REMOTE SENSING: A RAPID AND ACCURATE METHOD OF DATA ACQUISITION FOR A NEWLY FORMED MOSQUITO CONTROL DISTRICT[1]

V. E. WAGNER[2], R. HILL-ROWLEY[3], S.A. NARLOCK[2] AND H. D. NEWSON[4]

ABSTRACT. Using high altitude color-infrared photographic records of 2 Michigan counties obtained from the National Aeronautical and Space Administration, together with photointerpretations provided by the Remote Sensing Project, Michigan State University, a detailed map of mosquito breeding sites present in a newly formed mosquito control district was prepared in a relatively brief time and with a minimal expenditure of manpower. By combining these data with population densities determined in an unrelated health services study, the Saginaw-Bay County Mosquito Control District developed an area treatment priority system for their control operations. Additional ongoing and planned cooperative studies, using a variety of remote sensing data sources, are discussed.

INTRODUCTION

The Saginaw Bay Mosquito Control Commission (SBMCC) is a nonprofit, public funded corporation that provides health services in the form of mosquito and mosquito-borne disease control in 2 contiguous Michigan counties, Bay and Saginaw. This commission was formed on January 1, 1977, was funded by a 3-year local county tax millage and became operational during the summer of that year. A tax renewal vote is scheduled in the summer of 1979 to decide whether or not the commission is to be continued. With only a 2½ year period in which to organize, hire and train personnel, purchase equipment, and provide a level of mosquito control throughout the 2 counties that would assure continued public support in the 1979 election, it was realized that innovative and time-saving procedures would have to be followed whenever possible. It was known that early season *Aedes* would be a major problem in the 2 counties as would flood-water *Aedes* later in the summer. *Culex* control in urban and suburban areas also was thought to be important in view of the epidemic of St. Louis encephalitis (SLE) that occurred in these types of settlements during 1975. When the SBMCC began its operations, however, there was no inventory of the mosquito breeding sites present in the 2 counties, so one of the most immediate problems was to locate and map these habitats. The time and personnel available for this were not adequate to allow timely completion of the project using conventional methods, so by necessity other techniques had to be employed.

PREPARATION. In discussions between the SBMCC and the Michigan State University Remote Sensing Project (RSP), it was determined that remote sensing data available from the National Aeronautical and Space Administration (NASA) would be useful in contributing to an inventory of mosquito breeding habitats in Saginaw and Bay Counties. It was decided initially that 3 categories of information would be needed: the locations of 1) forested wetlands; 2) open wetlands and marshes; and 3) residential areas.

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[2] Saginaw Bay Mosquito Control Commission, 1416 South River Road, Bay City, Michigan 48906.

[3] Remote Sensing Project, 201 UPLA Building, Michigan State University, East Lansing, Michigan 48824. This project is supported under grant NGL 23-004-083 to Michigan State University and is administered by the NASA Office of Space and Terrestrial Applications.

[4] Departments of Entomology, Microbiology and Public Health, and Pesticide Research Center, Michigan State University, East Lansing, Michigan 48824. This study was supported, in part, by Agricultural Experiment Station Regional Project W-131.

Areas were mapped directly onto acetate overlays from NASA RB-57 high altitude color-infrared photography taken on May 13, 1975, at a scale of approximately 1:120,000 (1 in. equals 2 mi.). Similar imagery, taken on July 1, 1975 was used by the RSP during the interpretation for comparative purposes. The primary information, however, came from the May imagery because at this time water levels were at their highest, and tree foliage did not obscure the ground scene. Diazo copies of the interpreted and delineated acetate overlays were supplied by the RSP for use with prints of the NASA imagery that were purchased by the SBMCC. The information from the overlays was reduced to a scale of 1:175,000 (1 in. equals 2.75 mi.) and transferred to standard county highway maps. These maps and a 35 mm slide of each map were also supplied to the SBMCC.

The definitions used in the photo interpretation were as follows:

1. Forested wetlands—those forest areas which are seasonally wet. The May imagery recorded pre-leaf-out conditions so that wet areas with high levels of soil moisture or surface water were easily identifiable by their darker hue. These areas were for the most part not separable from other forested areas on the July imagery because of leaf out and soil water losses. Forested river bottoms and ponds within forested areas were also included in this classification.

2. Open wetlands and marshes—areas of open water. These were identified from the imagery and verified using 7.5′ and 15′ U.S. Geological Survey (USGA) topographic maps that record water bodies or closed depressions. It was a wet spring in 1975 and many of the open water bodies such as sewage treatment lagoons, water hazards on golf courses and ponds along major highways were included in this category. River floodplains that were inundated on the May imagery were included as open wetlands. Marsh areas are also primarily open water in the spring but these were distinguished by the presence of emergent vegetation and by comparison with the July imagery. The delineated areas of open wetlands and marshes were also checked against 7.5′ and 15′ USGS topographic maps to verify that all the areas on the maps marked as swamp were also included on the overlays. If there was a discrepancy, the final decision was based on imagery interpretation.

3. Residential—areas with contiguous groupings of 20 or more single or multiple family dwellings either in a strip or subdivision configurations. Strip development includes dwellings in a single strip, those that are staggered on both sides of a road, and short strips heading in more than one direction at a road intersection. Mobile home parks with 20 or more residences were also included in this category.

DEVELOPMENT OF OPERATIONAL PRIORITIES. The inventory of potential breeding sites thus obtained was also used in part to establish priorities for the commission's control and disease surveillance operations. Because areas with the highest human population densities did not correspond to the political divisions (cities and townships) and the delineated mosquito breeding sites were located somewhat randomly in both heavily and sparsely populated areas, some method was needed to identify the localities in which the most intense control operations should be employed. Becker (1976) had earlier calculated population cohorts for the postal ZIP code areas in the two counties as a means for predicting health service needs. By correlating this information with the inventory of residential areas developed by the Remote Sensing Project personnel, it was possible to categorize areas according to their population densities and potential mosquito breeding sites. This information subsequently was used to establish priorities for dispatching both mosquito control operations and disease surveillance activities (Fig. 1).

Areas designated Priority 1 contain 71% and 79%, respectively, of the residents of Saginaw and Bay Counties.

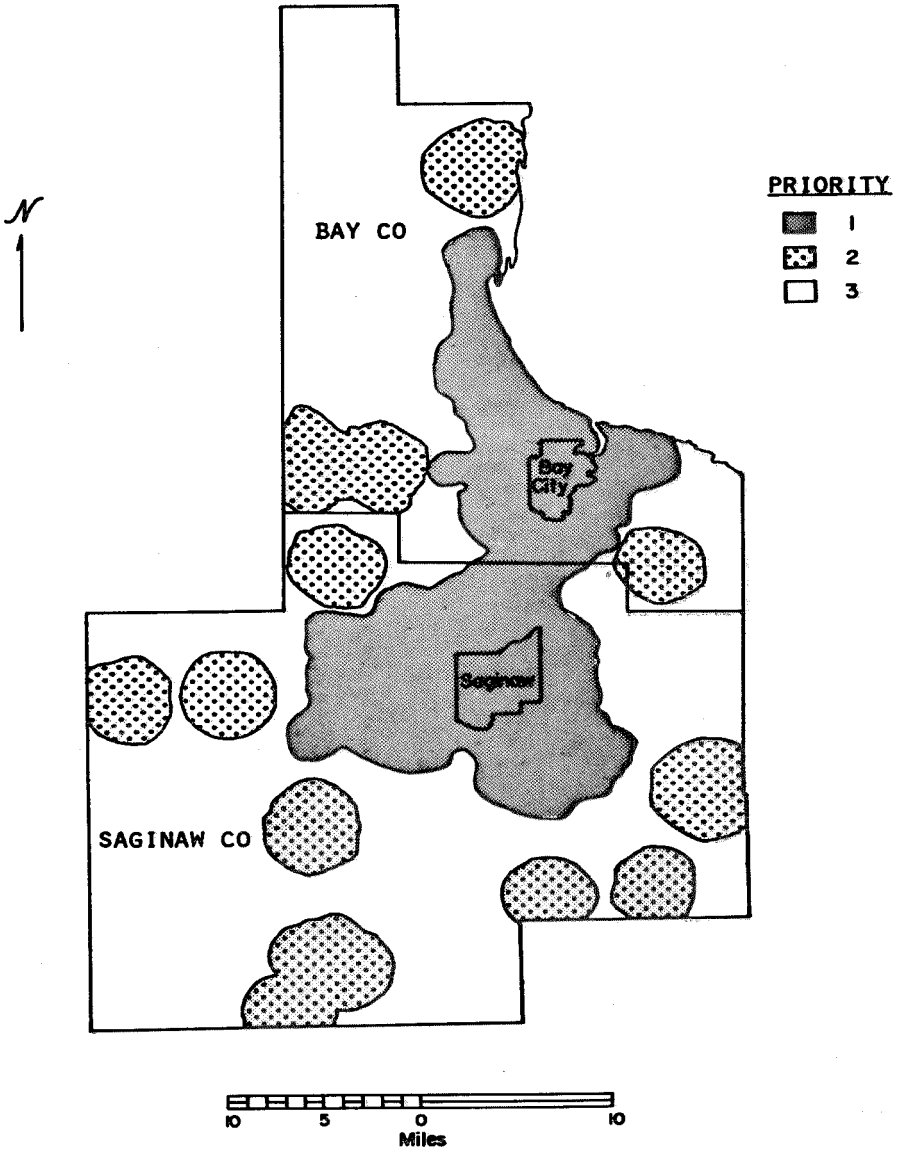

Fig. 1. Saginaw-Bay Mosquito Control Commission priority area.

Densely populated urban area were the source of human St. Louis encephalitis infections in the 1975 epidemic and contain the populations that would be most at-risk in the event of future outbreaks of this disease (Hopkins et al. 1975). Control operations planned for these areas consisted of routine larviciding and adulticiding, with emphasis on the former, as well as an extensive catch basin treatment program.

Priority 2 areas include primarily suburban populations clustered (in most cases) within 15 mi. of the outer perimeter of the Priority 1 areas. The population densities of these areas are lower than in the Priority 1 areas but are high enough that routine surveillance and control activities are feasible. The primary mosquito-borne disease risk in these areas is California encephalitis (CE) in those localities with populations of the tree-hole breeding mosquito, *Ae. triseriatus*, and, to a lesser degree, St. Louis encephalitis in settlements that have catch basin systems. Operations in Priority 2 areas consisted of routine surveillance by SBMCC personnel with larviciding and adulticiding when warranted. These routine activities are supplemented by responses to specific requests from residents of the Priority 2 areas.

Priority 3 areas consist of all land not designated Priority 1 or 2 and contain only 5% and 1.5% of the total populations of Saginaw and Bay Counties respectively. The very low population densities and the long distances between human habitations in these areas make routine surveillance and control operations impractical. Therefore, control operations are conducted primarily in response to requests rather than on a routine schedule.

Color codes were given to the 3 priority designations and their ZIP code boundaries together with the color indicating their operational priority classification, were transferred to standard county highway maps used by operations personnel. This clearly identified the relative priorities that had been assigned for mosquito control and mosquito-borne disease surveillance activities in each part of the district. In addition, the age cohorts for each ZIP code area were entered into a data matrix prepared for the IBM 1500 computer system housed in the commission headquarters. This matrix is continually being updated with biological data to maintain a contemporaneous information base on specific mosquito infestations and mosquito-borne disease activity within the district.

OPERATIONAL USE OF THE PRIORITY SYSTEM AND REMOTE SENSING DATA. A St. Louis encephalitis surveillance program was conducted in the summer of 1977, involving the collection of mosquitoes for arbovirus isolation attempts and bird sera to test for evidence of SLE infections. The site selections for the CDC light traps and bird traps used in the program were based upon the location of previous human SLE infections in priority areas 1 and 2. Blood samples and mosquito pools were submitted to the Ohio State Health Department for testing. A total of 36 mosquito pools were tested, but no arbovirus isolates were obtained. Two hundred and fifty-six bird sera were tested, using the hemagglutination inhibition technique, for SLE virus antibodies. Of these, 2 house sparrows, 1 adult and 1 juvenile, were positive. Both birds were collected in Priority 1 areas, 1 each in Bay and Saginaw Counties. The serological evidence of SLE infection in the juvenile bird is a clear indication that virus activity was present in 1977 even though no human SLE infections are known to have occurred then.

The forested wetlands inventory developed in 1977 was used to plan the control program for early season *Aedes* mosquitoes in the spring of 1978. Starting with standardized county maps (1:175,000 scale) on which the seasonally flooded woodlots had been plotted, the scale first was enlarged to approximately 1:45,600 and the location of individual woodlots in each township then was plotted on a separate 9″ × 12″ sheet. The actual scale of individual sheets was calcu-

lated using the distance between section boundaries (1 mile) as a reference for ground distance. A polar planimeter was used to determine the area of each flooded woodlot. The total area of the sites in each township was calculated and the cumulative acreage tabulated for each county. Because early season *Aedes* do not have extensive flight ranges, it was decided that pre-emergence treatments of all the breeding sites within a 2-mile radius of populated areas should provide adequate protection for these suburban localities. These treatment perimeters were plotted and the cumulative acreages of these treatment sites, by township, were calculated. A priority for the sequential treatment of the sites within each perimeter was established based upon the relative human population densities and acreage of the flooded woodlots. Each treatment zone was identified with its ZIP code designation in order that the data pertaining to it could be stored in the commission's computer system.

To update the breeding site inventory prepared in 1977 from the 1975 NASA remote sensing data, a light plane was flown over the forested priority 1, 2 and 3 areas in April 1978 by members of the Remote Sensing Project. Using 33mm infrared color photography, they were able to again delineate the flooded areas. These were compared with the map overlays prepared from the 1975 imagery and appropriate corrections were made. Subsequent on-the-ground inspections of these flooded sites indicated the breeding site inventory prepared from the remote sensing data was valid. The use of these remote sensing data sources greatly facilitated the location and identification of the early season *Aedes* breeding sites in a time period much shorter and with the expenditure of fewer man hours than would have been possible with the employment of more conventional techniques.

FUTURE PLANS

Cooperative efforts between the SBMCC and the RSP are continuing in two major areas. Work in the first areas, preparing a more detailed inventory of mosquito breeding habitats and other land use elements important in evaluating the potential for disease transmission, is in progress for sample townships in Saginaw and Bay Counties using a variety of remote sensing sources. The possibility of seasonal monitoring using data from the LANDSAT3 satellite will also be evaluated.

The second area deals with the establishment of a computer-based information system which would have the capacity to use sets of information in analyses which are directed toward surveillance of disease risk rather than just mosquito habitats. A variety of factors have been identified as being important in the transmission of encephalitis diseases. SLE and CE have different vectors with different habitats, and epidemiological evidence suggests that different age groups are at risk in the 2 diseases. This means that individuals present in certain areas will be more at risk than those in others and that the investigations needed to identify these areas, which also will improve control and surveillance capabilities, is a complex multifaceted problem. The objective of such investigations will be to refine a system which can use remote sensing and information system technologies to define, in spatial terms, the risks for the transmission of SLE and CE at the mosquito control district level, and in this way attempt to bridge the gap between very locally oriented studies and statewide disease surveillance systems.

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