



Mapping the risk of *Aedes aegypti* larval habitats using tree cover in Puntarenas, Costa Rica



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Tree cover and other characteristics of urban structure have been associated in urban environments with abundance and productivity of *Aedes aegypti* and other mosquito larval habitats. Tree cover can conceal containers, protect them from direct sunlight and desiccation, provide debris for larval nutrition, and promote adult survival by providing resting sites.^{1,2,3}

Dengue is the most important arboviral disease worldwide in terms of morbidity and mortality,⁴ and *Ae. aegypti* is the principal vector. Dengue is the main vector-borne disease in Costa Rica, and it is currently considered a serious public health problem.⁵ The purpose of this study was to create and evaluate predictive maps for *Ae. aegypti* larval habitats in the Greater Puntarenas Area, Costa Rica (Fig. 1), which employed parameters from linear regression models that had been obtained previously.



Fig. 1. Greater Puntarenas, Costa Rica. Color composite created from Quickbird multispectral bands.

Materials and Methods

Linear regression models that had been developed using a geographical sampling method in Puntarenas, Costa Rica were used.⁶ The number of mosquito larval habitats showed a significant association with tree cover (TREE) when corrected by the number of locations evaluated (LOCE) in grid cells. In addition, the model for *Ae. aegypti* container index was also significant:

$$\# \text{ larval habitats} = -10.187 + 35.933(\text{TREE}) + 1.716(\text{LOCE})$$

$$R^2 = 0.650, F = 28.75, p < 0.001$$

$$\text{Ae. aegypti container index} = 36.544 - 38.295(\text{TREE}) - 0.550(\text{LOCE})$$

$$R^2 = 0.188, F = 3.59, p = 0.040$$

To determine the proportion of tree cover and approximate number of locations in all of Greater Puntarenas, a grid of 50 by 50 m cells was employed to extract tree cover and built area data from a land cover map obtained using wet season Quickbird satellite imagery (2.4 m spatial resolution) (Fig. 2). Parameters from the significant regression models were used to determine the expected number of *Ae. aegypti* larval habitats in all cells that cover Greater Puntarenas: maps were created for the expected number of "wet containers" (potential larval habitats) (Fig. 3), *Ae. aegypti* container index (Fig. 4), and expected number of *Ae. aegypti* positive larval habitats per cell (Fig. 5).

The final map for expected number of larval habitats containing *Ae. aegypti* was evaluated during the wet season of 2010 by performing entomological field evaluations on 40 randomly selected 40 cells (Figs. 6), as has been described previously.⁵ All larval habitats within cells were identified, and a sample of mosquito larvae was collected when present in order to identify *Ae. aegypti*. The number of *Ae. aegypti* positive larval habitats was determined for each cell and compared to the expected number of habitats obtained from the maps.

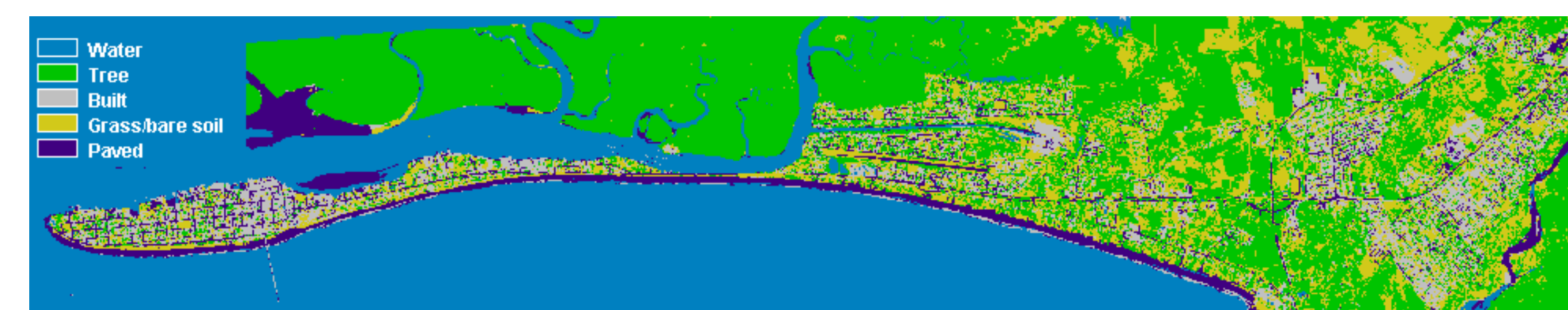


Fig. 2. Land cover map of Greater Puntarenas, Costa Rica.

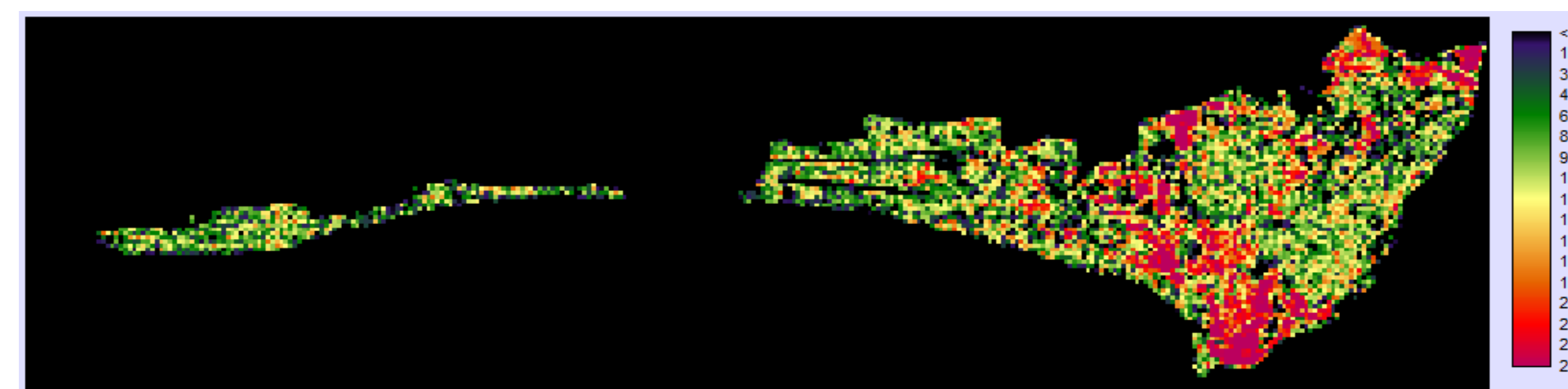


Fig. 3. Expected wet containers in Greater Puntarenas, Costa Rica.

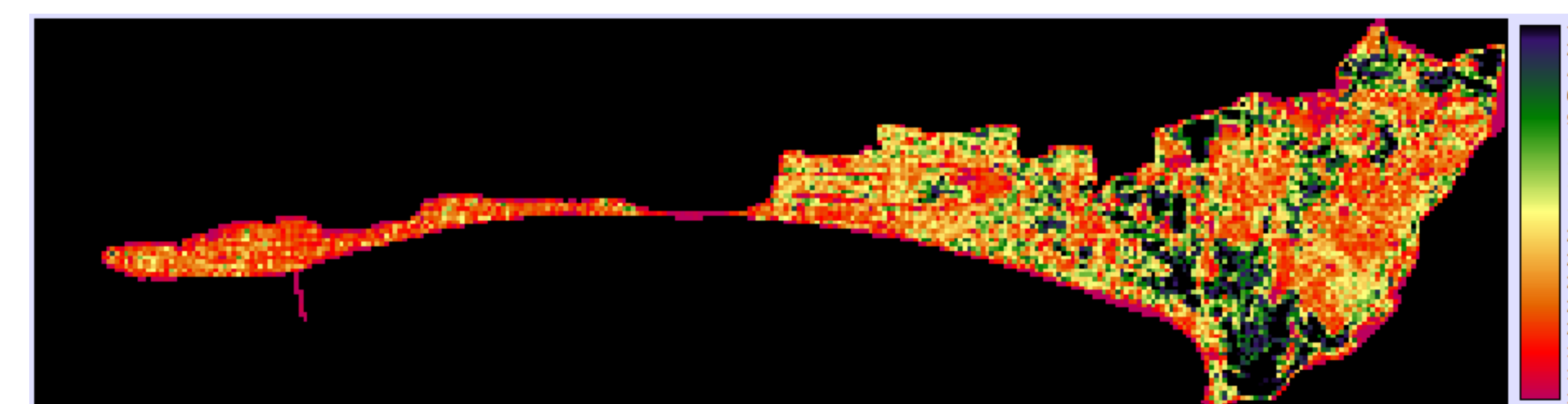


Fig. 4. Expected *Ae. aegypti* container index in Greater Puntarenas, Costa Rica.

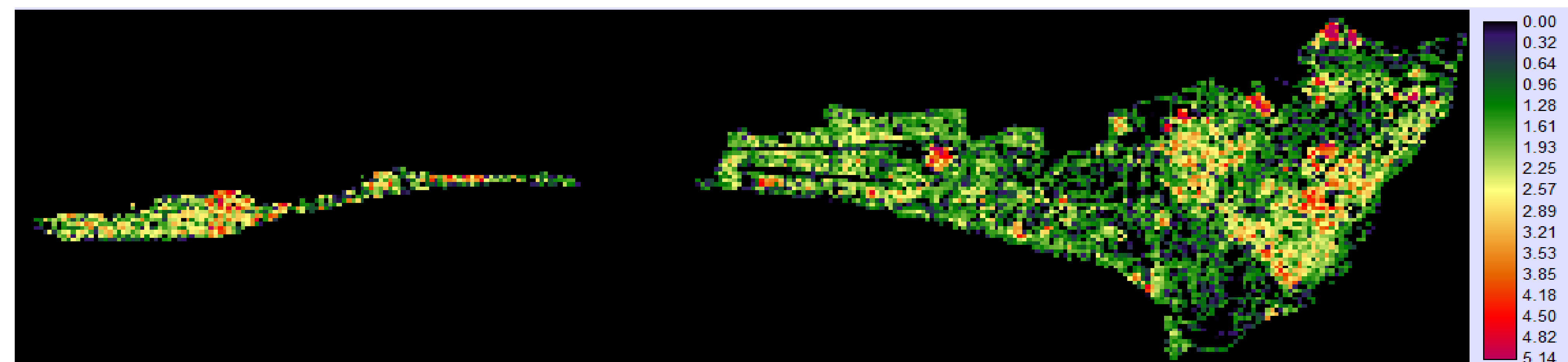


Fig. 5. Expected *Ae. aegypti*-positive containers per 50 by 50 m cells in Greater Puntarenas, Costa Rica.

Conclusions

Results show that vegetation cover can be used to generate adequate predictions of *Ae. aegypti* larval habitats in Greater Puntarenas, Costa Rica. Although tree cover can directly affect mosquitoes and suitability of larval habitats,^{1,2} it can also reflect local conditions that increase the likelihood of finding larval habitats (such as larger back yards with shaded and concealed areas).³ The predictive maps generated were able to partially estimate the number of *Ae. aegypti* larval habitats within +/- 2 habitats in 72.5% of cells. Considering the potential effect of ongoing vector control, it is possible to conclude that the presence of positive habitats was underestimated significantly only in 15% of cells, which can be considered the more serious errors for decision making. Since dengue incidence in Puntarenas has also been associated with tree cover,⁷ these maps can be used as a surveillance tool and to determine key areas within Greater Puntarenas where dengue vector control efforts can be directed due to a greater number of breeding sites expected. Maps such as these can be especially useful in locations where vector surveillance is difficult or lacking. To our knowledge, this is the first study to map expected *Ae. aegypti* larval habitats in urban areas utilizing high resolution satellite imagery and tree cover. This approach may be applicable to other urban areas in Costa Rica and the Region, where dengue is a serious public health problem.

Results

- 119 locations (86%) were evaluated in the 40 cells, and 241 wet habitats were identified
- *Ae. aegypti* container index was 19.5%, and Breteau location index was 39.5.
- The expected number of wet containers in all sample cells fell within the 95% confidence interval of predicted values.
- Only 13 cells (32.5%) harbored the exact number of expected *Ae. aegypti* positive habitats, although 23 (57.5%) contained the expected number +/- 1 habitat.
- In an additional 11 cells (27.5%), the predictive map overestimated the number of positive habitats by more than 1.
- In only 5 cells (12.5%), the estimate was greater than the observed by more than 2 habitats.
- In the remaining 6 cells (15%), the map underestimated the number of *Ae. aegypti* positive habitats by more than 1.

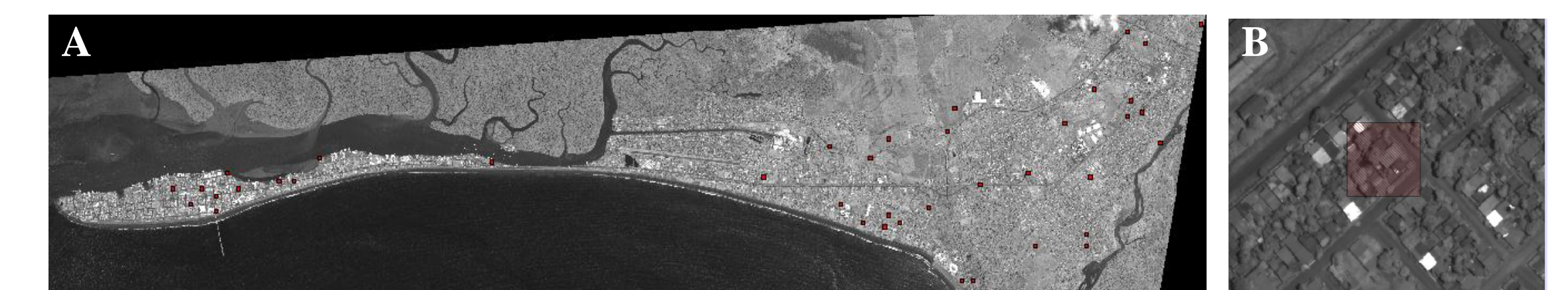


Fig. 6. A: Cells selected for entomological field evaluations in Greater Puntarenas, Costa Rica. B: Detail of a 50 by 50 m cell evaluated.

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