# AMCARF Project Status Report

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**Report Type:**

| ✓ | Report Type | Report Deadline |
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| | **Progress Report** | Friday, 15 July 2022 |
| X | **Annual Report** | Friday, 16 December 2022 |

**Project Title:** Informative & real-time arbovirus risk mapping based on surveillance data synchrony estimates

**AMCARF project number:** 2022 - 02

**Project Cost:** $15,667.00

**Project Leader:** Joseph R. McMillan

**Collaborators:** (Include cooperating laboratories and AMCARF supported personnel and percent effort)

- LOS from Dr. Philip Armstrong (CAES) & Dr. Luis Chaves (now with University of Indiana, Bloomington)

**Project Objectives:**

- Objective 1: Define synchrony of multi-generational mosquito species and arbovirus detection events among surveillance sites
- Objective 2: Forecast EEEV and WNV detection probabilities in unsampled spaces
- Objective 3: Develop visual and interactive online frameworks that inform arbovirus risk within and outside a surveillance network

**Total Project Progress:**

Objective 1 is near completion – a manuscript is under review with Journal of Medical Entomology.

Objective 2 is wrapping up. The *Culex pipiens* and WNV models have been finalized. I need to check predictions of WNV detection for years 2021 and 2022. Preliminary models for *Culiseta melanura* have been built as well as models of EEEV detections have been explored. Similar issues remain – generally low probability of EEEV detections (~ 10% during outbreak years)

Objective 3 is in development. Results from Objective 1 suggest simple, 5km buffers would be adequate for defining zones of highest risk for WNV and EEEV. Monthly WNV detection maps (Objective 2) can be generated as .pdfs directly from R (which is nice!). Once WNV predictions have been checked, I will begin working with CAES and they're IT department on flow pipelines to generate and post these maps to their website.

Budgetary information:

Summer salary payment mistake by TTU HR, resulting in full salary payment (despite salary coverage of ~ 0.75 mo in the grant). After approval from AMCA, software funds were diverted to cover overpayment since I was able to perform all analyses in R + TTU granted me access to their ArcGIS Pro Site license.

No cost budget extension granted through April 1st, 2023 – remaining funds will cover 2023 conference attendance/travel/registration and publication costs for Objective 1. Publication costs for Objective 2 will be shared between JRM and PMA.

**Key Research Accomplishments:**

*Objective 1: All analyses are complete, and a manuscript is under review with Journal of Medical Entomology.*

The primary result from Objective 1 is that species or arbovirus ID explains the most variance in patterns of timeseries synchrony. Also, spatial decay patterns of synchrony were, on average, double to triple the distance for mosquitoes compared to arboviruses. While this is an unexpected and exciting result, it does not easily lend itself to risk projections at the level of a trap site. Current thoughts are ~5 km buffer zones could be displayed around viral positive sites to indicate areas of highest risk (this distance corresponds to the maximum correlated distance for WNV and EEEV). Current targets of such maps are internal messaging among public health partners, but this is still in development.

*Objective 2: Full-scale WNV predictive models have been developed – only prediction confirmations of each model iteration remain. EEEV models are under detecting virus in outbreak years (to an extreme!!!) – utility of EEEV BRT models is in question.*

The prior update included information using autoregressive terms in the WNV training models – meaning, models included prior collection information on *Cx. pipiens* collections and WNV detections. After considerable discussion, our research team decided that this approach violated the objective of projecting risk into unsampled space, i.e., predictions leaned to heavily on information from the trap sites and required extrapolating information beyond the immediate surroundings of a trap. All subsequent models included only land cover and climate data, and for the most part capture the high-risk areas for WNV in the state. Predictions of 2021 and 2022 detections need to be compared to observed detections – after which, we will develop a manuscript for review.

We are using a similar approach to *Cs. melanura* collections and EEEV detections. As reported at midyear, EEEV detections are under predicted in outbreak years. We are discussing alternate pathways – such as only modeling EEEV risk in the highest risk counties of CT and contacting colleague from other states in the northeast reason requesting surveillance data – but there are no developments from these discussions at this point.

*Objective 3: Work will focus on buffer zones for actual detections and risk maps for likelihood of future detections. In discussions as to target audience, mode of posting (internal emails, internet, R Shiny Apps), and compatible pipeline with CAES systems.*

**Reportable Outcomes:**

One manuscript currently under review (comments received 1/12/23) at Journal of Medical Entomology (Medline Submission Proof attached in supporting data)

**Progress Assessment:** The below assessment is based on the timeline provided in the proposal.

Objective 1: Quantify spatial synchrony (complete)

Objective 1: GLMMs (complete)

Objective 1: manuscript preparation and submission (complete)

Objective 2: WNV BRT models (complete)

Objective 2: EEEV BRT models (in development)

Objective 2: Model validations (WNV – in progress; EEEV – not performed)

Objective 2: manuscript preparation and submission (in development)

Objective 3: R Shiny GUI (synchrony)

Objective 3: ArcGIS online (BRT models) (in development)

**Plans for the following year:**

I will address any reviewer comments as needed for prompt publication (Objective 1)

I will finalize WNV BRT models as outlined in proposal. As mentioned above in reportable progress, EEEV BRT models may have to be re-evaluated given the difficulties of achieving appropriate convergence levels. It may be the case that only WNV risk maps at the scale of the full state are they only suitable projections for public health use.

High risk buffer zones (from Objective 1) around WNV or EEEV positive sites are simple to create and distribute – I will work with CAES on best ways to generate such maps (either in R, ArcGIS, or Qgis) which can then be easily distributed to either public health partners and/or their online website.

Once all beta versions Objective 2 risk maps are developed, I will coordinate with CAES' IT division to establish a web-host for the maps within the station's domain. These maps will require a bit more work to adapt to their system (and train personnel on specific programs, if needed) because my current pipeline utilizes raster images from various sites that must be rescaled to match raster images of CT land cover. I am simplifying this process as much as possible, but it still requires some user inputs. R Shiny may be the appropriate way for CAES to perform this (so that I can maintain code and they can easily modify produced pdfs).

**Conclusion:** I believe our analyses are providing a robust and quantifiable measure of spatial relatedness in mosquito trap counts previously unexamined in the U.S. This information will not only be useful for understanding the limits of highly localized mosquito control operations but also for communicating mosquito and arbovirus risk assessments to the public and the many public health partners that work with CAES each mosquito surveillance season. I look forward to completing the research in early 2023 and working with CAES to implement these risk maps!

**Supporting Data:** *See email attachment.*