

1 **Spatiotemporal Distribution of Vector Mosquito Species and**
2 **Areas at Risk for Arbovirus Transmission in Maricopa**
3 **County, Arizona**

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21 Abstract

22 Mosquito-borne diseases are a major global public health concern and mosquito
23 surveillance systems are essential for the implementation of effective mosquito control
24 strategies. The objective of our study is to determine the spatiotemporal distribution of
25 vector mosquito species in Maricopa County, AZ from 2011 to 2021, and to identify the
26 hotspot areas for West Nile virus (WNV) and St. Louis Encephalitis virus (SLEV)
27 transmission in 2021. The Maricopa County Mosquito Control surveillance system
28 utilizes BG-Sentinel and EVS-CDC traps throughout the entire urban and suburban
29 areas of the county. We estimated specific mosquito species relative abundance per
30 unit area using the Kernel density estimator in ArcGIS 10.2. We calculated the distance
31 between all traps in the surveillance system and created a 4 km buffer radius around
32 each trap to calculate the extent to which each trap deviated from the mean number of
33 *Cx. quinquefasciatus* and *Cx. tarsalis* collected in 2021. Our results show that vector
34 mosquito species are widely distributed and abundant in the urban areas of Maricopa
35 County. A total of 691,170 *Culex quinquefasciatus*, 542,733 *Culex tarsalis*, and 292,305
36 *Aedes aegypti* were collected from 2011 to 2022. The relative abundance of *Ae. aegypti*
37 was highly seasonal peaking in the third and fourth quarters of the year. *Culex*
38 *quinquefasciatus*, on the other hand, was abundant throughout the year with several
39 regions consistently yielding high numbers of mosquitoes. *Culex tarsalis* was abundant
40 but it only reached high numbers in well-defined areas bordering natural and rural
41 areas. We also detected high levels of heterogeneity in the risk of WNV and SLEV
42 transmission to humans disregarding traps geographical proximity. The well-defined

43 species-specific spatiotemporal and geographical patterns found in this study can be
44 used to inform vector control operations.

45 **Keywords:** *Aedes aegypti*, *Culex quinquefasciatus*, *Culex tarsalis*, Arbovirus

46 Introduction

47 Mosquito-borne diseases are a major global public health concern [1–4]. The
48 incidence of dengue has substantially increased globally in the last decades, from
49 500,000 reported cases in 2000 to 2.4 million in 2010 and 5.2 million in 2019 [5]. The
50 current estimate is 390 million dengue virus (DENV) infections worldwide every year [6].
51 Between 2015 and 2018, there were more than 1 million confirmed cases of Zika in the
52 Americas followed by a significant increase in fetus malformation as a direct
53 consequence of Zika virus (ZIKV) infection during pregnancy [3,4].

54 Albeit on a smaller scale, arboviral infections have also increased in the United
55 States. The ZIKV was introduced multiple times in the United States in 2016 leading to
56 224 locally transmitted human cases in Florida and Texas [9–11]. Local transmission of
57 the DENV has also been reported in Florida. In 2020, Monroe County experienced a
58 major dengue outbreak with 65 confirmed locally transmitted cases [12–14]. In 2022,
59 33 locally transmitted cases of dengue were reported in Miami-Dade County [12].

60 While local outbreaks of dengue and Zika were reported in the United States, the
61 West Nile virus (WNV) has become endemic and the most widespread mosquito-borne
62 arbovirus in North America [15]. WNV has been detected in more than 60 mosquito
63 species in the continental United States (CONUS) [16]; however, selected species in
64 the genus *Culex* such as *Culex quinquefasciatus*, *Culex pipiens*, *Culex tarsalis*, and
65 *Culex nigripalpus* are responsible for driving most of the epizootic and epidemic WNV
66 transmission. Birds are the natural reservoir hosts of WNV as they are able to develop
67 viremia high enough to infect mosquito vectors. Humans, horses, and most mammals

68 are not able to amplify the virus to viremic levels high enough to infect mosquitoes and
69 are therefore considered dead-end hosts [16–18].

70 Since it was first detected in New York in 1999 [19], the WNV has progressively
71 become endemic in all states in the contiguous United States and has been sporadically
72 detected in Alaska, Hawaii, and Puerto Rico [20]. From 1999 to 2020 a total of 52,532
73 human cases were reported in the United States leading to 2,456 deaths [21].

74 Maricopa County, Arizona, is located in the Sonoran Desert ecoregion spreading
75 through 23,890 km². It has a hot desert climate with long hot summers and short winters
76 [22]. According to the 2020 census [23], Maricopa County has a population of 4,420,568
77 people, being the most densely populated county in Arizona as well as in the Sonoran
78 Desert ecoregion. There are three major cities in Maricopa County, Phoenix (the
79 Arizona state capital, and the fifth-most populous city in the United States), Mesa, and
80 Chandler. It has historically been one of the counties most affected by West Nile virus
81 disease in the United States with an average of 70 neuroinvasive cases reported every
82 year in the last decade (2010 to 2020). However, 1,427 neuroinvasive cases of West
83 Nile were reported in this county in 2021, the highest ever reported in a single county in
84 the United States [12].

85 Controlling mosquito populations is widely considered the most effective way of
86 preventing the spread of mosquito-borne diseases [24]. However, the development and
87 implementation of effective mosquito control strategies in urban areas are complex and
88 difficult to put into action [25]. They rely on a framework consisting of multiple
89 successive actions that need to be implemented for a successful intervention. The first
90 step in the implementation of effective strategies is the development of an extensive

91 and reliable mosquito surveillance system [26]. Such a system is key to assessing the
92 mosquito community composition, identifying factors influencing the population
93 dynamics of mosquito species, estimating the relative abundance of populations of
94 different vector mosquito species, and providing evidence for ascertaining and
95 anticipating patterns in mosquito population dynamics and demographics that are
96 essential for the development of mosquito control strategies. The aim of this study is
97 twofold: (i) determine the spatiotemporal distribution of mosquito species vectoring
98 different arboviruses (including WNV, St. Louis Encephalitis virus – SLEV, DENV, ZIKV)
99 in Maricopa County, Arizona, from 2011 to 2021; and (ii) investigate the hotspot areas
100 for WNV and SLEV transmission in 2021.

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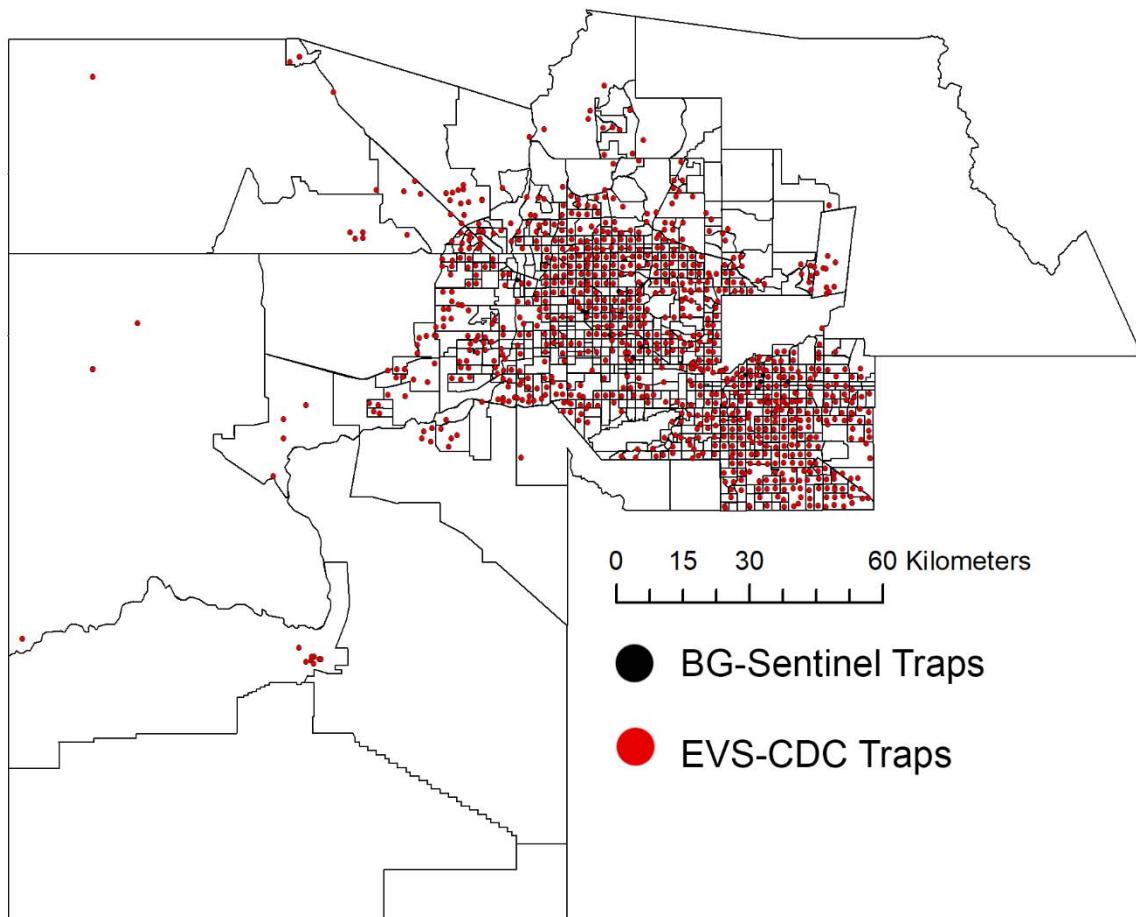
102 **Methods**

103 The Maricopa County Environmental Services Department Vector Control
104 Division surveillance grid covers the entire urban and peri-urban areas of the county
105 with approximately one trap per square mile. The surveillance system is comprised of
106 BG-Sentinel traps baited with BG-Lure (Biogents AG, Regensburg, Germany) (ranging
107 from 13 traps in 2016 to 8 traps in 2021) and EVS-CDC traps baited with CO₂ (ranging
108 from 478 traps in 2011 to 825 traps in 2021). Each trap is deployed once a week for 24
109 hours for 50 weeks a year (Figure 1). All collected mosquitoes are transported to the
110 Maricopa County Environmental Services Department Vector Control Division
111 Laboratory and morphologically identified to species using taxonomic keys [27]. BG-
112 Sentinel traps baited with BG-Lure and EVS-CDC traps baited with CO₂ attract female

113 mosquitoes seeking hosts for blood-feeding [28]. Even though male mosquitoes were
114 sometimes collected, male data was not included in the proposed analyses.

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118 **Figure 1. Map of Maricopa Mosquito Control Surveillance System.** BG-Sentinel
119 traps are shown in black; EVS-CDC traps are shown in red.

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122 For 2021, virological surveillance was done for all collected *Cx. quinquefasciatus*
123 and *Cx. tarsalis* mosquitoes in pools of up to 50 female mosquitoes. RNA was extracted
124 using MagMAX extraction kit (Thermo Fisher Scientific). Samples were prepared in a
125 PCR hood (Air Clean 600 PCR workstation “Reagent Prep Hood”). Each PCR reaction
126 included WNV and SLEV positive and negative controls (Table 1).

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129 **Table 1. West Nile and St. Louis Virus Real-Time RT-qPCR primers.**

Sequence (5' to 3')	Sequence name	Concentration (nM)
CAGACCACGCTACGGCG	WN3'NC - forward	600
CTAGGGCCGCGTGGG	WN3'NC - reverse	600
TCTGCGGAGAGTCAGTCTGCCGAT	WN3'NC-probe FAM	200
CTGGCTGTCGGAGGGATTCT	SLE2420 - forward	500
TAGGTCAATTGCACATCCCG	SLE2487c - reverse	500
TCTGGCGACCAGCGTGCAAGCCG	SLE2444-CAL FI Org	150

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132 Reactions were carried out using Taqman Master Mix (Thermo Fisher Scientific)
133 on a QuantStudio 5 at 50°C for 5 minutes, 95°C for 20 seconds, and 40 cycles of: 95°C
134 for 3 seconds and 60°C for 30 seconds. Samples were considered positive when Ct
135 values were below 34 and negative when qPCR reaction resulted in no detectable Ct
136 value after 40 cycles.

137 We used the geodesic method for densities in square kilometers to calculate the
138 magnitude-per-unit area (number of inputs per point - i.e., mosquito relative abundance)
139 using the Kernel density estimator in ArcGIS 10.2 (Esri, Redlands, CA). Figures were

140 created with layers available at the Maricopa County GIS Mapping Applications
141 available at: <https://www.maricopa.gov/3942/GIS-Mapping-Applications>.

142 We calculated the distance between all traps in the surveillance system (linear
143 distance in meters) and created a 4 km buffer radius around each target trap. Traps
144 within each buffer with no data were removed from the analysis. We also removed
145 outliers in each buffer by excluding observations that lie outside the expected range of
146 the variability of the mean ($\text{median} \pm 1.58 \times \frac{IQR}{\sqrt{n}}$) to calculate mean buffer values. If the
147 target trap was among the removed outliers, it was identified as a hot (cold) spot if the
148 number of collected mosquitoes was above (below) the buffer mean (Figure 5). Hot/cold
149 spot traps were defined to highlight unexpectedly high/low number of collected
150 mosquitoes relative to the traps in the same area - information useful for the design of
151 tailored mosquito control interventions. This analysis was conducted in R (version
152 4.2.2).

153 To assess the risk of arbovirus transmission posed by the abundance of vector
154 mosquito species, we used the 2021 data on mosquito vector species presence,
155 density, and infection rate to calculate the Vector Index (VI: average number of
156 mosquitoes collected by trap night multiplied by the infection rate) [29]. The infection
157 rate was estimated as the ratio of the mosquito pools that tested positive for WNV or
158 SLEV over the total number of tested pools. Then, we used ArcGIS to create a 1-km
159 buffer around each individual trap and extracted the 2020 total population from the U.S.
160 Census using the weighted centroid geographic retrieval methodology [30].

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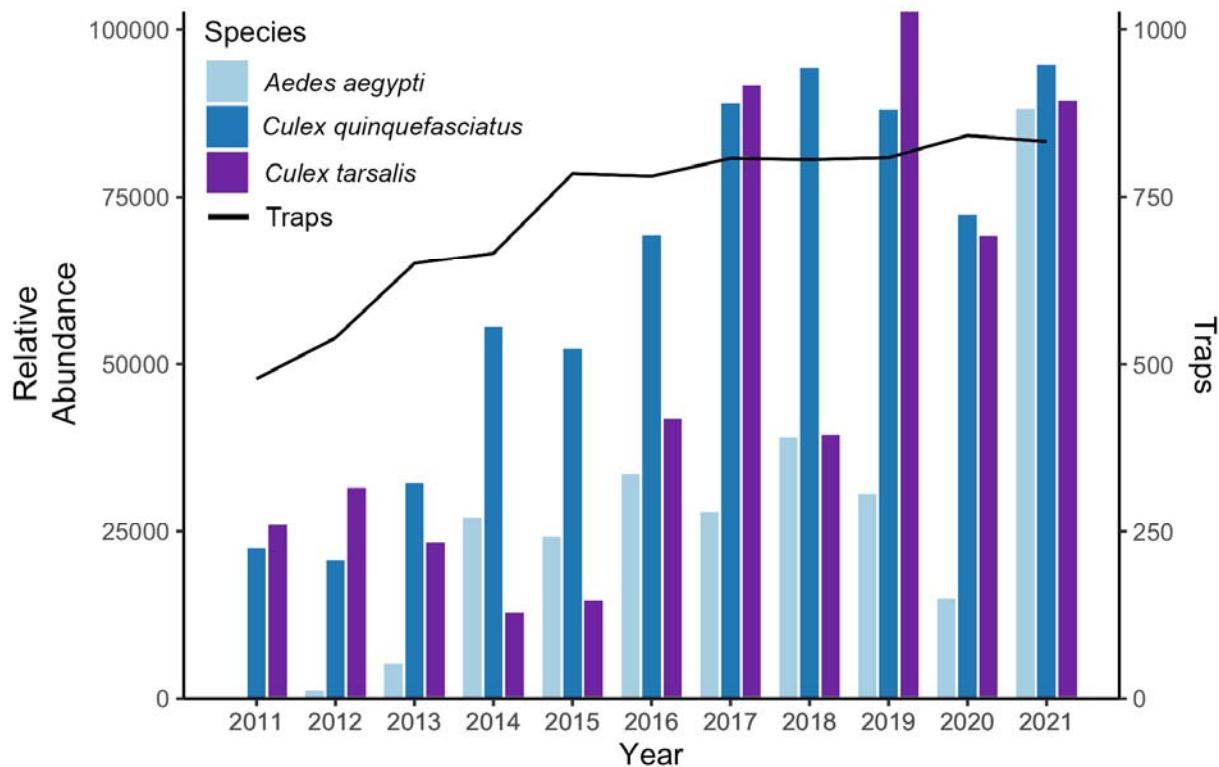
163 **Results**

164 *Spatiotemporal Distribution of Vector Mosquito Species in Maricopa County, Arizona*

165 The Maricopa County Environmental Services Department Vector Control
166 Division Surveillance System was comprised of 478 traps in 2011 and new traps were
167 gradually included over the years as the surveillance system expanded to 833 traps in
168 2021. From 2016 to 2021 the number of traps remained nearly constant. A total of
169 691,170 *Cx. quinquefasciatus*, 542,733 *Cx. tarsalis*, and 292,305 *Aedes aegypti* were
170 collected from 2011 to 2022 by the traps in the Surveillance System (Figures 2 and 3,
171 Supplementary Table 1).

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175 **Figure 2. Number of active traps in the Maricopa County Environmental Services**
176 **Department Vector Control Division Surveillance System (black line) and the**
177 **number of mosquitoes collected by year from 2011 to 2021.**

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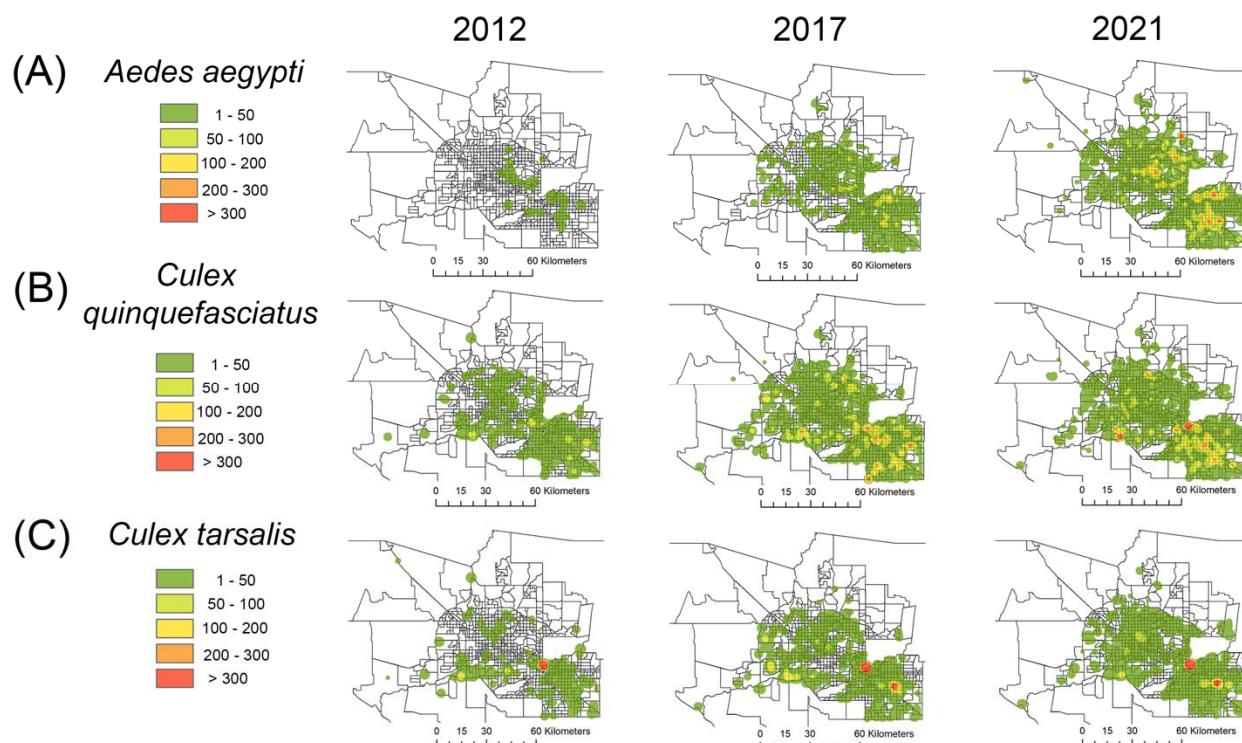
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180 Over the study period, *Ae. aegypti* gradually expanded its range and relative
181 abundance in the urban areas of Maricopa County. In particular, compared to 2020, a
182 substantial increase in the range of *Ae. aegypti* was observed in 2021 when a total of
183 88,187 specimens were collected by the traps in the surveillance system (Figure 3A and
184 Supplementary Figure 1A). In contrast to *Ae. aegypti*, *Cx. quinquefasciatus* was already
185 commonly found in the urban areas in Maricopa County in 2011. However, since 2011,

186 *Cx. quinquefasciatus* became more confined to specific areas of the county and was
187 particularly abundant in those areas. Since 2016, *Cx. quinquefasciatus* started to
188 increase in abundance, especially in the southeastern region of Maricopa County
189 (Figure 3B and Supplementary Figure 1B). Although *Cx. tarsalis* could be detected in
190 urban areas, this species was mainly confined to specific areas of Maricopa County,
191 primarily to areas inside or bordering natural or rural areas. By 2021, *Cx. tarsalis* had
192 gradually expanded its range, but it remained highly abundant in this ecological niche
193 (Figure 3C, Supplementary Figure 1, Supplementary Tables 2 and 3).

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197 **Figure 3. Kernel density-based heat map of the relative abundance of vector**
198 **mosquito species collected by the Maricopa County Environmental Services**

199 **Department Vector Control Division Surveillance System in 2012, 2017, and 2021.**

200 The color gradient represents the sum of mosquitoes collected by each trap in a 12-

201 month period; (A) *Aedes aegypti*; (B) *Culex quinquefasciatus*; and (C) *Culex tarsalis*.

202 The figure was produced using ArcGIS 10.2 (Esri, Redlands, CA), using layers available

203 at the Maricopa County GIS Mapping Applications available at:

204 <https://www.maricopa.gov/3942/GIS-Mapping-Applications>.

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207 Our results show great seasonal variations in the mean numbers of mosquitoes

208 collected in Maricopa County. Rainfall is one of the possible drivers for the proliferation

209 of mosquitoes in the region, and the peaks in abundance of *Cx. quinquefasciatus* and

210 *Cx. tarsalis* overlap with the peak of the rainy season in the Spring and later in early

211 Fall. Furthermore, rainfall is potentially an important driver for the increase in the

212 abundance of *Ae. aegypti* over the year until the beginning of the dry season, when the

213 abundance of *Ae. aegypti* populations is drastically reduced. Each of the three vector

214 mosquito species, *Ae. aegypti*, *Cx. tarsalis*, and *Cx. quinquefasciatus*, displayed

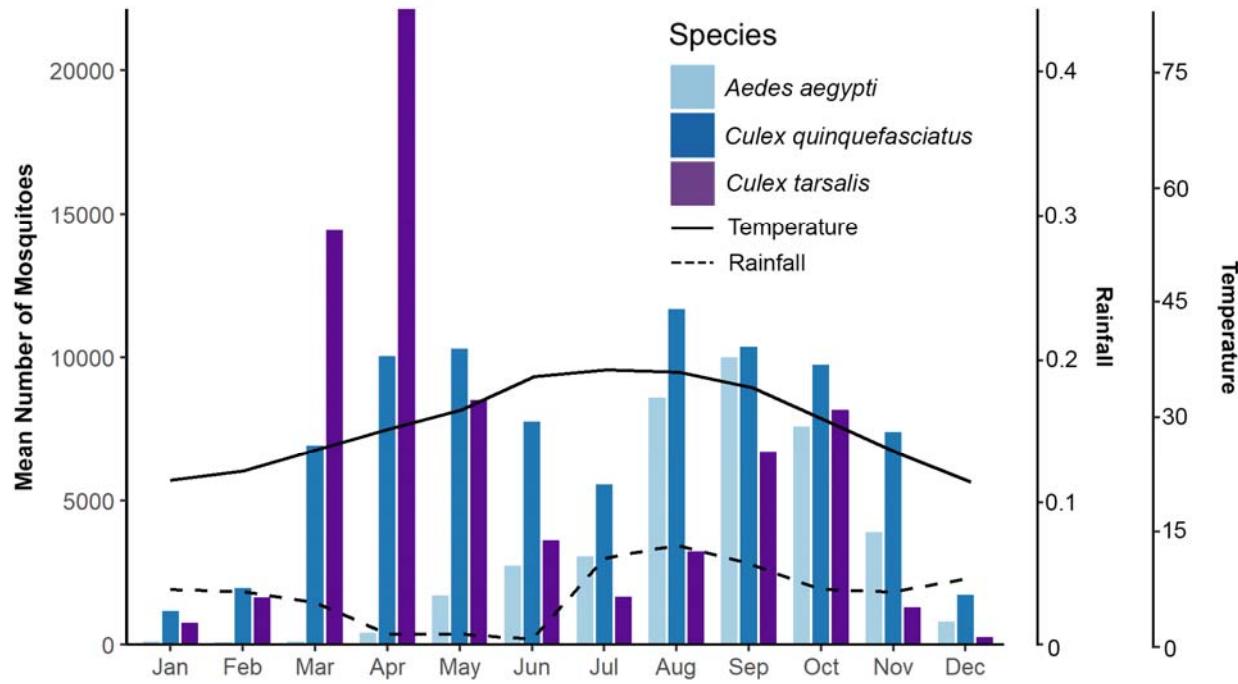
215 different population dynamic patterns peaking in abundance at different times of the

216 year. This indicates that even though rainfall is an important driver for their proliferation,

217 each species responded differently to the rainfall (Figure 4).

218

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221 **Figure 4. Mean number of *Aedes aegypti*, *Culex quinquefasciatus*, and *Culex***
222 ***tarsalis* collected by the Maricopa County Environmental Services Department**
223 **Vector Control Division Surveillance System from 2016 to 2021.** Solid line
224 represents the monthly mean average temperature (Celsius) between 2016 and 2021;
225 Dashed line represents the monthly mean average rainfall (centimeters) between 2016
226 and 2021.

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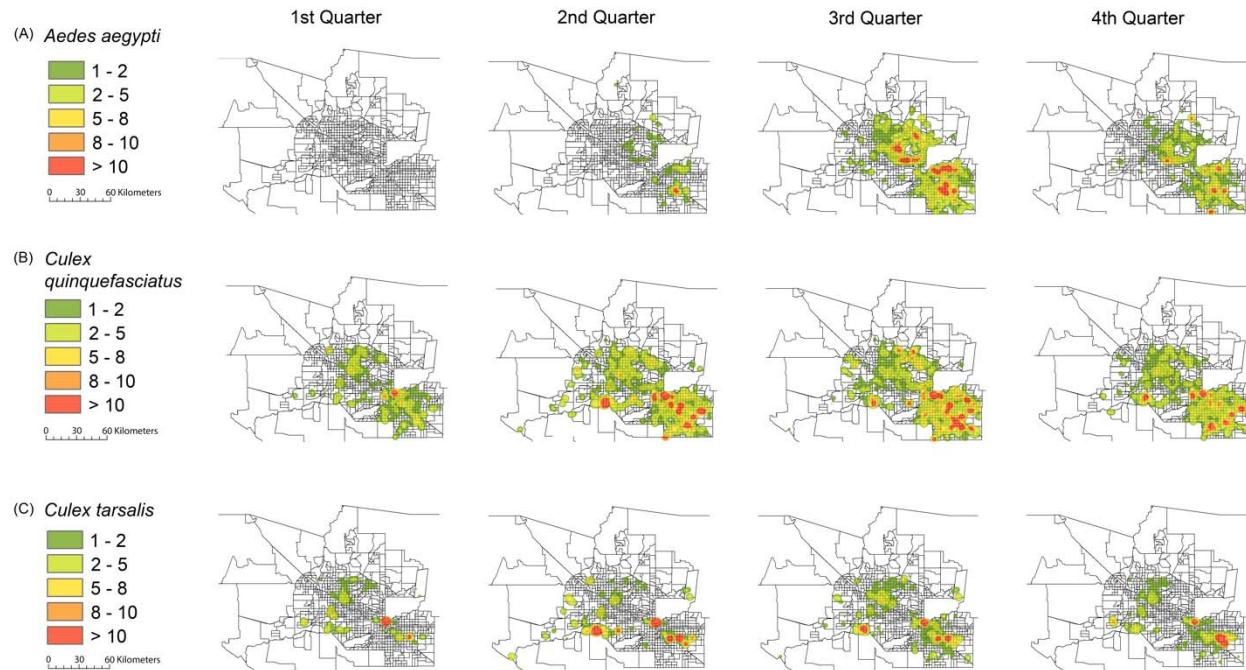
229 The mean number of collected *Ae. aegypti* varied greatly within each year. It was
230 virtually absent during the first quarter of the year yielding a low number of mosquitoes
231 collected by the traps in the surveillance system. It then gradually increased in
232 abundance and range during the second quarter, showing the highest abundance in the
233 southeastern part of the county. This species peaked in abundance during the third

234 quarter of the year covering most of the urban areas of Maricopa County and reaching
235 high abundance in several geographical areas. The mean number of *Ae. aegypti*
236 collected in the fourth quarter of the year was smaller than in the third quarter, albeit
237 areas with high abundance were still present (Figure 5A).

238 *Culex quinquefasciatus* was abundantly found in Maricopa County year-round.
239 The mean number of *Cx. quinquefasciatus* was the highest during the second and third
240 quarters of the year with many areas of the county yielding an average higher than 10
241 mosquitoes per trap per day. One region bordering rural and leisure areas in the
242 southeastern part of the county yielded more than 10 mosquitoes per trap per day on
243 average year-round (Figure 5B). *Culex tarsalis* was moderately affected by seasonality.
244 The mean number of *Cx. tarsalis* remained constant during the second, third, and fourth
245 quarters of the year with specific areas yielding high numbers of mosquitoes. During the
246 first quarter, collections of *Cx. tarsalis* were not as abundant as in the other quarters of
247 the year, but for one region bordering rural and leisure areas in the southeastern part of
248 the county. Furthermore, *Cx. tarsalis* yielded the highest average number of mosquitoes
249 collected in a selected group of traps bordering natural and rural areas. Even though the
250 mean number of *Cx. tarsalis* reached high levels in those specific areas, it was not
251 abundantly found in urban areas. (Figure 5C).

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255 **Figure 5. Kernel density-based heat map of the mean number of *Aedes aegypti*,**
256 ***Culex quinquefasciatus*, and *Culex tarsalis* collected by the Maricopa County**
257 **Environmental Services Department Vector Control Division Surveillance System**
258 **from 2016 to 2021.** The color gradient represents the mean number of mosquitoes
259 collected by each trap in a 3-month period. The figure was produced using ArcGIS 10.2
260 (Esri, Redlands, CA), using layers available at the Maricopa County GIS Mapping
261 Applications available at: <https://www.maricopa.gov/3942/GIS-Mapping-Applications>.

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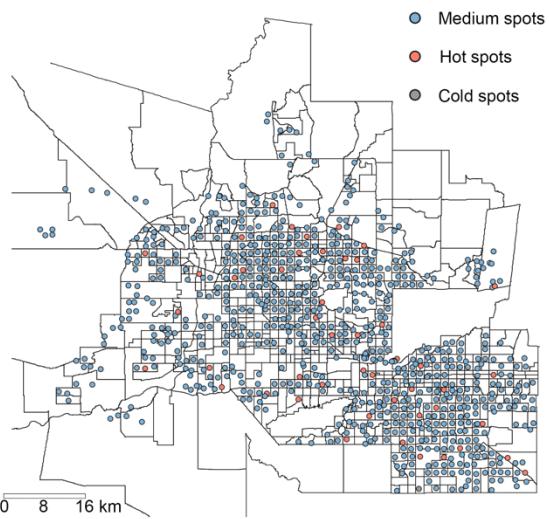
264 *Hotspot Areas for the transmission of WNV and SLEV in Maricopa County, Arizona*

265 To further our understanding and provide operational input in case of a WNV and
266 SLEV arbovirus outbreak in Maricopa County, we focused on the mosquito and

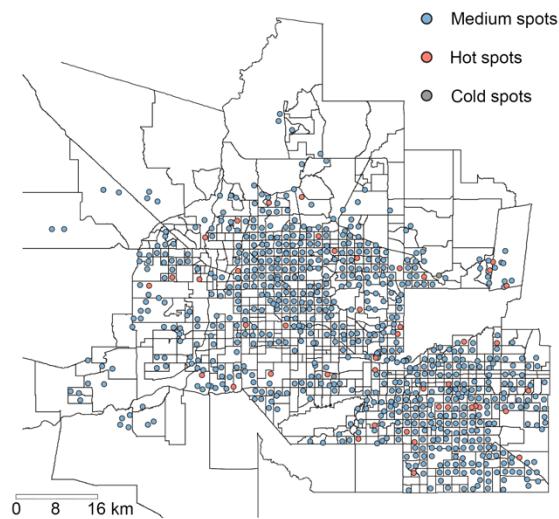
267 arbovirus surveillance data from 2021, when Maricopa County reported a record-
268 breaking number of neuroinvasive WNV cases. To identify highly conducive
269 environments for the proliferation of *Cx. quinquefasciatus* and *Cx. tarsalis*, we created a
270 4 km buffer radius around each trap (corresponding to 15 traps on average, range: 1-
271 34). Then, we calculated the number of traps in each of the buffers, and the total and
272 mean number of *Cx. quinquefasciatus* and *Cx. tarsalis* collected by the traps in the
273 cluster. Our results show that from the 820 traps that collected *Cx. quinquefasciatus*
274 female mosquitoes in 2021, 90 were above their respective buffer average, with 21
275 influential points (defined as traps yielding an average number of mosquitoes at the
276 97.5th percentile of each of the clusters). From the 754 traps that collected *Cx. tarsalis*
277 female mosquitoes in 2021, 76 were above their respective buffer average, with 19
278 influential points (Figure 6).

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Culex quinquefasciatus



Culex tarsalis



281

282 **Figure 6. Hot spot and cold spot traps that collected a higher (red) or lower (gray)**
283 **number of female mosquitoes *Cx. quinquefasciatus* and *Cx. tarsalis* relative to**
284 **the traps in their respective 4 km buffer radius in Maricopa County, Arizona in**
285 **2021.**

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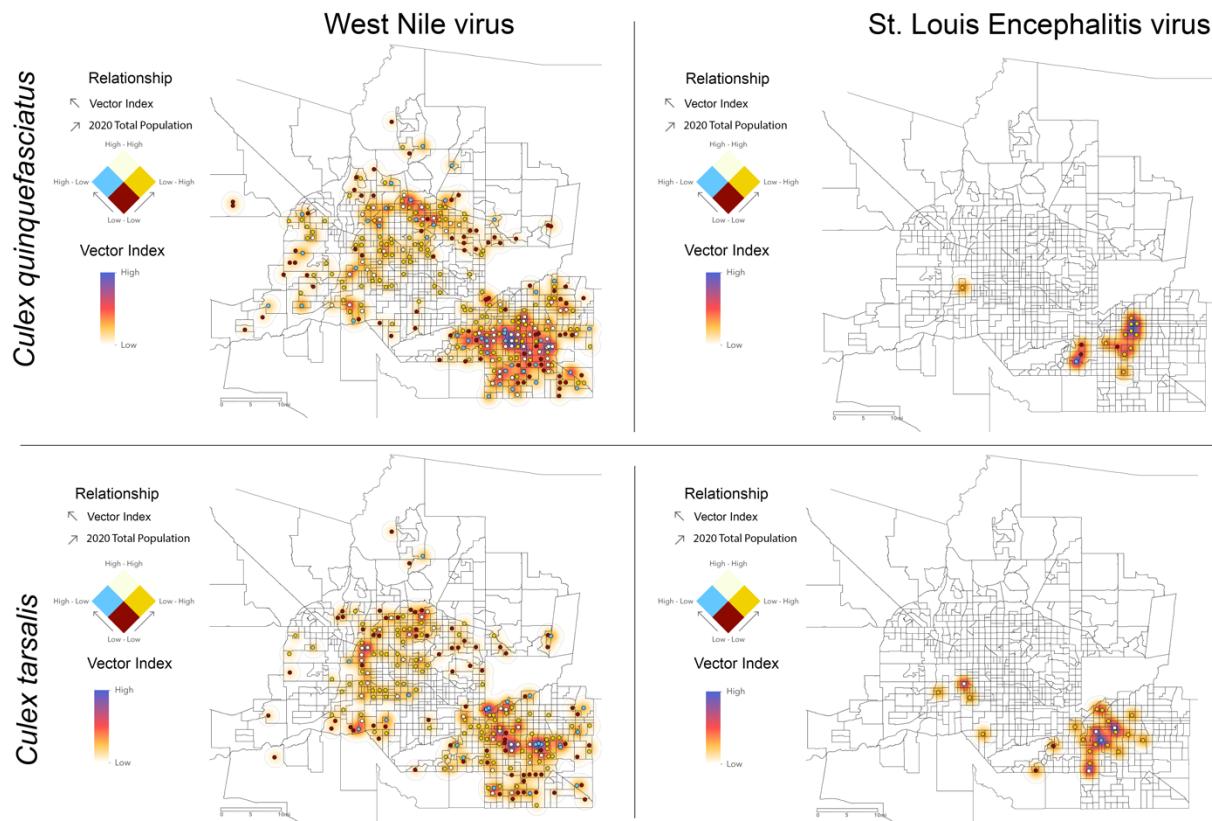
288 To assess the locations in Maricopa County, Arizona, with the highest WNV and
289 SLEV disease transmission risk, we calculated the VI. We then created a map and
290 overlaid the VI with human population density. Identifying locations with high human
291 population densities and high levels of infected mosquitoes serves as a powerful
292 indicator of the highest-risk locations for WNV and SLEV transmission.

293 Our results show high levels of heterogeneity in the risk of WNV and SLEV
294 transmission to humans disregarding the geographical proximity of the traps (i.e., the
295 risk of arbovirus transmission has been driven locally at the microgeographic scale and
296 varied greatly between closely located traps). In 2021, WNV was detected in *Cx.*
297 *quinquefasciatus* mosquito pools at least once in 304 different traps, with VI values
298 ranging from 0.02 to 0.12, and in *Cx. tarsalis* mosquito pools at least once in 222
299 different traps, with VI values ranging from 0.02 to 0.1. SLEV was detected in *Cx.*
300 *quinquefasciatus* mosquito pools at least once in 15 different traps. It was also detected
301 at least once in 24 different traps in *Cx. tarsalis* mosquito pools. In both cases, the VI
302 values ranged from 0.02 to 0.04 (Figure 7).

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Figure 7. High-risk areas for the transmission of WNV and SLEV in Maricopa County, Arizona in 2021. Relationship between the estimated average number of WNV and SLEV infected *Cx. quinquefasciatus* and *Cx. tarsalis* by trap night (Vector Index) in Maricopa County, Arizona, in 2021, and the 2020 total population from the U.S. Census in a 1-km buffer around each individual trap. White dots represent areas with high Vector Index and high human population density, blue dots represent areas with high Vector Index and low human population density, yellow dots represent areas with low Vector Index and high human population density, and dark red dots represent areas with low Vector Index and low human population. The overall heterogeneity of the

316 Vector Index for WNV and SLEV circulating in *Cx. quinquefasciatus* and *Cx. tarsalis*
317 populations are represented using a heatmap.

318

319 **Discussion**

320 Anthropogenic changes in the environment create favorable conditions for the
321 development of vector mosquito species that can exploit the resources available in
322 urban areas [31]. The decreased biodiversity in those urban areas increases the contact
323 rate between mosquito vector species and human hosts, increasing the risk of arbovirus
324 transmission to humans [14,32,33]. Our results show that vector mosquito species are
325 widely distributed and abundantly found in the urban areas of Maricopa County,
326 Arizona.

327 *Aedes aegypti* gradually become more abundant and expanded its range since
328 only one specimen was collected in Maricopa County in 2011. In 2012, 1,189 Ae.
329 *aegypti* were collected; by 2014 that number increased to 27,208, and by 2021 a total of
330 88,187 specimens were collected indicating a substantial increase in its relative
331 abundance over the years. A similar phenomenon could be observed for *Cx. tarsalis*
332 and *Cx. quinquefasciatus*, and although they were already present in great numbers
333 since 2011, with more than 20,000 specimens from each species collected that year,
334 reaching 89,401 collected specimens of *Cx. tarsalis* and 94,774 of *Cx. quinquefasciatus*
335 in 2021. We should stress that mosquitoes were collected using BG-Sentinel and CDC
336 traps, and new traps were gradually added during the period of this study increasing the
337 sampling effort over time. Even though our results show an increase in the relative

338 abundance of mosquitoes, the different sampling effort over the years remains a study
339 limitation.

340 The high abundance of vector mosquitoes in Maricopa County represents a
341 potentially dangerous scenario. *Aedes aegypti* is the primary vector of dengue,
342 chikungunya, yellow fever, and Zika viruses, and *Cx. quinquefasciatus* and *Cx. tarsalis*
343 are vectors of the WNV, Saint Louis Encephalitis, Eastern Equine encephalitis, and
344 Japanese Encephalitis viruses [34]. Moreover, differently from dengue and other *Aedes*-
345 borne diseases where humans do not represent dead-end hosts, for WNV and SLEV
346 the risk of human cases directly depends on the number of individuals exposed to bites
347 from infected mosquito vectors. Thus, the high concentration of human population in
348 urban areas of Maricopa County living in close proximity to infected mosquito vectors
349 has the potential to lead to major disease burden, as it was the case in 2021, when
350 1,427 neuroinvasive WNV cases were reported in the county [12].

351 The relative abundance of *Ae. aegypti* was highly seasonal with fewer
352 mosquitoes collected in the first 3 months of the year followed by a moderate increase
353 in numbers in the second quarter indicating that the environmental conditions were not
354 conducive to the proliferation of *Ae. aegypti* during the first quarter of the year.
355 However, as the year progresses, a substantial increase in the abundance of *Ae.*
356 *aegypti* was observed in the third and fourth quarters. The observed seasonal variation
357 in the abundance of *Ae. aegypti* can potentially be an important driver for arbovirus
358 transmission in Maricopa County as its abundance and range increase as the year
359 progresses, thus, potentially increasing the contact rate between *Ae. aegypti* and
360 human hosts. *Culex quinquefasciatus*, on the other hand, was abundantly found during

361 all seasons of the year. It was not as abundant in the first quarter as it was during the
362 remaining of the year, but it could be found throughout the urban areas during that time
363 of the year. Several regions consistently yielded high numbers of *Cx. quinquefasciatus*
364 mosquitoes indicating that those areas were hot spots and were able to support high
365 numbers of *Cx. quinquefasciatus* year-round. *Culex tarsalis* was also abundantly found
366 in Maricopa County but in contrast to *Ae. aegypti* and *Cx. quinquefasciatus*, it only
367 reached high numbers in well-defined areas bordering natural and rural areas.
368 However, this is not surprising because *Cx. tarsalis* larval habitats include irrigation
369 agricultural runoff, wetlands, sewage effluent, oil field run-off, and lake beds [35], and all
370 these habitat types are rarely associated with urban areas. Human cases of WNV
371 disease have been consistently reported in Arizona, being one of the most affected
372 states in the United States. The high abundance of *Culex* vector species, especially the
373 year-round presence of *Cx. quinquefasciatus*, has major implications for the likelihood
374 of WNV transmission in Maricopa County [12]. In sum, our results showed well-defined
375 spatiotemporal patterns for each of the species included in this study. However, further
376 analyses are needed to investigate the main drivers for the variations in the population
377 dynamics of each mosquito vector species that are essential for the development and
378 implementation of effective source reduction and other mosquito control strategies [36].

379 The cluster analysis results aimed to detect influential point traps that collected a
380 significantly higher number of either *Cx. quinquefasciatus* or *Cx. tarsalis* as compared to
381 other traps in their proximity indicate that resources available at the microgeographic
382 scale were responsible for their proliferation. Further analysis is needed to understand
383 which local geographic features (e.g., urban parks, fishing ponds, sports complexes, as

384 appears to be the case in our data) may have contributed to the observed patterns.

385 Identifying such factors is instrumental to guide vector control operations.

386 The identification of high-risk areas for the transmission of WNV and SLEV is
387 vital for the development of vector control strategies aiming at reducing the abundance
388 of *Cx. tarsalis* and *Cx. quinquefasciatus* and thus the risk of infection. Our results show
389 the overlap between areas with high human population densities and high levels of
390 infected mosquitoes. These areas are priority targets for the development and
391 implementation of vector mosquito control strategies. Furthermore, there is a need to
392 assess and validate the effectiveness of different control methods and strategies aimed
393 to reduce mosquito populations in urban areas. These activities could focus on how the
394 proliferation of vector mosquito species can be locally reduced by source reduction,
395 community engagement, and by modifying specific features of the urban built
396 environment [36–39]. Developing and implementing effective mosquito control
397 strategies is a difficult task with many factors that can potentially hinder the
398 effectiveness of mosquito control interventions, such as levels of insecticide resistance,
399 diel activity of target mosquito species, and outdated and ineffective mosquito control
400 tools [40–42].

401 Our analysis of high-risk areas for WNV and SLEV infection considers only the
402 density of the human population, disregarding other characteristics such as the
403 population's, age structure and underlying health status, as well as other social
404 determinants including individuals' socioeconomic status, and characteristics of the
405 neighborhood in which they reside [43]. Different segments of the population could
406 indeed be exposed to a heterogeneous risk of infection and disease depending on their

407 age, occupation (e.g., construction workers vs. office workers), adequacy of their
408 housing arrangement (e.g., presence of mosquito window screenings and A.C. units),
409 and the built environment in their neighborhood (e.g. presence of abandoned
410 lots/buildings that may provide more breeding areas). A segment of the population that
411 is at particular risk of arbovirus infection is represented by people experiencing
412 unsheltered homelessness as they are exposed nearly 24/7 to mosquito vector bites. It
413 has been shown that the prevalence of WNV in Houston, Texas, is higher in people that
414 have been homeless for more than one year when compared with the general
415 population [44]. In other metropolitan areas in the United States, including Maricopa
416 County, Arizona, it is so far unknown to what extent vulnerable and underserved
417 populations are being disproportionately exposed to arboviruses. These groups are
418 already affected by large disparities in terms of mortality and a broad array of other
419 health outcomes [45], and arriving at a better understanding of the nature and extent of
420 their disproportionate exposure to arboviral infections is crucial for designing policy
421 interventions that can mitigate such a preventable health disparity and advance health
422 equity.

423 Effective mosquito control operations rely on multiple factors, with the most
424 important being consistent and reliable mosquito surveillance systems, community
425 engagement, and targeted source reduction. Now, more than ever, effective mosquito
426 control strategies are needed to deal with a flux of importation of travelers carrying
427 arboviruses to prevent local outbreaks, and to curtail them when they start. Effective
428 mosquito surveillance systems are key for guiding and implementing mosquito control

429 strategies and should be considered a priority for local, state, and federal public health
430 professionals.

431

432 **Supplementary Table 1. Number of traps and mosquitoes collected by the**
433 **Maricopa County Environmental Services Department Vector Control Division**
434 **Surveillance System from 2011 to 2021.**

435

436 **Supplementary Table 2. Number of mosquitoes (*Aedes aegypti*, *Culex***
437 ***quinquefasciatus*, and *Culex tarsalis*) collected per trap.**

438

439 **Supplementary Table 3. Number of mosquitoes (*Aedes aegypti*, *Culex***
440 ***quinquefasciatus*, and *Culex tarsalis*) collected by the same set of 478 traps in**
441 **use since 2016.**

442

443 **Supplementary Figure 1. Kernel density-based heat map of the relative**
444 **abundance of vector mosquito species collected by the Maricopa County**
445 **Environmental Services Department Vector Control Division Surveillance System**
446 **from 2012 to 2021.** The color gradient represents the sum of mosquitoes collected by
447 each trap in a 12-month period; (A) *Aedes aegypti*; (B) *Culex quinquefasciatus*; and (C)
448 *Culex tarsalis*. The figure was produced using ArcGIS 10.2 (Esri, Redlands, CA), using
449 layers available at the Maricopa County GIS Mapping Applications available at:
450 <https://www.maricopa.gov/3942/GIS-Mapping-Applications>.

451

452

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455 necessarily reflect the official views of the Centers for Disease Control and Prevention
456 (CDC).

457

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