Salt marshes can be extremely hard to access, making monitoring these important habitats difficult. Remote sensing and GIS have greatly improved the ability of researchers to study salt marshes. Through the years scientists have used remote sensing and GIS to monitor marshes in different ways. This technology has been used to figure out the changes in the area of a marsh, plant species differentiation, and figuring out the soil elevation of the marsh.

One relatively simple but extremely useful use of GIS and remote sensing is for documenting changes of the marsh area over time. Through manual digitizing, heads up digitizing, or scanning, the area of the salt marsh can be digitized into GIS from aerial photographs. By going through this process for aerial photographs from at least two different times, you can see how the size of the marsh has changed over time (Cooper et al., 2001). Further work can build off of this initial analysis. For example, researchers can take sediment samples at the same time. By comparing the samples to the change in the salt marsh, they can posit a relationship between changes in marsh size and certain sedimentary processes (Kastler & Wiberg, 1996).

Advancements in hyperspectral technology have, in turn, led to advancements in how researchers can monitor salt marshes. Perhaps the most important is the ability to create vegetation maps from this imagery. Though there is some classifying and analysis to be done, reliable vegetation maps can be created from multispectral and hyperspectral imagery (Belluco et al., 2006). Even by itself, this is important for salt marsh monitoring because it enables scientists to see which areas of the marsh are healthier than others and to see where invasive species, such as phragmites and Lythrum salicaria (purple loosestrife). These vegetation maps can also be used to develop elevation models.

Salt marsh elevation data is of particular importance. The elevation of the marsh can be an indicator for its potential for erosion. If the marsh sits too low, there can be issues with strong storms and with sea level rise. Since salt marshes are inundated with water at high tide, it can be quite difficult to establish elevations. Through understanding the nature of the plant species, researchers can determine at what elevations those species would thrive. Comparing that to the existing vegetation map, they can create a DEM (Silvestri et al., 2003). In the event that researchers don’t have the vegetation maps, either because they don’t need them or it is too costly, LiDar can be used to determine the marsh elevation relative to the tidal elevations (Yang, 2005).

Though it doesn’t quite fall under the monitoring category. GIS and remote sensing can be used to determine a salt marsh’s suitability for restoration. By looking at the vegetation maps and DEMs of a number of sites, researchers can determine which sites are best suited for a potential marsh restoration project (Millard et al., 2013).

While it is clear that GIS and remote sensing have dramatically increased the ability of researchers to monitor salt marshes, there is still work that needs to be done. Currently, the work done to create the vegetation maps is far from simple. End spectra have to be chosen and the work has to be ground trothed by observations in the field. This is because there currently is no spectral library for salt marsh plant species (Zomer et al., 2009). If there was, the only significant deterrent to creating the vegetation maps would be the cost of obtaining the hyperspectral imagery. The development of such a spectral library would greatly enhance the ability to monitor salt marsh species and elevation. It is especially
important to make that information more widely obtainable as we begin to see the effects of climate change and sea level rise.

Annotated Bibliography


Belluco et al. examine whether different salt marsh vegetation species can be individually identified using remote sensing. They do so using many multispectral and hyperspectral data sets and detailed field observations at Venice Lagoon in Italy. Their remote sensing data consisted of Reflective Optics System Imaging Spectrometer, Compact Airborne Spectrographic Imager, Multispectral Infrared and Visible Imaging Spectrometer, IKONOS, and QuickBird. They looked at this data with three classifiers, followed by analysis using original spectral bands, a reduced number of bands using an extraction algorithm, and a reduced number of broader bands using spectral averaging. The paper got a bit dense when going into detail on their accuracy assessment. When they compared their remote sensing data to their concurrent field observations, they found that overall reliable vegetation maps can be derived from remote sensing in tidal environments. However, they acknowledged that remote sensing mapping may be uncertain when it comes to identifying Juncus and Spartina, two salt marsh plant species.


In this study, Cooper et al. quantified the changes in salt marsh area in Essex, England. They looked at the current area of the salt and compared their data to a studies performed in 1973 and 1988. Despite the limitations of the technology at these times, overall the 1988 study provided good quality, high detailed mapping, so it was able to be used by the researchers as a baseline. They used 1998 aerial photographs at 1:5000 scale for the majority of the study area. For the areas it didn't cover, they used 1997 aerial photographs at 1:10000 scale. They mapped the area of salt marsh onto tracing paper, using only 80% of the photos to minimize the distortion at the edges of the photographs. Once they were finished mapping, they were digitized directly into GIS and displayed the 1988 study on the screen as a reference file. Then they were finally able to run spatial analysis to identify and quantify the salt marsh area in each year and determine the net loss. A study like this one is important because while knowing elevation of a marsh and its susceptibility to sea level rise is helpful, it is also good to how much marsh has already been lost and the rate at which it is eroding.


In this study, Kastler and Wiberg used GIS, remote sensing, and sediment collections to determine the relationship between changes in marsh area and sedimentary processes. They did their studies at a mainland fringing marsh, a lagoon marsh, and an island fringing marsh. At each site they compared aerial photographs from two dates using GIS in order to document the change in the marsh boundaries. The first photographs were selected based upon availability while the second photographs were color infrared photographs from 1990. For one year they collected monthly sediment samples. Overall they
found that sedimentation rates do not keep up with the marsh submergence rates. Though they did not see evidence of marsh degradation as a result, they noted the potential for erosion.


This paper, as the title suggests, goes through how Millard et al. used GIS and remote sensing to do a suitability analysis of salt marsh restoration sites. Their sites were located in the Bay of Fundy. Aware of the seasonal considerations of remote sensing, they collected LiDAR data in both May, before vegetation emergence, and August, at maximum vegetation biomass. This allowed them to run accurate models for bare earth and canopy height. In addition, they ran an accuracy assessment using GPS elevations. They used these models to produce a DEM. In addition, they visually interpreted vegetation zones from aerial photographs and Quickbird multispectral imagery. This process was done for two potential restoration sites as well a reference marsh. The relationship between elevation and vegetation zones from the reference marsh was used to determine the suitability of the potential restoration sites. It is interesting that papers published a decade earlier discuss the need for a spectral library. Apparently it still hasn’t been created as Millard et al. visually interpreted the imagery. One would think that if the spectral library was available they would have used it.


Silvestri et al. experiment with the use of remote sensing to infer salt marsh morphology. They used an airborne hyperspectral remote sensor to gather data on salt marsh species distribution of the San Lorenzo marsh in Venice Lagoon, Italy. After using a MIVIS sensor to gather the data, they processed the data and classified the data by applying a simple decision rule. At the time of this paper, no spectral libraries were available for salt marsh species, so they selected Spartine marittima, Limonium narbonense, and Sarcocornia fruticose as end-member spectra. As there was already an established relationship between salt marsh species and soil elevation, they ran their final vegetation data through a model to create a DEM. Like the other paper, it got a bit dense when going into the processing and sub-pixel analysis. Overall, however, the logic behind this paper was easy to follow and particularly interesting.


In this paper, Yang discusses advancements in the application of GIS and remote sensing for estuarine ecosystem analysis. He talked about how it has been used for coastal water quality indicators, submerged aquatic vegetation mapping, coastal wetland mapping, landscape structure, and integrated assessments of an estuarine ecosystem. At the time this paper was published, it had been recently found that spectral mixture analysis and multiple endmember spectral mixture analysis are both suitable for mapping the major components of a salt marsh. Also, it had been found through combining Light Detection and Ranging data with high-resolution imagery, the marsh elevation relative to tidal elevation can be computed. This can be important when determining a salt marsh’s vulnerability to sea level rise. Yang briefly mentioned the advancements that are still to come. Comprehensive spectral libraries for wetland plant species and developing efficient methods would greatly improve the use of Remote Sensing and GIS for salt marsh monitoring.

In this paper, Zomer et al. use advancements in remote sensing technology for wetlands mapping and monitoring. They used hyperspectral imagers on airborne platforms at five sites to create a spectral library for mapping wetlands. The development of libraries like this is key for using hyperspectral imagery for wetlands monitoring. Their conclusion is extremely thorough. In it they discuss the limitations of this technology and what will be needed for global use. The limitations include methodological issues, technical issues, data availability, and cost. Besides improving tools and methodology, a standardized classification system for wetlands should be adopted. Another improvement that would allow for global use would be eventually launching a space-borne hyperspectral instrument.