CLIMATE VARIABILITY AND ADAPTATION IN THE DESERT SOUTHWEST

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Because climate varies over both spatial and temporal scales, it is important to view the potential impact of seasonal variation in a desert climate where extremes are common. Humans have adapted to life in the Sonoran desert through a number of mechanisms including irrigation, use of evaporative coolers to increase humidity (in lieu of air conditioners which reduce humidity), and life-style adjustments to the climate such as reduction of outdoor activities during the middle of the day. These modifications, coupled with human migratory patterns that are likely economically driven, have potential impacts on the natural ecology of a region such as the re-introduction of tropical disease vectors such as *Aedes aegypti* into the temperate zone. In an ongoing study, funded through NOAA's Climate Variability and Human Health program, surveillance has documented that *Aedes aegypti,* the vector for dengue fever and yellow fever, has found a suitable ecological niche allowing it to proliferate in a seemingly inhospitable environment where summer temperatures average in the high 90s and relative humidity is low.

Along the US/Mexico border, adaptation to climate variability may take the form of acclimatization to water shortage/usage. In the summers of 2002 and 2003, Arizona and Sonora, MX experienced drought conditions. This resulted in the city of Nogales, AZ delivering water by tanker to the Nogales, MX side because of an acute shortage of drinking water. Tankers were available on both sides of the border to facilitate the transfer of water to Mexico at a minimal cost of $2.53/1,000 gallons.[1]

Unfortunately, although this short-term solution did provide water to those in need, oftentimes the water was not chlorinated heavily enough to prevent diarrheal outbreaks, particularly in the squatter settlements (*invasiones)* where there is no running water and outdoor storage in 55 gallon drums is commonplace. Although the study focused on the potential for dengue fever to emerge in this region, oral re-hydration packets were often carried for distribution by public health colleagues in the *colonias* because of the increased incidence of diarrheal diseases in the summer months (Cecilia Rosales, personal communication, September 2003). In addition, even in neighborhoods where there is running water, reliability is limited, so water storage is necessary on most of the Sonoran side, a factor that may enhance the survivability of mosquito disease vectors.

There is a marked landscape contrast along the border region between Mexico and the United States because of a dearth of piped water on the Mexican side of the border in addition to absence of other infrastructural support for migrants to the border region who are seeking to establish residence. The lack of available piped water necessitates water storage, and this coupled with water leakage from aging pipes, have likely been among the many factors permitting mosquito populations to flourish. Ambos Nogales (Nogales, MX and Nogales, AZ) has both the vector for dengue fever (*Aedes aegypti*) and the vector for West Nile Virus (*Culex quinquefasciatus*) in abundance. Our study

(unpublished data) has documented the re-emergence of *Aedes aegypt* throughout this region including all quadrants of Tucson, AZ and the corridor from Ambos Nogales to Tucson. We have determined that usage of swamp coolers (evaporative coolers), a preferred method of cooling in a desert climate where humidity is low, increases the probability of *Aedes aegypti* in a given locale as does minimum temperature above 69° F (Hayden, dissertation research[2]). In the Tucson area, a further method of water storage known as water harvesting has the potential to increase mosquito breeding sites, ironically enough among the most environmentally savvy. Although information in documents encouraging water harvesting is provided by the city of Tucson regarding the need for covering tanks with fine mesh screens to prevent adult mosquitoes from escaping the screened lids, we have noted repeatedly that people in the city of Tucson who practice water harvesting, do not have mosquito-proof containers nor do they seem to be using *Bacillus thuringiensis israeliensis (Bti)* as there were mosquito larvae in the tanks we visually inspected and ample space for the adult mosquitoes to exit the holding tank through holes in the mesh. Because the mesh often becomes clogged with detritus, this necessitates the insertion of holes to allow water to flow into the tank.[3]

Furthermore, on a shorter timescale, climate variability in the form of the Mexican monsoon, a regional scale circulation pattern that enhances rain in the Sonoran desert[4], increases the number of positive sites as well as number of *Aedes aegypti* eggs, a proxy measure for adults, in this region. This study has shown an increase in the number of breeding sites and the mean number of *Aedes aegypti* eggs when comparing August 2002 mosquito surveillance to August 2003. In August 2003, 53.4% of the study sites were positive for *Aedes aegypti* compared to 37% in August 2002. The mean number of eggs at the 60 sites in August 2003 was 136.92 (SE 69.85) compared to 108.16 (SE 54.85) in August 2002 even though drought conditions continued throughout this time period. Normal monsoonal rainfall for Tucson, AZ is 6.06". In 2002, the monsoon totaled 5.79" and in 2003, the total was 5.82". In Nogales, AZ, normal monsoonal rainfall is 10.73". In 2002, a total of 6.16" was recorded, and in 2003, the total was 8.37".[4] It is evident from this study that mosquito populations flourish during the monsoon season in this region, notably August and September, and it may be that even a slight increase in precipitation during a drought cycle results in higher numbers of mosquito eggs. (See Figure 1 for 2002 mosquito surveillance)

Additionally, climate variability may exacerbate economic issues, which are pronounced in border regions. In the Sonoran region, migration to and through the border continues in record-breaking numbers in response to reduction in Mexican farm prices brought about by the North American Free Trade Agreement (NAFTA). In September 2003, 2,300 Mexicans who were apprehended in the Arizona desert by the U.S. border patrol were repatriated to Mexico.[5] The city of Nogales, Sonora is infrastructurally ill-prepared to deal with continual migration into a region where the official population is 180,000 (a population that has some city-provided services), but the unofficial population is 400,000. More than half of the residents of Nogales, Sonora lack running water, sanitation, or sewage, and little government support is available to increase services. This lack of infrastructure, coupled with the closure of many *maquiladoras* (foreign-owned factories)

along the border, may increase the motivation to migrate into the United States, and illegal crossings continue to be fraught with danger, particularly in a desert region.[5]

Given that the social structure of the region is not likely to change in the near term, it is imperative that social science be integrated with technology to ensure that citizens of both countries are apprised of the impact of continued drought, for example. An area of concern in this region, and one that is impacted by short term climate variability is water usage. Unrestricted lawn watering in the Tucson region and watering in the middle of the day when evaporation rates are high is routine. Local agencies who are responsible for ensuring that water is not wasted may benefit from information concerning a successful public information campaign regarding water usage and restrictions in enhancing the public's understanding of the importance of water conservation that was seen in Colorado in 2002 and 2003, a campaign that could readily be adopted by Arizona.

Furthermore, given the likelihood that new mosquito-borne diseases will become endemic in this region as in other parts of the United States, mosquitoes may, in fact, increase in number and geographic range in the event of more seasonal rainfall. Since there is no available vaccine to combat either dengue fever or West Nile virus, formative research must be undertaken to determine the best means of disseminating information to diverse populations about personal protection and reduction of mosquito breeding sites. Mosquito populations increase during the monsoon season, and along with this increase, the potential for dengue fever and West Nile virus is enhanced. Therefore, the importance of targeting monsoonal months for preventative intervention is critical. Our study has documented that tropical mosquito populations are able to adapt to drought conditions in a temperate zone, and it underscores the need for immediate and effective communication towards the prevention of disease, based on identification of barriers to prevention of the aforementioned diseases.

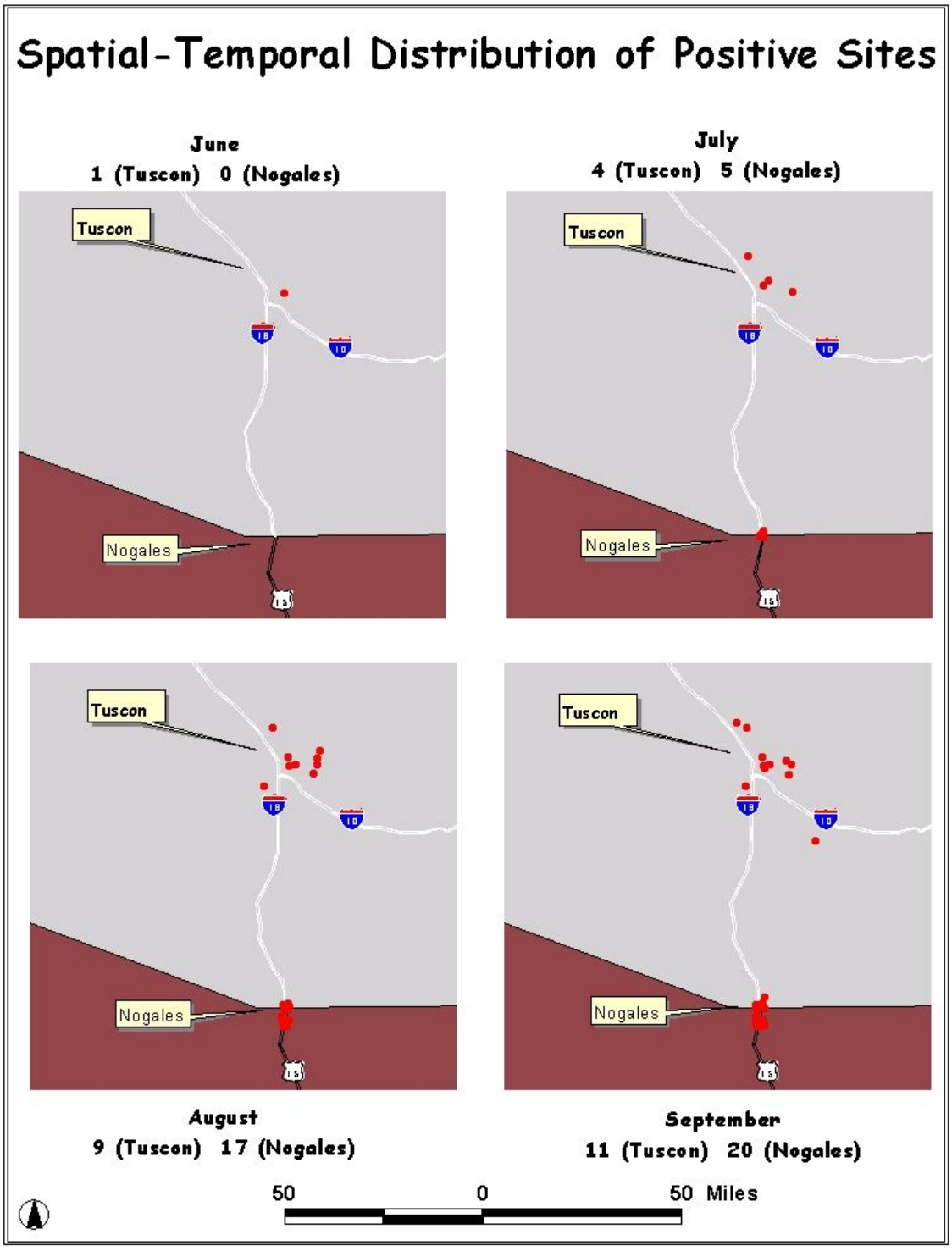

Figure 1. Spatial-temporal distribution of sites which were positive for *Aedes aegypti* in 2002.

References

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