PLANIMETRIC CHANNEL CHANGE ALONG THE LOWER CHIPPEWA RIVER IN WEST-CENTRAL WISCONSIN, 1938-2008

Nicholas E. King, Amy E. Wichlacz, Dr. Douglas J. Faulkner, University of Wisconsin - Eau Claire Geography and Anthropology Department

ABSTRACT

The Chippewa River, a major tributary to the Mississippi River in west-central Wisconsin, appears to be an exceptionally dynamic stream. This seems particularly true of the river downstream from Eau Claire, as suggested by numerous abandoned channels and bars of fluvial sediment found far from the present active channel. In this research, our objective was to identify and quantify recent planimetric channel change along a 52-km reach of the lower Chippewa River. To accomplish this, we used aerial photographs taken between 1938 and 2008 as base maps and, in ArcMap, digitized the river's active channel. From the digitized active channels, we generated a time series of maps illustrating 70 years of planimetric change. These maps clearly reveal significant change along anabranching sections and relative stability along single-channel meandering sections. The digital maps of the active channel also enabled us to quantify changes in channel planform morphology over the period of study. The most notable planimetric change was a progressive decline in the surface area of the active channel, from 14.2 km² in 1938 to 10.1 km² in 2008. The cause of this decrease, which exceeds 28%, is presently unknown, although flow regulation by upstream dams seems a likely contributing factor.

STUDY AREA

The Chippewa River begins in northern Wisconsin and flows in a southwesterly direction for ~425 km, draining a watershed of 25,000 km² to the Mississippi River. The river can be divided into two distinct parts—an upper and a lower river separated at the Dells Dam in the city of Eau Claire. The upper river, which is ~325 km long, mostly flows through a poorly drained landscape created by glacio-fluvial processes during the Late Wisconsin Glaciation. The upper river, as well as some of its tributaries, has several large dams located mainly along steep gradients; most of these are hydroelectric dams (Figure 1). The lower Chippewa River flows through a landscape of stream-dissected bedrock uplands and stream-carved valleys, which is distinctly different from the recently glaciated landscape of the upper river. The lower river also has no dams, although dams are located on some of its tributaries. The study area for this research is a 52-km stretch of river between Eau Claire and the downstream end of Nine Mile Island, located near the city of Durand (Figure 1).

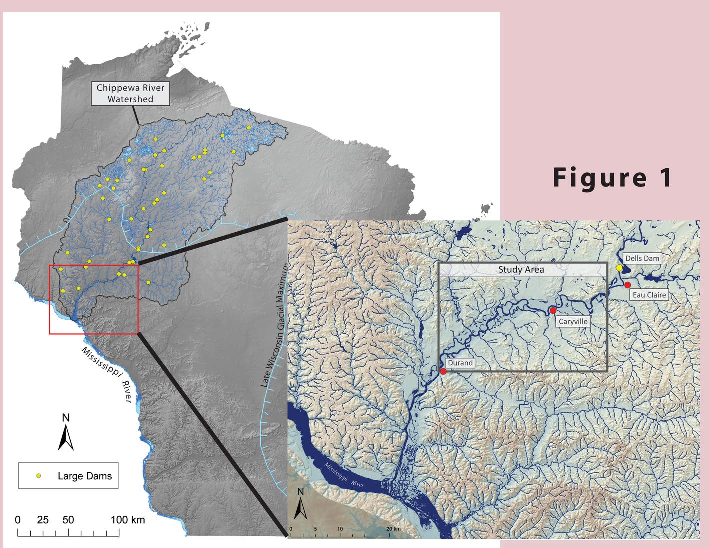


Figure 1

INTRODUCTION

The Lower Chippewa River appears to be a highly dynamic river, as suggested by active cutbanks found along its channel and oxbow lakes and abandoned channels found on its flood plain. But just how dynamic is it? The objective of this research is to reconstruct a recent history of channel change for the river in order to identify and quantify the changes that occurred over the last several decades

METHODS

For the first part of this research, we obtained and scanned prints of aerial photographs taken in 1938, 1951, 1958, 1965, 1972/73, and 1986/88. We then georeferenced the scanned photos, along with 1998 digital aerial photos obtained from the USGS, with the remote sensing software ENVI 4.5. For the geo-referencing process, we used 1992 digital orthophoto quadrangles as base maps. In addition, we obtained georeferenced digital aerial photos that had been taken in 2005 and 2008 as part of the National Agriculture Imagery Program. Then, we created geodatabases in ArcCatalog for the 1951, 1958, 1986/88, 1998, 2005 and 2008 channels as geodatabases had been previously created for all other years from prior research. Feature classes were created in each new geodatabase for the left bank, right bank, sandbars, islands, sloughs, and lakes (Figure 3). Next, we digitized the left bank, right bank, sloughs, islands, lakes and sandbars for each year using the georeferenced images as base maps in ArcMap 9.3 at a 1:3000 scale. We then created polygon files from the digitized right and left banks for each year using the Line to Polygon tool in ArcMap. The islands were then clipped out of the polygons (Figure 4). This allowed us to measure the planimetric area of the active channel for each year. (The active channel as we define it consists of the stream and adjacent unvegetated sandbars, and it excludes vegetated islands.) Lastly, the river was divided into five sections (Eau Claire, Caryville, Islands, Stretch, and Nine Mile) at easily identifiable locations along the river. The planimetric area of each section for each year could then be easily measured and compared (Figure 5).

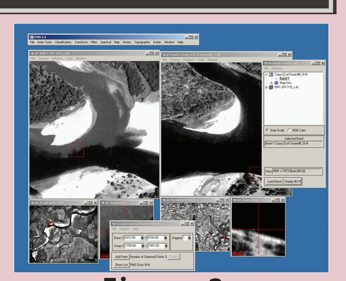


Figure 2

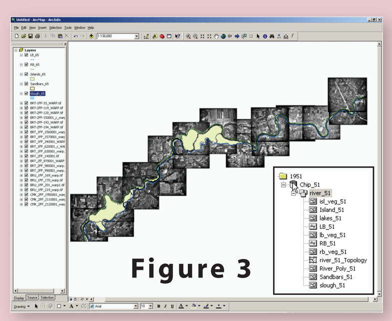


Figure 3

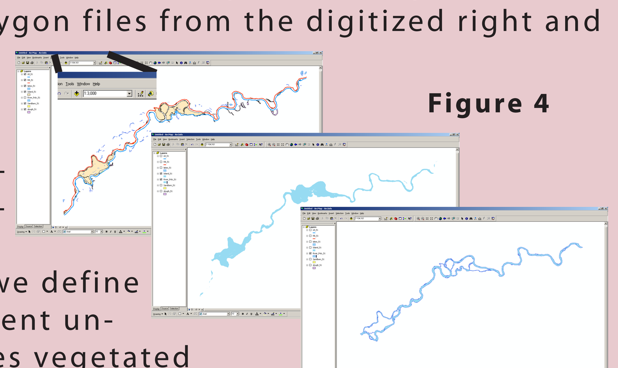


Figure 4

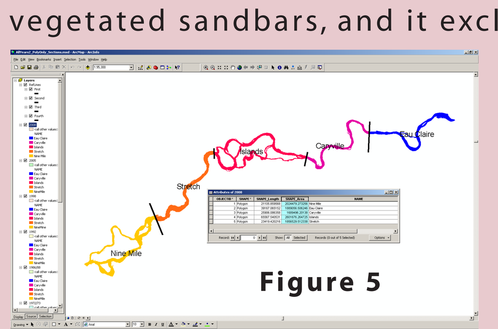


Figure 5

RESULTS

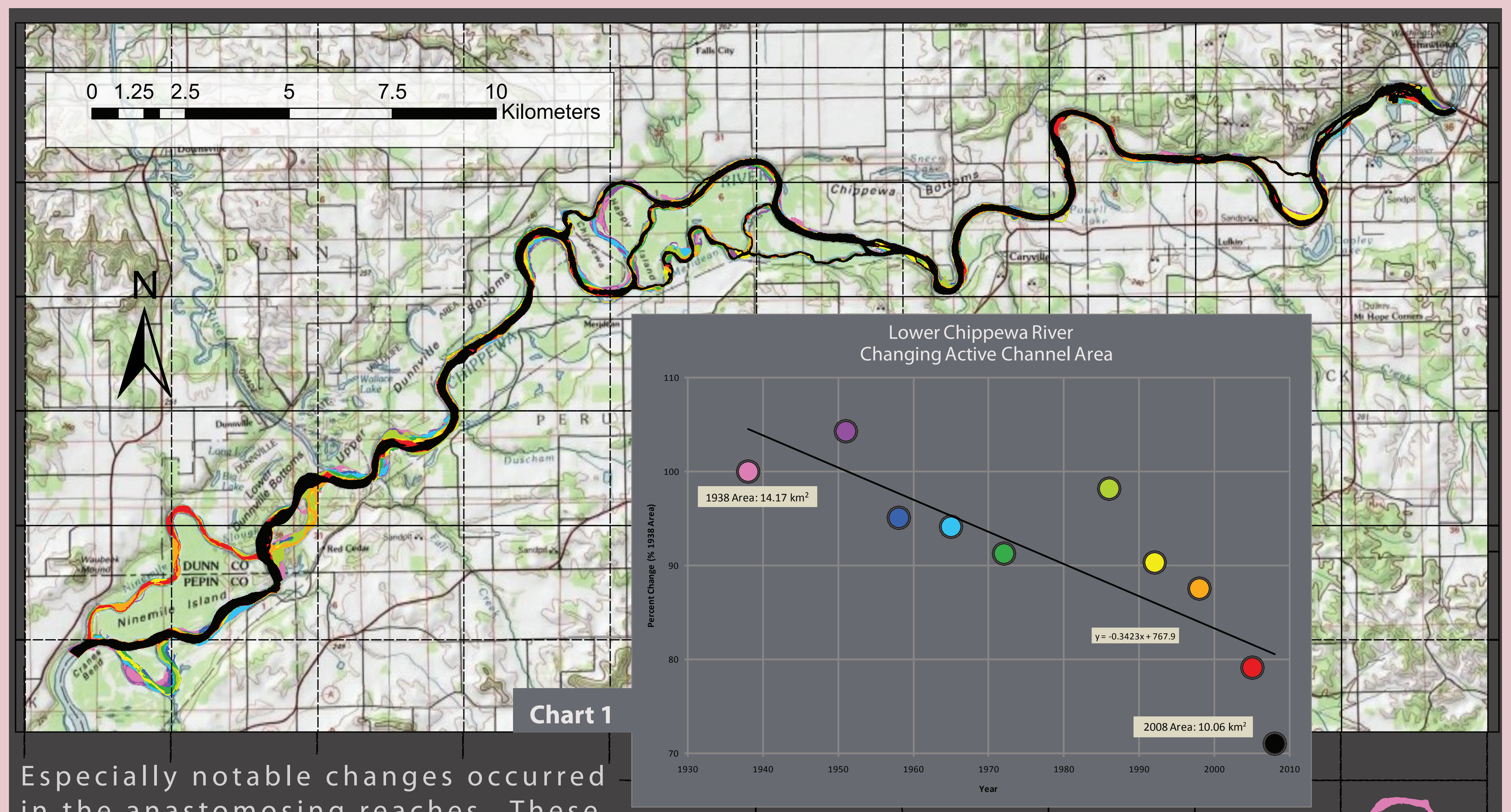
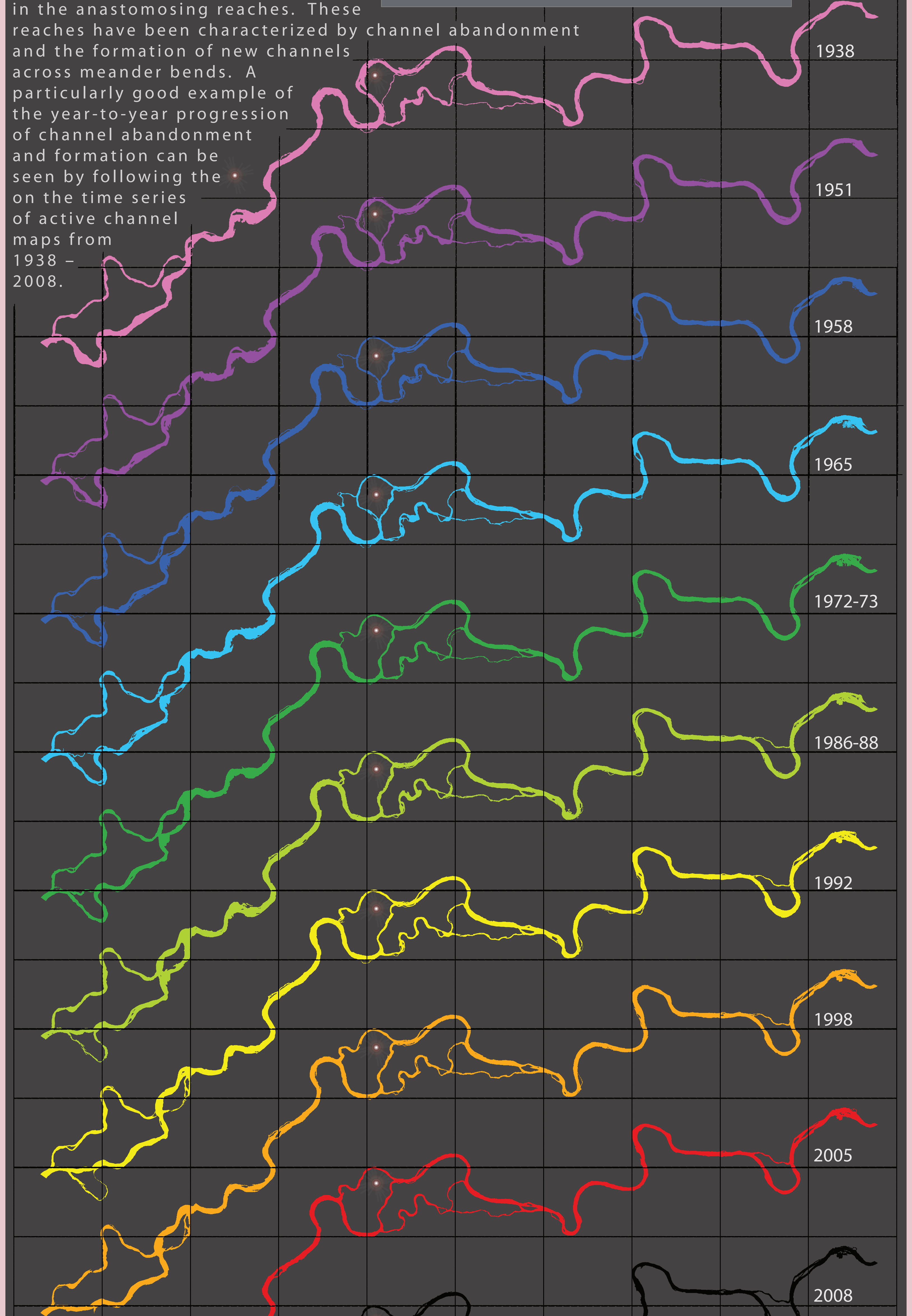


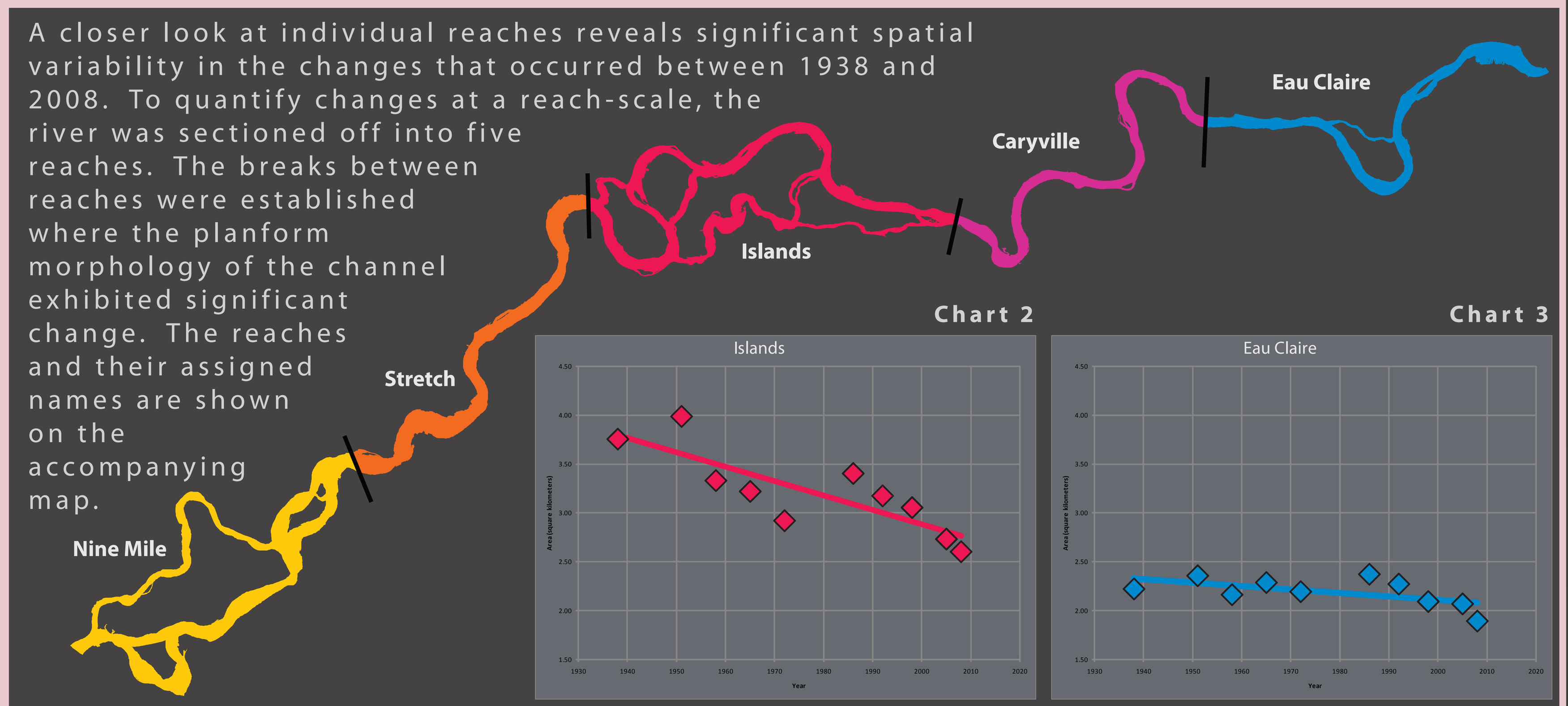
Chart 1

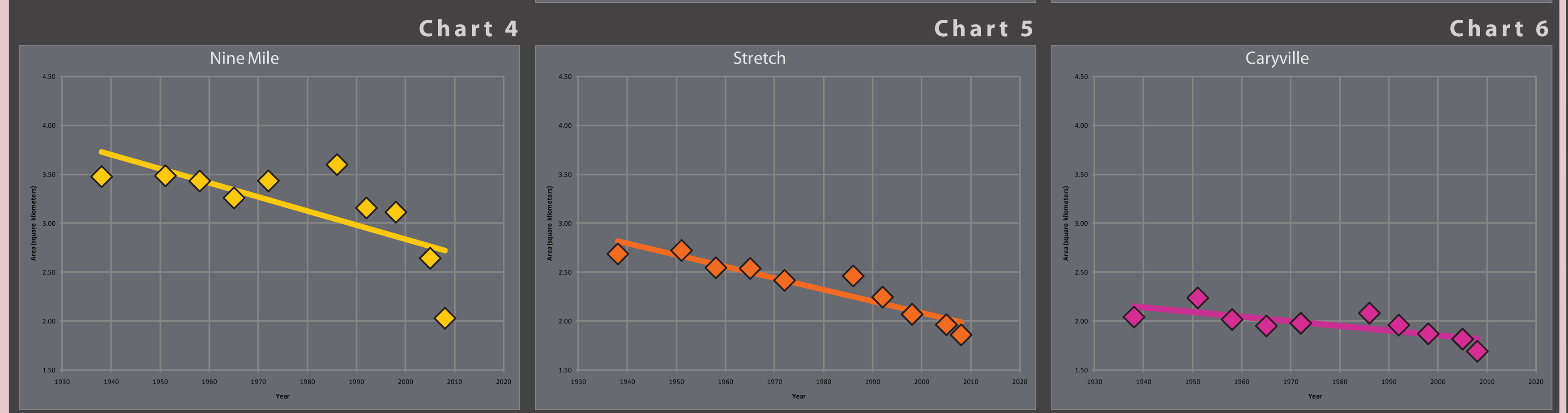
Especially notable changes occurred in the anastomosing reaches. These reaches have been characterized by channel abandonment and the formation of new channels across meander bends. A particularly good example of the year-to-year progression of channel abandonment and formation can be seen by following the on the time series of active channel maps from 1938 – 2008.



Our analysis of historical aerial photographs reveals that the active channel of the lower Chippewa River is shrinking. A comparison of our digitized channel polygons makes this declining trend evident. The changes are summarized in Chart 1, which shows the percent change of active channel area for each year of available aerial photography, using the planimetric area of the 1938 channel as a reference point. While active channel area increased between some years (from 1938 to1951 and from 1972/73 to 1986-88), overall, active channel area decreased dramatically, with an especially severe decline after 1986/88. As a result, in 2008 the area of river's active channel was only 70.9% of what it was in 1938.

A closer look at individual reaches reveals significant spatial variability in the changes that occurred between 1938 and 2008. To quantify changes at a reach-scale, the river was sectioned off into five reaches. The breaks between reaches were established where the planform morphology of the channel exhibited significant change. The reaches and their assigned names are shown on the accompanying map.





Charts 2 through 6 reveal the spatially nonuniform decline in active channel area. Between Eau Claire to the first anastomosing reach (comprising the Eau Claire and Caryville reaches) changes in area have been modest. In contrast, along downstream reaches, they have been much more remarkable, although the temporal trends along these reaches have not been the same. For example, active channel area along the Stretch reach declined fairly steadily from 1938 to 2008, while along the Islands and Nine Mile reaches, it decreased in a manner characterized by considerable year-to-year variability. And of these two, the Nine Mile reach exhibited little change in active channel area till after 1986, whereas the Islands reach began declining decades earlier. Spatially variable planimetric change has altered the relative area of active channel in each reach (as a proportion of the total active channel area) (Chart 7).

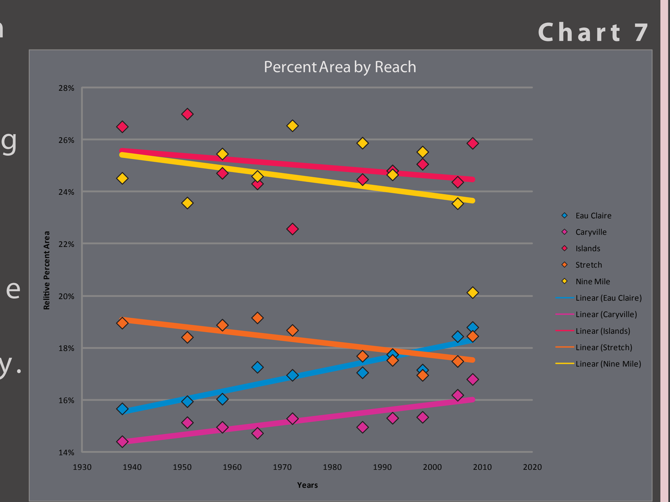
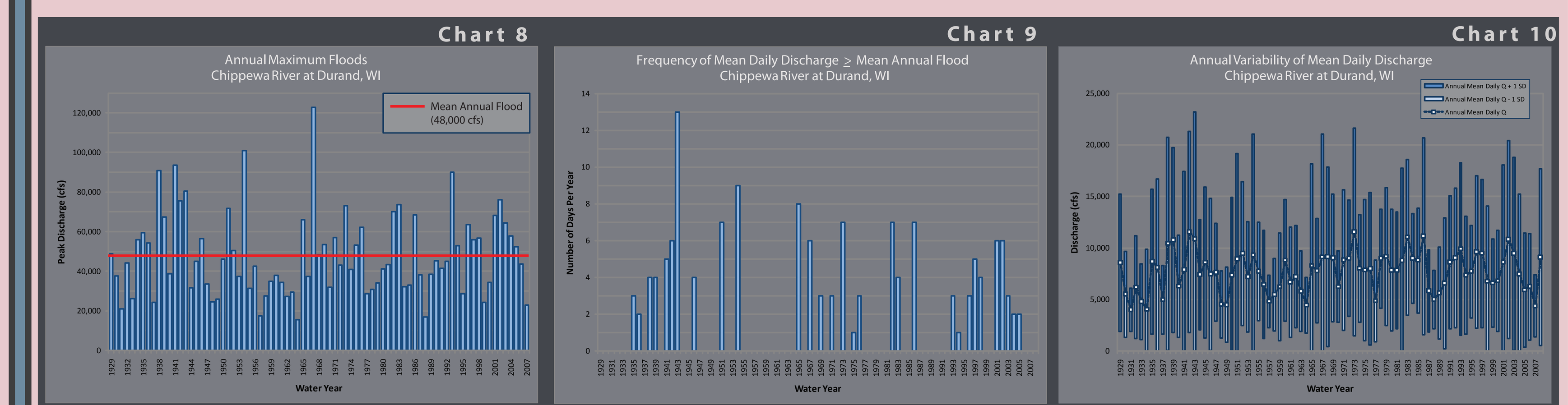


Chart 7

DISCUSSION

The causes of declining active channel area are not known, even though the process by which it has happened is apparent from aerial photographs. In general, channel area has shrunk as vegetation has encroached upon and filled side channels (especially in the anastomosing reaches) and become established on lateral sand bars and point bars along the main channel. It seems likely that the encroachment of vegetation is due to changes in the hydrologic regime of the river. However, analyses of streamflow records from the USGS gaging station at Durand, WI (located 5 km downstream from Nine Mile Island) reveal no trends that clearly explain the observed channel changes.



For example, while small annual maximum floods (Chart 8) between 1955 and 1964 may help explain the decline of channel area during that period of time, relatively large annual floods between 1993 and 2005 (a time of dramatic channel area decline) counter any conclusion that small annual floods are a primary cause. The annual record of flood duration (indicated by the number of days per year that stream Q equaled or exceeded the mean annual flood Q) (Chart 9) also fails to explain changes in channel area. The same is true for the record of annual flow variability (as measured by the standard deviation of the mean daily discharge) (Chart 10). Thus, the question of why the channel of the Chippewa River is shrinking remains unanswered.

CONCLUSION

Why the river is shrinking remains a mystery. One possibility is that the active channel is not actually decreasing in size; it could be getting deeper as well as narrower. However, anecdotal evidence from long-time residents of the area does not support the idea of a deepening channel. Possibly the river is still adjusting to the regulation of streamflow that began in 1917, when Wissota Dam was finished on the Chippewa River approximately 30 km upstream from Eau Claire. Wissota, the first sizeable hydroelectric dam on the Chippewa, is today one of 23 hydroelectric dams upstream from Eau Claire (see Figure 1). While none of these have significant flood storage capacity, their operation does affect the magnitude of relatively small, frequent floods. Thus, the Chippewa may still be responding to the hydrologic changes created by dams built in its watershed decades ago.

ACKNOWLEDGEMENTS

UWEC Office of Research and Sponsored Programs, Sean Hartnett, Christina Hupy, and the Xcel Lower Chippewa Natural Resources Fund. Special Thanks to <Edit>/<Undo> and <Control>/<Z>.