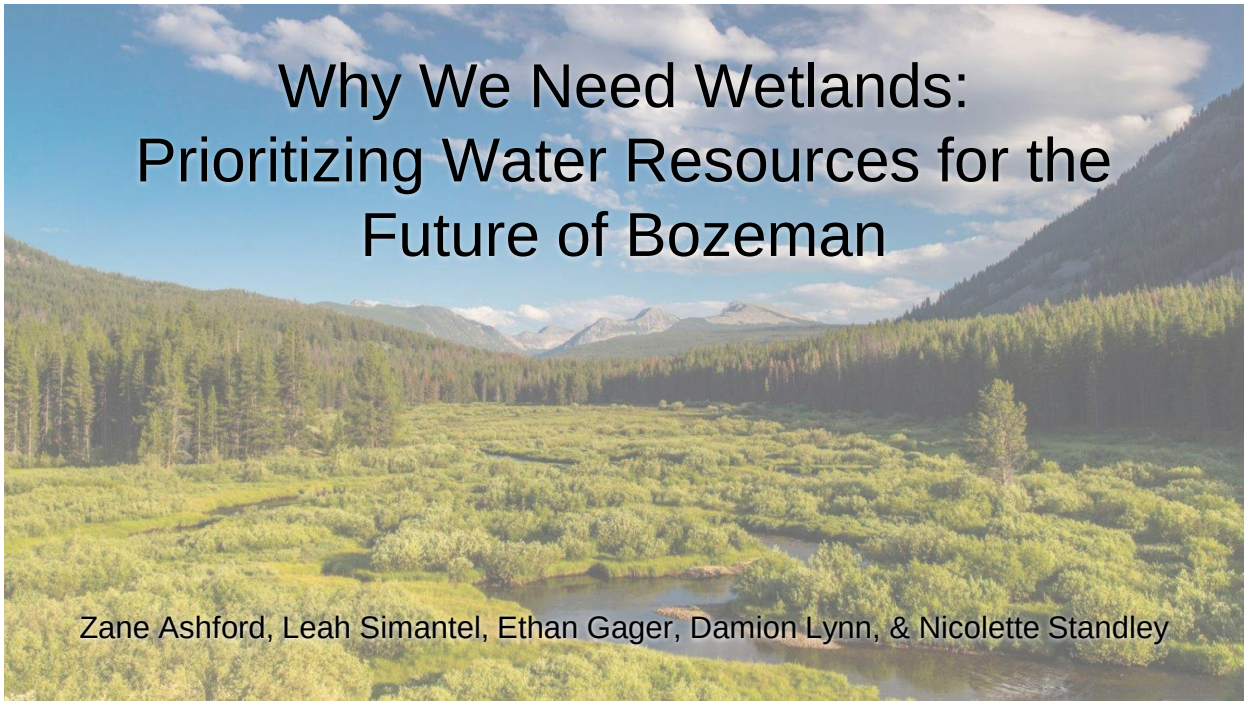

MSU LRES CAPSTONE


Why We Need Wetlands:
Prioritizing Water Resources for the Future of Bozeman
Zane Ashford, Leah Simantel, Ethan Gager, Damion Lynn, & Nicolette Standley

Bozeman's Growth

- Current population (2017): 46,596
  - Over 4.3% growth rate
  - 17,000 new residents since 2000.

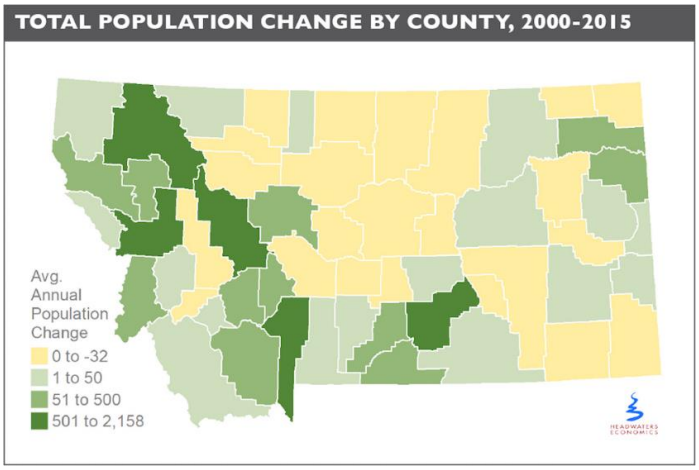


Figure 1. Annual growth in Montana counties (High Country News).

Why Are Wetlands Important?

- Filter sediments
- Nutrient/heavy metal retention
- Water storage
- Carbon sink
- Wildlife habitat
- Outdoor recreation

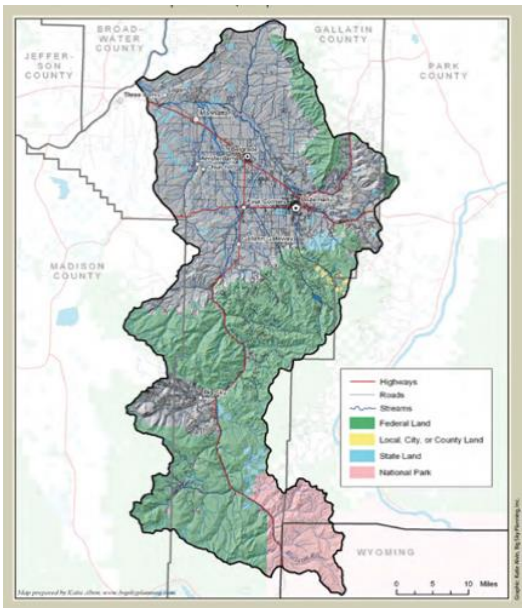
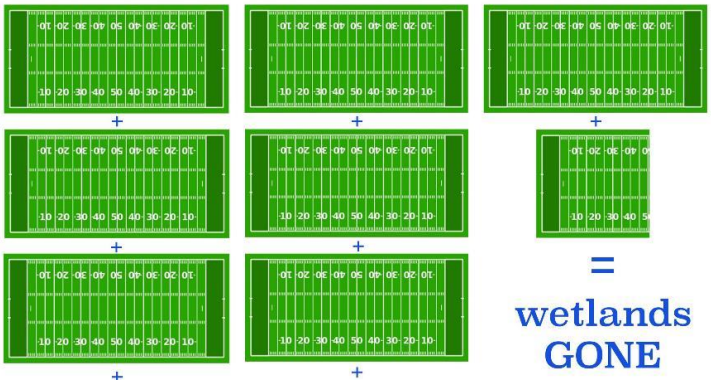


Figure 2. Map of the Gallatin Watershed (GLWQD, 2017).

Current Issues for Bozeman's Wetlands

- Ten acres of wetlands lost within the city limits in the past few months.
- Those wetlands were replaced in Twin Bridges, over 90 miles away.



Current Mitigation Practices

- Mitigation Sequence
- Compensatory mitigation
  - Mitigation Banks
  - In-Lieu Fee
  - On Site Mitigation by Permittee

Issues:

- Mitigation projects tend to skip over "avoidance"
- Monitoring
- Compliance / Loose Wording
- Scale of relocation - most important

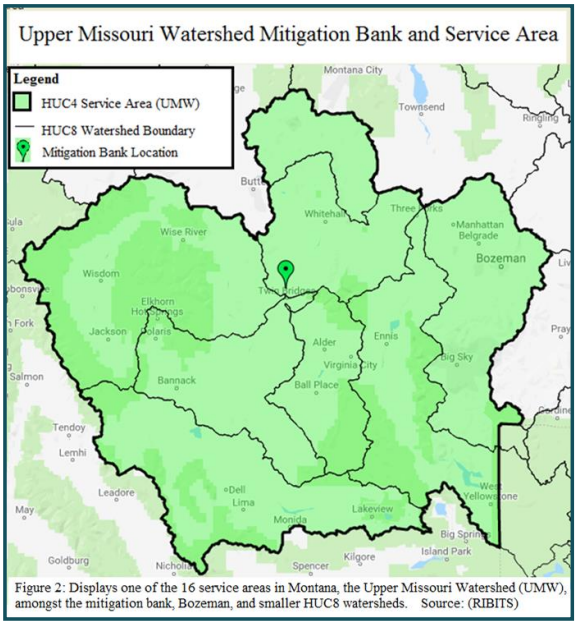


Figure 2: Displays one of the 16 service areas in Montana, the Upper Missouri Watershed (UMW), amongst the mitigation bank, Bozeman, and smaller HUC8 watersheds. Source: (RIBITS)

Localizing Wetland Mitigation

- Important to consider the scale of mitigation - impacts on the community and on local wildlife
- EPA emphasizes taking a 'watershed' approach: the more localized, the better!

Localized Mitigation: Retaining Ecosystem Services

- Loss of hydrologic services that serve the community
  - Water quality
  - Availability
  - Storage
- This puts more pressure on local water treatment facilities!
- Wildlife relocation
  - Up to 43% of threatened and endangered species rely on wetlands (USFWS)

Localized Mitigation: Other Factors

- There are different types of wetlands that serve several different functions; they are complex ecosystems!
- Natural wetlands are ideal reference sites.

Why is Avoidance Overlooked?

Critical Factors:

a. Lack of agreement on what constitutes “avoidance”;
b. Wetlands not identified/prioritized in advance of development;
c. Wetlands are economically undervalued;
d. Belief that technology can solve problems in the natural world;
e. Requirements for compensation inadequately enforced

Unified County-Wide Critical Areas Ordinance

- Bellingham, Washington example
- Guidance for protecting wetlands necessary to maintain public health, safety, and welfare
  - Buffer area

Wetland Assessment Guide

- Identify wetland sensitivity, rarity, and functions
- WA State Assessment Guide
  - 4 Categories based on functional score
  - Lower category wetland emphasizes highest need for protection
- Help local agencies/governments protect/manage wetlands

Potential Wetland Classification

CATEGORY 1

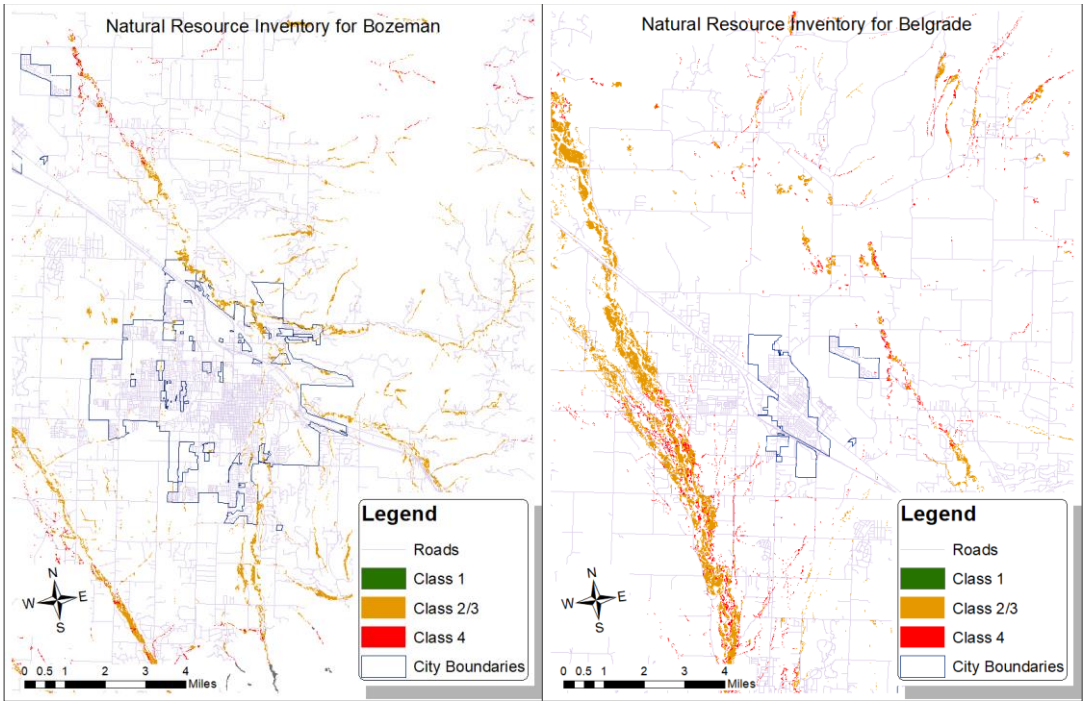
- Critical habitat of threatened/endangered, fish or wildlife

CATEGORY 2/3

- Occurrences of rare or important species to Montana

CATEGORY 4

- Two acres or less in size



Proposed Buffer Widths for Bozeman Wetlands

Class	Proposed Buffer Zones (ft)	Replacement Ratios
1	200-300	6:1
2		Forested 3:1
		Scrub-Shrub 2:1
3	50-200	Emergent 1:5:1
4	25-50	1.25:1

Recommendations for Bozeman

- Enforce avoidance
- Push for localized mitigation
  - Better performance/likelihood of meeting compliance standards
  - Better reference site
  - Socioeconomic benefits
- Mitigate at a HUC10 rather vs HUC4
- Critical Area Ordinance
- Wetland Rating Assessment


Questions?
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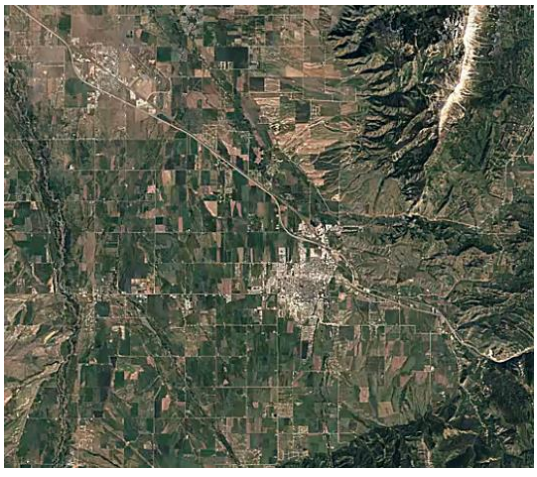
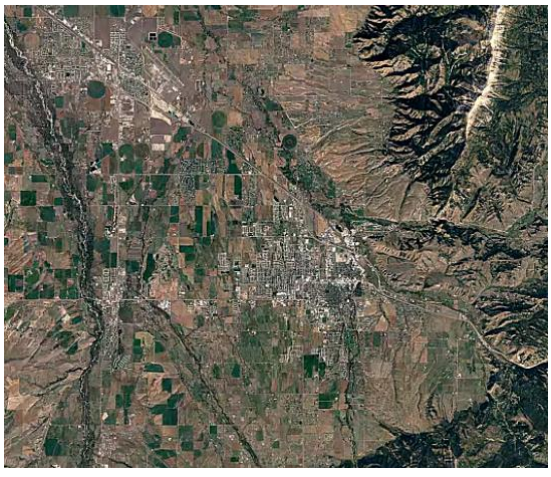
Land Use Planning in Gallatin County

Laura Mooney
Eric Stratton
Brody Wallace

Development in Bozeman



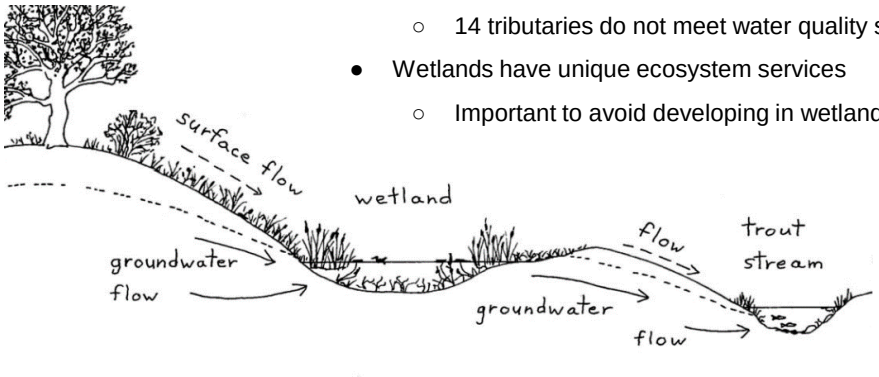
Gallatin Valley, 1984



Gallatin Valley, 2016

Why is this important?

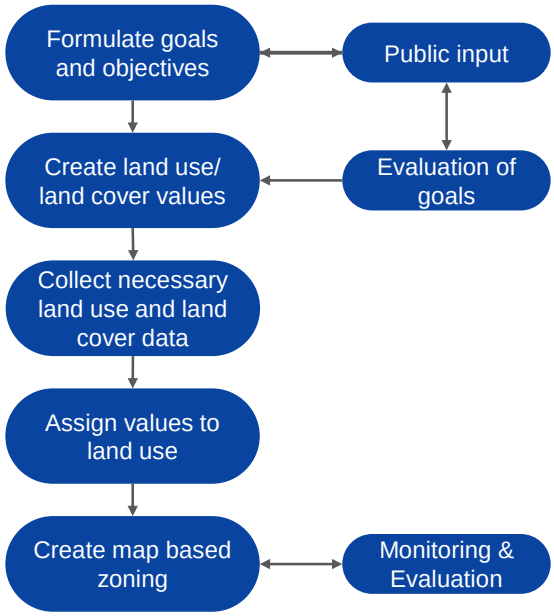
- Bozeman is growing! (U.S. Census, 2017)
  - As impervious coverage increases, surface runoff increase, and there is a decrease in infiltration (Arnold et al., 1996)
  - We are more stressed for water as population increases and runoff carries nutrients + pollutants
  - 14 tributaries do not meet water quality standards (Bullock et al., 2013)
- Wetlands have unique ecosystem services
  - Important to avoid developing in wetlands



How do we maximize development while minimizing disturbance?

- Land Disturbance Index (LDI)
  - Assigns numerical values to different land classes
  - Allows for assessment of environmental quality over a spatial scale
  - Determine areas that need most protection and which can be developed

LDI - Community Input



LDI Scoring Table

Soil

Farm Class	fafowet	fa	fowet
all areas are prime farmland	100	100	50
farmland of local importance	100	100	50
farmland of statewide importance	100	100	50
not prime farmland	0	0	0
prime farmland if irrigated	50	75	25

Land Cover

Land Class	fafowet	fa	fowet
open water	100	100	100
developed, open space	75	75	75
developed, low intensity	50	50	50
developed, medium intensity	20	25	25
developed, high intensity	0	0	0
barren land	50	0	0
deciduous forest	100	50	100
evergreen forest	100	50	100
mix forest	100	50	100
shrub/scrub	100	50	100
herbaceous	100	50	100
hat/pasture	50	100	0
cultivated crops	50	100	0
woody wetlands	100	25	100
emergent herbaceous wetland	100	25	100

fafowet = Farmland, Forrest and Wetland Prioritized
fa = Farmland Prioritized
fowet = Forrest and Wetland Prioritized

Cities

Buffer	fafowet	fa	fowet
0	0	0	0
100	25	25	25
250	50	50	50
500	75	75	75

Wetlands

Buffer	fafowet	fa	fowet
0	100	50	100
60	75	37	75
165	25	12	25

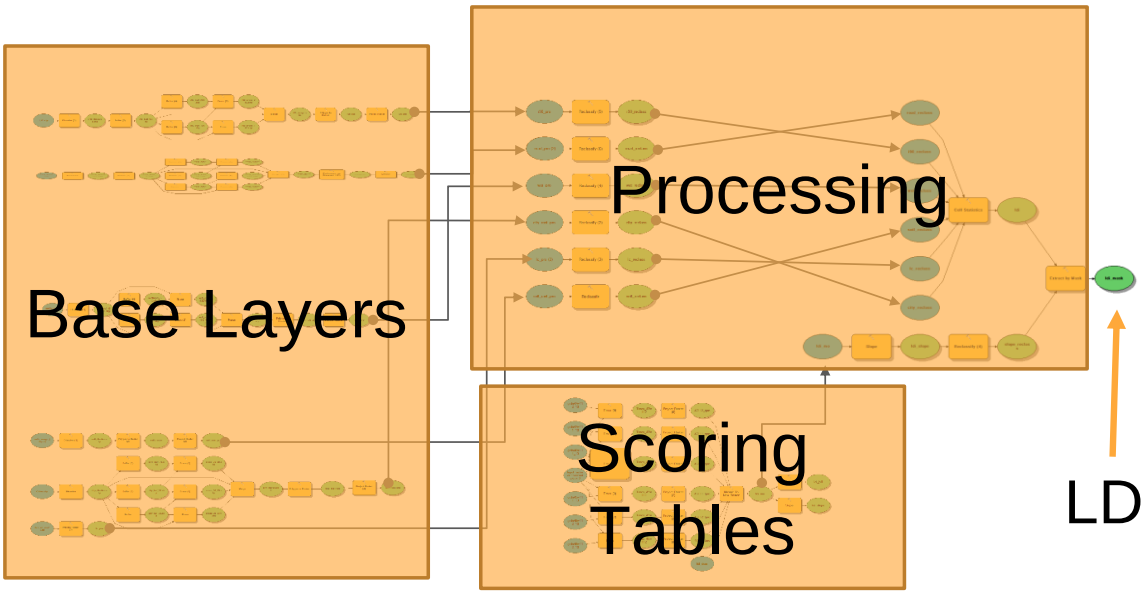
Roads_other

Buffer	fafowet	fa	fowet
7	0	0	0
15	25	25	25
30	50	50	50
60	75	75	75

Roads I-90

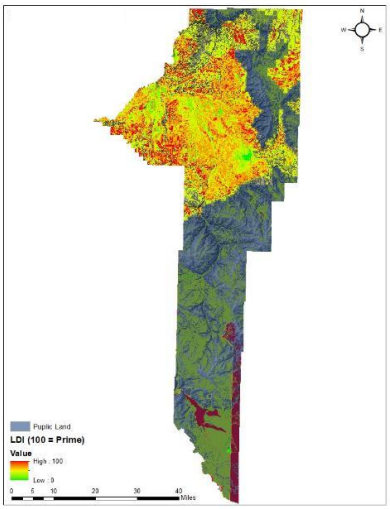
Buffer	fafowet	fa	fowet
80	0	0	0
100	25	25	25
250	50	50	50

LDI – A GIS Model

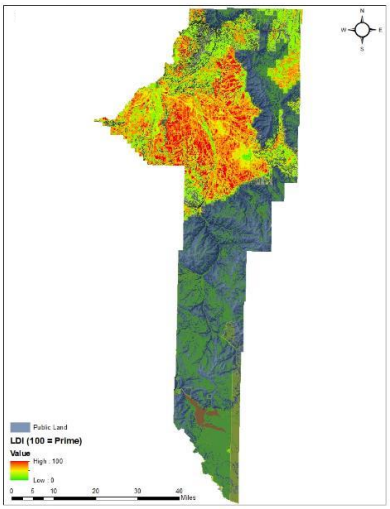


Three Scenarios

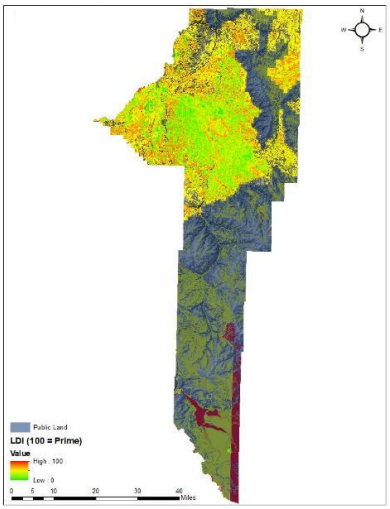
Farmland, Forest and Wetland Prioritized



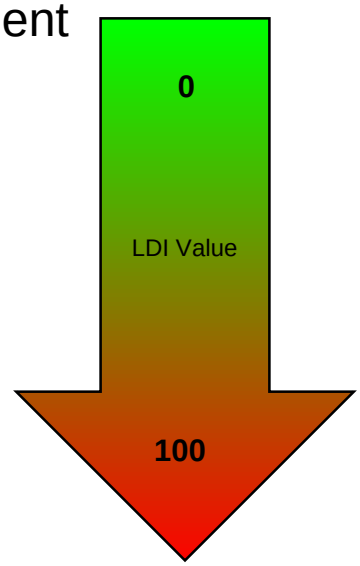
Farmland Prioritized

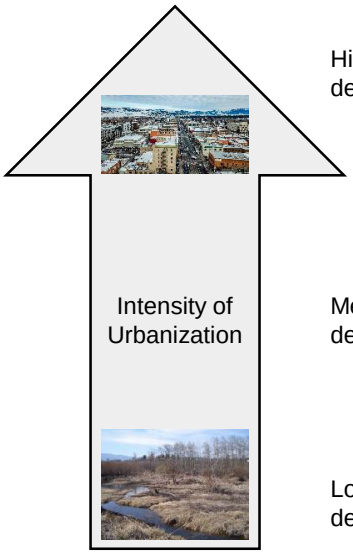


Forest and Wetland Prioritized



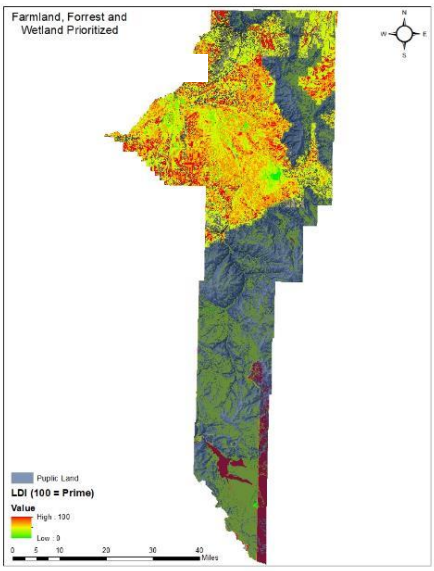
Development Planning





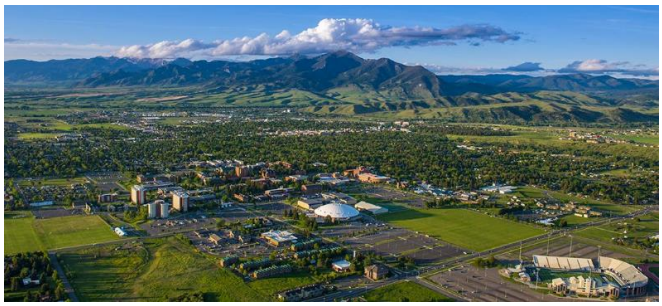
Questions?

Farmland, Forest and Wetland Prioritized



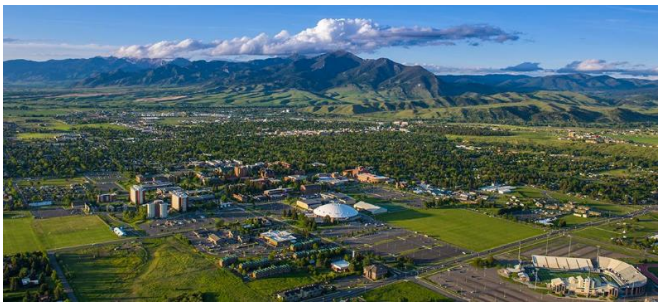
Urbanization and Groundwater in Gallatin Valley

Riley Elgerd, Edison Meece, Megan Tomczyk, Taylor Zabel



Problem

- Although Gallatin Valley has multiple water sources, it is predicted to have shortage of water within the near future
- In 2017 Bozeman averaged an average annual growth at 3.67 percent
- Gallatin River, Hyalite Creek, Lyman Creek, Bozeman Creek



Why is Groundwater important?

- Resource for agriculture, residences, and industry
- Belgrade's water source is groundwater
- Potential future for Bozeman's municipal water supply
- Groundwater is highly connected to surface water
  - Maintains baseflow in streams
  - "...Virtually all of the groundwater beneath the valley discharges to the Gallatin River and its tributaries" (Kendy, Eloise & Bredehoeft, John D., 2006)

Questions

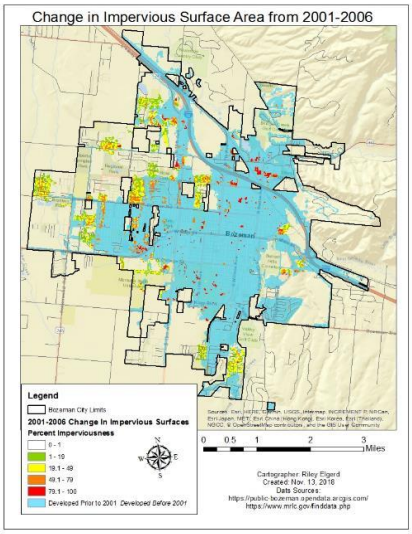
1) How will changes in surface cover from development affect water movement and groundwater recharge?

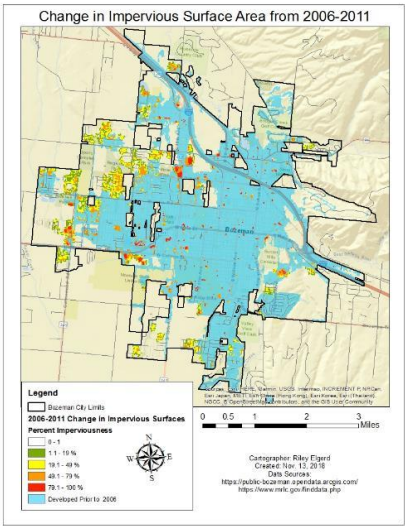
2) How do changes in irrigation methods affect recharge of groundwater?

3) How can groundwater pumping and the addition of exempt wells across the Gallatin Valley affect groundwater levels?

Changes In Land Surface Cover

- Changes in land cover classifications were assessed for 2001, 2006, and 2011.
- Increase in 1,600 acres (12.5%) of developed land over the 10 year analysis.





Weighted Curve Number: Runoff Simulation

- Curve Number is a coefficient of runoff based on impervious surface by area.
  - Ranges from 30 (high permeability) to 100 (totally impervious)
  - Used to determine runoff as percent of storm event.

- CN increased as impervious area increased!
  - 2001: **79.17**
  - 2006: **79.9**
  - 2011: **80.21**

$$Q = \frac{(P-I_a)^2}{(P - I_a) + S} \quad (1)$$

Q = runoff (in)
P = rainfall (in)
S = potential maximum retention after runoff begins
I_a = initial abstratctions

$$I_a = 0.2\,S \quad (2)$$

$$Q = \frac{(P - 0.2\,S)^2}{(P + 0.8\,S)} \quad (3)$$

$$S = \frac{1000}{CN} - 10 \quad (4)$$

Source: https://engineering.purdue.edu/mapserve/LTHIA7/documentation/scs.htm

Runoff as Impervious Surface Increases

- For simulating runoff, an average precipitation of 3 storm events from June of 2001, 2006, & 2011 was used
  - Simulation precipitation: 1.24 inches
  - Increase in 8 million gallons of runoff in 10 years!!!

- As Runoff increases, groundwater recharge decreases.
  - This is water that previously would have infiltrated to aquifer that is now being lost.

Year	Runoff (gallons)	Runoff (acre-ft)	% Runoff of Total Volume
2001	**54,648,700**	167.7	12.35%
2006	**58,414,900**	179.2	13.20%
2011	**62,168,900**	190.7	14.05%

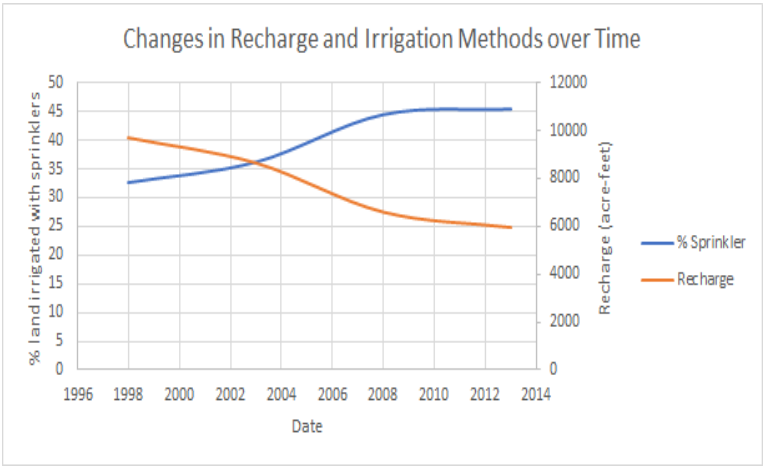
Irrigation Model

- Provides an estimation of the amount of water used by irrigation in Gallatin County
- Takes into account the main sources of recharge including soil infiltration, percolation and surface runoff
- Irrigation data was obtained from USDA agricultural census
  - Censuses were from 1998, 2003, 2008, 2013

Established Hydrologic Model

$Tw=\sum[(AiRi)-Rc]$
$Rc= \Sigma ((AiRi(1-Ei))-Eo)+Gri)$
$Eo= (700\ Tm/ (100-A)+15(T-Td))/ (80-T)$
$Gr= \Sigma(((AiRiEi)*Ml*D)-St)$

Shift in Irrigation Methods Effect on Recharge



- An increase in sprinkler irrigation is correlated with a decrease in recharge
- Increase in sprinkler irrigation significantly affects the total amount of water being applied to the fields
- No significant change to total amount of water used overall

Groundwater Pumping

- As Montana's population increases, so has the number of exempt wells drilled each year
- Surface water and groundwater Correlate: surface body either Drains or recharges water table
- In 1993 the Upper Missouri Basin was legislatively closed to any new surface water appropriations

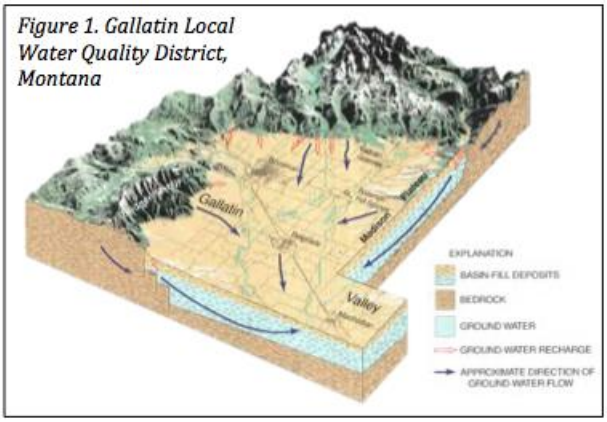


Figure 1. Gallatin Local Water Quality District, Montana

Summary

- As impervious surfaces increase, runoff will increase and groundwater recharge will decrease - storm events are a big loss
- As irrigation becomes dominated by sprinkler systems (less flood irrigation) , groundwater recharge will decrease
- As more exempt wells are constructed, groundwater will be utilized and levels will decline

GROUNDWATER LOSSES (3 SOURCES)!

Recommendations

- Quantify water use in Gallatin Valley:
  - Water applied in irrigation from groundwater and surface water
  - Water used per exempt well to quantify withdrawals (audits)

- Stormwater detention ponds below proposed stormwater treatment sites
  - Lower stream discharge during storm events
  - **Green Infrastructure**

- Groundwater Mitigation
  - Artificial recharge with return pumping
  - Practice of augmentation

http://www.anglerguide.com/montana/gallatinriver.html

Questions?

Low-impact development in the Gallatin Valley

Mitigating urbanization pressures on natural resources

Betsy French, Noelani Boise, Frida Isaksen-Swensen,
Nick Bragg, Stephanie Neises

Effects of Climate Change + Rapid Population Growth and Urbanization = Availability of Freshwater

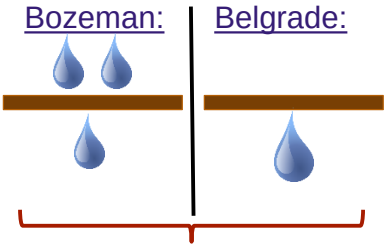
Multiple components...

Domestic and Urban Green-Infrastructure

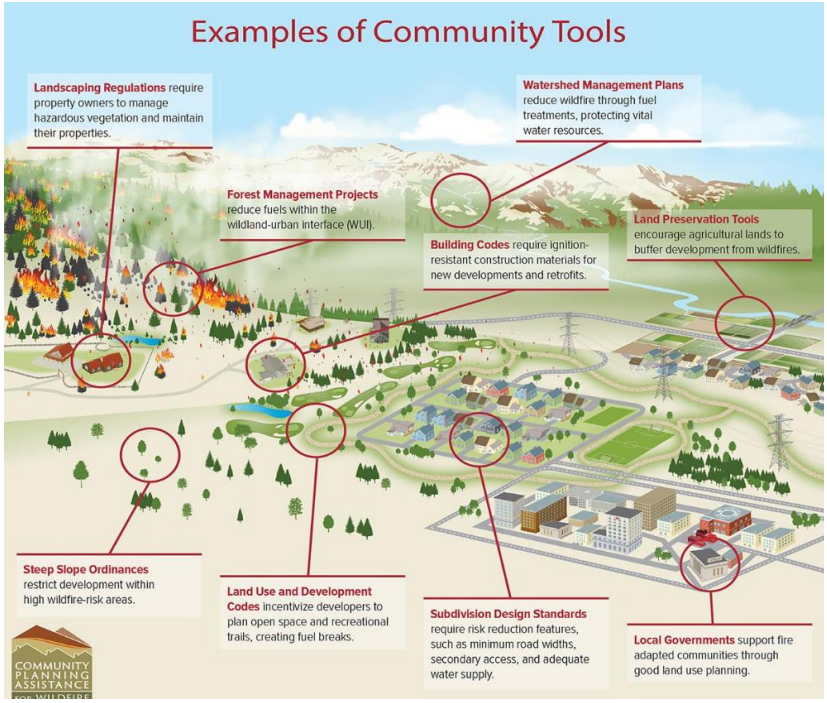
Urban Vegetation

Municipal Water Management

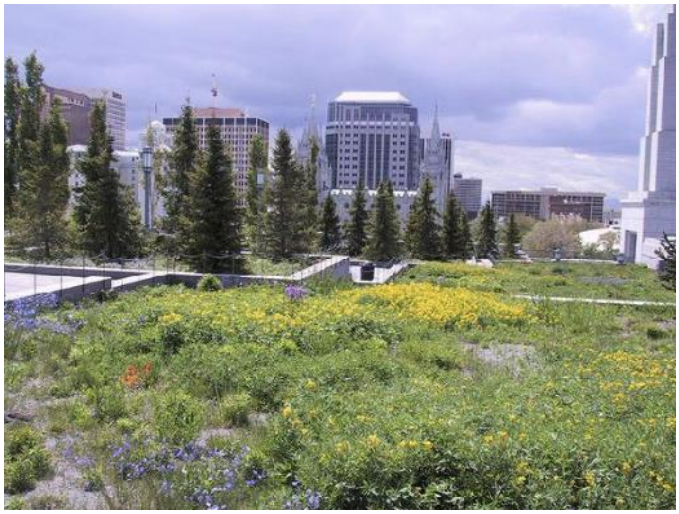
Wildland-Urban Interface



Different water sources require different methods of management



Green Infrastructure



Salt Lake City

Incorporation of natural elements and operations into urban infrastructure

Green Infrastructure: Benefits

Much easier and cheaper to be proactive!

- **Reduce costs of urban growth**
- **Increase natural capital**
- **Increase population potential as well as resilience of the urban system**

Green Infrastructure

Montana State Fund Building (Helena)

Denver Housing Authority

Rapid City

Urban Vegetation of Belgrade

- Thin gravelly soil
- One water source
- Dry / wind stricken

Plants Selected:
1. Native
2. Tolerant of known conditions

Why Plant Native?

Planting Native:

Xeriscaping:
Landscaping that involves little to no irrigation.

Cuts down on…
-Water 50%
-Maintenance & labor 30%
-Fertilizers 61%
-Fuel 44%
-Herbicides & pesticides 22%

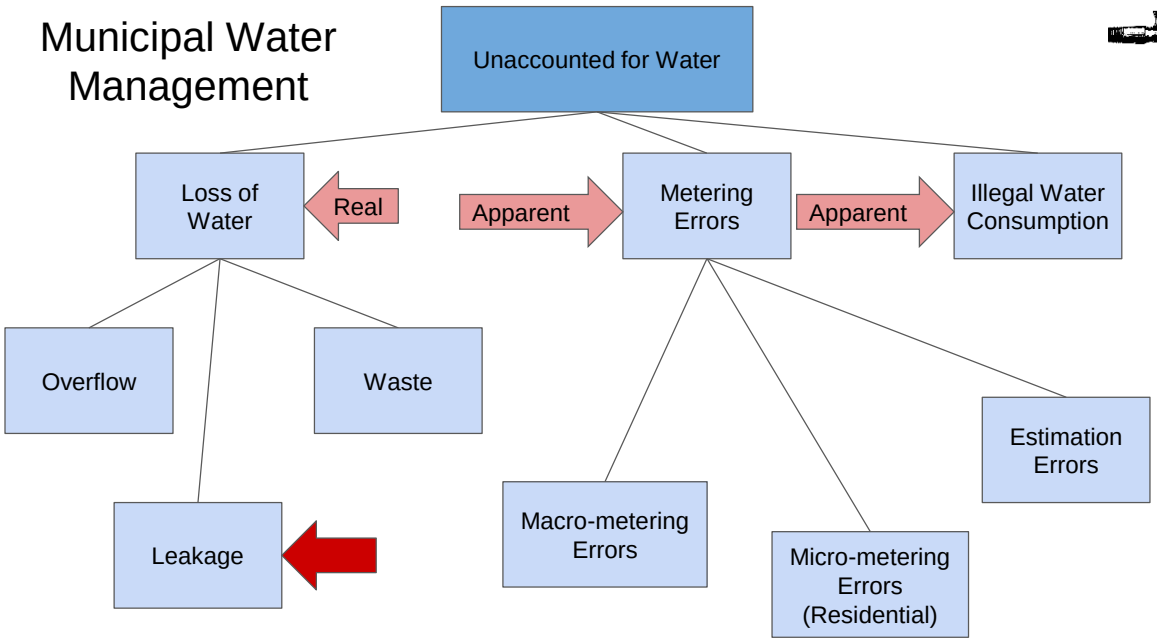
Urban Ecology:
Maintaining food webs and species interactions in an urban setting.

Plant Diversity = Insect diversity = Local bird and wildlife populations

Encouraging Community Involvement:

Incentives and Rewards
National Wildlife Federation
National Audubon Society

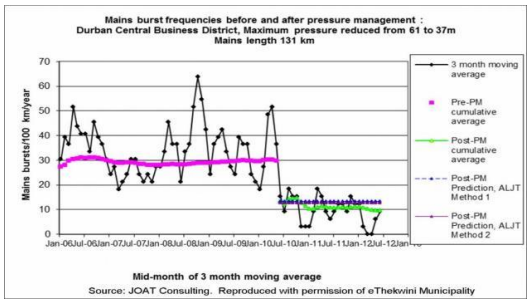
Municipal Water Management



Tools for Reducing Real Water Loss

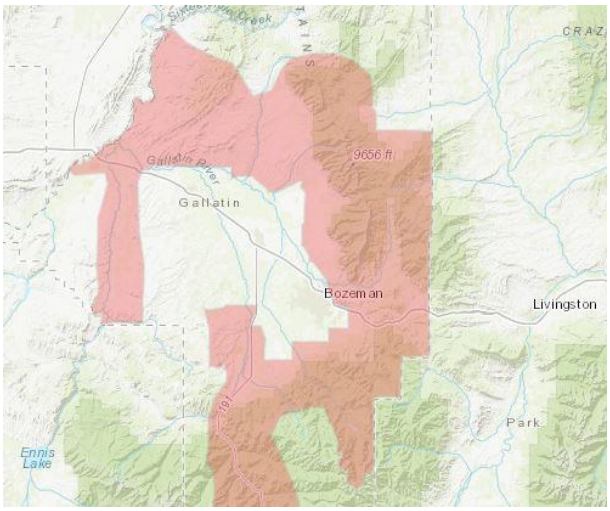
Water Auditing

LeakFinderST

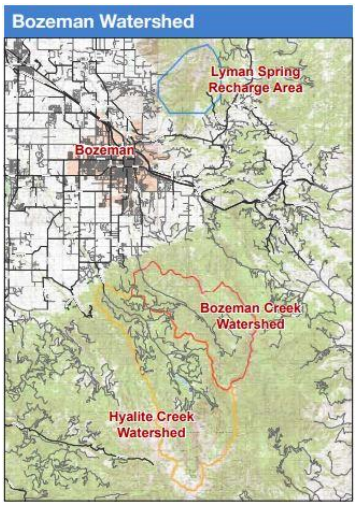


Pressure Management

Fire, Water, & The Wildland-Urban Interface (WUI)



Gallatin County Emergency Management



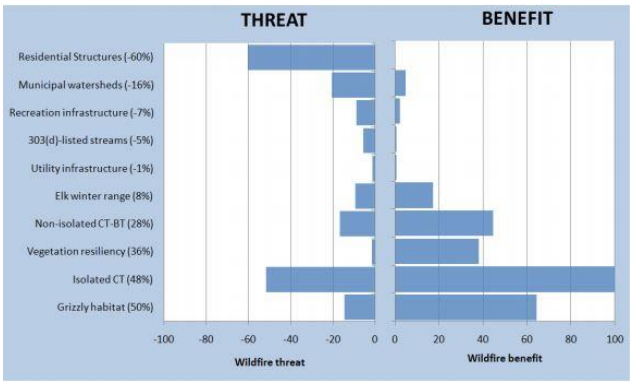
City of Bozeman

Fire, Water, & The Wildland-Urban Interface (WUI)

Table 4.74 Summary of Hazards for Gallatin County, Montana

Hazard	Probability of Major Disaster	Property Impact	Population Impact	Economic Impact	Future Development Impact	Relative Overall Risk
Wildfire	High	High	High	Moderate	Moderate	High
Earthquake	High	High	High	High	Moderate	High
Hazardous Materials Release	High	Moderate	High	High	Moderate	High
Flooding	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Communicable Disease and Bioterrorism	Moderate	Low	High	High	Low	Moderate
Drought	Moderate	Moderate	Low	High	Moderate	Moderate
Winter Storms and Extended Cold	Moderate	Low	Moderate	Moderate	Low	Moderate
Utility Outage	Moderate	Low	High	Moderate	Low	Moderate
Severe Thunderstorms Wind and Tornadoes	Moderate	Moderate	Moderate	Moderate	Low	Moderate
Ground Transportation Incident	Moderate	Low	Moderate	Moderate	Low	Moderate
Dam Failure	High	Moderate	Moderate	Moderate	Moderate	Moderate
Terrorism	Moderate	Moderate	Moderate	Moderate	Low	Moderate
Railroad Accident	Moderate	Low	Moderate	Moderate	Low	Moderate
Volcano	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Urban Conflagration	Moderate	High	Moderate	High	Moderate	Moderate
Avalanche and Landslide	Moderate	Low	Moderate	Low	Low	Low
Aviation Accident	Moderate	Low	Low	Moderate	Low	Low
, Civil Unrest, and Violence	Low	Moderate	low	Moderate	Low	Low

Gallatin County Emergency Management



Pyrologix

Fire, Water, & The Wildland-Urban Interface (WUI)

Prospective actions to mitigate risk:

- Do nothing (but we want to be PROACTIVE).
- Bozeman Municipal Watershed Fuels Reduction Plan
- WUI fuel thinning.
- Increase municipal water storage.
- Municipal groundwater source.

Pine Creek Fire, Park County, MT. Headwaters Economics.

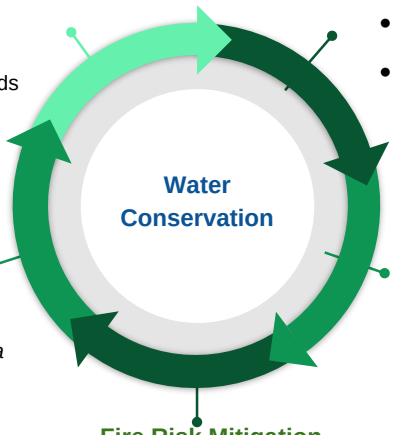
Current Policy

- Bozeman City Ordinances
  - "All landscaped areas shall be **perpetually maintained in a healthy condition**"
  - "include **one large canopy tree** for each 50 feet of total street frontage"
  - "at least 75 % coverage of an area with **natural grass, vegetative ground cover** or other natural living plant materials"

Low Impact Development

Green Infrastructure
- *Building Codes*
- Subdivision design standards
- Smart controllers in new development

Native Vegetation
- *drought-tolerant, native plants*
- Rebates for xeriscaping



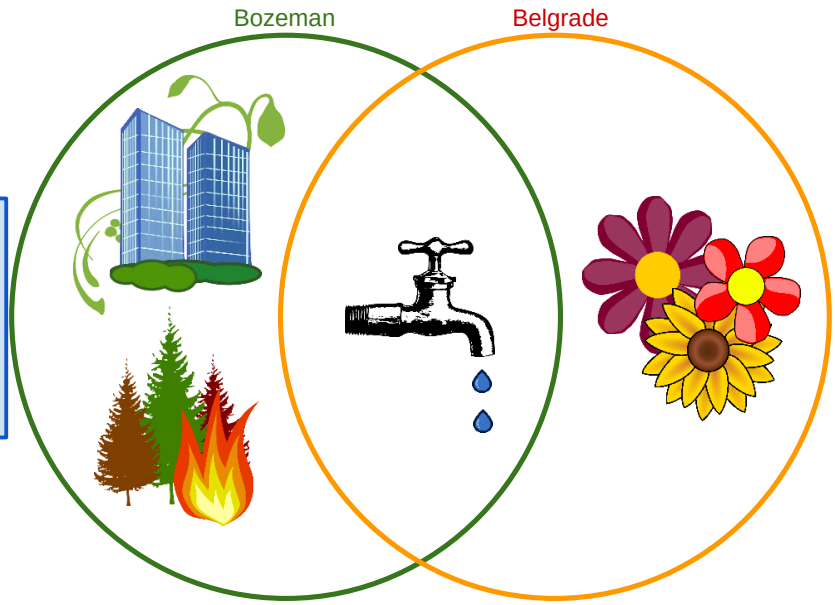
Policy and Regulation
- Restrict automated watering systems
- *Water allocation per unit area*
- Tiered fee schedule

Municipal Water Management
- Increase surface and ground storage
- Low pressure management
- *Mandatory water audits*

Fire Risk Mitigation
- Steep Slope Ordinances
- Land use and development code; low risk areas
- *Fuel reduction*

Solution:

- Combination of all methods
- Strategies guided by strengthened policy
- Proactive vs Reactive



Questions?