



# Historic channel changes in the Muskegon River, North-Central Michigan, USA

Michael J. Michalek and Alan F. Arbogast

The Muskegon River is the second largest river in Michigan, with a length of 348 km. The system originates in the north-central part of Lower Michigan at Houghton Lake and drains an area of 6,086 km<sup>2</sup> as it flows southwest toward Lake Michigan. Prior research on the upper half of the system demonstrates a complex late Pleistocene and Holocene history, with four alluvial surfaces (Arbogast et al., 2008). The system has been actively meandering on its current surface in the late Holocene, resulting in numerous abandoned meanders and oxbow lakes. This study assesses the extent of meandering in the upper Muskegon during the historic record by comparing stream patterns from the initial land survey in 1836 with aerial photos acquired in 1938 and 2010. The upper reach of the river is highly sinuous (~1.15 - 2.6) because it flows on a gradient that averages 0.25 m per km, which is much more gradual than downstream. The radius of curvature averages 65.6 m with curvature values as low as 13.5 m and as high as 385 m. Average meander wavelength of the upper Muskegon is 347 m, with an average belt width of 289 m. River positions at each time period were georectified in ArcGIS10 for comparative purposes. Results indicate that numerous changes have occurred in the position of the stream in the period of record, with numerous migrating cutbanks and cutoff meanders. The greatest change appears to have occurred between 1836 and 1938, suggesting the upper system is slowly moving closer toward a state of equilibrium now than it was a century ago.

## Introduction

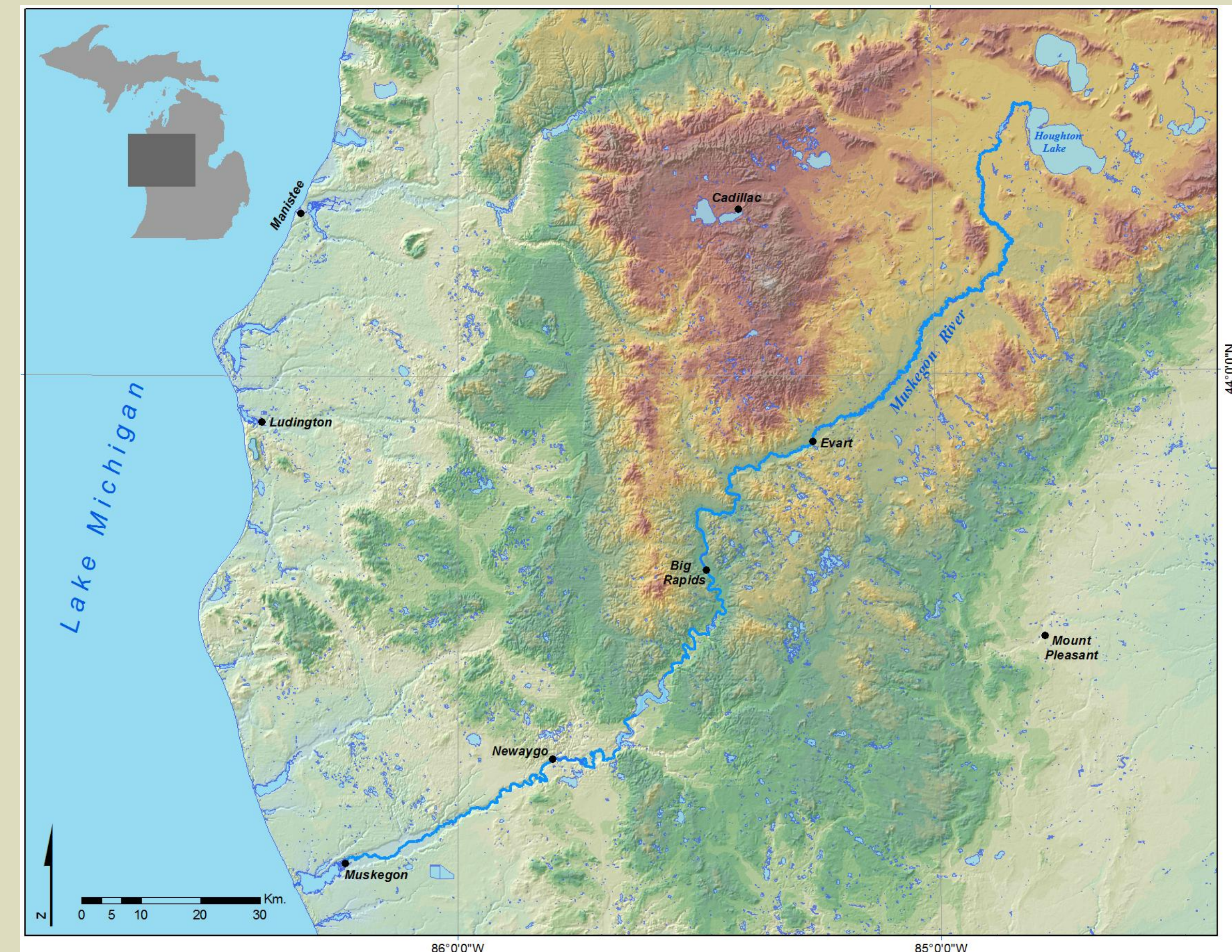


Figure 1. The course of the Muskegon River in Michigan

The Muskegon River originates at Houghton Lake and flows southwesterly for 348 km to Lake Michigan. The Muskegon watershed drains an area of 6,086 km<sup>2</sup> (Figure 1).



Figure 2. The upper Muskegon River.

Typical view of the Muskegon River in the upper portion of the river system (Figure 2).

## Methods



Figure 3. A representative reach of the Muskegon River in 1836, 1938, and 2010.

- Land survey maps (1836) and aerial photography images (1938 and 2010) were obtained and georeferenced in ArcGIS 10 for comparative purposes (Figure 3).
- Imagery was used to compare stream width, radius of curvature, sinuosity, and channel changes through time.

## Methods (Cont)

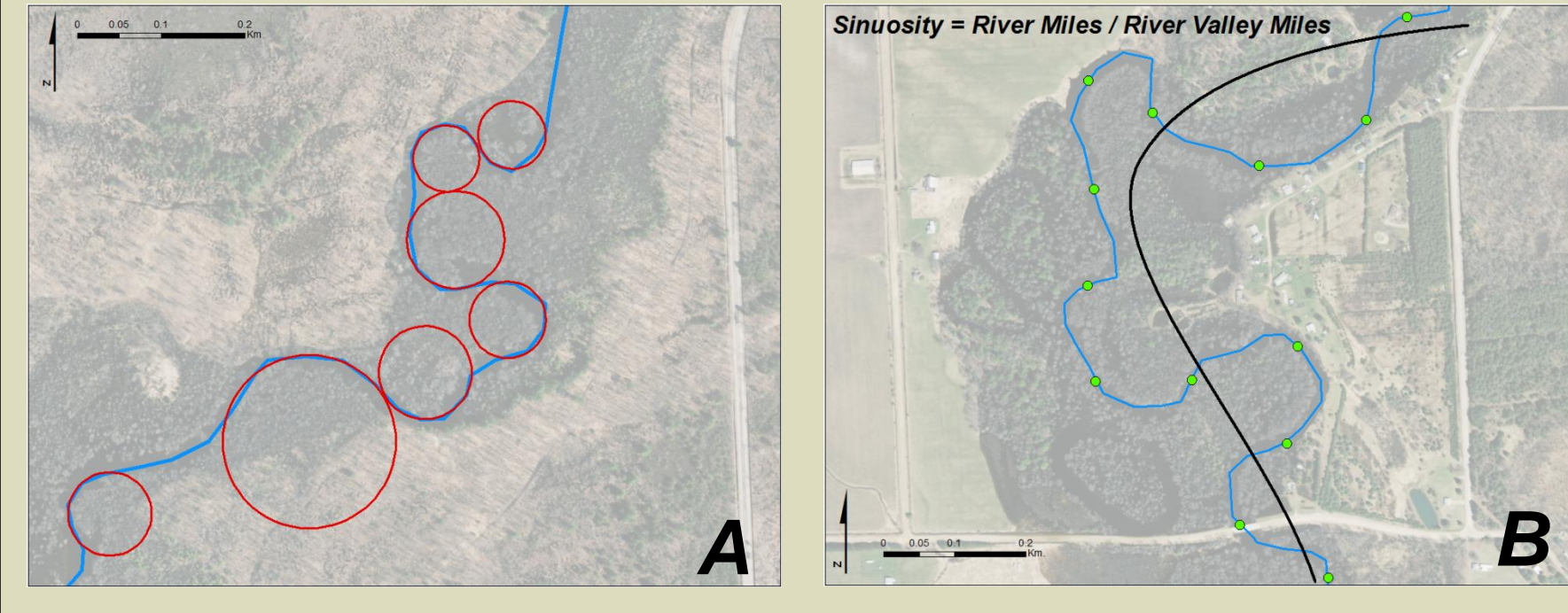


Figure 4. Calculating radius of curvature and sinuosity.

- Radius of curvature was calculated in ArcGIS 10 by placing circles on the inside of river meanders (Figure 4A).
- Sinuosity was calculated in ArcGIS 10 by dividing river miles by every five river valley miles (Figure 4B).

## Results

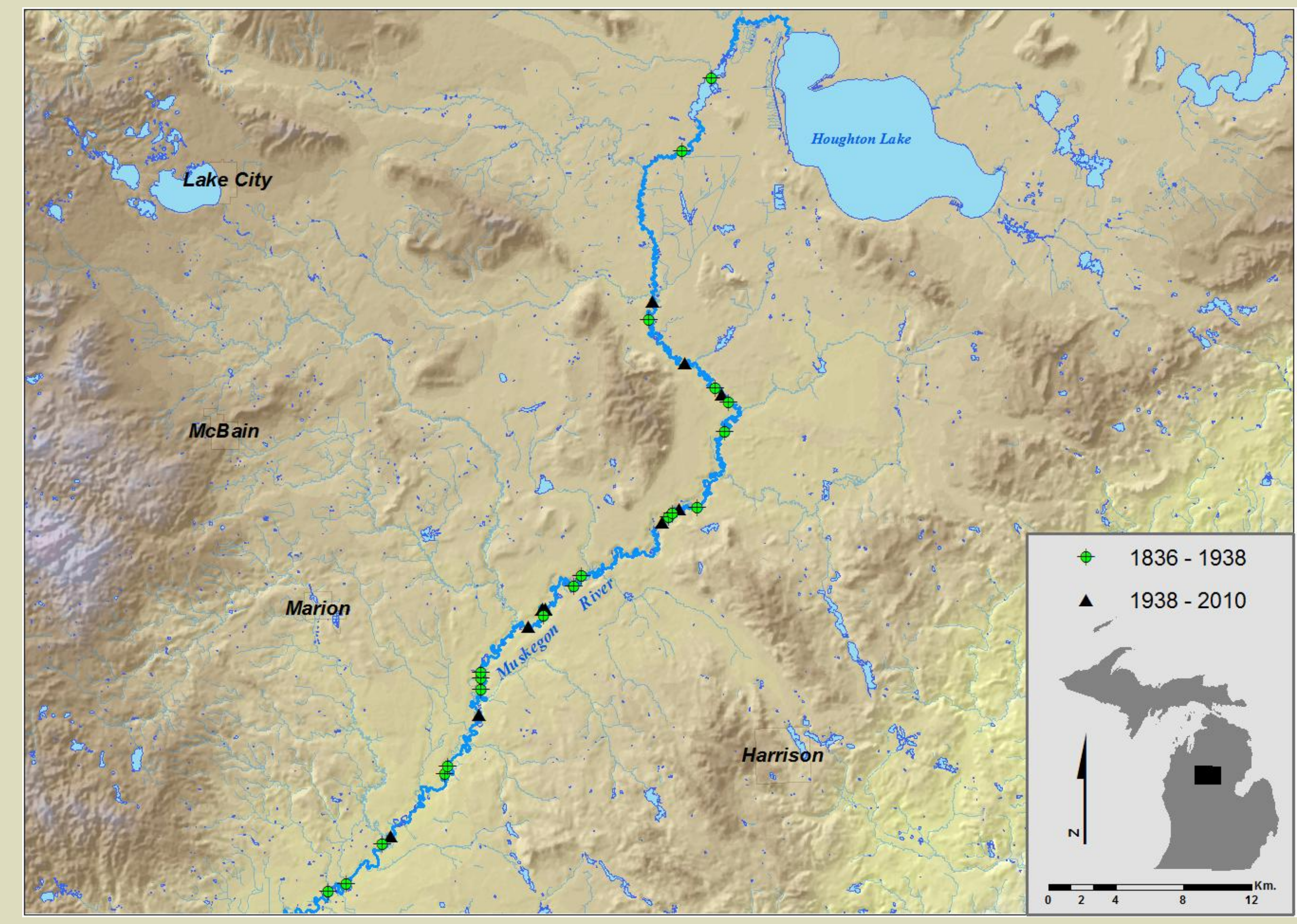


Figure 5. Locations of cutoff meanders on the upper Muskegon River from 1836 – 2010.

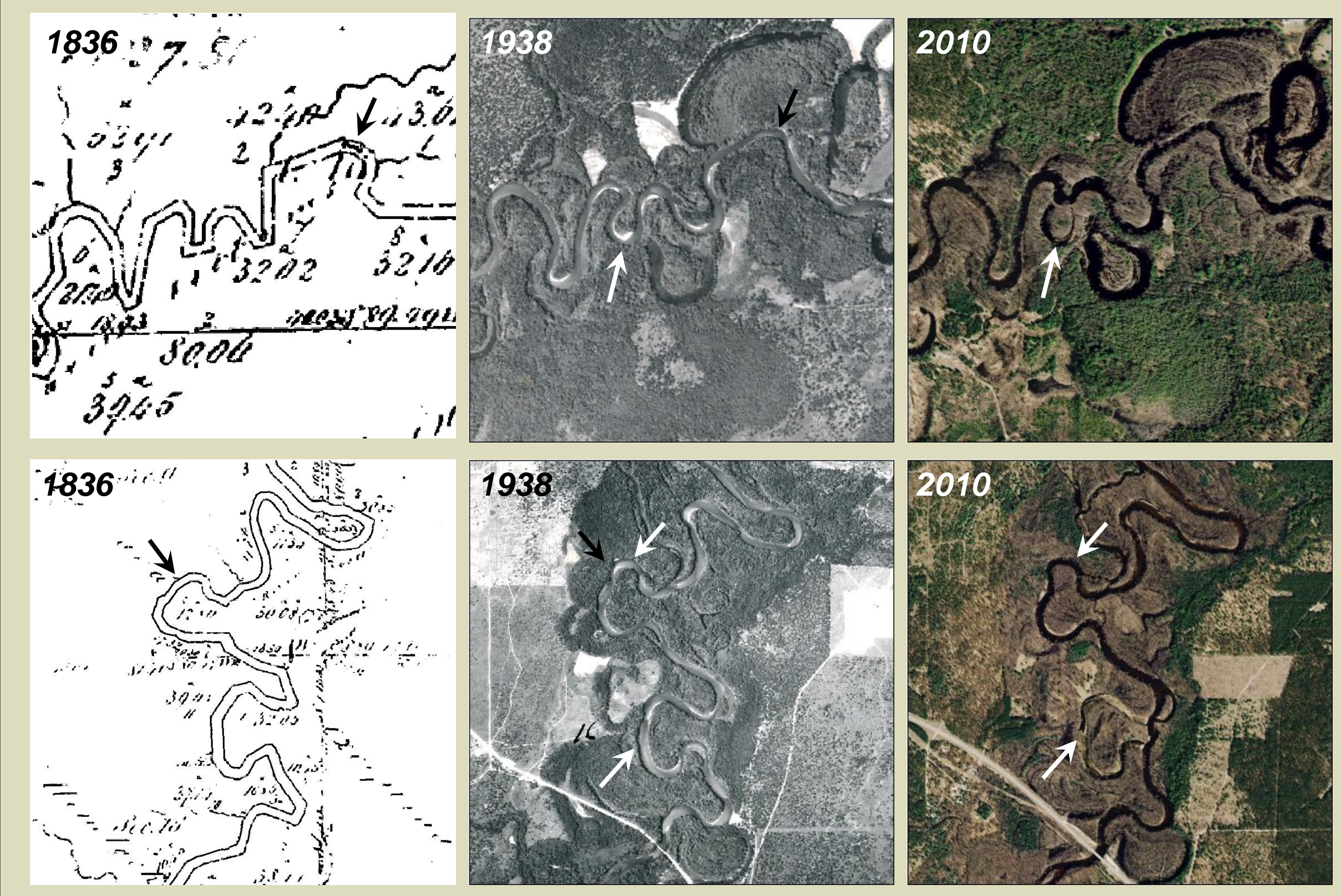


Figure 6. Channel changes in the upper Muskegon River from 1836 to 2010.

Cutoff meanders were mapped between 1836-1938 and 1938-2010 (Figure 5). Preliminary results suggest that fewer cutoff meanders are now occurring and are clustered in the center of the upper Muskegon River valley. Notice color coded arrows showing areas of change, black indicates changes between 1836-1938, while white represents changes between 1938-2010 (Figure 6).

## Results (Cont)

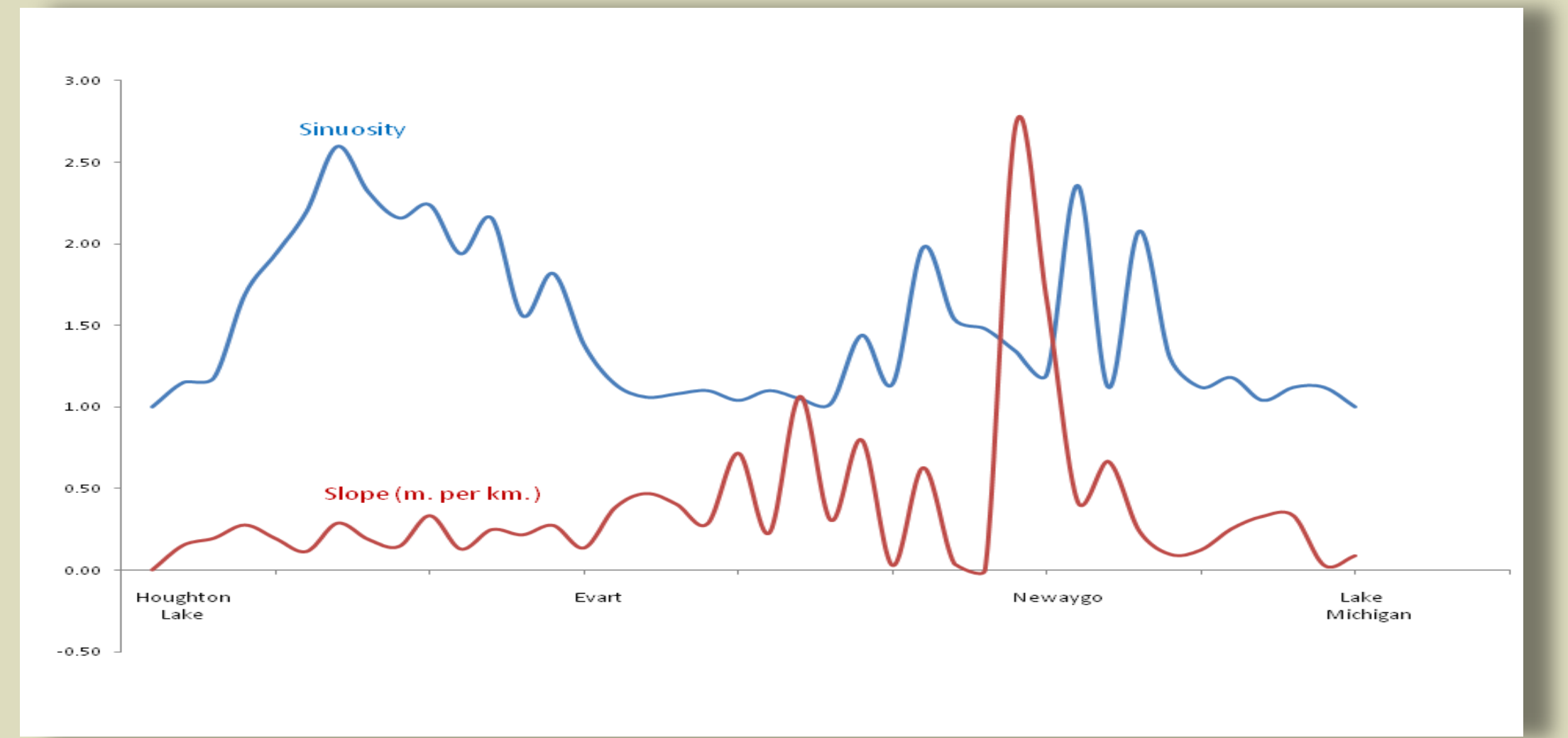


Figure 7. Sinuosity and slope of the Muskegon River.

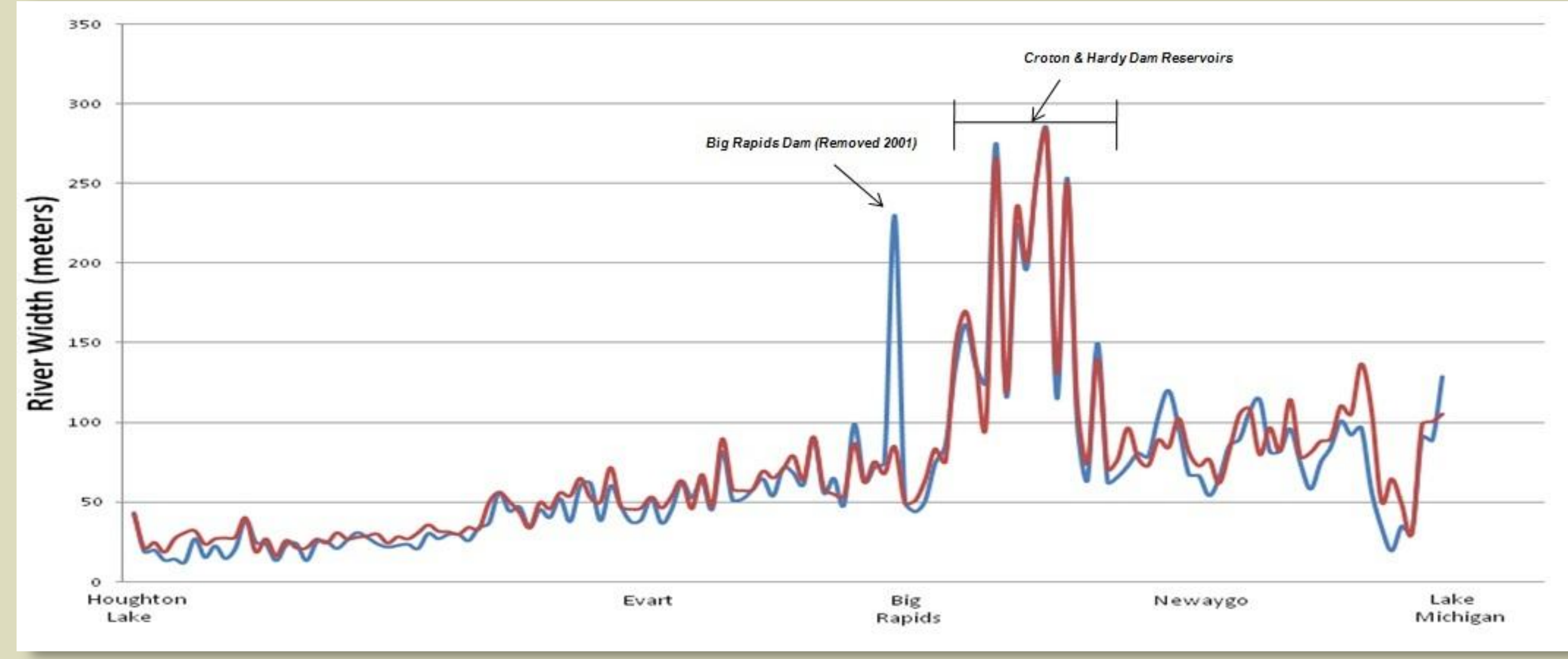


Figure 8. Comparing widths from 1938 to 2010. The blue line represents channel width in 1938, whereas the red line is the channel width in 2010.

Although changes in the position of meanders between 1836 and 2010 were recognized throughout the valley, the vast majority occur within the upper part of the system where the stream is most sinuous (1.8; Figures 5, 7). This pattern is likely related to the low channel slope (0.25 m/km) that occurs in this part of the valley.

In addition to the change in meander geometry recognized, this study also suggest that the width of the Muskegon River is now greater than it was in 1938. This change may be due to the effects of logging in the late part of the 19<sup>th</sup> century.

## Conclusions

This study demonstrates;

- Numerous cutoff meanders have been identified on the Muskegon River in the historic period.
- Meanders have occurred in the upper Muskegon River where there is a continuous low slope and high sinuosity.
- Channel width appears to have increased from 1938 to 2010, which may be related to the long-term effects of logging.
- More research needs to be done to verify these observations.

References:  
 Arbogast, A.F., Bookout, J.R., Schrotenboer, B.R., Lansdale, A., Rust G.L., Bato V.A., 2008. Post-glacial fluvial response and landform development in the upper Muskegon River valley in North-Central Lower Michigan, U.S.A. *Geomorphology* 102, 615–623.