Beaver Dam Capacity Model is Robust, but Sensitive to Vegetation and Slope in Siletz River Basin

Evan Hackstadt, Dr. Meghna Babbar-Sebens

Oregon State University | CCE | Engineering for Bouncing Back Better REU

Oregon State University

Background

- Siletz Watershed needs **restoration**.
- Beaver dams increase watersheds' drought & wildfire **resilience** [1].
- Policy effort: OR recently expanded beavers' **legal protections** [2].
- Beaver Restoration Assessment Tool (**BRAT**) [3] uses Mamdani Fuzzy Inference Systems (**FIS**) [4] to estimate maximum dam capacities.
- There is a lack of **comprehensive Sensitivity Analysis** on BRAT.

Objectives

Objective 1: Analyze Outputs
- Standard BRAT outputs for Siletz
- Identify trends & influence of inputs

Objective 2: Sensitivity Analysis
- One-at-a-Time: explore output change under local FIS adjustments
- Monte Carlo: explore outputs under global adjustments combinations

Methods

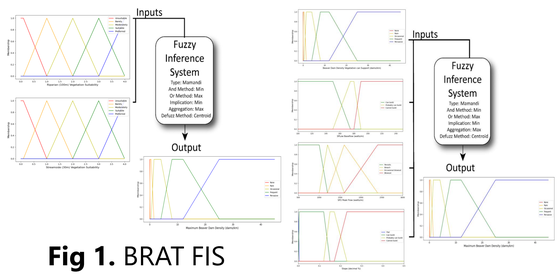

Fig 1. BRAT FIS

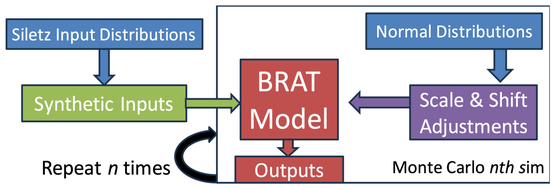

Fig 2. Monte Carlo Simulation Design

RESULTS

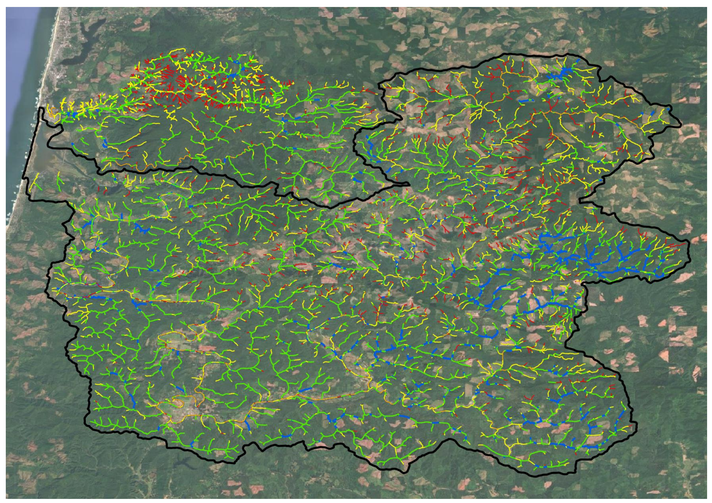

Fig 3. BRAT Outputs, Siletz Watershed

1: Standard Output Analysis

- Hydrology limits most reaches
- Slope, Peak Flow are most limiting

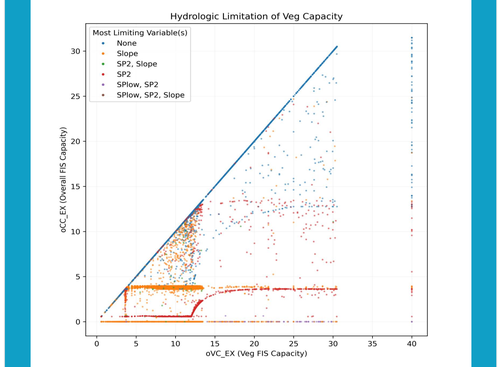

Fig 4. Hydro Limitation on Outputs

2: FIS Sensitivity Analysis

One-at-a-Time

- Sensitive to scaling Both FIS and large function shape changes.

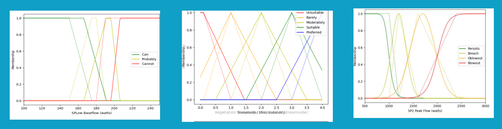

Fig 5. Shift, Scale, and Shape Examples

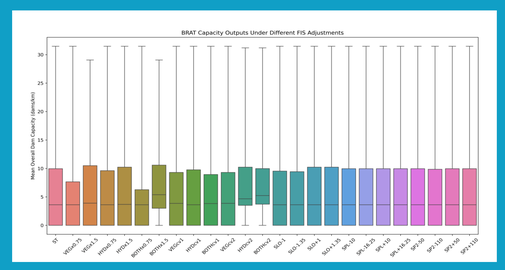

Fig 6. One-at-a-Time Analysis Results *(left-to-right: none, scale, shape, shift)*

Monte Carlo Simulation

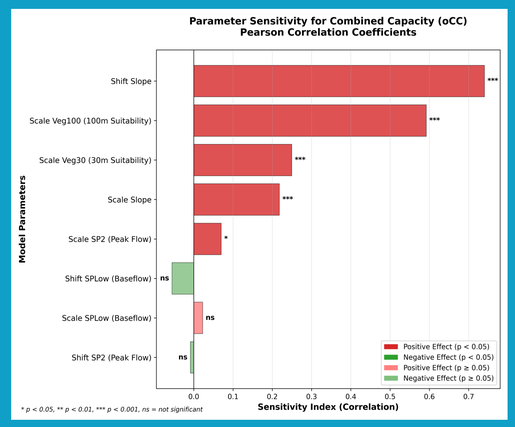

Fig 7. Monte Carlo Sensitivity Summary

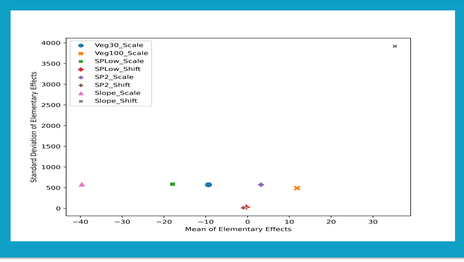

Fig 8. Monte Carlo Morris Elementary Effects

Key Conclusions

Objective 1:

1) Siletz is most limited by slope.
2) BRAT capacity is decreasing over time, but many opportunities remain upriver.

Objective 2:

1) BRAT is **conservative** and limitation-based. It requires compound adjustments to significantly change outputs.
2) The **scale & shape** of membership functions matter.
3) BRAT is most sensitive to shifting slope cutoffs and scaling riparian suitability.
4) Geater 100m riparian sensitivity is explained by more leniency in Vegetation FIS rule table.

Future Work:

1) Model **validation** via **community-based field data** would further increase confidence. We are building a survey to systematically collect this data.

Acknowledgements & References

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[1] C. E. Jordan and E. Fairfax, "Beaver: The North American freshwater climate action plan," WIREs Water, 2022.
[2] HB3464 2023 Regular Session - Oregon Legislative Information System.
[3] W. W. Macfarlane et al., "Modeling the capacity of riverscapes to support beaver dams," *Geomorphology*, Jan. 2017.
[4] E. H. Mamdani, "Application of fuzzy algorithms for control of simple dynamic plant," Proc. Inst. Electr. Eng., Dec. 1974.