Bridge Tree Catchments in GIS for Multi-span Structures in Vermont

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Background

Scour at the base of bridge piers is a significant issue and leads to many failures in footings during intense rainfall events. When there are also intense wind, there is a greater chance for large woody debris to accumulate at the base of the piers which accelerates the rate of scour and can lead to failures similar to the one shown in figure 1. Determining which bridges are at a greater risk of build-up of large woody debris can help structure managers determine where to deploy resources before or after a storm event. This can expedite cleanup up and inspection after hurricanes, nor'easters, or similarly damaging events.

Figure 1: Bridge pier failure due to scour (FHWA HEC-09)

Objectives

To determine which types of bridges or structures may be at the greatest risk of increased scour from large woody debris accumulation. Making real-time decision making on management and disaster response more efficient and making transportation networks more resilient to increased hazards during flood events.

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Statistical Data Methods

NBI Inventory: National Bridge Inventory data is sorted to include only those structures in Vermont with multiple spans and which spanned hydraulic crossings.

Statistical Clustering: A statistical methodology incorporating quantitative and qualitative attributes, K-Protype Clustering, is used to group the bridges into six clusters shown in figure 2. One representative bridge from each cluster was chosen for investigative analysis and can be seen in figure 3. Clustering is based on the following attributes from NBI:

- Total Span length
- Average Span Length
- Bridge Material
- Bridge Type

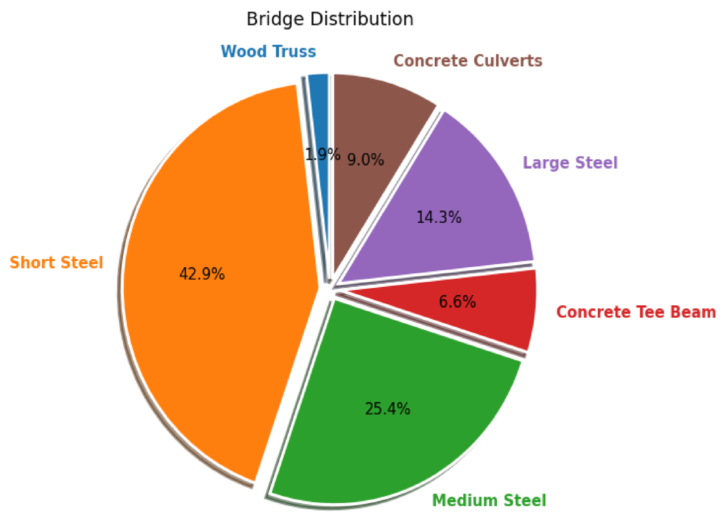

Figure2: Distribution of structures in named clusters

Spatial Data Methods

VTRANS Data: Imported spatial data from Vermont Open Geodata Portal for the following information:

- VT Long Structures – Bridges and Culverts
- VT Hydrography Dataset – cartographic extract lines
- VT Hydrography Dataset – cartographic extract polygons

Spatial Clustering: To assess if there are redundant bridges which may impact the accumulation of large woody debris on the downstream structure. Grouping bridges by varying distances, shown in figure 4, can help determine which distance may be considered optimal for removing redundant parallel bridges from LWD analysis. A center of structure offset distance of 100 meters was chosen to exclude downstream parallel structures.

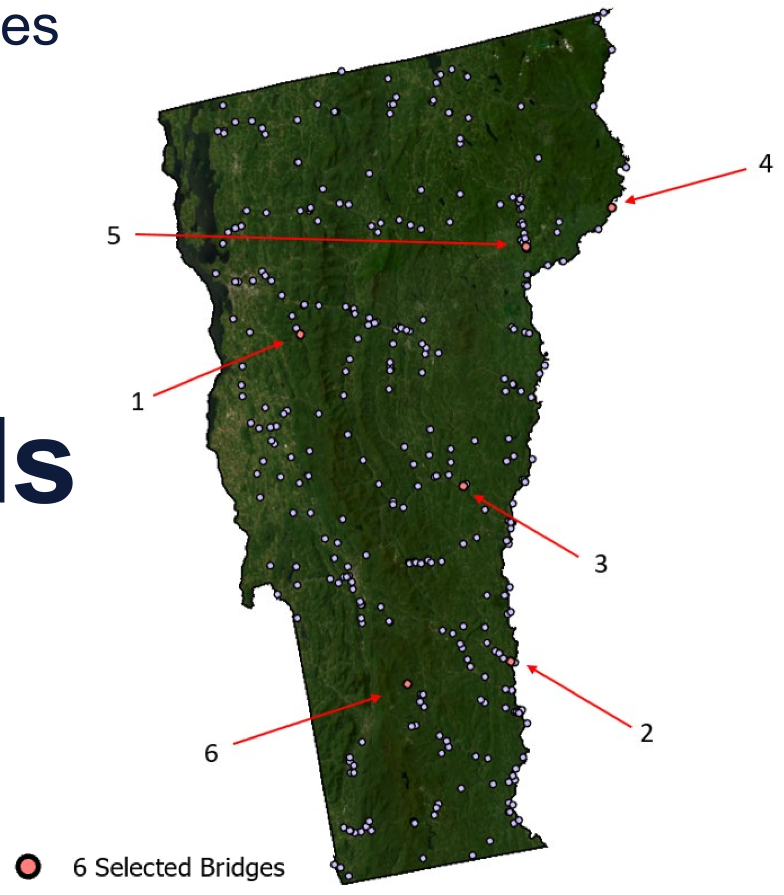

Figure 3: Locations of representative bridges in Vermont

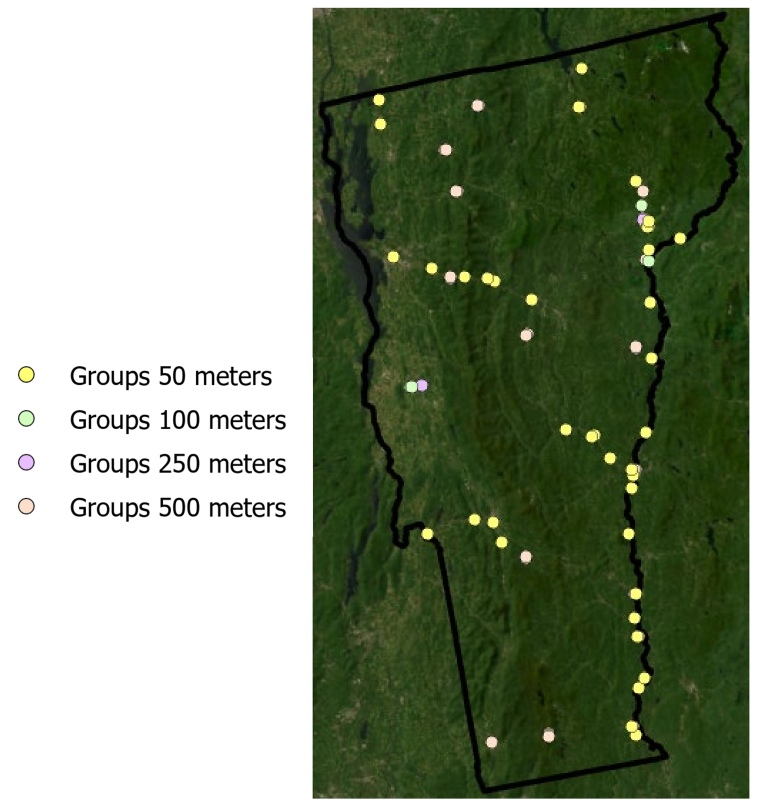

Figure 4:Bridges grouped by spatial distance

Preliminary Results

The mean and median tree height for each representative bridge were collected as well as the area of catchment in Table 1. These values may be used to predict the potential for large woody debris as well as the design log length for estimating the size of accumulated masses of debris. These values can be used for analysis on these representative bridges, but iterating over the entire set of bridges may provide clearer relationships between bridge clusters and tree catchment areas.

#	Structure Number	Area (square meters)	Cluster	Mean Tree Canopy Height (ft)	Median Tree Canopy Height (ft)
1	200016006614182	424640.0103	medium_span_steel	23.45	24.23
2	200120004L02052	263485.3148	concrete_tee	18.83	20.12
3	200211001404082	592122.3983	short_span_steel	21.23	22.56
4	207000012703112	609057.946	concrete_culvert	17.84	18.90
5	100514B01705141	472563.9467	wood_truss	14.53	14.94
6	200089017N14172	956114.8693	long_span_steel	23.67	25.60

Table 1: Descriptive statistics for tree catchment areas

Bridge Tree Catchments: Starting with the representative bridges, we use the hydrography and structure geodata to create upstream buffer zones to estimate potential for large woody debris. This can be done by incorporating tree canopy height data from NASA's Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC). This can be seen in figure 5.

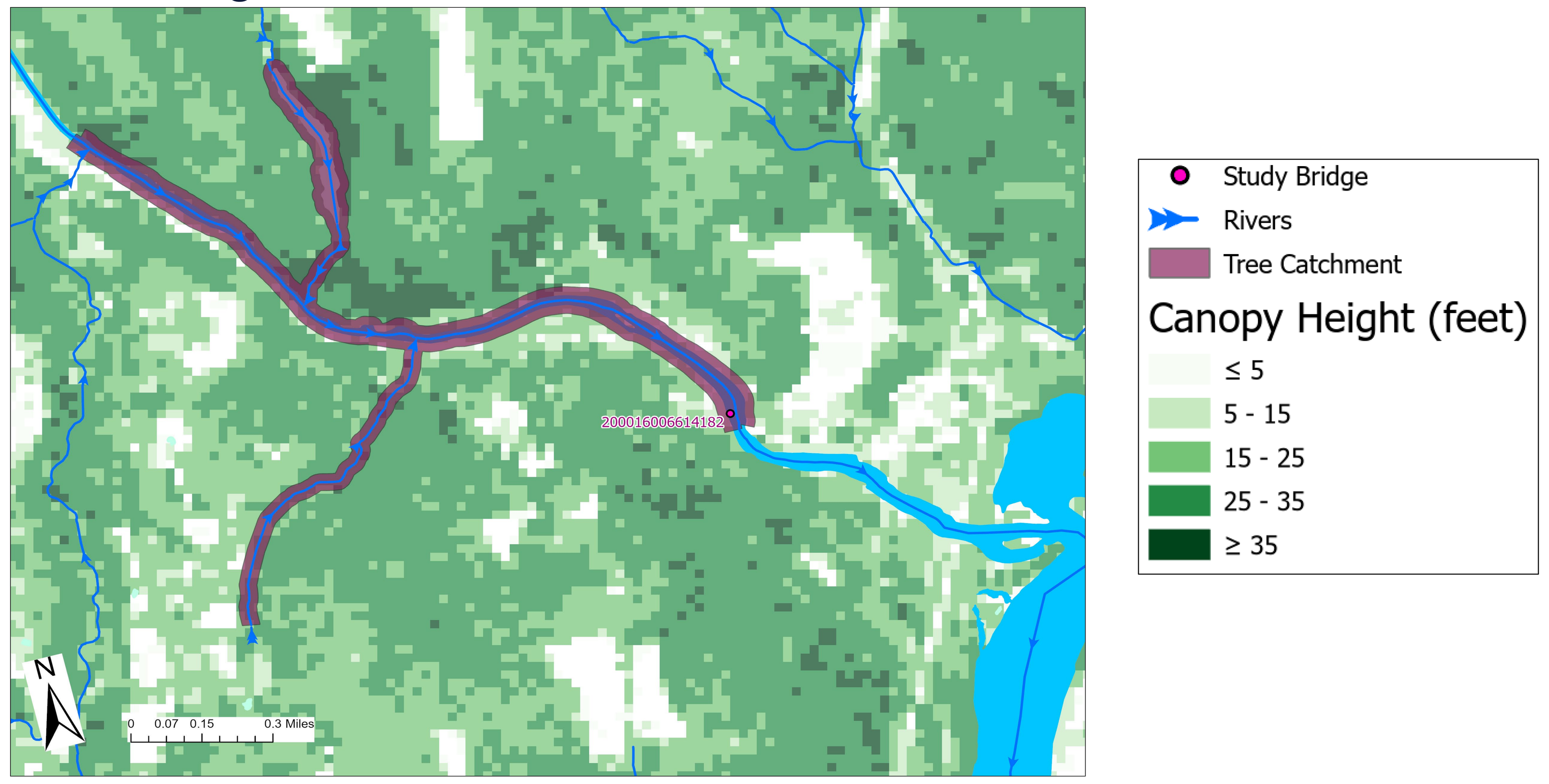

Figure 5: Bridge Tree Catchment of the representative Medium-Span Steel Bridge

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