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Evaluating Geomorphic and Hydrological Responses to Beaver Dam Analogs: Integrating Machine Learning, Field Data, and Flume Experiments to Inform River Restoration

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Rivers across the world are responding to natural and anthropogenic disturbances including post-glacial landscape evolution, land-use changes, and climate change. Beaver Dam Analogs (BDAs) have emerged as a low-tech, process-based restoration tool designed to mimic the geomorphic and hydrological functions of natural beaver dams and increase water retention, sediment storage, flood attenuation, and habitat creation. Despite the adoption of BDAs in selective areas in North America uncertainties remain regarding their effect on fish habitat and potential flood risks under failure scenarios. These uncertainties continue to constrain permitting, implementation, and acceptance of BDAs as a widely accepted restoration method. This research integrates machine learning, field observations, and controlled physical experimentation to evaluate how BDAs influence fluvial processes across spatial and temporal scales. A province-wide habitat suitability model is being developed using satellite imagery, environmental variables, and a database of mapped beaver dam locations. This model identifies stream conditions most conducive to successful BDA implementation and highlights areas where environmental characterstics may limit suitability. Second, controlled experiments in the University of British Columbia's river flume laboratory test how variations in BDA design affect channel morphology, sediment transport, and flow dynamics. These experiments simulate incised channel conditions typical of many degraded systems and quantify geomorphic responses under varying discharge regimes and dam configurations. Third, field data from ongoing restoration projects combined with flume-derived relationships will inform the development of a flood risk model. This component assesses hydraulic impacts and potential dam failure scenarios, addressing key management concerns related to downstream infrastructure and fish passage. The results will directly support the British Columbia Wildlife Federation, and the Lheidli T'enneh First Nation in refining restoration strategies and developing evidence-based guidelines for BDA design and implementation.