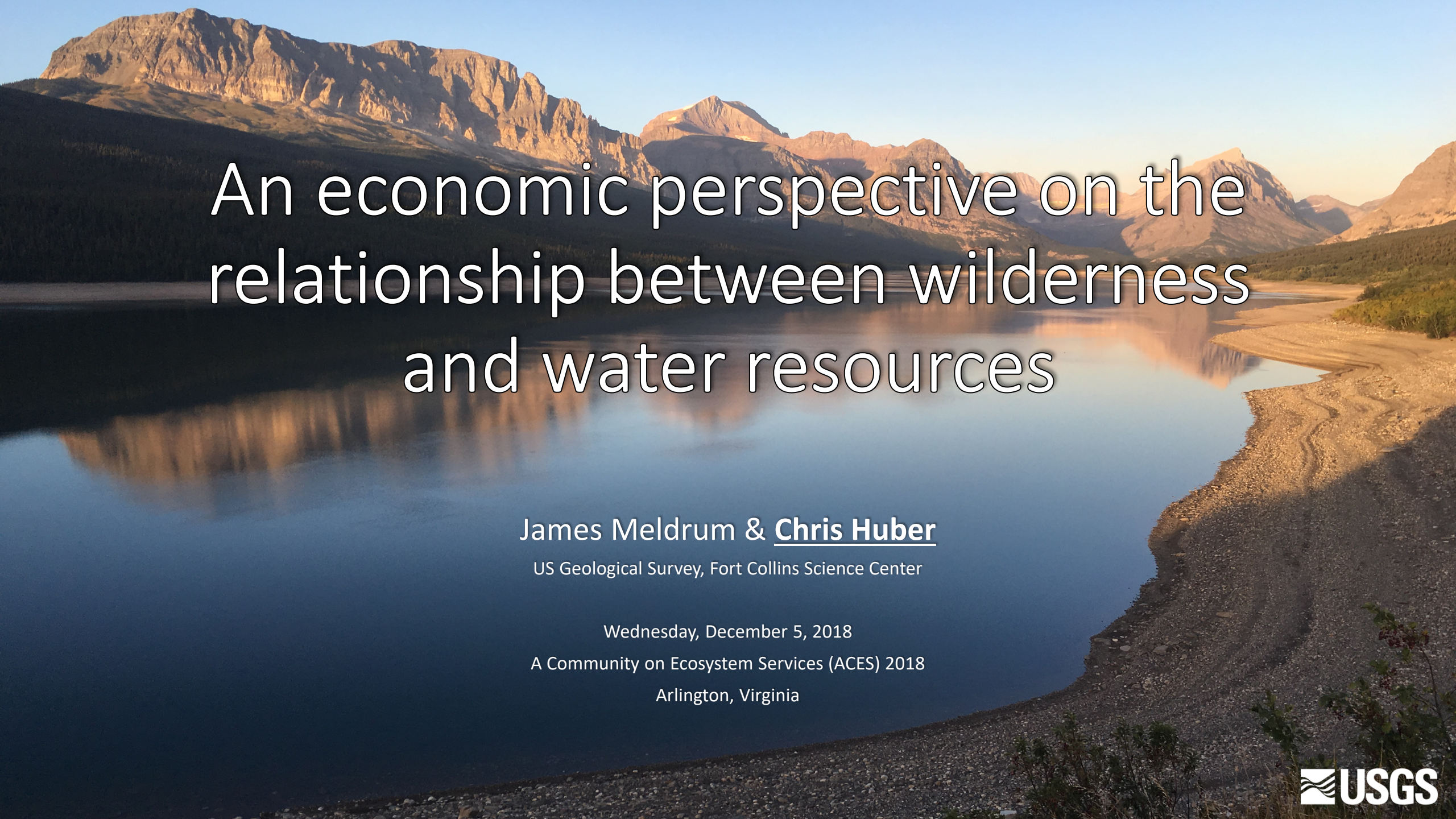

An economic perspective on the relationship between wilderness and water resources

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Claim: Wilderness and Water Benefits

- Morton (1999): role of wilderness is watershed protection (*benefits include* ***supporting native fish, reduced water treatment costs,*** *and* ***the possibility of selling water for drinking***)

- The North American Intergovernmental Committee for Wilderness and Protected Areas Cooperation (NAWPA) describes how wilderness provides a consistent supply of "**some of the world's highest-quality drinking water**," as well as water for use by **industry, fish and wildlife populations, recreationists and more** (2012)

- Some wilderness areas were designated with the purpose of preserving healthy watersheds, such as the Rattlesnake Wilderness in Montana for its use "...**by people throughout the Nation who value it as a source of...clean free-flowing waters stored and used for municipal purposes for over a century**"

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Research Questions:

Importance of wilderness to water-related ecosystem services:

1. Can water resources be used to help conceptually connect people to wilderness?

2. Does wilderness *add* to water benefits?

What can we say about designated wilderness and water resources through and economic lens?

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Approach:

1. We examine spatial and hydrological relationships that link United States' wilderness areas to downstream users

2. Next, we generate an estimate of the total economic value of the water flowing from wilderness is discussed (focusing our attention to the limitations of this approach)

3. Finally, we outline preferred valuation approaches for future case studies

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First, how much water?

- **Brown et al. (2016)** flow estimates are a 30-year average of the mean annual water yield, as modeled by the Variable Infiltration Capacity (VIC) model, implemented at a daily time-step over 1981-2010 for each 1/8º by 1/8º grid cell across the conterminous U.S.
- **Notable results include:**
  - USFS yields 18% of water supply from 11% of U.S. land
  - Approximately 25% of the water that originates on USFS lands in the conterminous U.S. comes from wilderness

Further processing allows us to construct estimates of total annual runoff within a given region that originates within all designated wilderness areas (including NPS, BLM, and FWS)

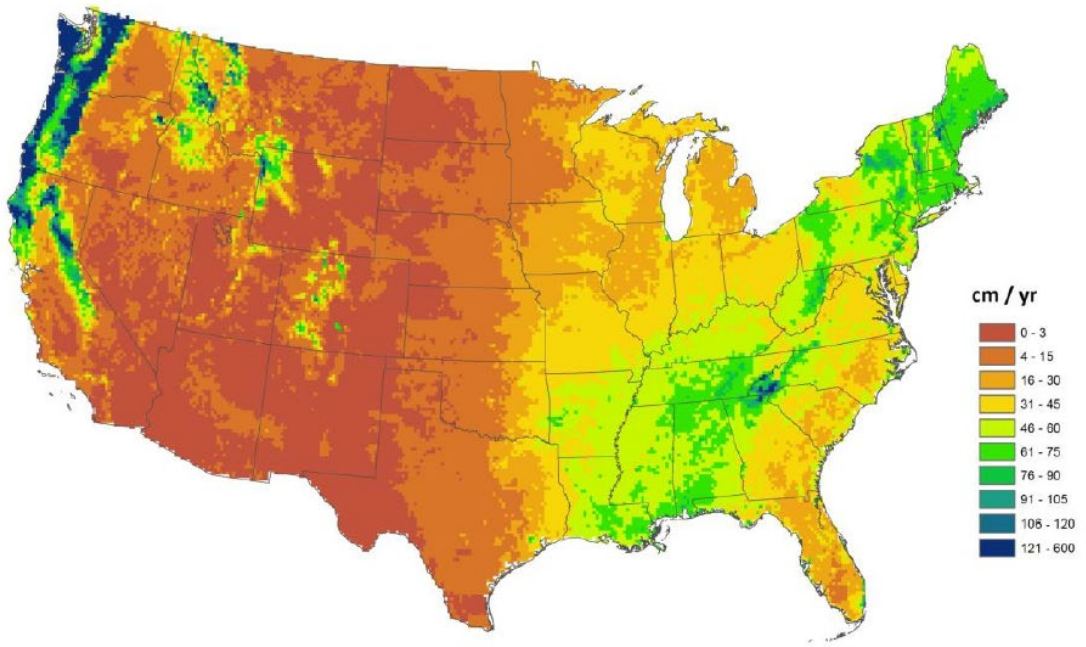

Figure 2 from Brown et al. (2016): Mean annual water yield depth (cm/yr) by 144 km^2 grid

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First, how much water?

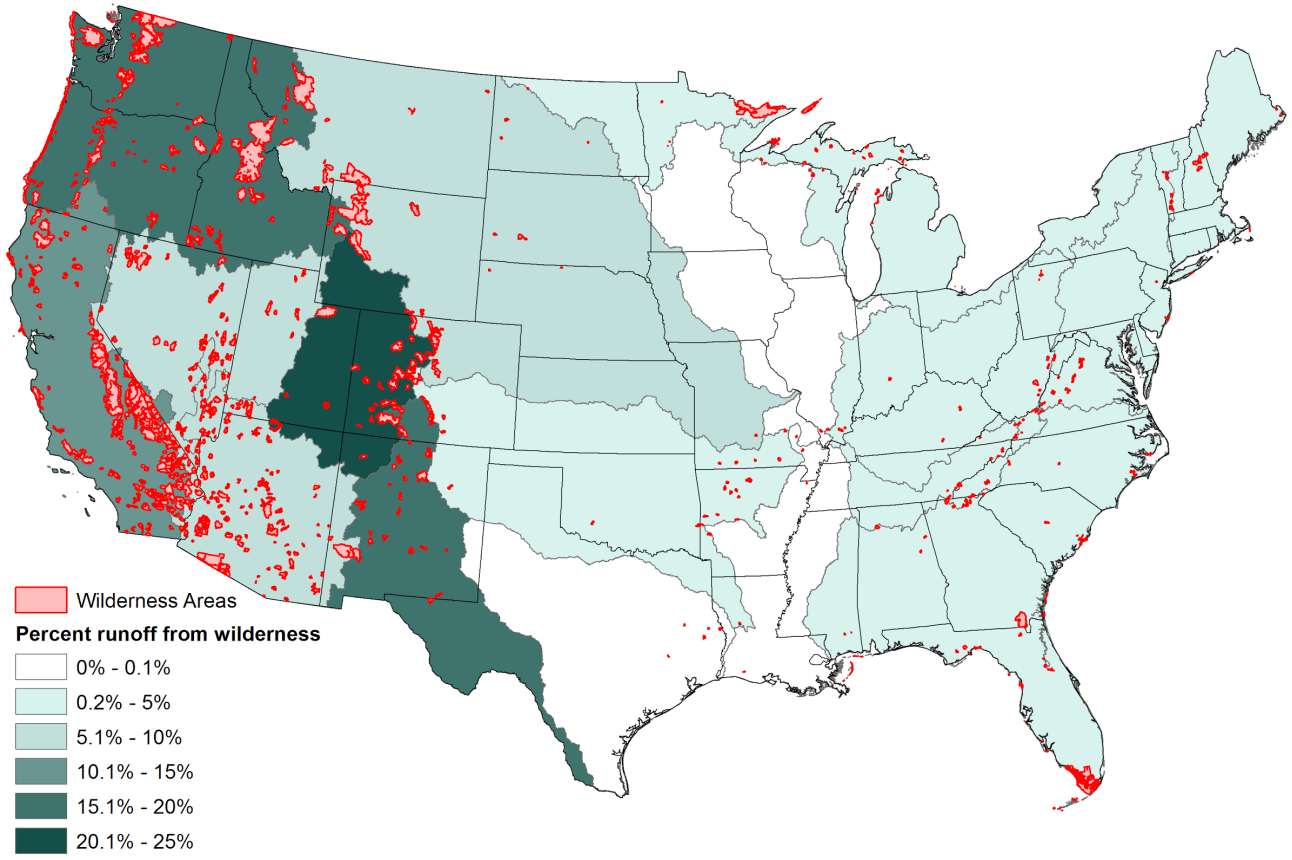

Figure 1: Percentage of freshwater runoff from wilderness areas versus freshwater runoff from all areas within a water resource region (HUC2 area)

- Value is < 1% for 10 out of 18 HUC2 regions
- The Souris-Red-Rainy and Missouri regions, in the central US, receive 5% and 7% of their runoff from wilderness
- The western US ranges from a low of 8% for the Lower Colorado region to 18% in the Pacific Northwest and 25% in the Upper Colorado

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First, how much water?

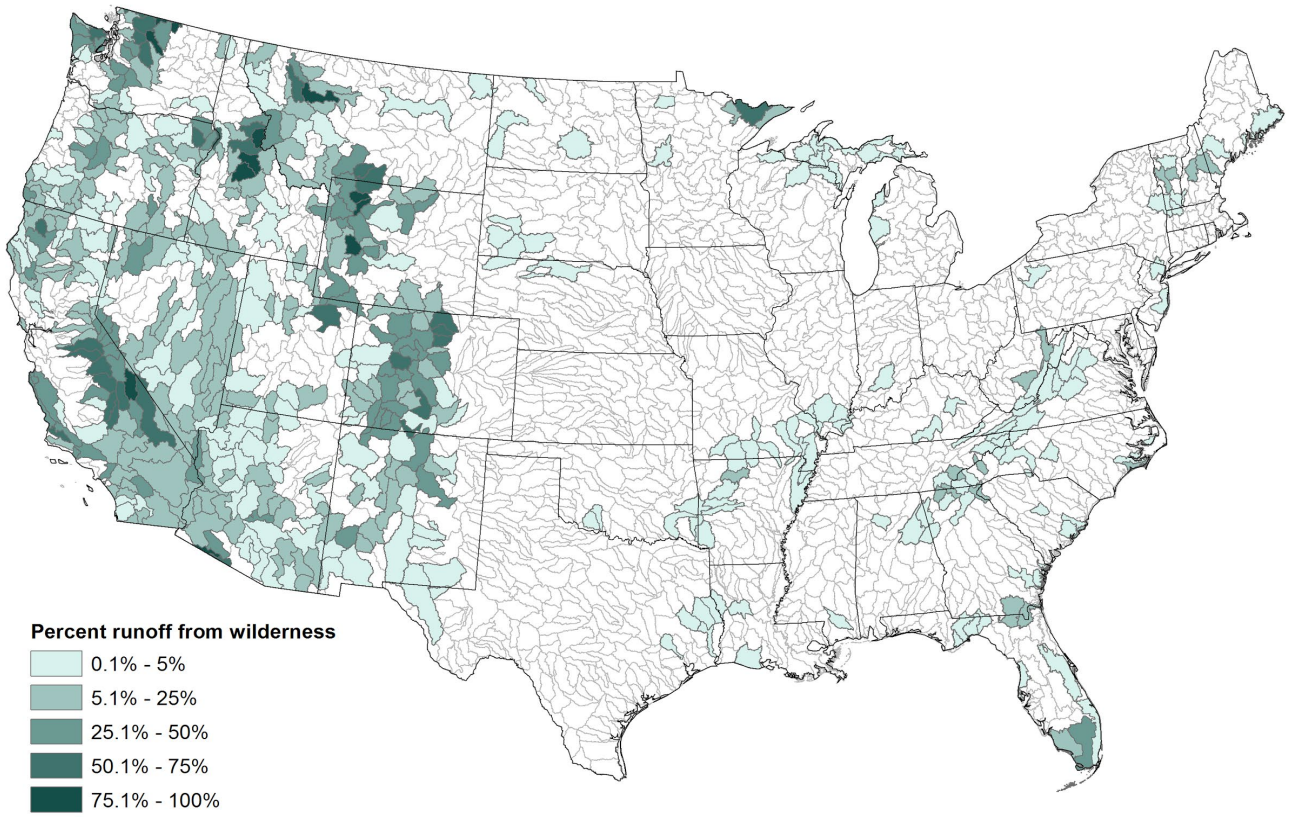

Figure 2: Percentage of freshwater runoff from wilderness areas versus freshwater runoff from all areas within a water resource region (HUC8 area)

- Some HUC8 watersheds derive nearly all their runoff from wilderness areas
- Many in western US deriving more than 50% of runoff from wilderness
- In the eastern US, there exist numerous watersheds for which a non-negligible proportion of the runoff originates in wilderness.
- Watersheds with higher percentage of water originating in wilderness tend to lie along the major mountain ranges of the US

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Wilderness and drinking water

- USDA Forest Service's Forest to Faucets (F2F) database to link water supplies to one source of demand: drinking water
  - Pairs runoff data with flow routing, surface drinking water intake locations, and population metrics to estimate the relative importance of watersheds across the country for drinking water (*See Weidner and Todd 2011 for details*).
  - Calculated at the HUC12 scale

- We use **F2F data** to identify wilderness areas that contain at least one half of the total area of a subwatershed considered as highly important for downstream drinking water, (i.e., wilderness areas that provide an important contribution to drinking water)

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Wilderness and drinking water

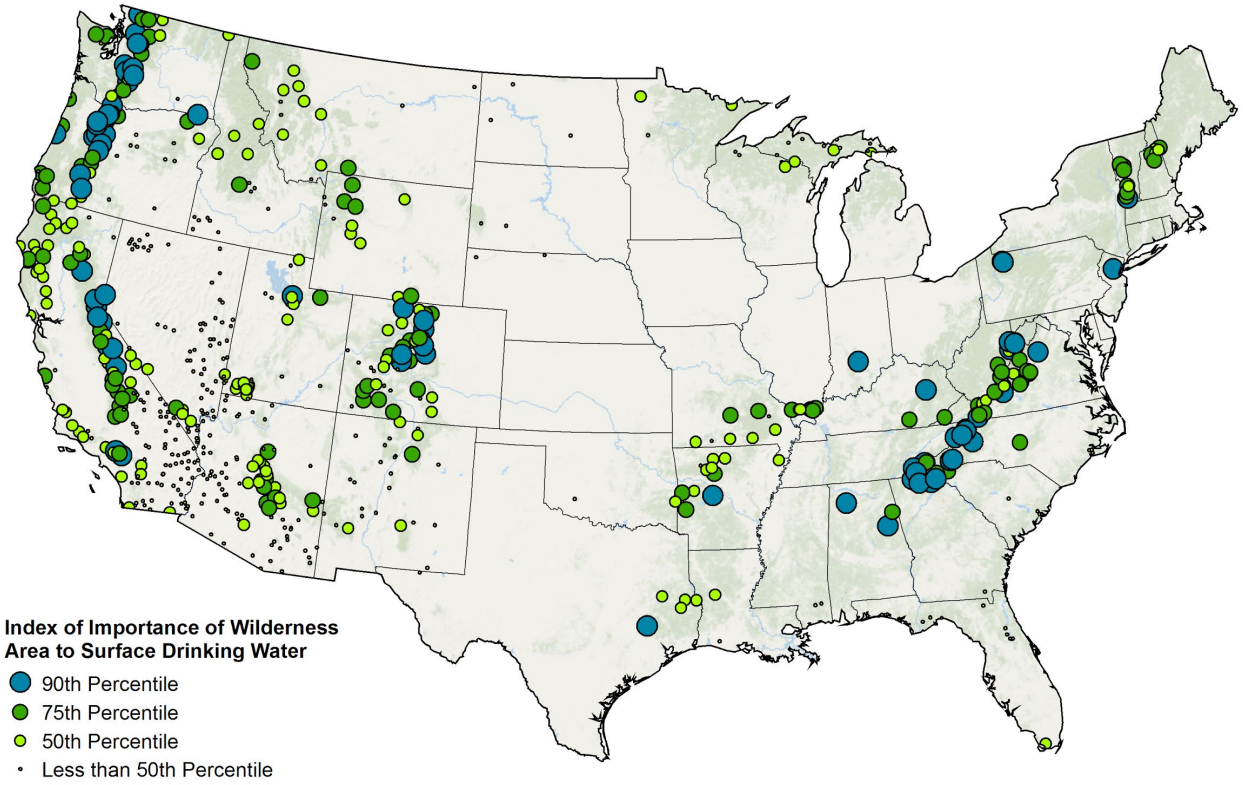

Figure 4: Ranking of subwatersheds that intersect designated wilderness areas in terms of drinking water importance relative to all subwatersheds (based on analysis of the F2F Surface Drinking Water Importance Index; Weidner and Todd 2011).

- F2F drinking water importance index ranking for subwatersheds that intersect a designated wilderness area
- Most of the wilderness areas run along mountain ranges
- We also see the clearer balance between the eastern and western halves of the country in this metric than in metrics that do not account for population density

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Economics of water

- Need to account for **full costs and benefits** of water allocation projects and land management that may affect the availability, timing, and quality of water necessary for society
- Economic theory says that the policy-relevant case is at the **margin**, i.e., at the last additional unit of water affected by some action
- Economic efficiency criteria provide a useful frame for two reasons (*Young and Loomis, 2014, pg. 25*):
    1. maximizing net economic benefits is an important objective in a world of scarcity and competing uses
    2. provides a useful way to evaluate the opportunity costs of competing projects or objectives

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“Benefit Transfer” from Brown (2004)

- In an unpublished discussion paper, Brown (2004) compiled estimates of the full marginal value of instream flow, summed across marginal values of different uses of water specific to each water resource region across the country

- Brown emphasized that:

  “these [marginal value estimates] are large scale averages based on numerous assumptions” (p. 44), but also notes that these marginal values *“can be considered a lower bound on average value*” (p. 96)

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Water resource region	Mean annual freshwater runoff from wilderness (million acre-feet)*	Percent of total mean annual water supply that is from wilderness*	Marginal value per acre-feet per year (2017$)**
1. New England	0.69	1%	$ 9
2. Mid-Atlantic	0.48	0%	$ 12
3. South-Atlantic-Gulf	2.46	1%	$ 11
4. Great Lakes	0.33	0%	$ 23
5. Ohio	0.42	0%	$ 12
6. Tennessee	0.47	1%	$ 20
7. Upper Mississippi	0.04	0%	$ 13
8. Lower Mississippi	0.03	0%	$ 7
9. Souris-Red-Rainy	0.46	5%	$ 9
10. Missouri	6.36	7%	$ 56
11. Arkansas-White-Red	0.61	1%	$ 19
12. Texas-Gulf	0.04	0%	$ 28
13. Rio Grande	0.86	16%	$ 61
14. Upper Colorado	4.04	25%	$ 76
15. Lower Colorado	0.36	8%	$ 112
16. Great Basin	1.23	9%	$ 72
17. Pacific Northwest	45.46	17%	$ 27
18. California	12.61	14%	$ 60
*Source: Authors' calculations of data reported in Brown et al., 2016			
**Source: Table 26, Brown 2004, inflated to 2017$; see caveats and discus			

- Brown's (2004) marginal value estimates by water resource region, and the amount of runoff originating in wilderness within each water resource region
- Large geographic heterogeneity in both the mean annual runoff from wilderness and the estimated marginal value of that runoff,
- Positive correlation between value and mean runoff

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Like wilderness lands, Brown (2004) describes these values in the context of national forests:

Reporting on the total value of resources originating on national forests can leave an incorrect impression, because ***not all of the value of resources flowing from a national forest... is attributable to national forest management****. The total value of all the resources is to some extent the result of purely natural events. For example, trees grow and water flows without help from land managers. The contribution of national forest management is to enhance or protect these outputs, and to make some of them available for purchase, thereby adding value (e.g., forest management makes timber available for harvest by controlling wildfire and administering sales, and watershed management may protect the quality of water flow). Thus, in reporting on the* ***total value of resource flows from the national forests, the agency is not claiming that all of that value is attributable to the agency's management. Rather, it is asserting that such value originates on the national forests.*** *(p. 93, 2004)*

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Added value of wilderness to water: *A better counterfactual is needed*

- Wilderness would otherwise be under protection as national forest, park, monument, or wildlife refuge (Latimer, 2000)

- Water treatment costs: **Warziniack et al. (2016)** "*that converting 10 percent of the average watershed from forest to developed area would increase chemical treatment cost from $2.52 to $20.48 annual per million gallons treated*" (p. 51)

- Nonmarket valuation techniques: **Loomis et al. (2000)** and **Holmes et al. (2004)** both use this approach to estimate the benefits of fully restoring two rivers at around $5 per household per mile, for the Platte River and the Little Tennessee River, respectively

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Addressing the research questions:

Importance of wilderness to water-related ecosystem services:

1. Can water resources be used to help conceptually connect people to wilderness?

   Yes! Wilderness areas include many watersheds of high-importance drinking water

2. Does wilderness *add* to water benefits?

   We consider "back-of-the-envelope" estimates of the total economic value of water from wilderness but note the challenge and importance of counterfactuals

   More interdisciplinary research is needed to quantify benefits of wilderness areas on water resources

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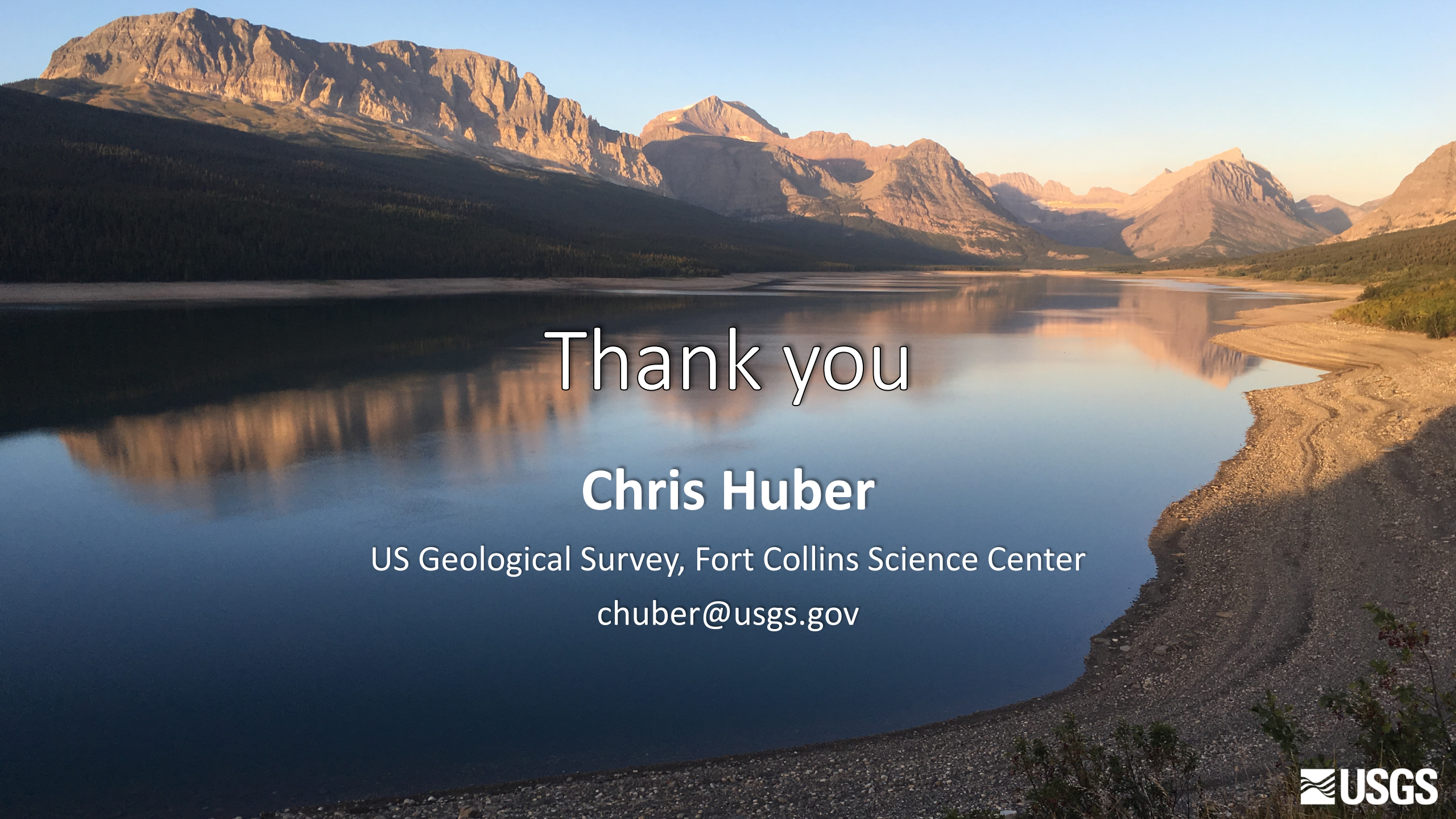

Thank you

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