Assessment of 2015 West Nile Virus Outbreak Risk in South Dakota Based on Accumulated Spring Temperatures

Prepared by the South Dakota Mosquito Information System Project, South Dakota State University, Brookings, SD. For more information contact Dr. Michael C. Wimberly (michael.wimberly@sdstate.edu) or Dr. Michael B. Hildreth (michael.hildreth@sdstate.edu)

Introduction
The development rates of West Nile virus and the population dynamics of its mosquito vectors are highly sensitive to ambient temperature. Therefore, in temperate climates, mosquito population growth and WNV amplification can be affected by the timing of spring onset and subsequent temperature fluctuations during spring and summer. Early spring onset and rapid accumulation of degree days above the virus development threshold of 14.3 degree C can increase WNV infection rates in mosquito and bird populations and lead to high numbers of human cases, as documented in a number of previous studies (e.g., Reisen et al. 2006, Neilsen et al. 2008). In the Northern Great Plains, including South Dakota, Chuang and Wimberly (2012) found that between 2004 and 2011, counties with anomalously high numbers of human WNV cases were associated with earlier spring greenup and warmer spring temperatures. An important mechanism behind these relationships is assumed to be a decrease in the extrinsic incubation period (EIP), the time from when the mosquito acquires a WNV infection to the time that it can transmit the virus, as a function of increasing temperature.

Methods
Daily mean temperatures were calculated using climatological data from the North American Land Data Assimilation system (NLDAS). For each day, the relationship from Hartley et al. (2012) were used to calculate the proportion of an extrinsic incubation period completed during that day as a function of temperature. These values were used to calculate the number of extrinsic incubation periods (EIP) completed through the end of May, which is the earliest time of year when human cases are reported. Yearly EIP values for every NLDAS grid cell were subtracted from the long-term (1984-2013) means and divided by the long-term standard deviations to generate standardized anomalies that were mapped for South Dakota and the surrounding states (Figure 1). The maps indicated that in South Dakota, EIP anomalies were often negative in years with low levels of human WNV disease (2008, 2009, and 2011), and positive in years with higher levels of human WNV disease (2006, 2007, and 2012). However, there were also years with positive EIP anomalies and few WNV cases (e.g., 2004 and 2010) and years with negative EIP anomalies but relatively high levels of WNV (e.g., 2013).
Relationships between historical EIP anomalies and human WNV cases were evaluated from 2004-2014 for eastern and western South Dakota, using the Missouri River to divide the state. This stratification was based on the finding that eastern South Dakota has exhibited consistently higher WNV incidence than western South Dakota since 2014 (Wimberly et al., 2013). There was a weak but statistically significant correlations between EIP and West Nile neuroinvasive disease cases in the eastern South Dakota (r=0.63, p=0.038), but not in western South Dakota (r=0.32, p=0.34) (Figure 2). A time series analysis of weekly WNV cases in eastern South Dakota from 2004-2013 also found that accumulated growing degree days above the WNV development threshold (14.3 degree C) through May were associated with higher numbers of WNV cases during the summer months from June-September (M. Wimberly, unpublished data).

Conclusions
During the spring of 2015, South Dakota experienced intermediate levels of accumulated EIP (Figure 1). These values were slightly higher than average in eastern South Dakota and slightly lower than average in western South Dakota. Past years with similar EIP levels through the end of May have included both outbreak years (2005 and 2006) as well as years with low human case numbers (2004 and 2010). In combination with the slightly higher than average temperatures observed over the preceding winter, the observed ATC levels suggest that there is a potential for high levels of WNV activity and human cases in eastern South Dakota in 2015 if temperatures remain high. Entomological and epidemiological surveillance data should be monitored carefully for corroborating evidence of WNV activity. In particular, an early increase in minimum infection rate by the end of June, combined with the higher-than average ATC anomaly during the spring and the lower-than-average freezing degree day anomaly over the preceding winter, could be interpreted as a strong indicator of high WNV transmission during the upcoming 2015 season.

References


Figure 1: Maps of anomalies in the number of extrinsic incubation periods (EIPs) through the end of May for South Dakota and the surrounding states. Units are standard deviations. Positive values warmer than average spring temperatures with a higher number of transmission cycles and negative values indicate colder than average spring temperatures with a lower number of transmission cycles.
Figure 2: Plots of average extrinsic incubation periods (EIPs) through May versus West Nile neuroinvasive disease cases for (a) Eastern South Dakota (east of the Missouri River) and (b) western South Dakota (west of the Missouri River). Blue lines represent the EIPs for 2015.