SUMMARY OF HYDROCLIMATIC HAZARDS IN VERMONT

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as input to the Vermont State Hazard Mitigation Plan
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Vermont experiences a humid continental climate that is characterized by extremes in temperature and moisture availability. The 2006-2007 time frame exemplifies the flip-flop that is characteristic of the state. April 2006 was particularly dry, but followed by excessive precipitation and flooding during May and June. Moisture excess and ideal temperature conditions later created the potential for a severe ice jam event along the Winooski River in the capital district of Montpelier in the late winter/early spring of 2007. Following the Valentine's Day blizzard, the spring of 2007 was also marked by large swings in temperature. By May, a mild drought had set in, and as is often observed during drought years, heat waves and new maximum temperature records were set. Almost all of the previous temperature records had been set in the 1891-1896 period. The 2007 drought was not as severe as that of 1998-1999 due to periods of cool temperatures during the summer and timely rains that were sufficient to recharge surface soil moisture, although subsurface moisture remains depleted, as do streamflow levels.

The most frequently occurring hydroclimatic hazards in Vermont are:
- severe storms (including thunderstorms and tropical cyclonic remnants)
- winter storms (including ice storms and blizzards)
- drought
- flooding (including flash floods, urban flooding, ice jams and river flooding)
- fires
- air pollution
- temperature extremes
- wind (including microbursts and shirkshires)

This report will provide a synopsis of drought, soil moisture (as a surrogate for wildfires) and temperature extremes across Vermont.

DROUGHT

Drought is a recurring hazard that tends to be a summer occurrence, but it can occur at any time of the year. This hazard is cyclic in nature such that severe droughts are rare, last for several years and affect the entire state. Less severe droughts are much more frequent and localized in extent. Localized. moisture deficits are often a function of the topography, soil type and precipitation receipt, while statewide impacts are driven by the regional storm systems. The timing of the onset and duration of a drought influences the population affected (e.g. farmers in the summer, water management and tourism in the fall and winter) The nature of a drought also varies by Vermont's three climate divisions (Figure 1) - the northeastern division (1), the western (2) and the southeastern (3).

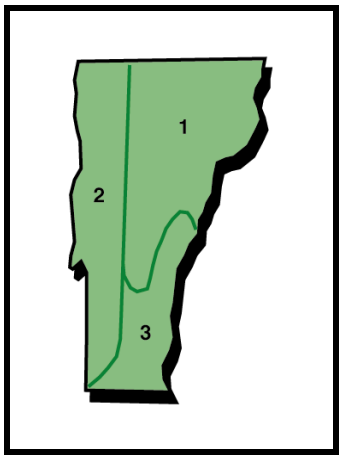


Figure 1: Climate divisions for northern New England, including the northeastern (1), western (2) and southeastern (3) in Vermont (courtesy National Climatic Data Center).

Figure 2 highlights the monthly departure from average precipitation across the three divisions, via a probability based statistic called the Standardized Precipitation Index (SPI). SPI values greater than +1 denote excess precipitation while less than -1 show moisture deficits. Several points can be made:

- the droughts of 1998-1999 were more severe than any others in the last 10 years
- droughts appear to recur every two years over the last decade
- the northeastern division (1) appears to be consistently wetter than the rest of the state
- the southeastern division (3) is consistently drier than the rest of the state, and is at times the only part of the state experiencing drought
- the southeastern division (3) displays a strong coupling between the atmosphere and hydrology.

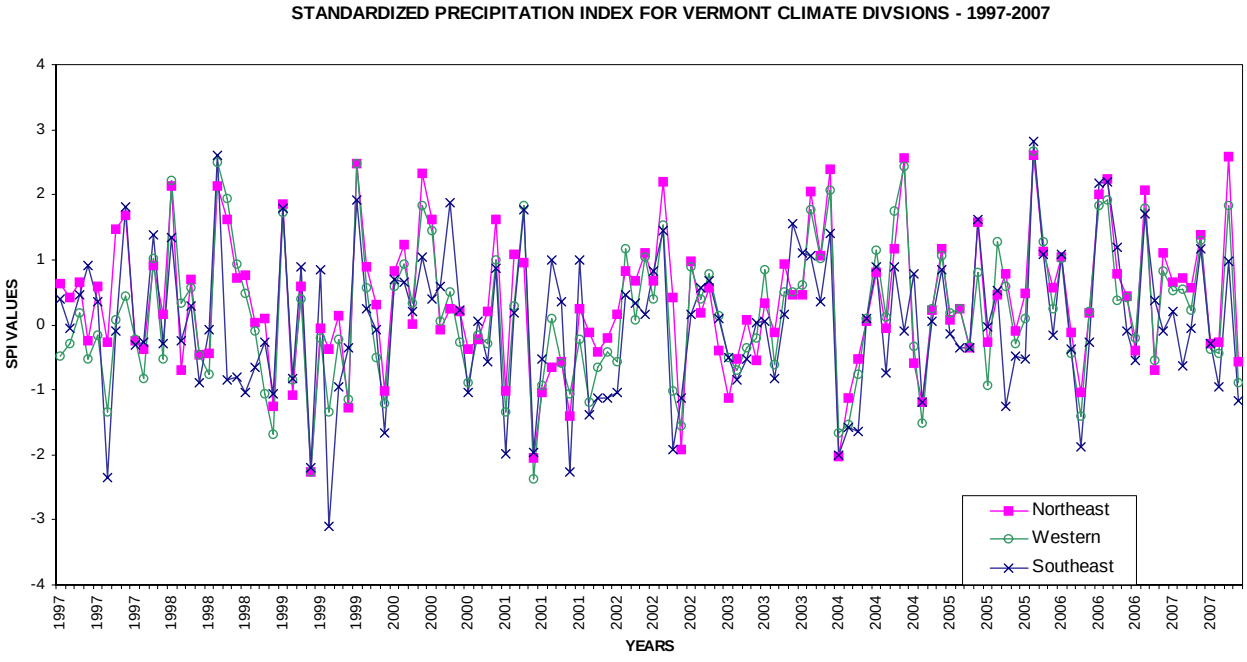
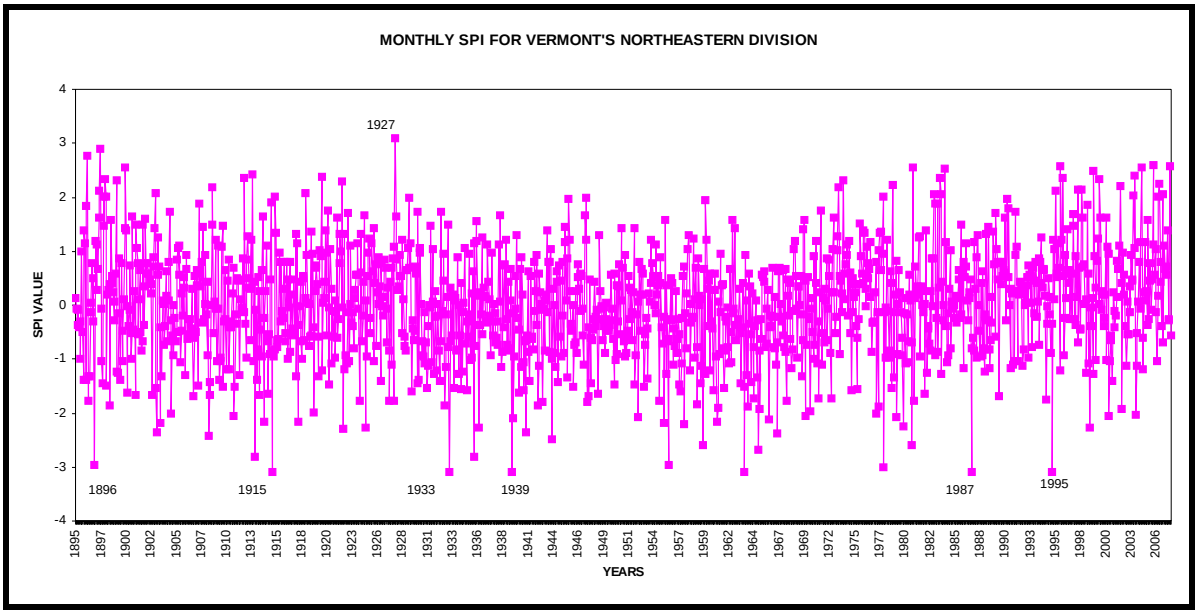


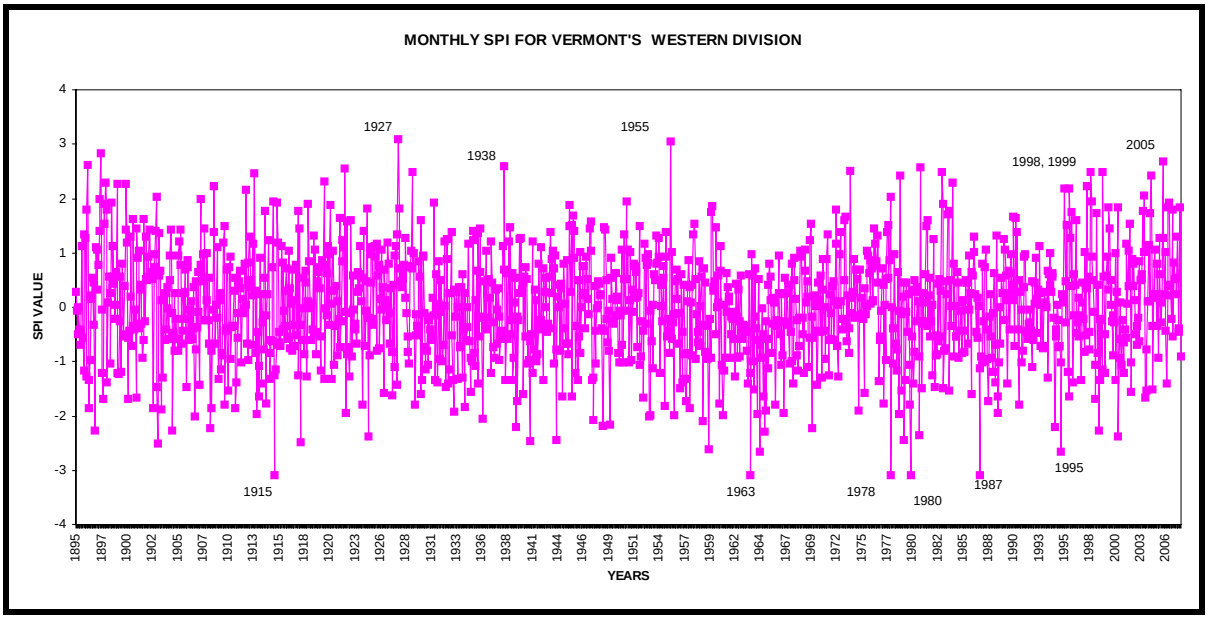
Figure 2: Monthly Standardized Precipitation Index (SPI) for 1997-2007 across Vermont

In order to set the historical climatological context for the current droughts and those of the last decade, it is important to examine the entire period of record, which for Vermont starts in 1895. Figures 3a-c summarize the SPI values for each climate division. The magnitude of the 2007 drought pales in comparison to other historic droughts of the 1890s, 1930s, 1960s and 1990s.

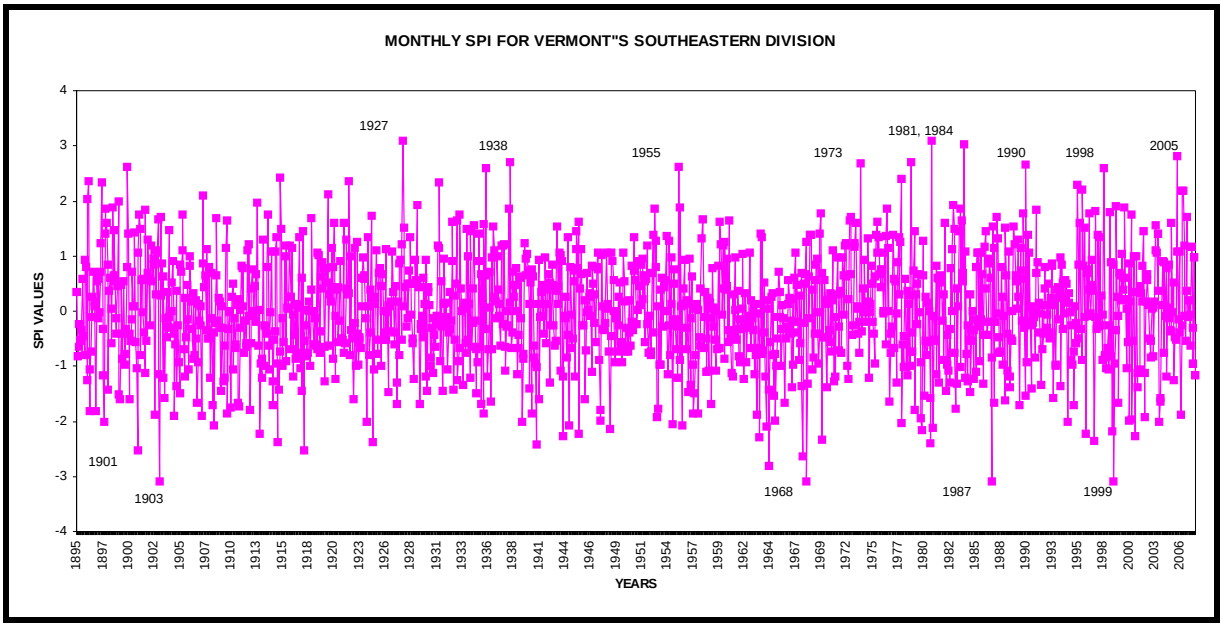
Figure 3: Monthly Standardized Precipitation values from January 1895 to August 2007 for the northeastern division (a), western division (b) and southeastern division (c).

a





b)



c)

The quantification and monitoring of drought as a hazard in Vermont requires a multi-scale approach both spatially and temporally. A wet month could be the result of one or two storms and not several weeks of evenly distributed precipitation. Similarly, divisional statistics are gross averages that hide the localized nature of the precipitation deficits. This was clearly illustrated by the beneficial rains which fell statewide on 14-15 September, briefly recharging streams to normal or above normal levels (Figure 4), followed by a return to low base flow conditions since that time (Figure 5).

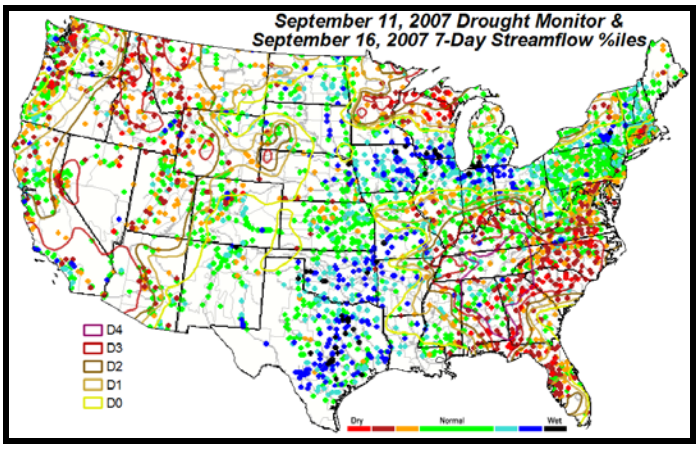


Figure 4 Stream flow percentiles on 16 September 2007

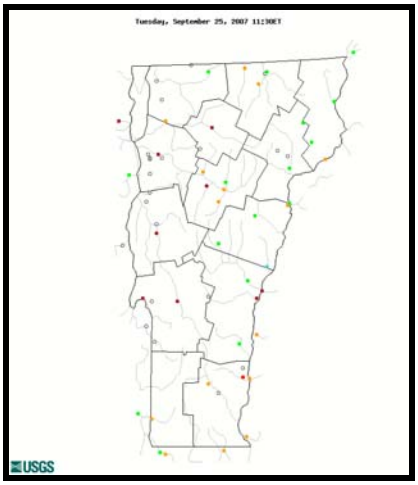


Figure 5 USGS gauging levels on 25 September 2007.

SOIL MOISTURE

Surface moisture conditions can be summarized by the Palmer Z-index (Figure 6). This moisture anomaly "is the product of the moisture departure of the most recent 4 weeks and a climate weighting factor. This index can be used as an indicator of forest fire ignition." http://www.cpc.noaa.gov/products/analysis_monitoring/cdus/palmer_drought/wpdanote.shtml Unlike droughts in recent years, the 2007 case differed in that statewide, the surface moisture anomalies were of shorter duration and less intense. These factors would help explain the rapid recovery of shallow-rooted vegetation such as lawns following soaking rains (e.g. the aforementioned mid-September precipitation).

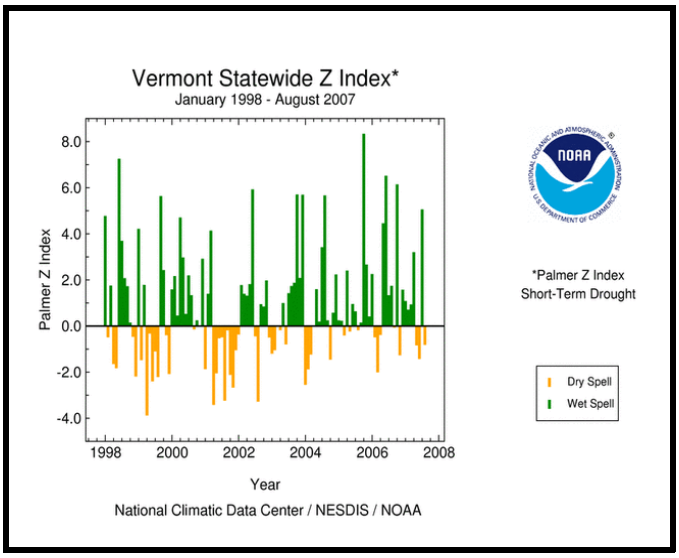


Figure 6 Statewide Z-anomaly index for January 1998 to August 2007.

In terms of divisional level data, surface moisture deficits in 2007 were first observed in the western and southeastern divisions in June (Figure 7a). July was characterized by soil moisture excess in western Vermont and especially in the northeastern division. In August, severe moisture deficits were observed in the southeast (Figure 7b).

a)

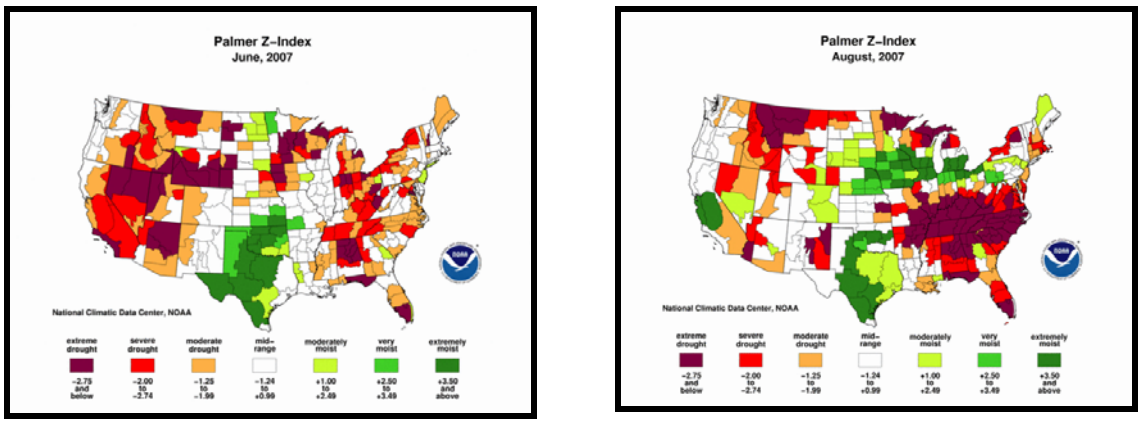


Figure 7 Palmer Z anomaly index for June 2007 (a) and August 2007 (b).

Appendix 1: Observed locations of hail, damaging winds and tornado paths in Vermont and upstate New York : 1950-2000 (Courtesy National Weather Service/ Burlington).