# Runoff generation from shallow water table southeastern forested watersheds: Unusual behavior of paired watersheds following major disturbance

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INTRODUCTION:

The US Forest Service established four research watersheds on the Santee Experimental Forest between 1963 and 1968. These watersheds were established on low gradient coastal plain soils and generally have less than 10m of total elevation change from basin divide to outlet. Two (Watersheds 77 and 80, WS77and WS80) were set up as long term paired experimental watersheds. WS77 was instrumented in 1963 and was the basis of our initial understanding of shallow water table forest hydrology in warm climates. WS80 was established in 1968 and has since been used as the control watershed.

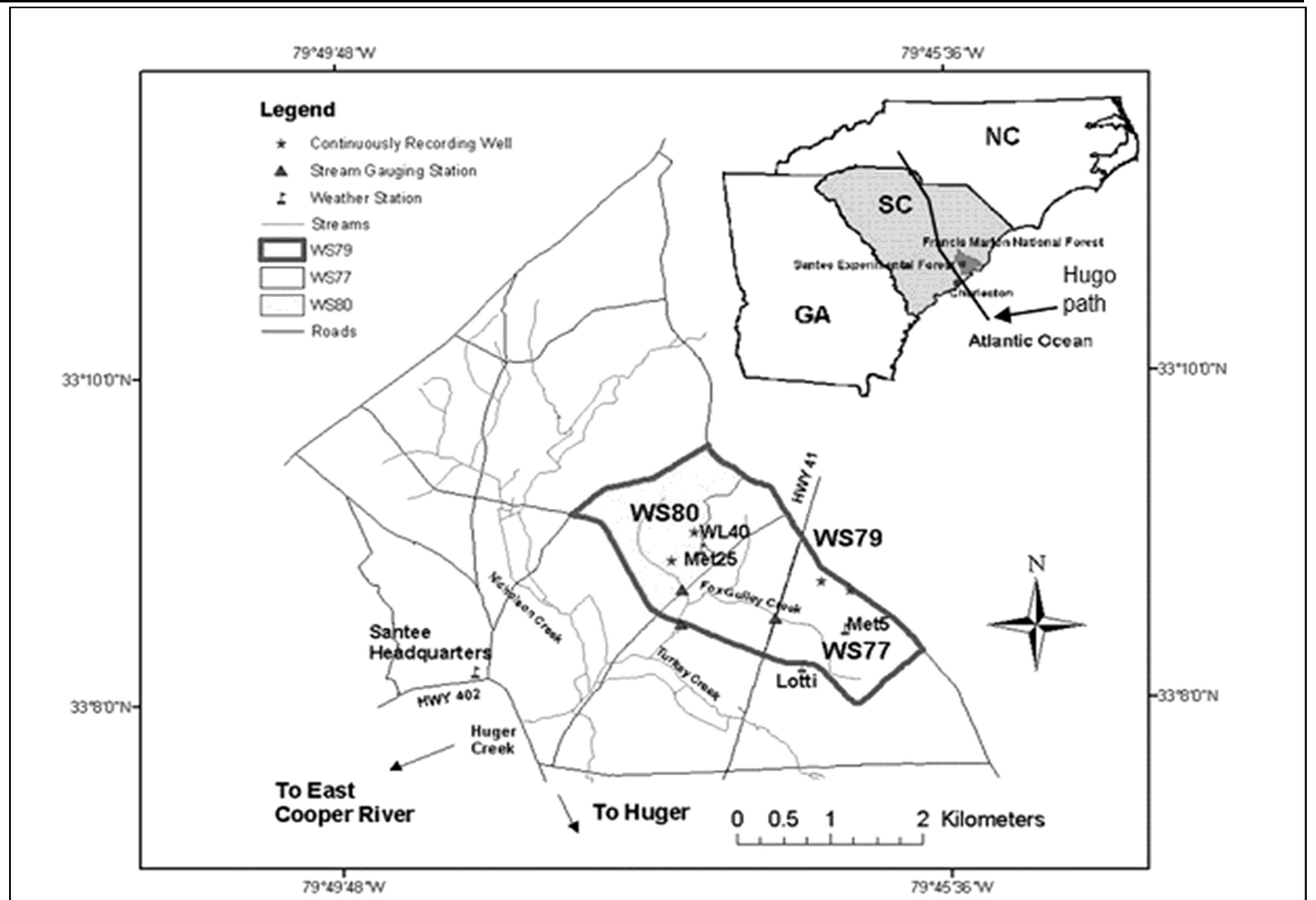



Figure 1. Locations of watersheds 77 and 80 (WS77, WS80) in the Santee Experimental Forest. WS77 Was instrumented in 1963, The combined WS79 was instrumented in 1966, and WS80 was instrumented in 1968. In 1989 the eye of Hurricane Hugo passed just west of the watersheds.

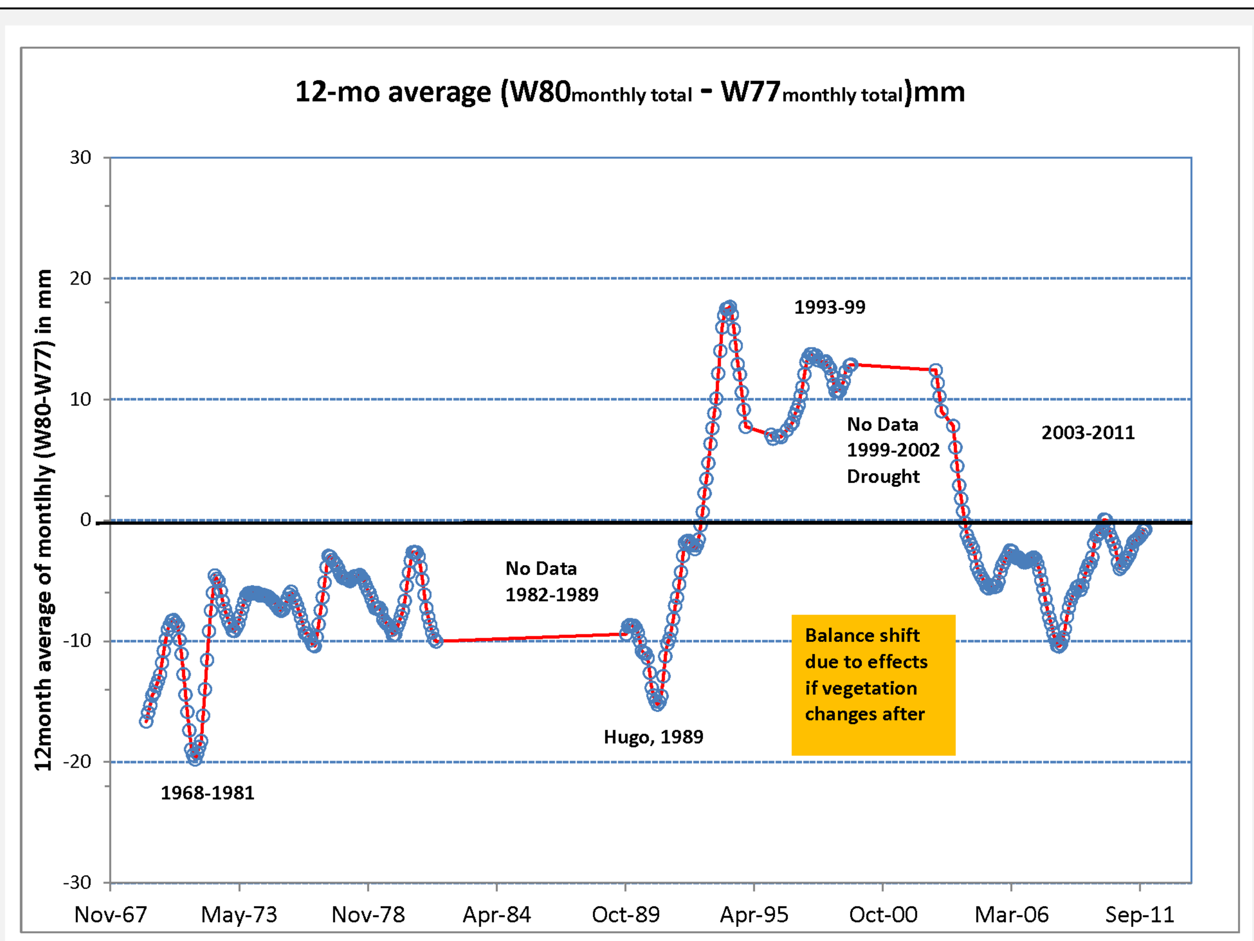



Figure 2. 12-month moving average difference in monthly flow data between the control (WS80) and treatment (WS77) watersheds.

The 12-month moving average difference in monthly flow data present several interesting questions (Williams et al., 2012):

1.Why did two watersheds with similar soils, vegetation, rainfall, and slope produce differing amounts of runoff?

2.Did Hurricane Hugo (Sept 1989) affect two watersheds in close proximity in differing ways?

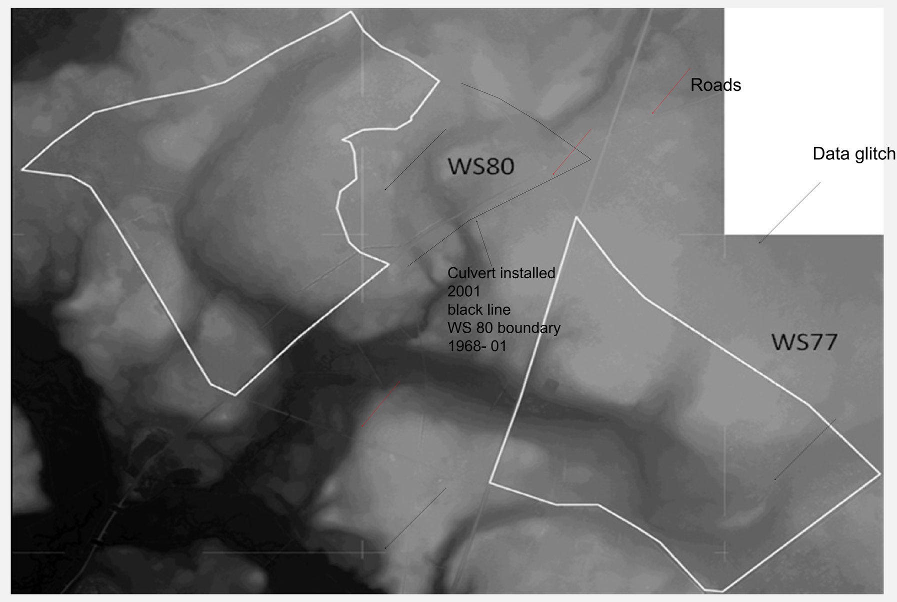
3.Are hurricane effects solely responsible for the reversed flow relationship?

3a. If so, why did the reversal not occur until three growing seasons after the hurricane?

4. Was the possible alteration in ET dynamics due to regenerated vegetation species and growth alone responsible for the reversal of flow for 10 years until 2003?

5.What changed in 2003 causing the relationship to return to the pre-hurricane state?

Figure 3. LIDAR based topography




Watersheds WS77 and WS80 have a concave hypsometry and are expected to be dominated more by surface runoff than subsurface drainage. On the basis of hypsometric integral, WS77 is expected to yield more flow than WS80. (Figure 4: WS77=0.405 compared to WS80=0.285). The percent difference between the two hypsometric integrals is greater than 6 % ( 29.6 %) indicating a real difference in topography.

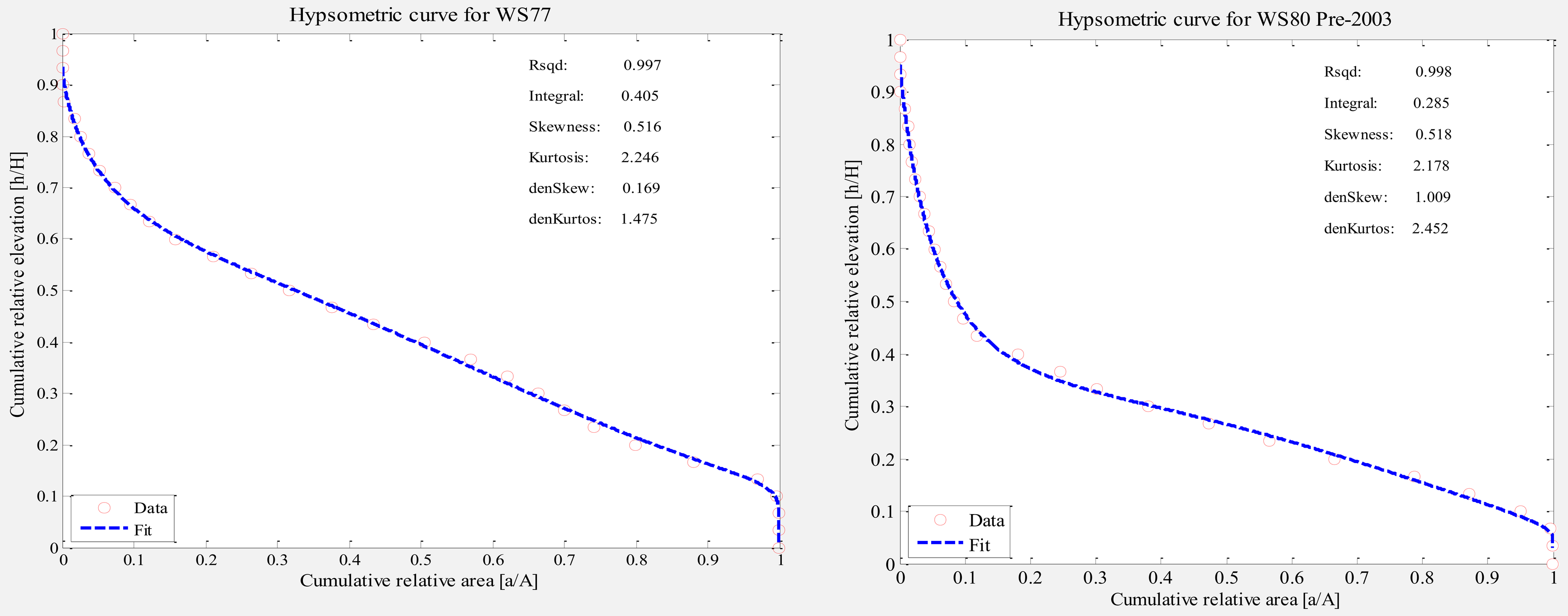



Figure 4: Properties of hypsometric curves for WS77 and WS80. Hypsometric integral less than 0.5 and positive density skewness are characteristics of landforms dominated by surfaces runoff rather than subsurface drainage

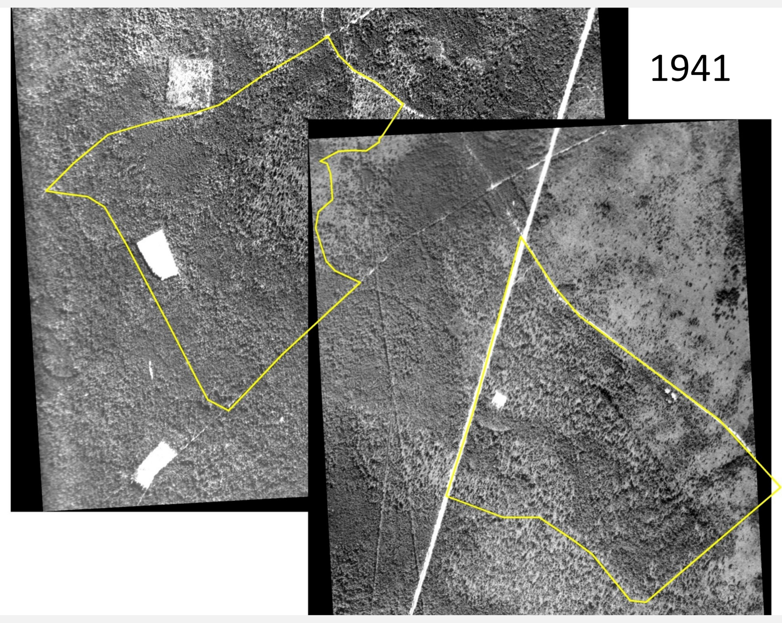
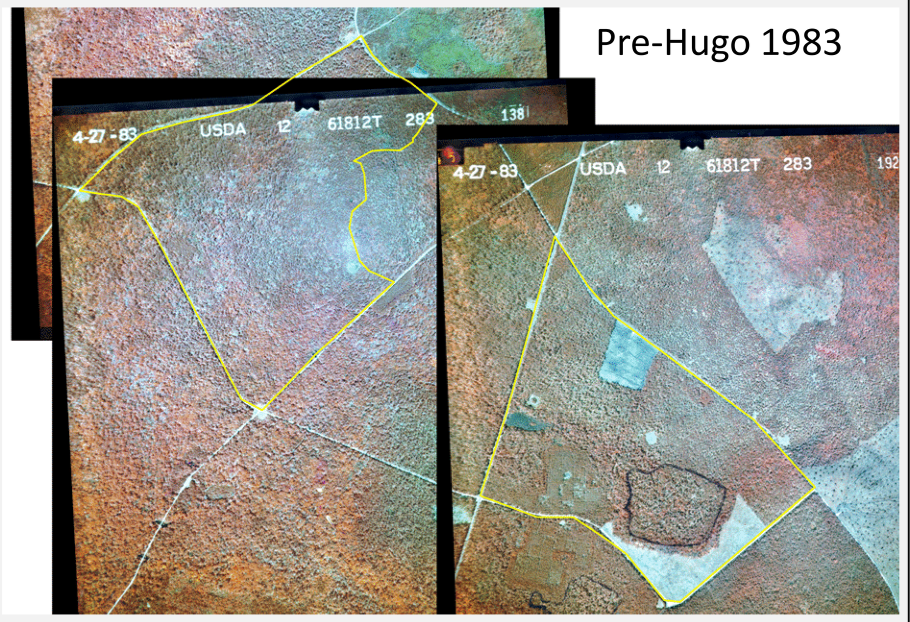
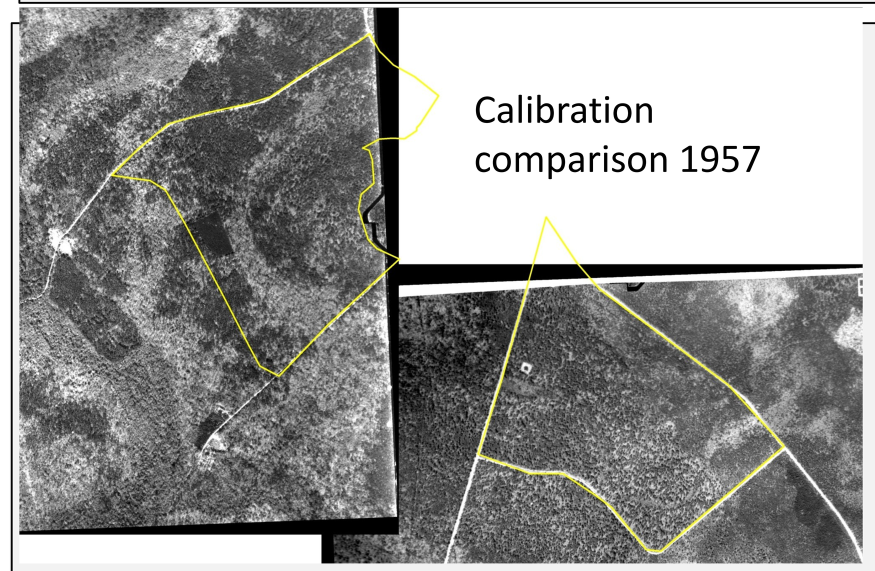



Figure 5: Early photography indicates that both watersheds were well forested for more than 20 years before the any work was done.

Figure 8. After the winter burning study was completed there were additional cuts made in WS77 .




Calibration 1969-1976

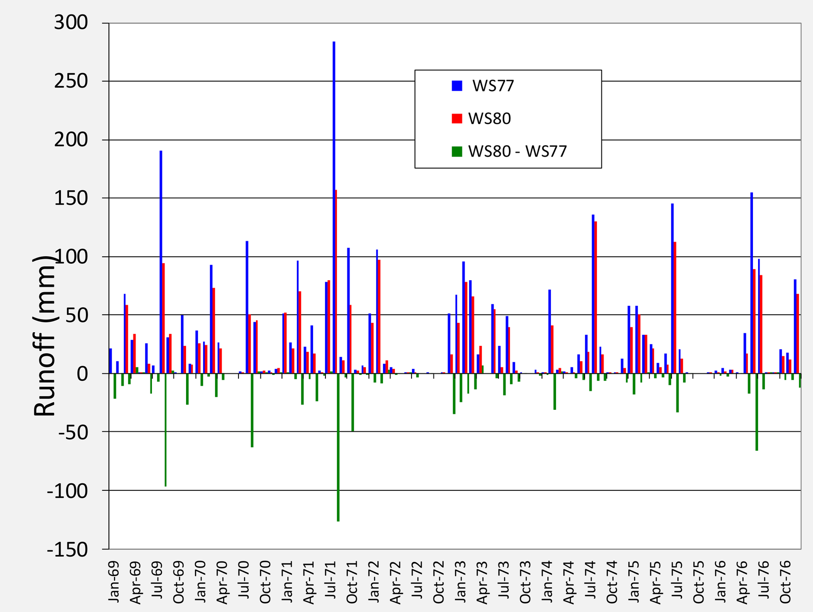



Figure 6: W77 mean monthly flow exceeds WS80 by 9.88    2.03 mm/month. WS80 exceeded WS77 in only 12 of 84 months. Note WS77>> WS80 during months of high discharge. If we compare the 1957 photograph to 1941, vegetation was more complete on both watersheds, with essentially complete crown cover on both

Winter Burning experiment 1973

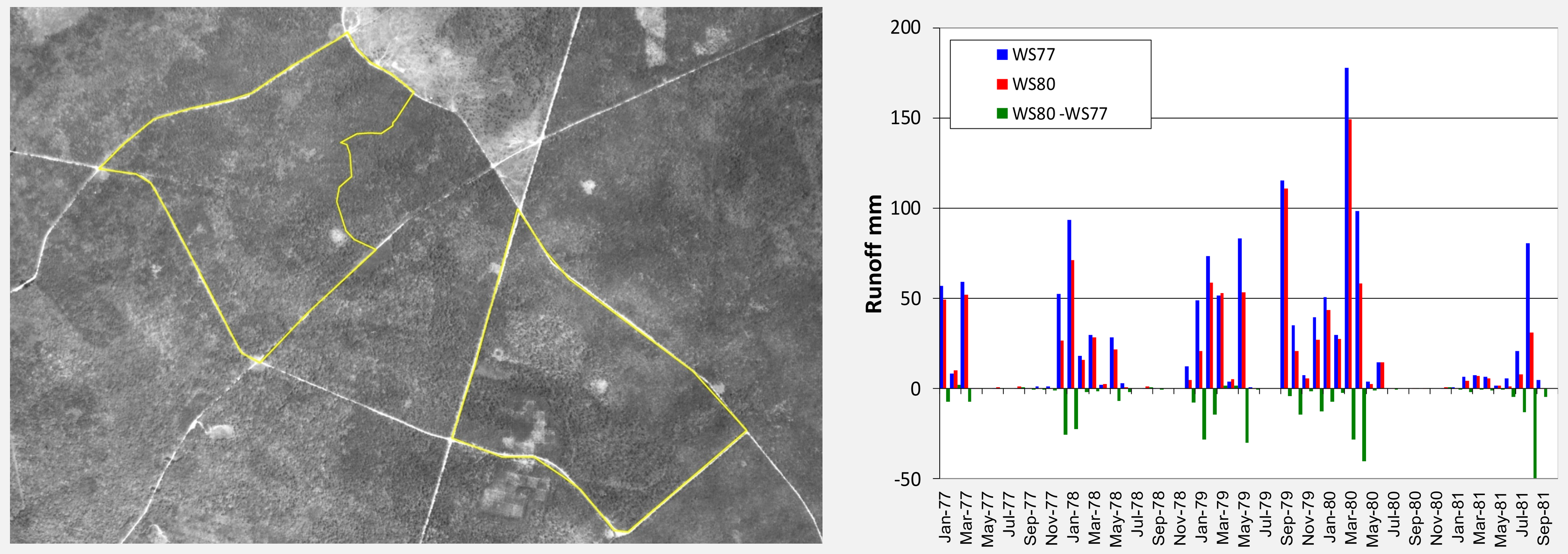



Figure 7: WS77 mean monthly flows exceeds WS80 by 5.82    1.44mm/mo. WS 80 exceeded WS 77 in only 10 of 60 mo. Smaller average difference but no monthly flow exceeded 200mm. Note small experimental cutting in WS 77 near Lottie road.

Early Post Hugo 1991

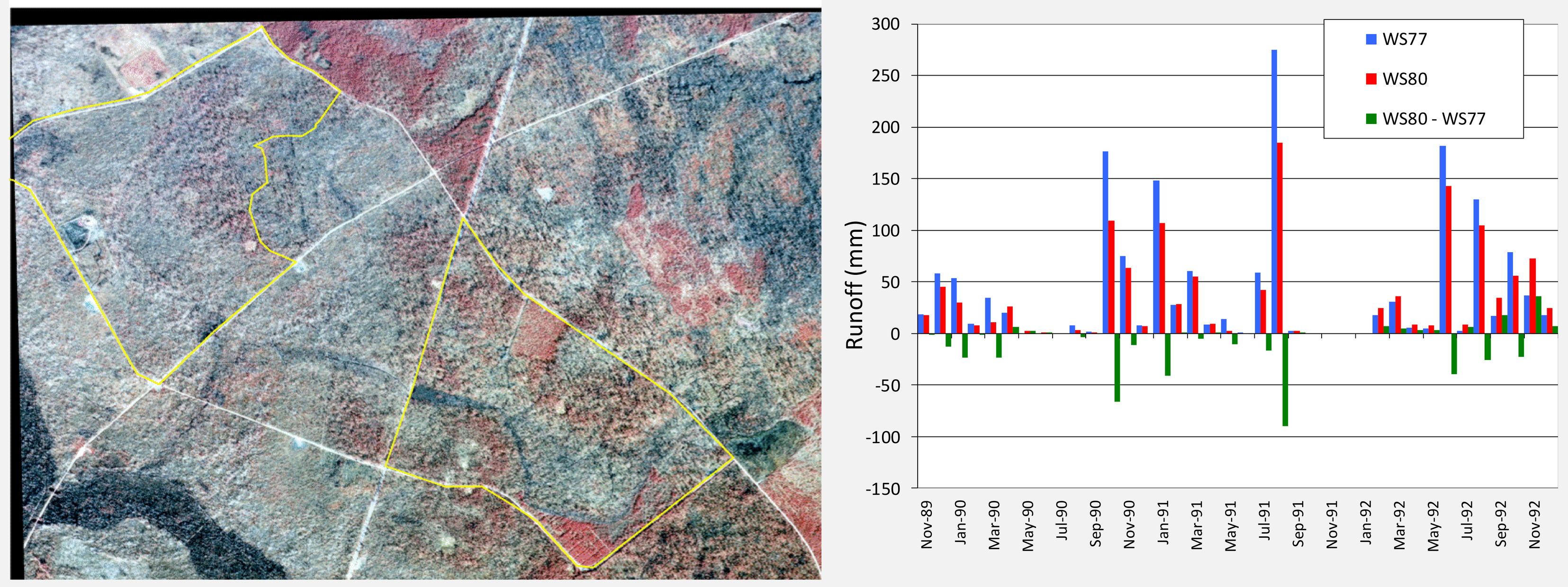



Figure 9: Immediately after the Hurricane WS 77 continued to exceed WS 80 by 9.63    3.61mm/month. WS 80 exceeded WS 77 in 14 of 38 months. Monthly flows over 200mm WS77>> WS80. Note both watersheds greatly disturbed only small trees in 1983 cut survived

Mid Post Hugo 1999

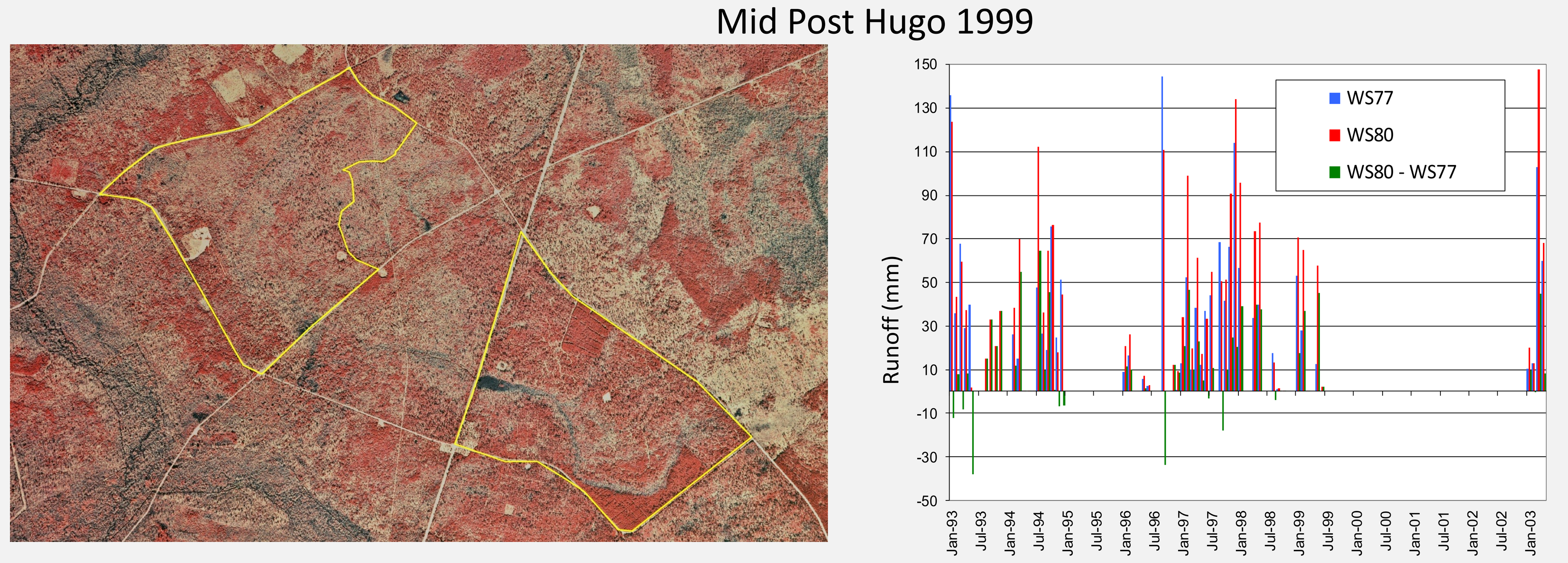



Figure 10: **W80 exceeded W77 by 11.54    2.49mm/mo.** W77 exceeded W80 in only 6 of 60 months, note prolonged drought in 2000-03. WS77 > WS 80 in large flow summer 93 and fall 96. Note healthy young trees and more general red color on WS77.

Late Post Hugo 2006

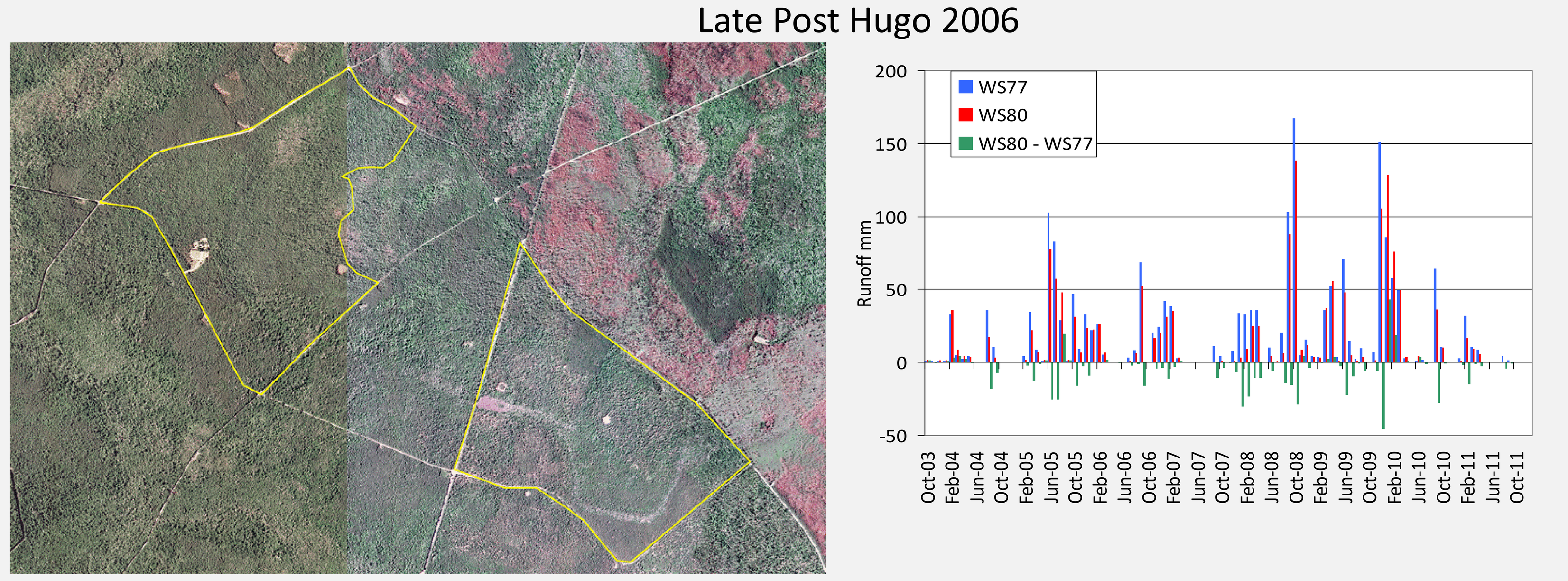



Figure 11: W77 exceeds W80 by 5.09    1.13mm/mo. WS 80 exceeded WS77 in 21 of 99 months. Difference same as winter burning with flows below 200mm. In addition to flow returning to calibration conditions 2006 aerial photos also show healthy crowns on both watershed.

**Conclusions :** 1.Watershed 77 topography has a higher hypsometric integral that may be associated with greater runoff, suggesting that the calibration difference may be due to topography. 2.Changes in vegetation seen in aerial photographs suggest the reversal may be due to changes in water balance (greater ET on WS77) between the watersheds, as advanced regeneration grew more quickly on WS77.

**New questions :** The present topographic hypsometry is due to geomorphology of previous sea level dynamics and not result of present hydrologic process. By what mechanism does relict topography create flow differences that become more dominant in wet conditions? Was the reversal simply due to water balance changes or does it impact this unknown mechanism?