Supplementary Materials

Integrating Drone Imagery into High Resolution Satellite Remote Sensing Assessments of Estuarine Environments

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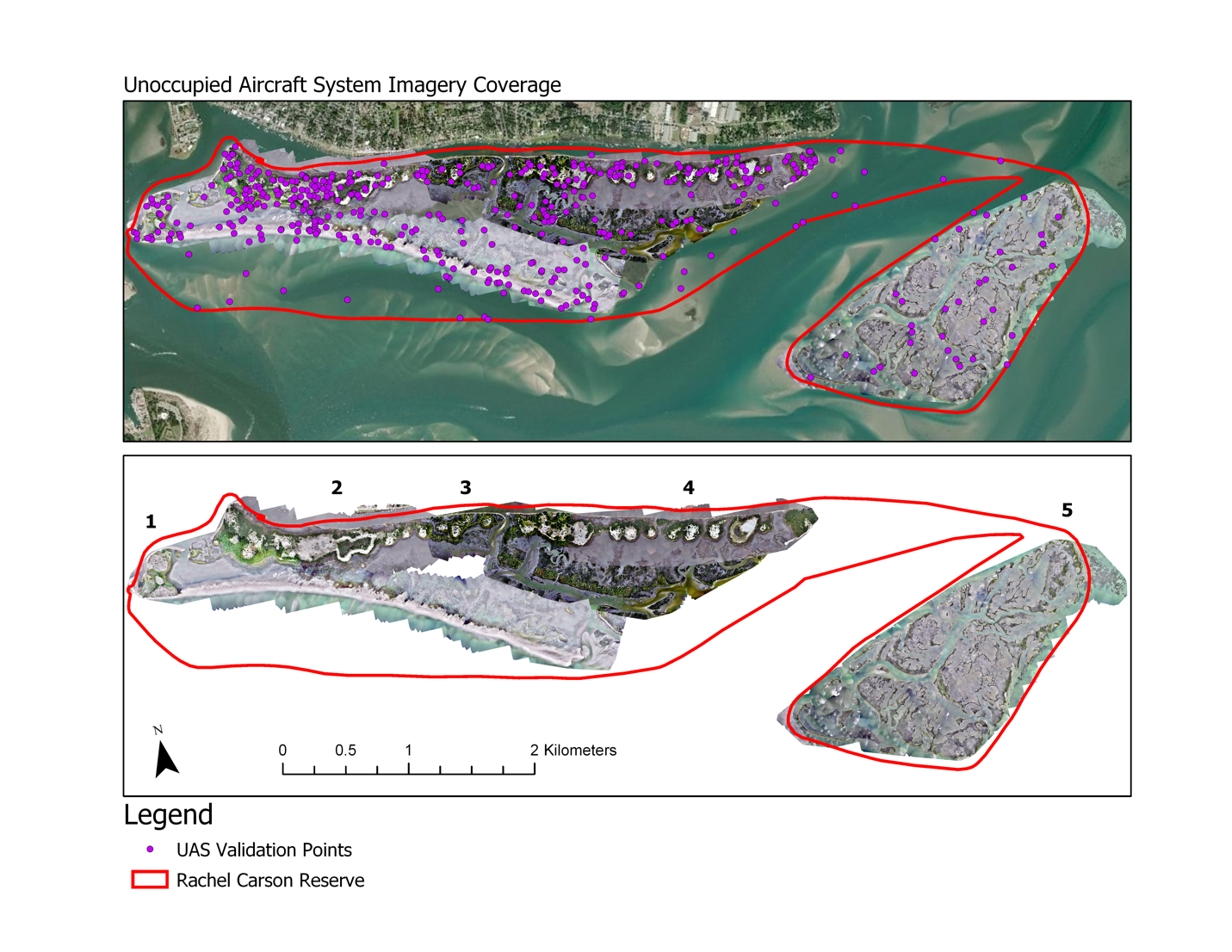
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**Abstract:** Very high-resolution satellite imagery (≤5 m resolution) has become available on a spatial and temporal scale appropriate for dynamic wetland management and conservation across large areas. Estuarine wetlands have the potential to be mapped at a detailed habitat scale with a frequency that allows immediate monitoring after storms, in response to human disturbances, and in the face of sea-level rise. Yet mapping requires significant fieldwork to run modern classification algorithms and estuarine environments can be difficult to access and are environmentally sensitive. Recent advances in unoccupied aircraft systems (UAS, or drones), coupled with their increased availability, present a solution. UAS can cover a study site with ultra-high resolution (<5 cm) imagery allowing visual validation. In this study we used UAS imagery to assist training a Support Vector Machine to classify WorldView-3 and RapidEye satellite imagery of the Rachel Carson Reserve in North Carolina, USA. UAS and field-based accuracy assessments were employed for comparison across validation methods. We created and examined an array of indices and layers including texture, NDVI, and a LiDAR DEM. Our results demonstrate classification accuracy on par with previous extensive fieldwork campaigns (93% UAS and 93% field for WorldView-3; 92% UAS and 87% field for RapidEye). Examining change between 2004 and 2017, we found drastic shoreline change but general stability of emergent wetlands. Both WorldView-3 and RapidEye were found to be valuable sources of imagery for habitat classification with the main tradeoff being WorldView’s fine spatial resolution versus RapidEye’s temporal frequency. We conclude that UAS can be highly effective in training and validating satellite imagery.

**Keywords:** drones; unoccupied aircraft systems; RapidEye; WorldView-3; estuarine; wetland; change detection; LiDAR; NERR; habitat mapping



**Figure S1.** Unoccupied Aircraft System (UAS) imagery of the Rachel Carson Reserve. Top shows the outline of the Reserve with all mosaics, UAS validation points, and a base map of satellite imagery for reference. Bottom shows just the outline of the Reserve and the UAS mosaics labeled by flight number. Note: all validation points not covered by UAS imagery were clear subtidal haline points and thus did not need additional resolution beyond that of the satellite imagery to determine class.

**Table S1.** Full confusion matrices for unoccupied aircraft system and field-based validations.

**I**n the excel “Table S1 Full confusion matrices for unoccupied aircraft system and field-based validations.xlsx”.

**Table S2.** Flight details forunoccupied aircraft system (UAS) imagery of the Rachel Carson Reserve.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Flight # | Survey Area | UAS Type | Camera | Ground Sampling Distance (m) | Date |
| 1 | Bird Shoal | eBee Plus | S.O.D.A | 0.025 | 09/14/2017 |
| 2 | Town Marsh | eBee | Canon IXUS 127HS | 0.027 | 10/12/2016 |
| 3 | Carrot Island | eBee | Canon S110 | 0.026 | 09/24/2016 |
| 4 | Carrot Island | eBee | Canon IXUS 127HS | 0.026 | 10/12/2016 |
| 5 | Middle Marsh | eBee | Canon S110 | 0.031 | 08/12/2016 |

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