The SECAS Third Thursday Web Forum

Developing standardized geospatial metrics for salt marsh management and restoration
Agenda

- Introduction
- Monthly topic
- Q&A and discussion
- Preview of next webinar
- Staff updates
Developing standardized geospatial metrics for salt marsh management and restoration

Neil Ganju, Woods Hole Coastal and Marine Science Center

5-19-2022
Developing standardized geospatial metrics for salt marsh management and restoration

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Salt marshes: biogeomorphic features with increasingly significant value

16,000 km² of salt marsh in USA

Valuable habitat, carbon stock, and coastal protection

Large body of work on marsh vertical response to external conditions and stressors

But…marsh loss is ultimately a three-dimensional process

Sea-level rise, waves, and sediment deficits responsible for widespread marsh loss
Sediment budgets as an indicator of wetland trajectory

- An expanding marsh must import sediment to keep up with SLR and wave erosion
- A contracting marsh will export sediment as marsh plain is lost to tidal flats and channels
- Therefore the sediment budget is a proxy for trajectory; negative sediment budget indicates instability
- Can we measure the sediment budget in main tidal channels to diagnose instability?
Net sediment budget highly correlated with UnVegetated-Vegetated Ratio

- Net budget measured at 8 sites nationally
- UVVR determined using aerial imagery over marsh
- All sites in deficit!
- Tipping point ~ 0.10
- Further independent studies suggest thresholds between 0.10 and 0.15

Ganju et al. 2017
Wasson et al., 2020: UVVR > 0.15 indicates greater instability

- A “stable” marsh has an optimal UVVR
- Instability increases the UVVR
- Once unstable, runaway expansion creates a faster change in UVVR as UVVR increases
National UVVR at 30-m resolution
- Fractional vegetation cover and UVVR across coastal wetlands
- Composite and annual value for 2014-2018 period
- Data access: Couvillion et al., 2021
- Development and application: Ganju et al., 2022
Important caveats about satellite-based UVVR!

It is accounting for the signal within a 30 x 30 m pixel.

It accounts for bare sediment within the pixel, i.e., a sparsely vegetated plain will get a higher UVVR than a densely vegetated plain.

Some areas of SC and GA fall into this category.

Therefore be careful comparing regions, safest to use comparatively within a region/system.
Important caveats about satellite-based UVVR!

Open water areas larger than 30 x 30 m are excluded and given no value.

If we want to neglect open water and get an idea of UVVR of just marsh plains: $UVVR_{lo}$

If we want to consider open water and large-scale fragmentation of complexes, aggregate over wetland areas and include open water: $UVVR_{hi}$

The difference between these two will also tell you something about internal marsh plain density vs. open-water fragmentation.
## Estuary-by-estuary aggregation

<table>
<thead>
<tr>
<th>Name of domain</th>
<th>State</th>
<th>Total area (km²)</th>
<th>( \text{UVVR}_{10} )</th>
<th>( \text{UVVR}_{90} )</th>
<th>Vegetated fraction</th>
<th>Vegetated area (km²)</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chesapeake Bay</td>
<td>DE, MD, VA</td>
<td>1266</td>
<td>0.17</td>
<td>0.25</td>
<td>0.80</td>
<td>1014</td>
<td>6.2%</td>
</tr>
<tr>
<td>Albemarle and Pamlico Sounds</td>
<td>NC, VA</td>
<td>874</td>
<td>0.06</td>
<td>0.08</td>
<td>0.93</td>
<td>809</td>
<td>5.0%</td>
</tr>
<tr>
<td>Delaware Bay</td>
<td>NJ, PA, DE</td>
<td>593</td>
<td>0.19</td>
<td>0.23</td>
<td>0.81</td>
<td>481</td>
<td>3.0%</td>
</tr>
<tr>
<td>Barataria Bay</td>
<td>LA</td>
<td>689</td>
<td>0.12</td>
<td>0.50</td>
<td>0.67</td>
<td>459</td>
<td>2.8%</td>
</tr>
<tr>
<td>Terrebonne Bay</td>
<td>LA</td>
<td>695</td>
<td>0.25</td>
<td>0.74</td>
<td>0.57</td>
<td>399</td>
<td>2.4%</td>
</tr>
<tr>
<td>Wax Lake Delta, Atchafalaya</td>
<td>LA</td>
<td>344</td>
<td>0.01</td>
<td>0.08</td>
<td>0.93</td>
<td>319</td>
<td>2.0%</td>
</tr>
<tr>
<td>St. Helena Sound</td>
<td>SC</td>
<td>458</td>
<td>0.61</td>
<td>0.68</td>
<td>0.59</td>
<td>272</td>
<td>1.7%</td>
</tr>
<tr>
<td>Timucuan Preserve</td>
<td>FL</td>
<td>236</td>
<td>0.26</td>
<td>0.32</td>
<td>0.76</td>
<td>179</td>
<td>1.1%</td>
</tr>
<tr>
<td>Plaquemines-Balize Delta</td>
<td>LA</td>
<td>204</td>
<td>0.11</td>
<td>0.36</td>
<td>0.74</td>
<td>150</td>
<td>0.9%</td>
</tr>
<tr>
<td>Ossabaw Sound</td>
<td>GA</td>
<td>211</td>
<td>0.41</td>
<td>0.43</td>
<td>0.70</td>
<td>147</td>
<td>0.9%</td>
</tr>
<tr>
<td>Mississippi Sound</td>
<td>MS</td>
<td>173</td>
<td>0.11</td>
<td>0.19</td>
<td>0.84</td>
<td>146</td>
<td>0.9%</td>
</tr>
<tr>
<td>Barnegat and Great Bays</td>
<td>NJ</td>
<td>181</td>
<td>0.22</td>
<td>0.29</td>
<td>0.77</td>
<td>140</td>
<td>0.9%</td>
</tr>
<tr>
<td>San Francisco Bay</td>
<td>CA</td>
<td>162</td>
<td>0.19</td>
<td>0.32</td>
<td>0.76</td>
<td>123</td>
<td>0.8%</td>
</tr>
<tr>
<td>Galveston Bay</td>
<td>TX</td>
<td>122</td>
<td>0.21</td>
<td>0.29</td>
<td>0.78</td>
<td>95</td>
<td>0.6%</td>
</tr>
<tr>
<td>DE/MD/VA Coastal Bays</td>
<td>DE, MD, VA</td>
<td>130</td>
<td>0.33</td>
<td>0.45</td>
<td>0.69</td>
<td>90</td>
<td>0.5%</td>
</tr>
<tr>
<td>Columbia River</td>
<td>OR</td>
<td>86</td>
<td>0.10</td>
<td>0.16</td>
<td>0.86</td>
<td>74</td>
<td>0.5%</td>
</tr>
<tr>
<td>Mobile Bay</td>
<td>AL</td>
<td>55</td>
<td>0.09</td>
<td>0.12</td>
<td>0.89</td>
<td>49</td>
<td>0.3%</td>
</tr>
</tbody>
</table>
We aggregate vegetation fraction of pixels inside the estuary’s hydrologic unit(s) and wetland classes, then convert to UVVR.

If we include all the open water, we get $\text{UVVR}_{\text{hi}} = 0.08$.

If we only consider marsh plain pixels and exclude open water greater than 30 x 30 m, we get $\text{UVVR}_{\text{lo}} = 0.06$.

For this area, indicates intact marsh plains and little fragmentation.
We aggregate vegetation fraction of pixels inside the estuary’s hydrologic unit(s) and wetland classes, then convert to UVVR.

If we include all the open water, we get $\text{UVVR}_{\text{hi}} = 0.68$.

If we only consider marsh plain pixels and exclude open water greater than 30 x 30 m, we get $\text{UVVR}_{\text{lo}} = 0.61$.

For this area, indicates degraded and fragmented marsh plains (but also sparse vegetation).
State-by-state aggregation

<table>
<thead>
<tr>
<th>State</th>
<th>Total area (km²)</th>
<th>UVVR_{lo}</th>
<th>UVVR_{hi}</th>
<th>Vegetated fraction</th>
<th>Vegetated area (km²)</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Louisiana</td>
<td>6843</td>
<td>0.10</td>
<td>0.31</td>
<td>0.76</td>
<td>5228</td>
<td>32.1%</td>
</tr>
<tr>
<td>Florida</td>
<td>4607</td>
<td>0.08</td>
<td>0.12</td>
<td>0.89</td>
<td>4113</td>
<td>25.3%</td>
</tr>
<tr>
<td>South Carolina</td>
<td>1911</td>
<td>0.52</td>
<td>0.58</td>
<td>0.63</td>
<td>1213</td>
<td>7.5%</td>
</tr>
<tr>
<td>Georgia</td>
<td>1640</td>
<td>0.46</td>
<td>0.49</td>
<td>0.67</td>
<td>1099</td>
<td>6.8%</td>
</tr>
<tr>
<td>Texas</td>
<td>1151</td>
<td>0.22</td>
<td>0.28</td>
<td>0.78</td>
<td>898</td>
<td>5.5%</td>
</tr>
<tr>
<td>North Carolina</td>
<td>992</td>
<td>0.14</td>
<td>0.18</td>
<td>0.85</td>
<td>842</td>
<td>5.2%</td>
</tr>
<tr>
<td>Maryland</td>
<td>850</td>
<td>0.18</td>
<td>0.24</td>
<td>0.80</td>
<td>684</td>
<td>4.2%</td>
</tr>
<tr>
<td>New Jersey</td>
<td>772</td>
<td>0.24</td>
<td>0.30</td>
<td>0.77</td>
<td>593</td>
<td>3.6%</td>
</tr>
<tr>
<td>Virginia</td>
<td>811</td>
<td>0.33</td>
<td>0.50</td>
<td>0.67</td>
<td>542</td>
<td>3.3%</td>
</tr>
<tr>
<td>Delaware</td>
<td>278</td>
<td>0.16</td>
<td>0.21</td>
<td>0.83</td>
<td>230</td>
<td>1.4%</td>
</tr>
<tr>
<td>Mississippi</td>
<td>246</td>
<td>0.09</td>
<td>0.13</td>
<td>0.89</td>
<td>218</td>
<td>1.3%</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>154</td>
<td>0.13</td>
<td>0.27</td>
<td>0.79</td>
<td>122</td>
<td>0.7%</td>
</tr>
<tr>
<td>Washington</td>
<td>136</td>
<td>0.23</td>
<td>0.31</td>
<td>0.76</td>
<td>104</td>
<td>0.6%</td>
</tr>
<tr>
<td>Oregon</td>
<td>100</td>
<td>0.10</td>
<td>0.16</td>
<td>0.86</td>
<td>86</td>
<td>0.5%</td>
</tr>
<tr>
<td>Alabama</td>
<td>96</td>
<td>0.10</td>
<td>0.14</td>
<td>0.88</td>
<td>84</td>
<td>0.5%</td>
</tr>
<tr>
<td>Maine</td>
<td>90</td>
<td>0.10</td>
<td>0.25</td>
<td>0.80</td>
<td>72</td>
<td>0.4%</td>
</tr>
<tr>
<td>New York</td>
<td>95</td>
<td>0.41</td>
<td>0.62</td>
<td>0.62</td>
<td>59</td>
<td>0.4%</td>
</tr>
<tr>
<td>California</td>
<td>61</td>
<td>0.22</td>
<td>0.38</td>
<td>0.73</td>
<td>44</td>
<td>0.3%</td>
</tr>
<tr>
<td>Connecticut</td>
<td>39</td>
<td>0.25</td>
<td>0.47</td>
<td>0.68</td>
<td>27</td>
<td>0.2%</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>20</td>
<td>0.13</td>
<td>0.26</td>
<td>0.79</td>
<td>16</td>
<td>0.1%</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>9</td>
<td>0.27</td>
<td>0.61</td>
<td>0.62</td>
<td>6</td>
<td>0.0%</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>2</td>
<td>0.15</td>
<td>0.29</td>
<td>0.77</td>
<td>2</td>
<td>0.0%</td>
</tr>
<tr>
<td>Total</td>
<td>20903</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>16,281</td>
<td>100%</td>
</tr>
</tbody>
</table>

South Atlantic LCC encompasses ~30% of nation’s coastal wetland areas

Florida the overall winner for wetland integrity, likely due to dense canopies of mangrove in southern areas of the state
Applications of the UVVR

• Assessing tidal wetland change across site and regional scales
• Identifying vulnerable areas using annual variability
• Hypothetical decision matrix: using UVVR and elevation
• Comparing vertical trends with UVVR across the Southeast
Assessing tidal wetland change: mangrove dieback from *Irma* (2017)

Storm surge, wind, ponding caused dieback in SW Florida, especially near Flamingo.

Lagomasino et al. (2021) documented loss in canopy height and vegetative cover using lidar, aerial imagery, and Landsat (3 month interval).

Annual Landsat data captures loss as well, and gives baseline data across regional scales.
Assessing tidal wetland change: sediment placement in Louisiana

Two sediment placement projects near Lake Pontchartrain, as part of USACE mitigation

Sediment placed in bare/open-water areas

Both areas saw over 40% increase in vegetated area in 3 years

Given widespread restoration efforts, comprehensive data across region simplifies tracking project success
Applications of the UVVR

• Assessing tidal wetland change across site and regional scales
• Identifying vulnerable areas using annual variability
• Hypothetical decision matrix: using UVVR and elevation
• Comparing vertical trends with UVVR across the Southeast
Identifying vulnerable areas: Mackay Island NWR, NC

Recall we have a UVVR value at each pixel for each year, 2014-2018.

Can we use the fluctuation in UVVR to establish stability and certainty at the same time?

Use the threshold value of 0.15 for both composite value and 5-year standard deviation.
Identifying vulnerable areas: Mackay Island NWR, NC

Each dot represents 30 m pixel, with five-year composite value vs. standard deviation

**Class 1** pixels are consistently below stability threshold of 0.15 (i.e. good), and don’t fluctuate much

**Class 2** areas are below stability threshold of 0.15 but there are big annual outliers (e.g. overwash event, dieback)

**Class 3** areas are above stability threshold of 0.15 and there are large annual fluctuations (water levels, controlled burn)

**Class 4** areas are consistently above stability threshold of 0.15, and they don’t fluctuate much
Identifying vulnerable areas: Mackay Island NWR, NC

Unstable, low uncertainty: 13% Areas at risk

Unstable, high uncertainty: 15% Managed impoundments and open water areas

Stable, high uncertainty: 1% Not significant

Stable, low uncertainty: 71% Areas with intact marsh plain
Applications of the UVVR

- Assessing tidal wetland change across site and regional scales
- Identifying vulnerable areas using annual variability
- Hypothetical decision matrix: using UVVR and elevation
- Comparing vertical trends with UVVR across the Southeast
Determining strategies: hypothetical decision matrix

UVVR

Elevation

High

Low

Protect

Monitor

Restore

Do nothing
Protect
Monitor
Restore
Do nothing
Applications of the UVVR

• Assessing tidal wetland change across site and regional scales

• Identifying vulnerable areas using annual variability

• Hypothetical decision matrix: using UVVR and elevation

• Comparing vertical trends with UVVR across the Southeast
Comparing SET vertical trends with UVVR across the Southeast

Eighteen FWS-SER SET sites
Differentiated by vegetation type
SLR range = 2 to 5 mm/y
Elevation change = -10 to 7 mm/y
Full disclosure: I have been critical of SETs in the past…
Outliers (black circles)

SMK: UVVR currently including large swaths of upland forest, UVVR should increase in revision

RRV and POC: UVVR not ideal for forested and pocosin wetlands with significant canopy cover
WAW: Waccamaw NWR, South Carolina

SET trend > 7 mm/y

UVVR nearly 0, i.e. completely vegetated

Robust marsh plain promotes vertical stability, through organic burial, sediment trapping, encouraging stability of the substrate.
HSN: Harris Neck NWR, Georgia

SET trend ~ 1 mm/y

UVVR ~ 1, i.e. half vegetated (not good)

Degraded marsh plain prevents vertical stability, through reduced organic burial, sediment export, and weakening of the substrate.
Objective, spatially integrative metrics for CONUS

Geospatial analysis: stability and the UVVR
- Formalized and standardized method
- Customizable on multiple scales
- Based on field studies, bolstered by recent modeling and analysis

Guiding management and restoration
- Selecting the best strategies
- Objectively quantifying vulnerability
- Tracking restoration success and episodic loss

Future progress and challenges
- Extending UVVR back to 1985, and onwards with newer satellites
- Optimizing efforts across projects and agencies
- Producing science from wealth of data
Data access

ScienceBase
• For the geospatial user
• All years of data, for all three coasts

Coastal Change Hazards Portal
• For quick exploration, show-and-tell
• 5-year average value, with click-and-display

Coastal Wetland Synthesis Storymap
• Background and publications
• Links to all UVVR data and viewers
Lifespan: a universal metric for planning

Combines SLR, elevation, and UVVR into easily digestible metric

Represents timescale of when a marsh parcel must cannibalize its own sediment to keep pace with SLR

Customizable for different SLR scenarios and restoration actions

Provides powerful tool for messaging the importance of restoring natural conditions

MD: ditched

VA: unditched
Collaborative conservation of coastal marsh systems: A science update from the Atlantic Coast Joint Venture
Staff updates

- Wrapping up workshops
Wrapping up workshop

• Last of 16 virtual workshops wrapping up right now

• Look for a blog in the May newsletter summarizing the feedback we received

• Already exploring improvements to the data and methods based on input

• Final Southeast Blueprint planned for release this fall in time for SEAFWA
How to get involved in SECAS

• Sign up for the SECAS newsletter
  secassoutheast.org

• Connect with SECAS staff or partners
  secassoutheast.org/staff
  secassoutheast.org/partners

• Explore the Southeast Conservation Blueprint
  secassoutheast.org/blueprint
Questions?