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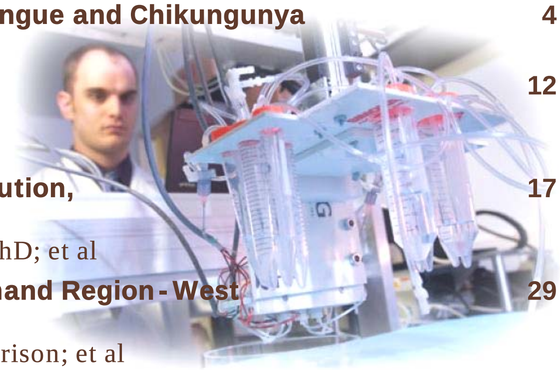
July – September 2011



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Online Spatial Database of US Army Public Health Command Region-West Mosquito Surveillance Records: 1947-2009

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Abstract

Mosquito surveillance records from the US Army Public Health Command Region-West (APHCR-W) were georeferenced and made available online via the database mapping application MosquitoMap (www.mosquitomap.org). This article briefly reviews the history of the APHCR-W surveillance program and some characteristics of the resulting dataset, which numbers over 100,000 records mainly from US Department of Defense (DoD) facilities in the western United States from 1947 to 2009. The value of past and future DoD mosquito surveillance efforts can be increased by reporting the location of collection data in online spatial databases such as MosquitoMap.

Introduction

Mosquito surveillance of military installations has been conducted and reported by the US Army since the early years of World War II. Baseline mosquito species collection data, standardized by trap index, have been reported annually, allowing comparisons between years and within a single year. For example, the report for 2006[1] reported 46 mosquito species in 8 genera, which were collected from 24 installations, subinstallations, and other facilities within the 20 states comprising what is now the Army Public Health Command Region-West (APHCR-W) area of responsibility, including US Army (9), Army Reserve (2), National Guard (2), US Navy (6) and one from the National Park system.

Britch et al[2] explored relationships between the Normalized Difference Vegetation Index* and 2003-2005 APHCR-W mosquito surveillance data, for a subset of mosquito species and locations, including Fort Riley, Kansas, Fort Lewis, Washington, and Yuma Proving Ground, Arizona. They sought to identify instances of population patterns that suggested a response to climate, and concluded that the mosquito surveillance data could be useful for future climate-based models developed to forecast population dynamics of medically important mosquitoes.

Mosquito surveillance is seen as important intelligence to support the planning of effective mosquito control programs. Mosquito trap data at the APHCR-W dates from 1947, making this one of the longest running mosquito surveillance programs in the world, and providing a unique resource for understanding changes in mosquito occurrence and abundance in the United States. These data were available via the APHCR-W website†, but georeferencing, which allows collection locations to be mapped for spatial analyses, was lacking. This article discusses a project to georeference these data and make them available online in a geographical information systems setting.

Surveillance Program History

The US Army Public Health Command (APHC) lineage can be traced back over 70 years to the Army Industrial Hygiene Laboratory (AIHL) which was established at the beginning of World War II under the direct jurisdiction of The Army Surgeon General. It was originally located at the Johns Hopkins School of Hygiene and Public Health, with a staff of three and an annual budget that did not exceed $3,000. Its mission was to conduct occupational health surveys of Army operated industrial plants, arsenals, and depots. These surveys were aimed at identifying and eliminating occupational health hazards within the Department of

*http://earthobservatory.nasa.gov/Features/MeasuringVegetation/measuring_vegetation_2.php
†http://phc.amedd.army.mil/topics/phcrspecific/west/Pages/default.aspx

Defense's (DoD) industrial production base and proved to be beneficial to the nation's war effort. In 1960, the AIHL became known as the US Army Environmental Hygiene Agency (AEHA). Its mission was expanded to support the worldwide preventive medicine programs of the Army, DoD, and other federal agencies through consultations, supportive services, investigations, and training. It was redesignated the US Army Center for Health Promotion and Preventive Medicine (CHPPM) in 1995 with the mission to provide worldwide technical support for implementing preventive medicine and public health and health promotion/wellness services into all aspects of America's Army and the Army Community, as well as anticipating and rapidly responding to operational needs and adapting to a changing world environment. In 2009, CHPPM was reorganized and became the Army Public Health Command.

The need for entomologists and pest surveillance, particularly for the southeastern United States where malaria was a threat, became apparent with the establishment of Army training camps during the mobilization program of World War II.[3] Weekly collection of mosquitoes from set collecting stations and reporting the species caught and their abundance was instituted by most of the Army posts in the 4th Service Command during this time.[3] Surveillance and control efforts in the United States was seen as necessary training for the job of controlling insects of medical importance in overseas theaters of operation.[3] After the war, the 9th Service Command Medical Laboratory, located at Fort Baker, California, began keeping records of mosquitoes captured on military installations along the US west coast. Colonel Stanley J. Carpenter, a noted Army Entomologist, cowrote the landmark book, *The Mosquitoes of North America,* while stationed at Fort Baker.[4] This handbook remains an indispensable guide to mosquito identification, and his identifications of mosquitoes are still recorded in the current APHCR-W mosquito database. Colonel Carpenter was later reassigned to Fort Baker to the renamed 6th Army Area Medical Laboratory, where he worked until his retirement in 1960.[5] In 1974, the health and environmental resources of the 6th Army Laboratory were transferred to the Fitzsimons Army Medical Center, Colorado, and designated as a subordinate command under AEHA. During the transition, records of mosquito collections in the western United States were transferred to the new subordinate command. In addition, mosquito surveillance was expanded to include Army installations in 23 western states, including Alaska. In 1999, the subordinate command moved from Fitzsimons to Fort Lewis, Washington, and in 2009 was redesignated the Army Public Health Command Region-West. Mosquito surveillance data have been maintained from 1947 until today. This command currently identifies mosquitoes from all Army installations in 20 western states. All mosquito collections have been transcribed from archived record cards and placed into a database.

Materials and Methods

The task of georeferencing the APHCR-W data presented numerous challenges due to base closures and lack of access to maps that detailed the sites mentioned in collection data. In early 2010, 294 files comprising individual base files and yearly files from 1947-1951 through 2009 were obtained (F.A.M. unpublished data, 2010), which allowed inclusion of these data on the database mapping application MosquitoMap*.

Surveillance data from different years were combined into one Microsoft Excel spreadsheet. In the absence of maps detailing individual sites, we opted to summarize their location by defining the centroid of the base and estimating uncertainty using published information about the area of the base. The internet provided particularly useful information, including general information lists of bases, and links to some specific base information which sometimes included map coordinates. For estimating spatial uncertainty, we used area data that is publicly available on the internet, and *The Base Structure Report*.[6] When area was given in acres, uncertainty in meters was calculated in Excel using the formula

=SQRT((Acres×4046.85642)/3.1416)

Batch georeferences for street addresses were obtained using GPS Visualizer†, with Google set as the source. Input data were first edited to remove nonessential information, and arranged in a standard order to minimize geocoding errors. Output addresses were checked against input to identify discrepancies, and results that had a low precision level (to street or city, for example) were flagged to be further checked. Discrepancies were usually resolved through a

*http://www.mosquitomap.org
†http://www.gpsvisualizer.com/geocoder/

combination of internet searches for key terms and orientation with Google Earth*. Use of the historical imagery, altitude, distance along a path, street view, and the link to Google Maps in Google Earth, were found to be particularly useful for resolving problematic collection sites. When georeferences could not be resolved to street level, the township where the collection was made was georeferenced using Biogeomancer Workbench 1.2.4[†].

A small minority of records had georeference information, either various geodetic formats or military grid reference system (MGRS). The MGRS grid zone identifier and 100,000 meter square identifier information was missing, so approximate location, as determined in Google Earth, was used to obtain a first approximation in the program GeoTrans V2.4.1[‡], then the northing and easting information entered to obtain the precise decimal degrees georeference. In most cases, these coordinates were checked in Google Earth to see if the location corresponded with any text information that was recorded for the collection site. The point radius method portrays uncertainty or error as a radius around a geocoordinate.[7,8] Uncertainty was estimated in the Manis Georeferencing Calculator[§] from Biogeomancer, or estimated by visual assessment of the extent in Google Earth, or as the radius of a circle described by the calculated area.

Data were filtered in Excel for unique locations, and these point data were converted to shape files for mapping in DIVA-GIS 5.2**. Further data cleaning was undertaken by the "check coordinates" option of DIVA-GIS, a "point-in-polygon" method,[9] which identifies points located outside all polygons and points that did not match relations for the country and state names. Data were imported into ARCVIEW GIS 3.3 (Environmental Systems Research Institute, Inc, Redlands, CA) for graphical display.

We composited yearly files into one Excel sheet, with a sequence number added to recreate the original order. A new column was added with genus, subgenus, species, and author information taken from the MosquitoMap collection form, which is based on the online Systematic Catalog of Culicidae.[10] The mosquito species recorded were checked for current taxonomic status. The geolocations of records were checked in DIVA-GIS for agreement with the country and state of occurrence. The location of each species was mapped and this checked against known records for these species. Records with trap catches labeled "Not operated," "Negative," "Misc. Culicidae," "Aedini" (n=18,269), and one record labeled "*Ochlerotatus atlanticus/tormentor*" were placed in a separate Excel sheet. Those records that could not be georeferenced (n=267), and anomalous records, the distribution of which did not agree with established knowledge (n=15), were also separated. This left 100,610 georeferenced and quality controlled records. Data fields were rendered into the MosquitoMap format, and records were uploaded into MosquitoMap in November 2010.

SPECIES ACCUMULATION CURVES

The application EstimateS 7.5.1[††] was used to investigate under-sampling and spatial aggregation in the data. EstimateS calculates randomized species accumulation curves (also known as sample-based rarefaction curves) and computes a variety of species richness indicators. For an idealized complete inventory for an area, the species accumulation curve will form an asymptote near the true species richness, and taxa that are *rare* will be observed more than once. The expected richness function in EstimateS is called Sobs (Mao Tau). A Coleman curve is calculated by randomly reassigning specimens to samples and then recalculating the species accumulation curve, thus removing any clumping in the data. The present study used the EstimateS incidence-based coverage estimator (ICE), which depends on the presence and distribution of rare taxa, to estimate the lower bounds of species richness and to assess the degree of undersampling. The present study used the default values in EstimateS, that is, 50 randomizations for estimators and 10 for the upper abundance limit for rare taxa. The yearly presence (1) or absence (0) of each species was the input for EstimateS.

RESULTS

There were 858 unique location points (Figure 1), for 100,610 records, representing 201,905 male and 1,198,281 female specimens. The mean radius of geographic uncertainty was 7,970.8 m (SD=7542.0), with a range of 88 m to 80,547 m. Of these, 21% had

*http://www.google.com/earth/index.html
†http://bg.berkeley.edu/latest/
‡http://geoengine.nga.mil/geospatial/SW_TOOLS/NIMAMUSE/webinter/geotrans.html
§http://manisnet.org/search.shtml
**http://www.diva-gis.org/
††http://viceroy.eeb.uconn.edu/estimates

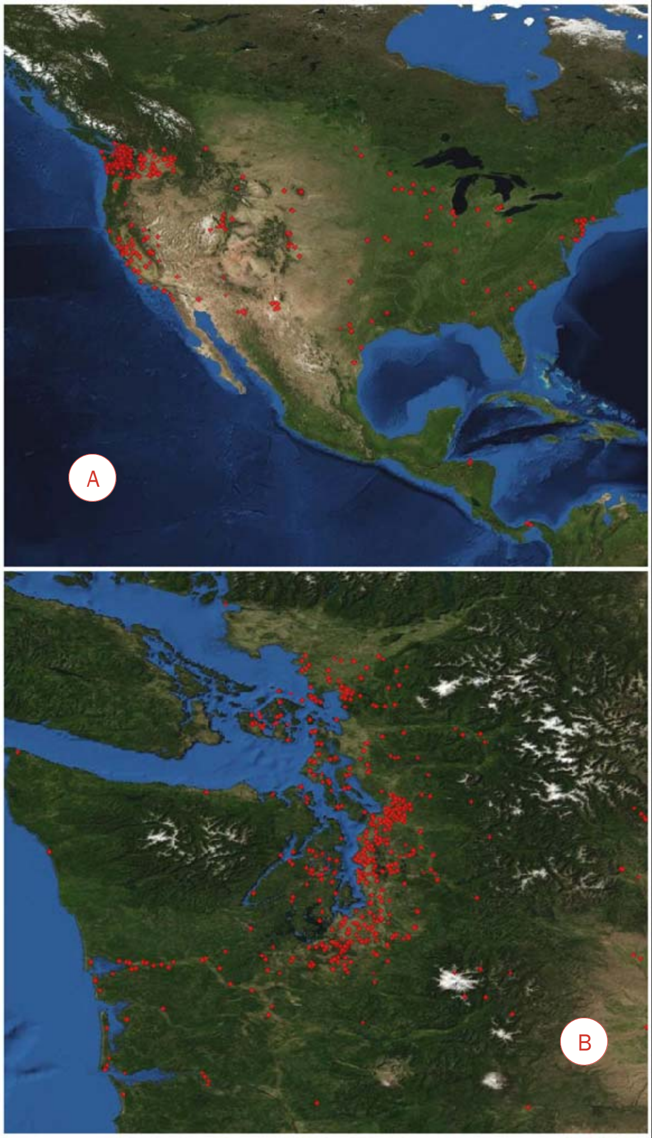

Figure 1. Geographical distribution of surveillance records from the PHCR-W dataset for the 48 US states (panel A), and a close-up of Puget Sound area of Washington state (panel B).

Breakdown of the mosquito surveillance records in the PHCR-W dataset by state.

State	No. Years	No. Records	No. Species
AK	14	273	20
AL	1	22	8
AZ	49	17313	31
CA	49	9144	34
CO	49	11389	26
CT	1	2	2
GA	1	190	17
HI	1	6	2
IA	1	1	1
ID	1	6	3
IL	24	7759	38
IN	6	38	7
KS	35	30197	38
MD	1	2	2
MI	8	135	19
MN	12	437	20
MO	27	8497	41
MT	2	2	2
ND	3	112	14
NJ	2	21	8
NM	15	631	17
NV	6	50	9
NY	1	3	3
OH	2	21	9
OK	1	68	13
OR	7	45	10
SC	1	26	10
SD	1	3	3
TX	19	2874	26
UT	22	631	16
WA	36	9039	40
WI	20	1098	30
WY	7	446	15

an uncertainty of 2,000 m or less, 56% were 8,000 m or less, and 85% were 12,000 m or less.

The majority of locations were from the state of Washington, but, as shown in the Table, more records came from Kansas, Arizona, and Colorado. In all, 33 US states were sampled. Figure 2 shows yearly changes in species (number of species, species accumulation) and sampling effort (logarithm of the number of records, logarithm of the number of US states that were sampled). A change in the early to mid 1970s and in the 2000s can be seen from the data. This effect, broken down by state, is shown in Figure 3, and the number of species by state in Figure 4.

There are 105 species names; 14% of species were caught in only one year, and 26% in one or two years. The singleton species were: *Aedes burgeri* Zavortink, *Ae. dupreei* (Coquillett), *Ae. euplocamus* Dyar and Knab, *Ae. provocans* (Walker), *Ae. pullatus* (Coquillett), *Ae. varipalpus* (Coquillett), *Ae. washinoi* Lanzaro and Eldridge, *Anopheles judithae* Zavortink, *An. vestitipennis* Dyar and Knab, *Coquillettidia venezuelensis* (Theobald), *Culex arizonensis* Bohart, *Mansonia titillans* (Walker), *Psorophora mathesoni* Belkin and Heinemann, *Uranotaenia anhydor syntheta* Dyar and Shannon, *Ur. lowii* Theobald. Four out of the 15 singleton species were caught in 1996, and a majority of the other infrequently found species were caught in

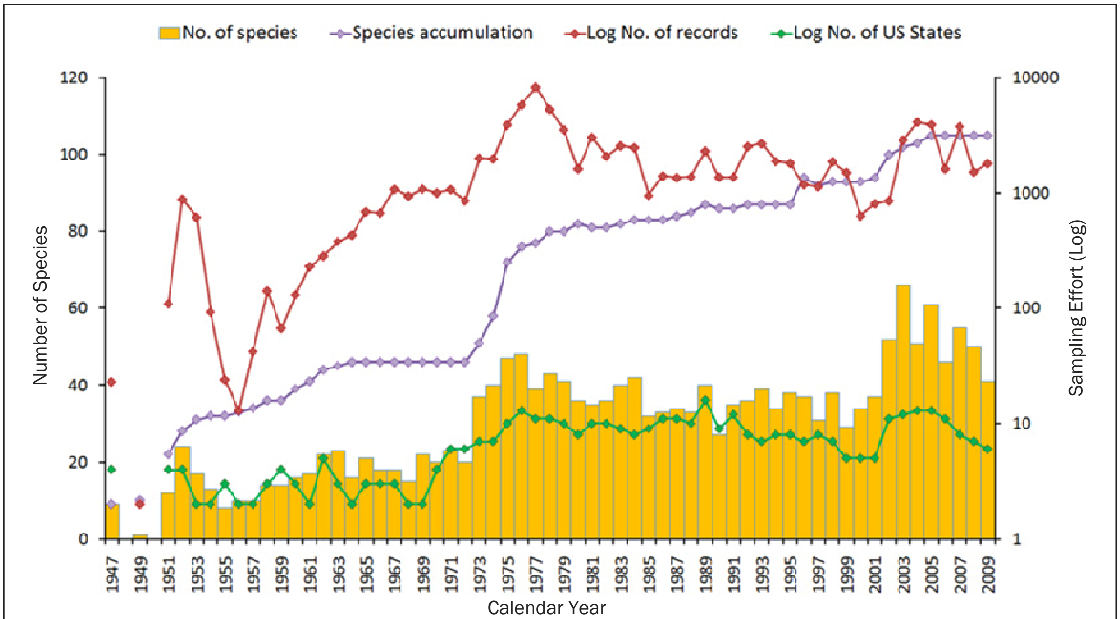

Figure 2. Yearly changes in species (number of species, species accumulation) and sampling effort (log plot of the number of records, log plot of the number of US states that were sampled) from the PHCR-W mosquito surveillance dataset. Note the change in the early to mid 1970s, and in the 2000s.

1973-1978, and 2002-2005, when many new US states were surveyed. The 10 most frequently collected species (lowest to highest) were: *Cx. quinquefasciatus* Say, *Ae. vexans* (Meigen), *Culiseta incidens* (Thomson), *Ps. columbiae* (Dyar and Knab), *Cx. erythrothorax* Dyar, *An. franciscanus* McCracken, *Cx. pipiens* Linnaeus, *Ae. dorsalis* (Meigen), *Cx. tarsalis* Coquillett, *Cs. inornata* (Williston). New state records arising from the APHCR-W surveillance program comprised *Ae. fulvus pallens* Ross in Missouri,[11] *Ur. sapphirina* (Osten Sachen) in Colorado,[12] and *Ae. thelcter* Dyar in Arizona.[13]

The results using all years resulted in very high estimates of species numbers using EstimateS. Because of this, and the clear difference between pre- and post-1975 collection data, we report analysis of post-1975 results. Post-1975 data comprised 101 of the 105 species collected over the 1947-2009 period. The curves resulting from the EstimateS analysis are shown in Figure 5. EstimateS advised that the coefficient of variation was >0.5, so the Classic option was used and reporting was limited to the ICE estimate for incidence-based richness. The largest ICE mean estimate was 112 species and Sobs was 97 species, being very close to the total number recorded, 105 species. According to the Online Mosquito Catalog,[10] 166 species occur in the US, but a subset of these occur in the geographic area sampled by the APHCR-W surveillance program. Thus, species recorded from the APHCR-W data may be approaching the total number of species actually present within the area of surveillance.

Most records pertain to collections on US military facilities, but this was not always the case. Other locations included National Parks, water and sewage treatment plants, roadside collections, food processing factories, and private residences. For example, in 2003 and 2007, many residents in Washington cooperated in a mosquito survey that was a collaboration between APHCR-W and the Washington Department of Health.

DISCUSSION

According to Heyer et al,[15] for a complete inventory of species, the estimators and Sobs coincide and asymptote together, whereas for a relatively under-sampled fauna, the estimator curves are much higher (65%) than the observed curves. In the most under-sampled taxa, the Sobs curve may also be linear,[15] but this was not observed in the present study. A general coincidence of the Coleman (not shown) and Sobs curves in Figure 5 is evidence against patchiness in the distribution of data points, especially for rare species.

Compared with the arthropod, vertebrate, and plant species analyzed in Heyer et al,[15] the mosquito curves in Figure 5 suggests an inventory, for the area under

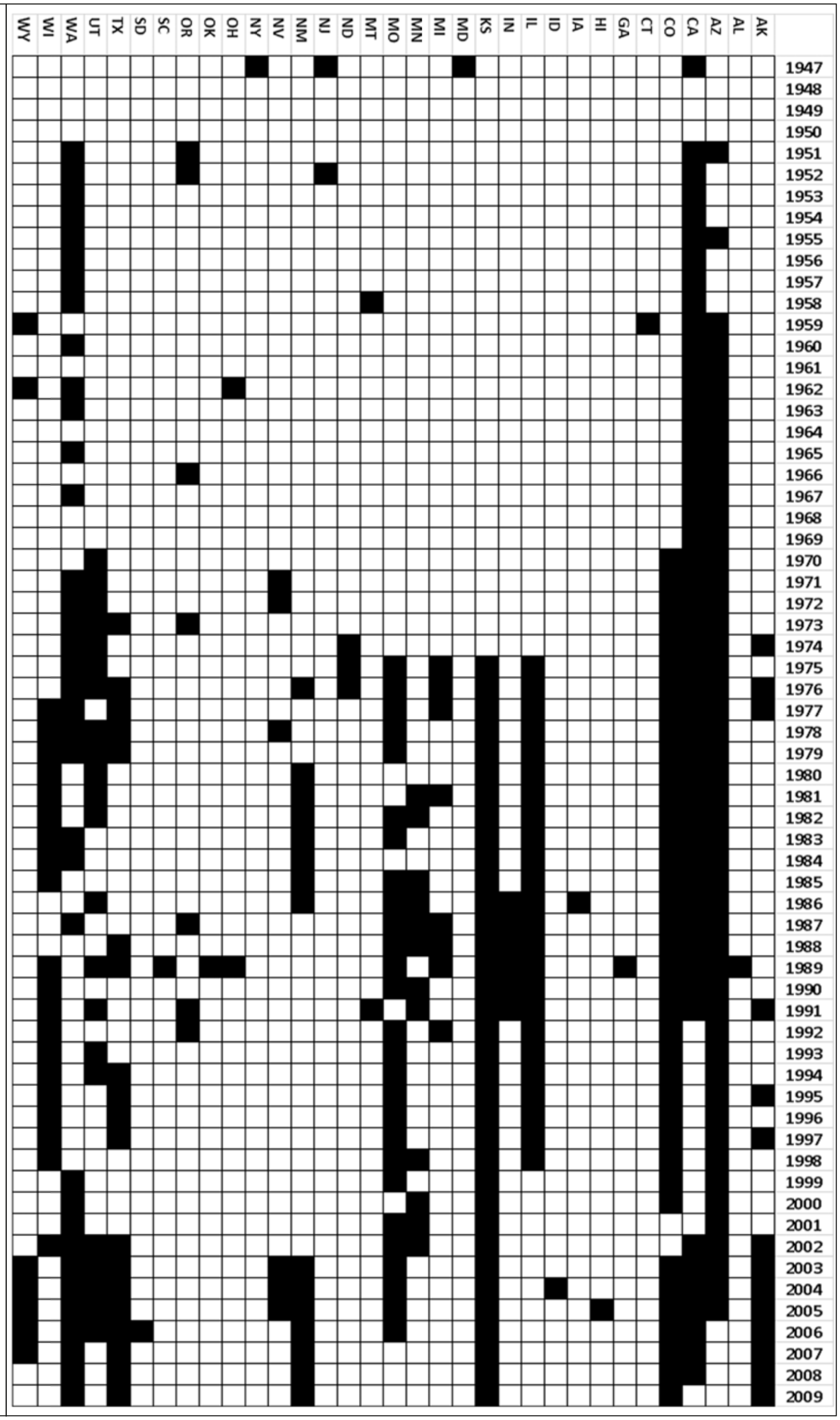

Figure 3. Presence (solid fill) or absence (no fill) of mosquito surveillance records from the PHCR-W dataset by state for years 1947 through 2009.

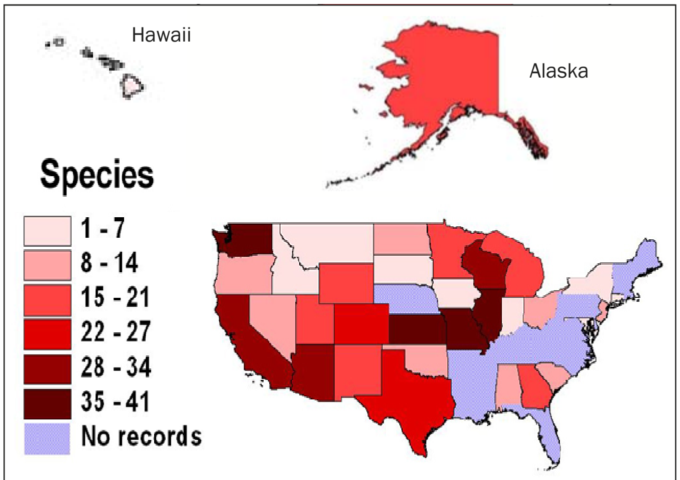

Figure 4. Total number of species recorded in the PHCR-W dataset for each state.

study, that is approaching completeness. For a complete inventory, values for uniques tend toward zero, as they will have been observed multiple times. Values for Sobs and ICE appear to be reaching an asymptote and the uniques curve is starting to decline. It is possible that the rarity of many mosquito species is an artifact, perhaps by nonrandom sampling, which distorts the results. Occasional introductions of species that do not become established may inflate the number of species, whereas climate change may make the environment more or less suitable for different species, thereby having unpredictable effects on total species number.

The geographical range of APHCR-W surveillance in the continental United States has changed over the years (Figure 3), and the Base Realignment and Closure cycle is one possible factor among many that may affect surveillance coverage in the future. The current primary focus of DoD vector surveillance appears to be at the level of the military installation rather than statewide or nationwide. However, it is a synthesis of information and a coordinated response at these coarser spatial granularities that the effect of climate change and spread of invasive species and emerging vector-borne diseases will most profitably be addressed. This was demonstrated most forcefully following the emergence of West Nile virus (WNV) in the United States in 1999, when the Army Surgeon General directed the creation and implementation of a WNV Surveillance and Control Program for Army installations.[16] A multiagency collaboration and the formation of an ad hoc WNV committee of the Armed Forces Pest Management Board enabled Army, Navy, Marine, and Air Force installations to use mosquito surveillance and control, dead bird surveillance, and human case monitoring to minimize the risk of WNV to personnel on military installations.[16] The WNV threat also resulted in a collaboration between APHCR-W and the Washington [state] Department of Health regarding training, mosquito identification, and exchange of mosquito surveillance data, including data from APHCR-W for 1973-2005, which resulted in a checklist and distribution records for mosquitoes of the state of Washington.[17]

Furthermore, longer term surveillance datasets are more valuable for identifying permanent rather than short-term perturbations in vector populations, and for establishing action thresholds or control decision rules. As surveillance data are made more accessible, and tools to assist their analysis are made available online, the utility of these data for decision makers such as health planners and integrated pest management personnel will increase. According to Debboun et al,[16]

> …carefully planned surveillance plays a critical role in assessing vector-borne disease threats because the information gained can influence decisions on the use of medical preventive interventions, such as chemoprophylaxis, and pesticide usage.

According to Britch et al,[2] mosquito surveillance at military installations should be continued or even augmented, to improve and automate the ability to fore-

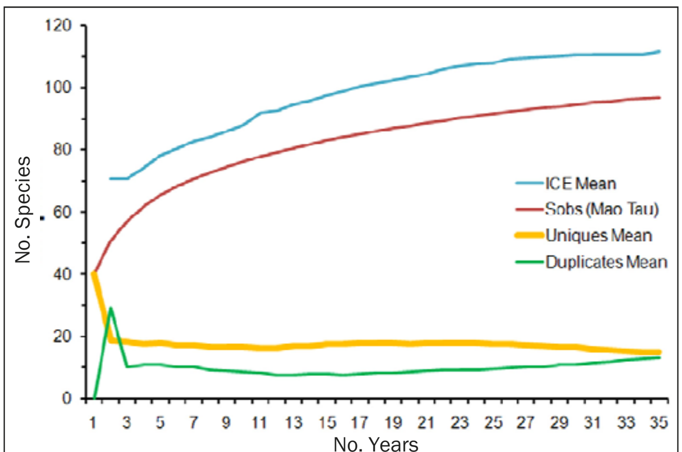

Figure 5. Species richness estimators and patchiness indicators for mosquito species from the PHCR-W database calculated with the program EstimateS.

ICE indicates incidence-based coverage estimator.[14]

Sobs (Mao Tau) [mean] indicates empirical species accumulation curve.

Uniques mean indicates number of species occurring in only one year.

Duplicates mean indicates number of species occurring in only 2 years.

cast mosquito population changes favorable for mosquito-borne diseases. We agree, and would add that uniform adoption of georeferencing standards for recording the location of mosquito collections would add value to these data.

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References

1. *Mosquito Surveillance at Installations Supported by the USACHPPM-West, Fort Lewis, Washington, February-October, 2006*. Pest Management Study ESD Project No. 18-RF-2981-07.
2. Britch SC, Linthicum KJ, Anyamba A, et al. Satellite vegetation index data as a tool to forecast population dynamics of medically important mosquitoes at military installations in the continental United States. *Mil Med*. 2008;173:677-683.
3. Carpenter SJ. Insect Control In Army Camps. *J Econ Entomol*. 1944;37:470-474.
4. Carpenter SJ, La Casse WJ. *Mosquitoes of North America - North of Mexico*. Berkeley, CA: University of California Press; 1955:353.
5. Nielsen LT. Memorial lecture, Colonel Stanley Jennings Carpenter, 1904-1984. *J Am Mosq Control Assoc*. 1998;14(3):353-354.
6. *The Base Structure Report (BSR) FY 2007 Baseline*. Washington, DC: Office of the Deputy Undersecretary of Defense (Installations and Environment); 2007. Available at: http://www.acq.osd.mil/ie/download/bsr/BSR_FY2007_Baseline.pdf. Accessed June 3, 2011.
7. Wieczorek J, Guo Q, Hijmans R. The point-radius method for georeferencing locality descriptions and calculating associated uncertainty. *Int J Geogr Inform Sci*. 2004;18(8):745-767. Available at: http://www.herpnet.org/herpnet/documents/wieczorek.pdf.
8. Chapman AD, Wieczorek J, eds. *Guide to Best Practices for Georeferencing*. Copenhagen, Denmark: Global Biodiversity Information Facility, 2006. Available at: http://www.herpnet.org/herpnet/documents/biogeomancerguide.pdf. Accessed January 15, 2010.
9. Chapman AD. *Principles and Methods of Data Cleaning – Primary Species and Species-Occurrence Data*, Ver 1. Copenhagen, Denmark: Global Biodiversity Information Facility; 2005.
10. Walter Reed Biosystematics Unit (WRBU). Systematic catalog of Culicidae. 2010. Available at: http://www.mosquito catalog.org/.
11. Maloney FA. New record for *Aedes fulvus pallens* in Missouri. *Mosq News*. 1978;38:294.
12. Maloney FA. New record for *Uranotaenia sapphirina* in Colorado. *Mosq News*. 1980;40:451.
13. Maloney FA, Reid BJ. New record for *Aedes thelcter* in Arizona. *J Am Mosq Control Assoc*. 1990;6:138.
14. Chao A, Hwang W-H, Chen Y-C, Kuo C-Y. Estimating the number of shared species in two communities. *Statistica Sinica*. 2000;10:227-246.
15. Heyer WR, Coddington J, Kress WJ, et al. Amazonian biotic data and conservation decisions. *Environ Biodivers*. 1999;51:372-385.
16. Debboun M, Robert L, O'Brien L, Johnson R, Bene S. Vector control and pest management. *Army Med Dept J*. April-June 2006:31-39.
17. Sames WJ, Duffy A, Maloney FA, Townzen JS, Brauner JM, McHugh CP, Lilja J. Distribution of mosquitoes in Washington State. *J Am Mosq Control Assoc*. 2007;23:442-448.

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