and outreach before reaching a crisis stage.

Drought planning could involve tools and triggers specific to the Upper Yellowstone (e.g. controlled groundwater areas, temporary instream flow leasing, temporary leasing for any use).

Planning takes place at all levels (state, county, watershed, public supply, individual level)

Increasing resilience takes:

- Conservation, working together, defining desired conditions to maintain local priorities, talking to your neighbors to increase awareness, being water aware.

Topic: Montana Climate Trends and Water Supply

"Changing Climate and Water: Montana and the Greater Yellowstone Ecosystem"

Goal: To better understand the trends and changes occurring with climate and water supply occurring throughout history on a broad scale as well as local trends in Montana and the Greater Yellowstone Ecosystem.

Presenter: Cathy Whitlock, Montana State University and Montana Institute on Ecosystems

Presentation Abstract:
Cathy's presentation provided an overview of the broader historical climate trends as well as the changes and trends in water and climate in Montana and in the GYE.

Some take-home observations from presentation and resulting discussions among participants included:

- Looking at climate trends from a Paleoclimate perspective show that we are entering a unprecedent climate period. The last 115 years are the warmest of the last 1700 years (with a 1.8° F increase in the US), 2013-2017 are the warmest five years on record in US and globally, and May 2018 was the warmest of the last 124 years in the U.S. (5.2° F above the average). In 2017, 17 weather-climate disasters had losses exceeding $1 billion.
- The Montana Climate Assessment (MCA) was developed in an effort to synthesize, evaluate, and share credible and relevant scientific information about climate change in Montana with the citizens of the State. The process was stakeholder driven in that listening sessions and questionnaires from landowners drove the process and stakeholder responses informed the MCA strategy.
- How is Climate changing in the GYE? Between 1950-2015 average temperatures have risen 2-3°F, and winter and springs have warmed the most. In addition, growing seasons are 12 days longer. In the future, the GYE will see additional warming of 4-6°F by 2050 (about 9.5°F by 2100), and precipitation will increase slightly in winter, spring and fall, and slightly decrease in summer. The GYE will continue to see a decrease in snowpack and SWE (Snow Water Equivalent), and we will start to see snow in the form of rain. With increased springtime temperatures we will start to see changes in the timing of runoff, and earlier peak run-off. Rising temperatures exacerbate drought conditions, such as we will see more days of the year over 90°F. These changes will affect Montana agriculture projections. Decreasing snowpack will reduce late season irrigation capacity (affect hay, sugar beet, malt barley, garden/potato production). A longer growing season could enable crop diversity but with greater vulnerability, and an increase in the number of days over 90°F will impact wheat and stress livestock. Winter annual weeds will also increase.
- The indirect impacts of an altering climate include an increase in large fires and number of fires and a longer fire season. The impacts on Summer recreation include a general longer summer recreation season which will result in more visitors and infrastructure use, more human-wildlife interactions, and a more concentration on aquatic activities. The higher temperatures and low flows will increase conflict between Yellowstone cutthroat and non-native fish, increase fish diseases, and increase angling and boating restrictions.

Research/Management Questions/Opportunities

1. As a result of these changes public conversations should be focused on water and water storage, floods and droughts, wildfire response, livestock and crop decisions, economic implications, and human health considerations.
2. The opportunity for a GYE Climate Assessment is ripe. High-resolution climate information is available and possible topics include tourism and recreation, fish and wildlife, water supply and demand, fires and forest management. Public-private partnerships will be critical and process will need to be stakeholder driven.

On-line Resources:
2017 Montana Climate Assessment: http://montanaclimate.org/
Montana Institute on Ecosystems: http://www.montanaioe.org/

"Climate Vulnerability in Montana's Agricultural Sector and Park County"

Goal: To better understand the basic hydro-geological framework (aquifers), patterns of groundwater development, storage and recharge trends, and groundwater quality, as well as understanding of how our groundwater is being monitored.

Presenter: Marco Maneta, University of Montana

Presentation Abstract:
Marco's presentation provided an overview of climate and precipitation trends across Montana Counties and how these changes are impacting Montana's agricultural sector. Research shows precipitation during growing season is declining.

Some take-home observations from presentation and resulting discussions among participants included:

- Summer precipitation in western Montana has been declining over the last 50 years or so.
- The length of period between summer rain events has been increasing, with potential impacts for rainfed agriculture.
- Atmospheric aridity (dryness) has also been increasing over the past few decades over the summer months, augmenting atmospheric water demand.
- An analysis of the sensitivity of county-scale production anomalies (yield * area harvested) to precipitation anomalies show that counties in eastern Montana are most vulnerable to precipitation shortfalls. These counties report reductions in alfalfa, wheat and Barley productions as soon as anomalies persist more than 3 months prior to the onset of the growing season.
- Western Montana shows more resilience, requiring longer persistence of precipitation shortfalls (>9 months) for county scale production to decline.
- For Park County, alfalfa yields and production has been relatively stable the last 20 years or so, while wheat and barley production has been declining due to a reduction in the planted area for these crops.
- Alfalfa production has been stable even through the dry years in the record, indicating that production variability is to some extent decoupled from precipitation variability. This is due to the prevalence of irrigation and possibly to the fact that irrigated acreage has not expanded rapidly.

- Analysis suggest that Park county is less vulnerable to drought than other counties downstream.
- Analysis does not address, however, if there are negative impacts when irrigation intensifies to maintain agricultural production during dry years. Stress on other water users (fisheries, ecosystem, recreation, etc) were discussed during the meeting.

Contact:
Marco Maneta, University of Montana, Geosciences Department
Email: marco.maneta@mso.umt.edu Phone: 406-243-2454