P 1.11 DEVELOPMENT OF CLIMATE INDICES FOR MONITORING VECTORS OF WEST NILE VIRUS

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1. INTRODUCTION

The NOAA National Climatic Data Center (NCDC) initiated a National Climate Impact Indicators Program in 2001 to focus on developing indices that more closely measure the impacts of climate and climate variability on sectors of the United States economy and society. With support from the Climate Observations and Services Program, NCDC and three Regional Climate Centers are developing several indices to quantify weather and climate conditions associated with abundance of vectors for West Nile virus (WNV).

Disease vectors, such as mosquitoes, have climatic thresholds that govern their abundance and potential for disease transmission. Though daily weather and seasonal-to-interannual climatic variability influence many disease vectors (National Research Council, 2001), this information is not always employed in insect control activities. The reasons for the disconnect between climatic information and vector management are (1) relationships between climate and infectious disease are highly dependent upon local-scale parameters and not thoroughly researched and (2) interaction between climatologists and entomologists has not previously been at the level where information can be readily employed in vector management.

Our research seeks to improve understanding of vector-climate relationships by identifying areas at risk for increased vector abundance. This work is intended to aid decision-making in vector control and medical pre-positioning in the event of increased disease risk. Subsequent decision-maker actions may then inhibit or even in the most nominal circumstance prevent disease outbreaks. This paper provides a brief status report on three target areas in the United States: Midwest, Northeast, and Southeast.

2. REGIONAL ACTIVITIES

2.1 Midwest

Relative abundance of *Culex pipiens* and *Cx. restuans* was estimated by collecting egg rafts throughout the twin cities of Champaign and Urbana, Illinois. The Illinois Natural History Survey collected egg rafts daily and their larvae were reared and identified to species in the third to fourth instar (Robert Novak, personal communication). The relative abundance of each species was then computed.

Annual collection was begun in the late 1980s. This period includes substantial variations in summer climate conditions. Mean summer temperatures ranged from 21.1°C (4^{th} coolest in 112 years of record) in 1992 to 24.5°C (7^{th} warmest) in 1995. Total summer precipitation ranged from 13.9 cm (10^{th} driest) in 1991 to 60.7 cm (2^{nd} wettest) in 1993. Thus, we expect to be able to identify climatic influences on the population.

Results from 2002 show the transmission of WNV to horses or humans is related to the abundance of *Cx. pipiens* (Robert Novak, personal communication). Furthermore, *Cx. restuans* dominate early in the season but *Cx. pipiens* take over later in the season; this change in relative abundance varies considerably from one year to the next, apparently due in large part to climatic variability. The timing of this crossover from *Cx. restuans* to *Cx. pipiens* dominance may provide the basis for a climatic index applicable to the central United States.

2.2 Northeast

Uncertainties as to whether temperature data from the National Weather Service Cooperative Observer Network adequately represents the microclimatic conditions associated with mosquito habitats focused the New York effort on collecting temperature and mosquito data from typical container-breeding mosquito habitats. In New York, tire dumps and waste

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tire sites on dairy farms constitute major mosquito breeding grounds. These sites have unique radiative characteristics that presumably lead to distinct microclimatic conditions. Several important mosquito vectors of encephalitis viruses such as WNV develop in these tires. Determination of temperature-based mosquito development rates in these habitats may be a powerful tool in the prediction of future outbreaks.

Four such sites were monitored from May through October 2003 in four Central New York counties. Microclimatic temperature data within the tires were collected through the season using Hobo® data loggers with submersible water and air probes. One site was located within 0.5 km of the Freeville 1NE Cooperative Network station allowing the relationships between microhabitat and Cotton Region shelter temperature to be compared directly. Figure 1 shows a general agreement between shelter and tire temperature. Typically, the water exhibits the lowest average temperatures while those measured at the Cooperative station tend to be the highest. On average during this period, the tires' air temperature was 0.45°C cooler than that measured at Freeville, while the tire water was 1.67°C cooler.

The concentration of *Cx. restuans* (solid black) is typically an order higher than that of the other species, hence in Figure 2 this species is presented using units of larva/hl. *Cx. pipiens* (dashed), the most important avian WNV vector in the state, were typically absent from our samples until early July. At this time, nearly 450 base 10°C degree-days (gray solid) had accumulated. From mid July through the end of the season the abundance per liter of *Cx. pipiens* either exceeded or was similar to that of *Cx. restuans*. A third and potentially important vector species *Ochlerotatus japonicus* (dotted), also failed to appear until mid-July. In contrast to the Freeville dairy farm site, *Cx. pipiens* were essentially absent from the tire dump, sampling site. At this site, located approximately 55 km northwest of the farm, *Oc. japonicus* larva became more abundant than *Cx. restuans* starting in early July

An interesting feature of Figure 2 is the marked drop in *Cx. pipiens* larvae associated with the August 4 sample. This sample followed a week of excessive rainfall (over 8.9 cm at Freeville). Based on these limited data we speculate that heavy rainfall may flush eggs and larvae from their breeding contains, resulting in lower counts in subsequent samples.

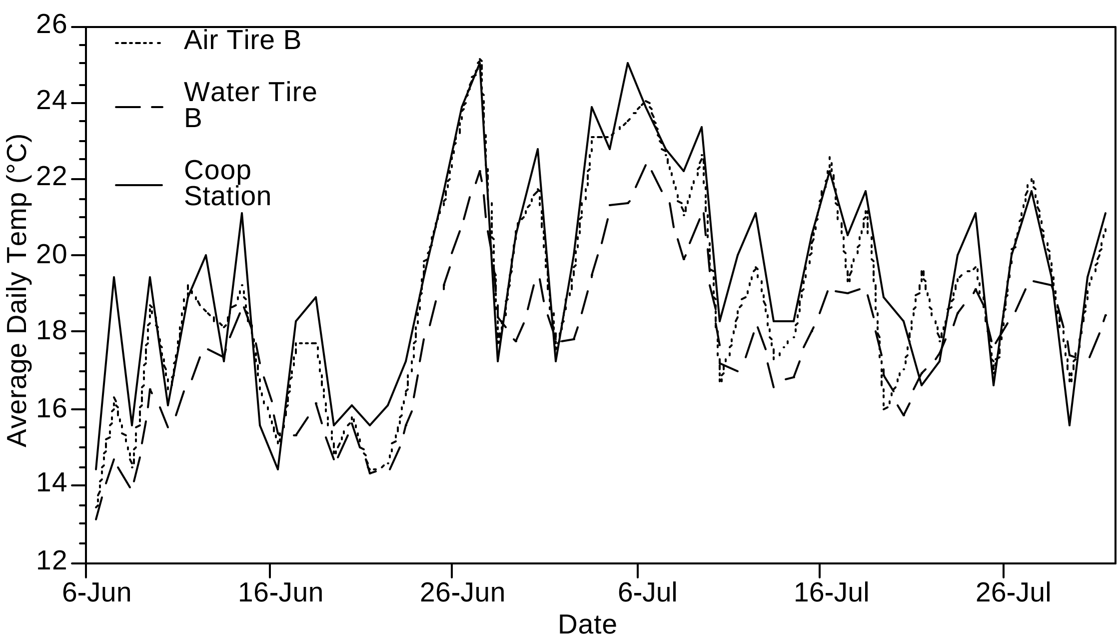

Figure 1 Cotton region shelter temperature compared to tire temperatures

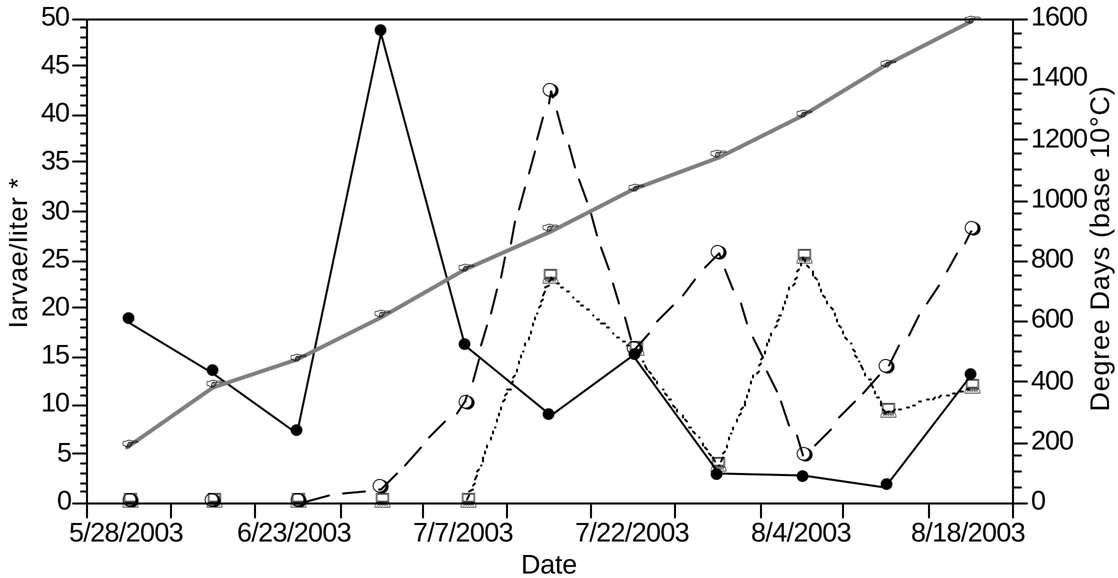

Figure 2 Relationships between temperature (using both Freeville data and the site specific values), larval abundance, and development rates.

2.3 Southeast

Eight WNV-transmitting mosquitoes were identified as problem vectors in the southeastern United States: *Cx. quinquefasciatus, Cx. pipiens, Cx. restuans, Cx. salinarius, Cx. nigripalpus, Cx. tarsalis, Aedes albopictus, Oc. triseriatus* (Evans et al. 2003, Sardelis et al. 2001). Collectively, these species may breed in lake margins, drainage ditches, and natural or artificial containers. The quantity and quality of water bodies or the existence of water in containers determines potential breeding grounds. Although the dependence on water in the life cycle of mosquitoes is complex and varies between species, our analyses will focus on relating hydroclimatic parameters to abundance of mosquito species that may transmit WNV. Simple hydroclimatic variables such as actual evaporation and water surplus can be derived from readily available average daily temperature and total daily precipitation.

Mosquito data from South Carolina were acquired from a statewide monitoring program that has been keeping digital records since 1998. A subset of surveillance data from 2000 to 2002 were processed and mapped by county and by month. Annual total populations of *Oc. triseriatus* (Figure 3), *Cx. salinarius* (Figure 4), and *Ae. albopictus* (Figure 5) increased in spatial coverage statewide; more counties observed these species and in increasing numbers over the time period. Table 1 shows April through October statewide-average precipitation for South Carolina from 2000 through 2002. Increased mosquito abundance during this time corresponded to a return of near-normal precipitation in August of 2002. Preliminary findings from 2003 suggested a trend toward wetter conditions across South Carolina correlated with increased mosquito abundance (Chris Evans, personal communication).

Table 1 April through October statewide-average precipitation summary for South Carolina.

Year	Sum (cm)	Normal (cm)	Departure (cm)	Percent of Normal
2000	62.30	74.47	-12.17	85
2001	54.86	74.47	-19.61	74
2002	71.70	74.47	-2.77	96

Although there may be some relationship between statewide seasonal climate and mosquito abundance, this only provides a cursory examination. To construct climate indices, mosquito surveillance data will need to be collected under a variety of climatic conditions. Ongoing activities involve obtaining mosquito surveillance data that was recorded over finer spatial and temporal scales. To that end, we have acquired five years of data (1994-1998) from thirty fixed locations in Beaufort County, SC and six years of data (1998-2003) from ten fixed locations in Georgetown County, SC. We will be receiving multiyear datasets from mosquito surveillance programs in Charleston County, SC, Chatham County, GA, and Polk County, FL. A fundamental challenge in using surveillance data for research is that surveillance data are used operationally to trigger control activities, such as insecticide applications, or to test for the existence of pathogens in the mosquito populations, such as WNV or the more hazardous Eastern Equine Encephalitis.

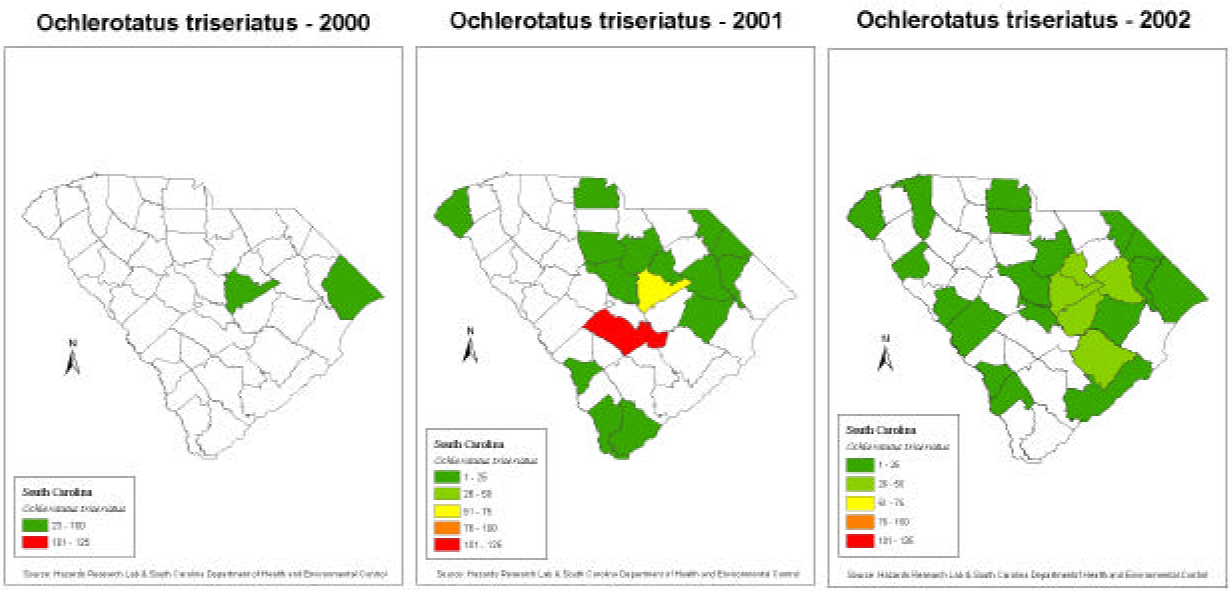

Figure 3 County total *Oc. triseriatus* trap collections during a potion of our study period (source: South Carolina Department of Health and Environmental Control [SC DHEC]).

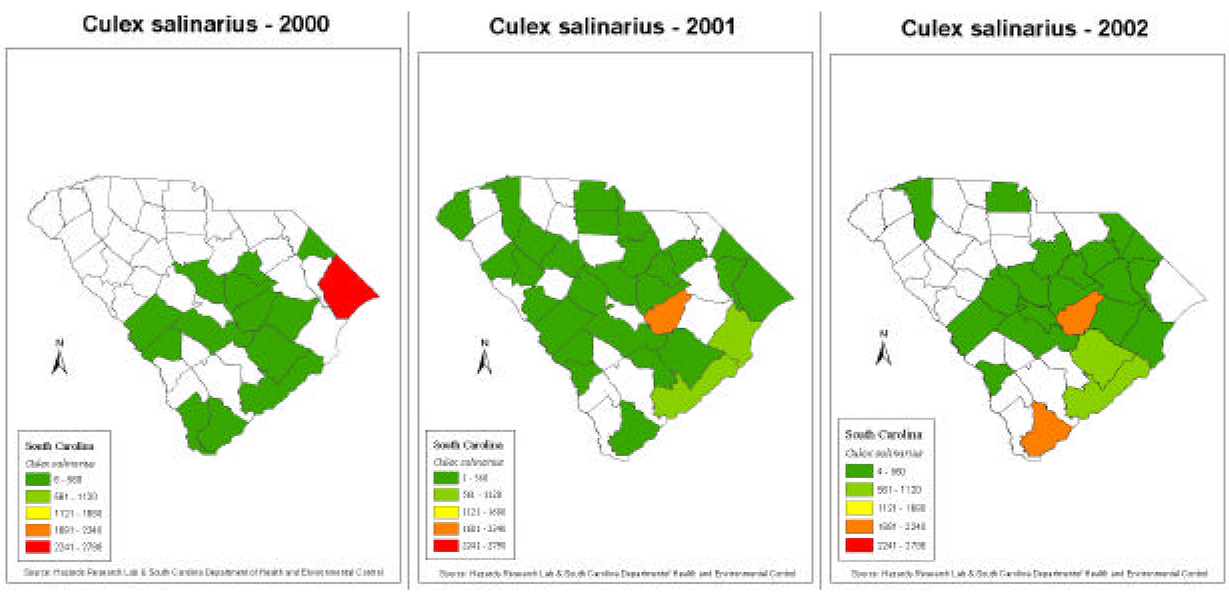

Figure 4 County total *Cx. salinarius* trap collections during a potion of our study period (source: SC DHEC).

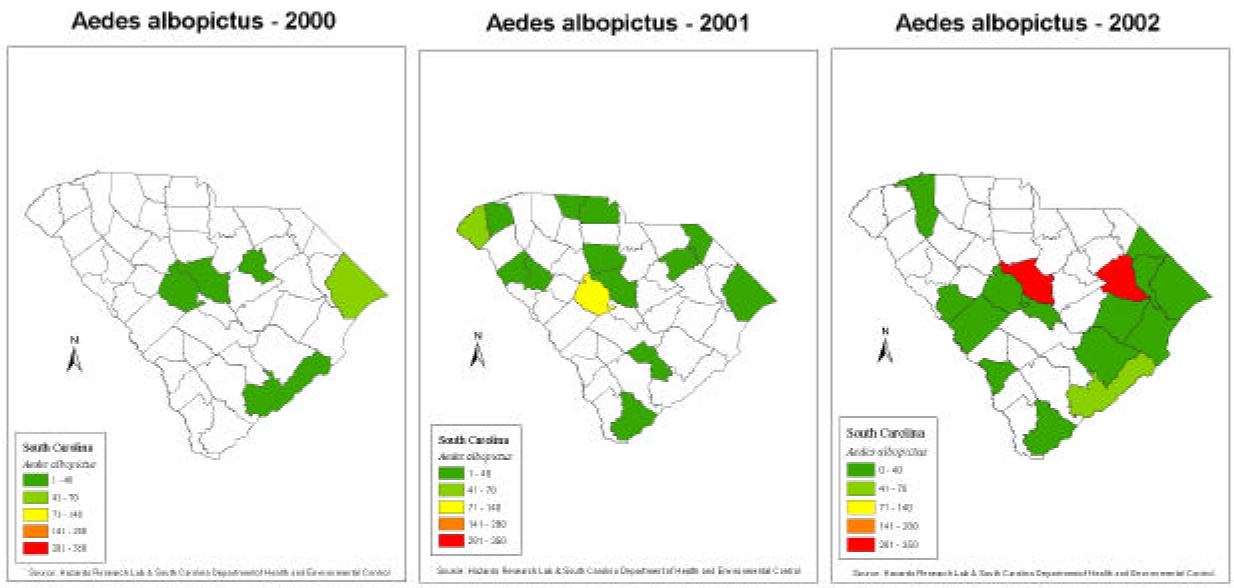

Figure 5 County total *Ae. albopictus* trap collections during a potion of our study period (source: SC DHEC).

3. DISCUSSION

The purpose of this research is to investigate relationships between weather and climate and mosquito abundance, especially vectors of West Nile virus. This work is expected to quantify weather and climate triggers or thresholds for early warning of increased mosquito populations. Disease early warning systems could be based on a complement of antecedent and ongoing climatic conditions, ecological indicators, and epidemiological surveillance systems.

We are taking complimentary approaches to these problems in three regions of the United States: Midwest, Northeast, and Southeast. Although there are differences in the primary vectors between these regions, there are also substantial differences in the habitats and life cycles of primary vectors within these regions. Our anticipation is that findings from these locations will be applicable in other part of the humid eastern United States. Although there are some similarities, other mosquito species are competent vectors for WNV transmission in the west (e.g., California, Goddard et al., 2002).

4. ACKNOWLEDGEMENTS

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