Geospatial Risk Identification System (GRIdS): Developing a Risk-based Driven West Nile Virus Response Grid System

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Overview

Following Orange County's worst West Nile virus (WNV) epidemic in 2014, Orange County Mosquito and Vector Control District (OCMVCD) has taken steps to increase early detection of WNV virus activity and decrease control response time. In 2019, OCMVCD implemented a Geospatial Risk Identification System (GRIdS) derived from 15 years (2004 – 2018) of location data for WNV human cases and virus positive dead birds. OCMVCD used this information to construct a hot-spot analysis to spatially identify three County regions based on WNV risk: high, medium, and low, with the goal of distributing surveillance resources more efficiently. Each area was divided into blocks (one gravid trap per block) with dimensions set to accommodate OCMVCD's ground based adulticiding resources. Each block was further divided into smaller cells to delineate sections for additional weekly mosquito sampling that was activated upon an initial WNV detection. The area with the highest density of WNV activity, based on human cases and dead birds, was assigned a tighter surveillance grid compared to the medium and low risk areas. Within each risk area, the blocks established a standard unit for calculating infection rates based on routine and extended trapping efforts. During 2019, the grid system proved to enhance the communication of risk to constituents and stakeholders at a neighborhood level. The grid system and surveillance plan further strengthened inter- and intra-agency communication allowing for a more rapid control response.

The Question

After a comprehensive evaluation of our West Nile Virus surveillance system, we asked:

- Are the routine traps equally distributed?
- How can we use the traps to create an operational response grid?
- Are there areas lacking surveillance coverage?
- Can we shorten response time for areas with high infection rates?
- How much area can one ground based, wide-area adulticiding vehicle treat in one night?

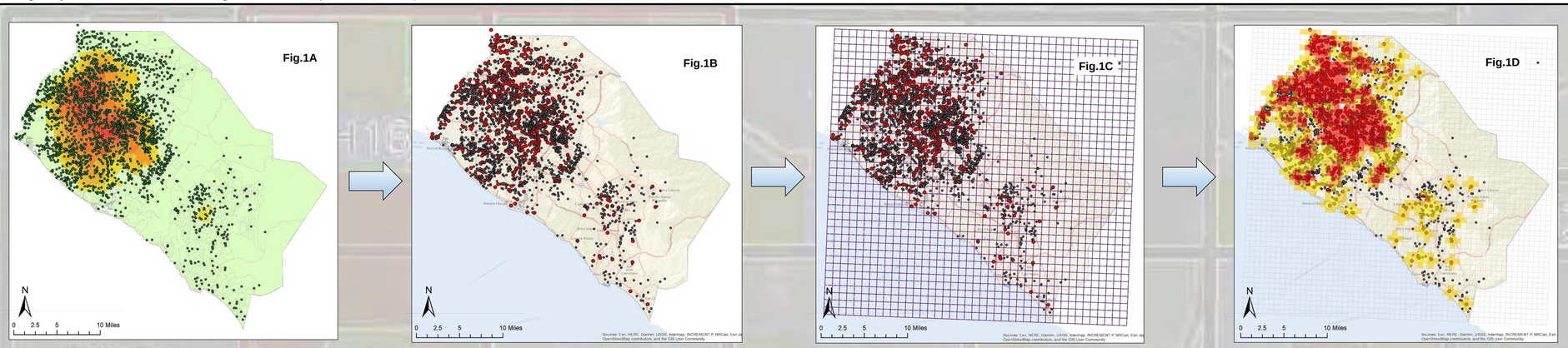

Fig. 1A: Hotspot analysis (HSA) of population density using Census Block Group Data (U.S. **Census Bureau**, 2019). Also, 2004 – 2018 human cases and dead birds are layered over the census model for comparison. Fig. 1B Hotspot Analysis starts with plotting West Nile virus positive human cases and dead birds. Fig. 1C: The comprehensive analysis uses "point of infection" locations to aggregate into a fishnet cell structure. Fig. 1D Fishnet cells are aggregated for point density analysis using Getis Ord Gi* density model. (ESRI, Redlands, 2019)

The Outcome

- Grids are created to have equal sized geographic units to make comparisons across the county.
- Each grid is weighted by the amount of cases and dead birds within it.
- More cases and dead birds per cell equal a higher risk and more surveillance.
- Red = highest human cases and dead birds per square mile (density)
  Yellow = moderate density
  No color = low density
- Analysis helped identify three distinct regions of WNV risk.
- Grid sizes were established based on three levels of WNV activity

The Build-out: Block it!

- The feature output is a stratified rectilinear polygon outlining 3 areas of concern.
- 3 different size grids incorporating cell size as risk area changes.
- Cell sizes are regional according to surveillance resolution.
- Higher risk areas have smaller cell areas:
  - High Risk = 0.5 sq. mi (Blue)
  - Medium Risk = 1 sq. mi (Tan)
  - Low Risk = 2 sq. mi (Pink)
- Cells are grouped into blocks (9 cells per block)
- High risk blocks = 4.5 sq. mi

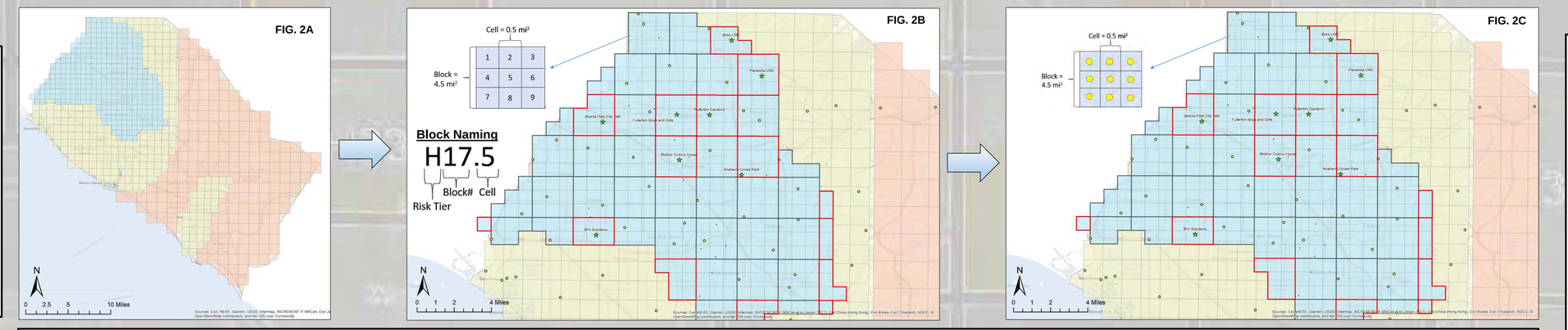

Fig. 2A: Risk areas based on HSA shows a stratified regional system. Fig. 2B: High risk area: cells are grouped into blocks. Routine trapping analysis shows blocks without routine surveillance. New routine sites are added (Green Stars). Fig. 2C: Blocks/cells are used to identify locations for extended trapping once routine trapping location results in a positive (Yellow Dots).

Send it!

- Extended Trapping Framework is now in place for every block (Yellow Dots)
- Centralized Routine Trapping adjustments are considered for the grid. Routine Traps moved to Cell 5 of every block for equal distribution.
- Naming Convention for Risk Blocks are as Follows:

  H17.5
  Block# Cell
  Risk Tier

- Additional routine surveillance traps added to blocks identified as missing surveillance.

Grid System in Action: Does it work?

- Calculating Vector Index (VI) based on blocks, via routine and extended trapping results, provides a heighten resolution of current infestation areas. VIs are calculated only if a block has at least 1 positive sample for that week.
- Tracking hotspots early in the season is on a finer scale, compared to county level, and risk ratings are easily calculated for each block.
- Truck-mounted ULV treatment of a single block by 4 trucks.(1 truck can treat 2.5 cells per night or 1.25 sq. mi).
- Three different blocks were treated in 4 weeks (37, 38, 39, and 40), based on sustained high VI rates.

*INSET: Weekly tracking of Block H17's positive cells, shown in red.

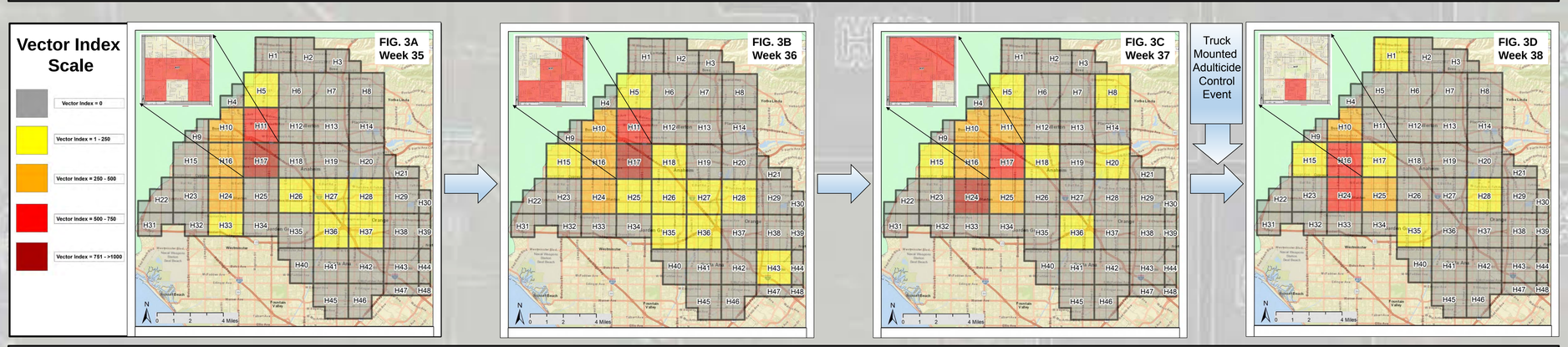

Fig. 3A and 3B: Weekly Vector Index (VI) calculations for High Risk Blocks based on positive mosquito samples from routine locations and extended trapping locations, within each block. Fig 3C and 3D: Week 37 shows block H17's VI before truck-mounted ULV treatment in that block. Week 38 shows block 17's calculated VI post-treatment.

Conclusions

- Infection Rates are easily calculated per block, increasing surveillance sensitivity.
- Blocks that have met the trigger for truck-mounted adulticiding, show significant reduction in infection rate and VI (P-value < 0.01) post treatment.
- Trapping distribution can be prioritized to areas of concern.
- Grids are easily communicated amongst constituents.
- Decrease internal decision-making process time = faster response to areas of increase virus activity.

References

ESRI "Spatial Analyst". ESRI 2017. ArcMap: Release 10.6.2. Redlands, CA: Environmental Systems Research Institute

Barker et al. 2010. Population-based strategies for surveillance site allocation; *Proc Mosq Vec Control Assoc of California*, 78: 27-28.