TOBACCO SETTLEMENT REVENUE OVERSIGHT COMMITTEE
TOBACCO SETTLEMENT REVENUE (TSR) FUNDING REQUEST

Name of entity requesting TSR funds: **New Mexico State University**

Name(s) of each program for which TSR funds will be used: **Safeguarding New Mexico from the Spread of Mosquito-Borne Viruses**

Description of each program, including its purpose:
Please see attached.

Have you requested TSR funds prior to this request? **No**

Have you received TSR funds prior to this request? **No**

If yes, in what fiscal years? **Not applicable**

What will you use the requested funds for? Please include goals and objectives.
In the near future we are highly likely to see outbreaks of the mosquito-borne viruses Zika, chikungunya and dengue in New Mexico, as both of the major vectors of these viruses, *Aedes aegypti* (yellow fever mosquito) and *Aedes albopictus* (Asian tiger mosquito) occur in the state. However NM lacks information on the distribution of these mosquitoes as well as the distribution and degree of mosquito resistance to insecticides. This information is critical for mounting an effective vector control campaign. Moreover NM's dependence on chemical insecticides is unsustainable and must be supplemented with alternative techniques. We propose to meet these needs and thereby safeguard NM from mosquito-borne viruses via three aims:
Aim 1: Map the distribution of the mosquito vectors Ae. aegypti and Ae. albopictus across New Mexico.
Aim 2: Quantify levels of insecticide resistance in Ae. aegypti and Ae. albopictus across New Mexico.
Aim 3: Develop Sterile Insect Technique (SIT) for vector control in New Mexico.

Is this a change from previous years' use? **No**

If yes, please describe the change and reason(s): ___________________________________

Amount requested (Total amount, and amount for each program): **$636,816**
What other sources of funding are applied to this purpose? **None**
Name, title, telephone, email and mailing address of contact person:
Vicente Vargas, 505 710 8560, v_vargas@nmsu.edu. NMSU Government Affairs, Las Cruces, NM 88005

Date: **August 31. 2016**

COVER PAGE FOR NM TOBACCO SETTLEMENT GRANT APPLICATION

Project Title: Safeguarding New Mexico from the Spread of Mosquito-Borne Viruses

Names	Affiliations
Principal Investigator: Kathryn A. Hanley	NMSU Biology
Co-Principal Investigator: Immo A. Hansen	NMSU Biology
Additional Investigators:	
Michaela Buenemann	NMSU Geography
Sang-Yon Cho	Electrical and Computer Engineering

Total Budget Requested: $636,816

Period of Performance Requested: Start July 01, 2017 End: June 30,2018

PROJECT SUMMARY:

The epidemiology of mosquito-borne viruses in the Americas has undergone a cataclysmic shift in the past decade. In 2013, chikungunya virus was introduced into the Caribbean and spread across both Central and South America; the first locally-transmitted case of chikungunya disease within the U.S. was documented in 2016. In 2014 dengue virus caused a bi-national outbreak of dengue disease along the border between Sonora, Mexico and Yuma, Arizona. In 2015 Zika virus emerged in Brazil and spread across South and Central America, causing an epidemic of microcephaly in newborns and triggering a public health emergency of international concern. New Mexico is particularly vulnerable to introduction and spread of these viruses for three reasons. First, all three viruses are transmitted by the mosquitoes *Aedes aegypti* and *Aedes albopictus,* which occur in New Mexico. Second, with dengue virus established along the U.S.-Mexico border and chikungunya and Zika moving rapidly northward, epidemics are expected in Mexican border communities, resulting in far more introductions to the U.S. by land travelers (181 million persons cross from Mexico into the U.S. annually) than have occurred to date via air travel. Many of these travellers will move to or through New Mexico. Finally, New Mexico is currently ill-prepared to control the spread of these viruses. There are no available vaccines or antiviral treatments for dengue, chikungunya or Zika virus. Thus vector control is the only available strategy to curb virus spread. Vector control in New Mexico is implemented primarily through spraying of chemical insecticides, which is ineffective when the distribution of mosquitoes is incompletely known or when high levels of insecticide resistance are present in mosquito populations. Moreover chemical insecticides are damaging to the environment. At present neither the geographical distribution of the mosquito vectors within New Mexico nor their level of insecticide resistance is known. The proposed program will take a three-pronged approach to remedy these problems. First, we will expand our ongoing efforts to conduct systematic mosquito collections across the state in order to accurately map mosquito vectors of disease. Our current work is funded by a one-year contract from the New Mexico Department of Health that will sunset in December 2016; a longer span of collection will allow a more complete and accurate map to be generated. Second, we will use the CDC "bottle assay" to test the resistance of target populations of *Aedes aegypti* and *Aedes albopictus* around the state to the chemicals most commonly used to kill adult mosquitoes, including pyrethrins, pyrethroids, and the organophosphates malathion and naled. Finally, we will implement and evaluate the efficiency of sterile male release for control of *Aedes aegypti* populations in New Mexico. These projects will be conducted by an experienced, established, well-integrated team of collaborators with a track record of successful research and public health innovation.

Specific Aims. In the near future we are highly likely to see outbreaks of the mosquito-borne viruses Zika, chikungunya and dengue in New Mexico, as both of the major vectors of these viruses, *Aedes aegypti* (yellow fever mosquito) and *Aedes albopictus* (Asian tiger mosquito) occur in the state. However NM lacks information on the distribution of these mosquitoes as well as the distribution and degree of mosquito resistance to insecticides. This information is critical for mounting an effective vector control campaign. Moreover NM's dependence on chemical insecticides is unsustainable and must be supplemented with alternative techniques. We propose to meet these needs and thereby safeguard NM from mosquito-borne viruses via three aims:
Aim 1: Map the distribution of the mosquito vectors *Ae. aegypti* and *Ae. albopictus* across New Mexico.
Aim 2: Quantify levels of insecticide resistance in *Ae. aegypti* and *Ae. albopictus* across New Mexico.
Aim 3: Develop Sterile Insect Technique (SIT) for vector control in New Mexico.

Significance. Zika, dengue, and chikungunya viruses are grave threats to human health. Zika virus was introduced into the Americas in 2015 and has infected millions of people since; tragically Zika can infect fetuses, causing microcephaly and other forms of brain damage. Dengue virus, the agent of dengue fever, infects an estimated 390 million persons each year around the world. Chikungunya virus, which causes disabling joint pain, arrived in the Americas in late 2013; there have been almost one million cases of chikungunya disease in the Americas in 2016 alone. All 3 viruses are transmitted primarily by the mosquito species *Ae. aegypti* and *Ae. albopictus.* **Both species occur in New Mexico.** Authorities have long been concerned about movement of dengue across the U.S.-Mexico border, and similar concerns are now being raised regarding Zika and chikungunya. In coming years, epidemics of all 3 viruses are expected in Mexican border communities, resulting in far more introductions into the U.S. by land travelers (181 million persons cross into the U.S. annually) than have occurred via air travel. Lacking vaccines or antiviral therapies for any of these viruses, the only strategy to curb outbreaks will be to control their vectors. **New Mexico, despite its vulnerability to introduction of these viruses, is currently ill-prepared to mount a vector control campaign to curb their spread.** Effective vector control depends upon accurate knowledge of the geographical distribution of vectors, as well as the distribution and degree of mosquito resistance to chemical insecticides used for vector control. This information is not available for NM. Moreover, reliance on chemical insecticides is unsustainable due to evolution of resistance and environmental contamination. Thus novel, chemical-free strategies for vector control must be incorporated into the NM armament for mosquito control.

Innovation. This project will build on our first-in-kind effort to map the distribution of *Ae. aegypti* and *Ae. albopictus* mosquitoes in NM. We will complement this effort by designing novel mosquito traps, whose efficacy will be compared to standard traps. Mosquito data will be integrated with remotely sensed and other geospatial data in cutting-edge computer models of species distributions. We have already established seamless communication with the New Mexico Department of Health (NM DoH) to move our data from the field to public health officials. Vector control via chemical insecticides depends on knowing not only where to deploy such insecticides but also which insecticides will be effective for a given population. We will conduct lab-based analyses on insecticide resistance to give a fine-grained picture of resistance to common insecticides across the state, and these data will become available in real time to vector control professionals to mount a successful first response in case of a Zika, dengue, or chikungunya outbreak. Finally, the development and implementation of alternative 'green' mosquito control strategies for NM will fundamentally expand our virus-fighting toolbox and provide sustainable alternatives that can be used in combination with classic vector-control insecticides and, ultimately, replace them. Successful implementation of a sterile insect technique for disease-transmitting mosquitoes will set a precedent for the vector control and research communities.

Approach

Aim 1: Map the distribution of Ae. aegypti and Ae. albopictus in NM. Hanley and Buenemann recently won a 1-year contract with the NM DoH (May 2016 – May 2017) to conduct the first systematic study of the distribution *Aedes aegypti* and *Aedes albopictus* in the state. In brief, we used GIS and remote sensing to randomly select mosquito field sampling sites in 6 land cover types (urban, agricultural, range, forest, wetland, and barren) across 24 NM counties. We are currently conducting mosquito collection using 3 mosquito trap types at each of the identified sites. Our work has already yielded the first report of *Aedes aegypti* in Chaves County. Our results are communicated directly to the New Mexico DoH on a biweekly basis. We will use these data to develop a series of species distribution models (SDMs). The idea behind SDMs is that the probability of presence of a species (e.g., a particular mosquito) can be predicted in a spatially explicit and continuous fashion by integrating two types of data in a spatial modeling framework: 1) species' presence or abundance data collected at point locations in the field; and 2) environmental explanatory data layers acquired through remote sensing and other geographic information sciences and technologies (Fig 1). SDMs are currently the only available means for generating mosquito distribution maps because mosquitoes are too small to be detected via remote sensing and fieldwork can only be conducted in selected sites across an area of interest. To generate mosquito SDMs, we will use data from our mosquito collections, acquire a series of environmental data layers that might help explain the distribution of mosquitoes across the state (e.g., variables related to climate, topography, and land use), and integrate the mosquito and environmental data using an SDM based on presence-only data (Maxent).

The DoH contract project is limited both temporally (to one year) and spatially (to two-thirds of New Mexico's counties) and the SDM modeling relies on a single approach. The proposed research would allow us to expand this work to a second year of collections across the entire state. Additionally, Cho's group will develop an innovative, cheap and effective mosquito trap based on artificial skin to improve our mosquito capture rates; these traps will be tested via side-by-side collections with standard traps. We will generate 2 SDMs based on presence-only data (Maxent, logistic regression) and 3 SDMs based on abundance data (generalized additive models, random forests, Bayesian additive regression trees). We will evaluate all SDMs independently and in comparison with respect to their predictive performance, ecological realism, and credibility, as well as degrees and sources of uncertainty. SDMs with the greatest predictive performance will be used to generate final maps of the target mosquito vectors in NM. All of our results from the proposed work will continue to be communicated to the NM DoH, **thereby revealing regions at risk for transmission of Zika, dengue, and chikungunya viruses and facilitating effective deployment of vector control.**

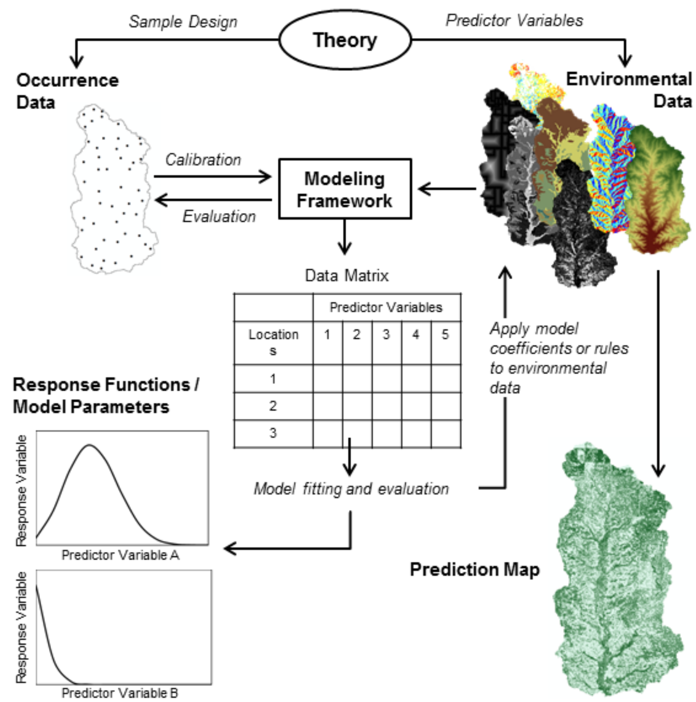

Figure 1. General framework for species distribution modeling.

Aim 2: Quantify levels of insecticide resistance in Ae. aegypti and Ae. albopictus in NM. *Adult* mosquitoes will be collected live from each county in which they occur and held in separate population cages in our insectary. Adults will be fed blood, eggs will be collected by our standard methods, and county-specific strains of each species will be maintained. We will use a standard, kit-based bioassay provided by the CDC to test resistance of each strain to chemicals commonly used to kill adult mosquitoes, including pyrethrins, pyrethroids, and the organophosphates malathion and naled. These data will be translated into spatial maps and provided directly to NM DoH, who will in turn inform NM vector control agencies.

Aim 3: Develop Sterile Insect Technique (SIT) for Vector Control. SIT works through release of sterile male insects in the environment that mate with wild females. These females then produce eggs that are sterile and the insect population declines. Mosquito SIT requires production and release of large numbers of sterile males. We will increase *Ae. aegypti* production in the Hansen laboratory to 200,000 mosquitoes per week (100,000 males) using artificial feeding systems and synthetic diets we have developed previously. Mosquito males will be separated as pupae and gently sterilized in our Faxitron MultiRad350 X-ray irradiator. We will develop novel UAV (i.e. drone)-based release methods for SIT mosquitoes. Release sites will be guided by Aim 1, and abundance of *Ae. aegypti* before and after sterile male releases will be monitored in conjunction with Aim 1. We will engage and educate the community about our efforts via fliers, interviews, and public presentations.