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Benthic Algae Monitoring of Montana Rivers

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Background

The proliferation of nuisance algal blooms is a growing problem, leading to decreased benthic biodiversity,[1,2] disrupted pH and dissolved oxygen levels,[1,3,4] and limited recreational opportunities[4,5] in freshwater systems across the country. Recently, rivers flowing out of the GYE have begun experiencing this problem, with the 2023 declaration of the Gallatin River as an impaired waterway due to excessive algal growth that exceeded established thresholds for algae. In this presentation, we describe methodologies we developed along the Upper Clark Fork River (UCFR), where we developed hyperspectral imaging methodologies from an unoccupied aerial vehicle (UAV) platform to measure algal growth by building spatial distribution maps of nuisance algae while estimating chlorophyll *a* standing crops. These methodologies are now being applied to the Gallatin River to assess their efficacy as a water quality monitoring tool, while also informing the design of a low-cost algae imager.

Methods

The methodologies we have developed, called Spectral Processing for Algae Monitoring and Mapping (SPAMM), were created between 2020-2024 by collecting and analyzing UAV-based hyperspectral image data coupled with *in-situ* algae samples at numerous field sites along the UCFR. Imagery along three, 1-km-long field sites between 2020-2021 were analyzed for percent algal cover and average chlorophyll *a* standing crops between June and September. Here, we applied SPAMM to image data collected from our UAV-based hyperspectral imaging system flown over several field sites along the impaired section of the Gallatin River to assess percent algal cover, estimate average standing crops, and report areas of algal growth above current state standards. The most important wavelengths for performing these analyses were extracted and used to inform the design of a multispectral algae imager.

Results and Conclusions

The classification algorithm used to build spatial distribution maps of algae growth and assess percent algae cover showed excellent performance, with training and validation accuracies greater than 99% relative to visually labeled training data. The classification algorithm was used to assess percent Cladophora growth at three field sites along the UCFR across the 2020-2021 growing seasons, revealing that growth followed a typical pattern in 2020, with maximal growth in late July or early August, while peak growth in 2021 occurred much earlier, with measurements suggesting that peak growth occurred in early June.

The regression algorithm used to predict chl *a* standing crops was trained using 149 *in-situ* samples then applied to the imagery collected across the 2020-2021 summer growing season. Estimates of standing crops showed significant spatial variability, but a portion of every field site exceeded state standards once algae had been established.

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Upcoming analysis of two field sites along the Gallatin River will also be presented, with analysis of percent algae cover and chl *a* standing crops. It is our hope that SPAMM can be adapted as a water quality tool in support of current spatially limited *in-situ* efforts.

References

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