Assessing Ecosystem Health and Carbon Capture of Coastal Restoration

USING DRONES, REMOTE SENSING AND MACHINE LEARNING

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CDM Smith

Agenda

- Blue Carbon
- Study Overview
- Sensors
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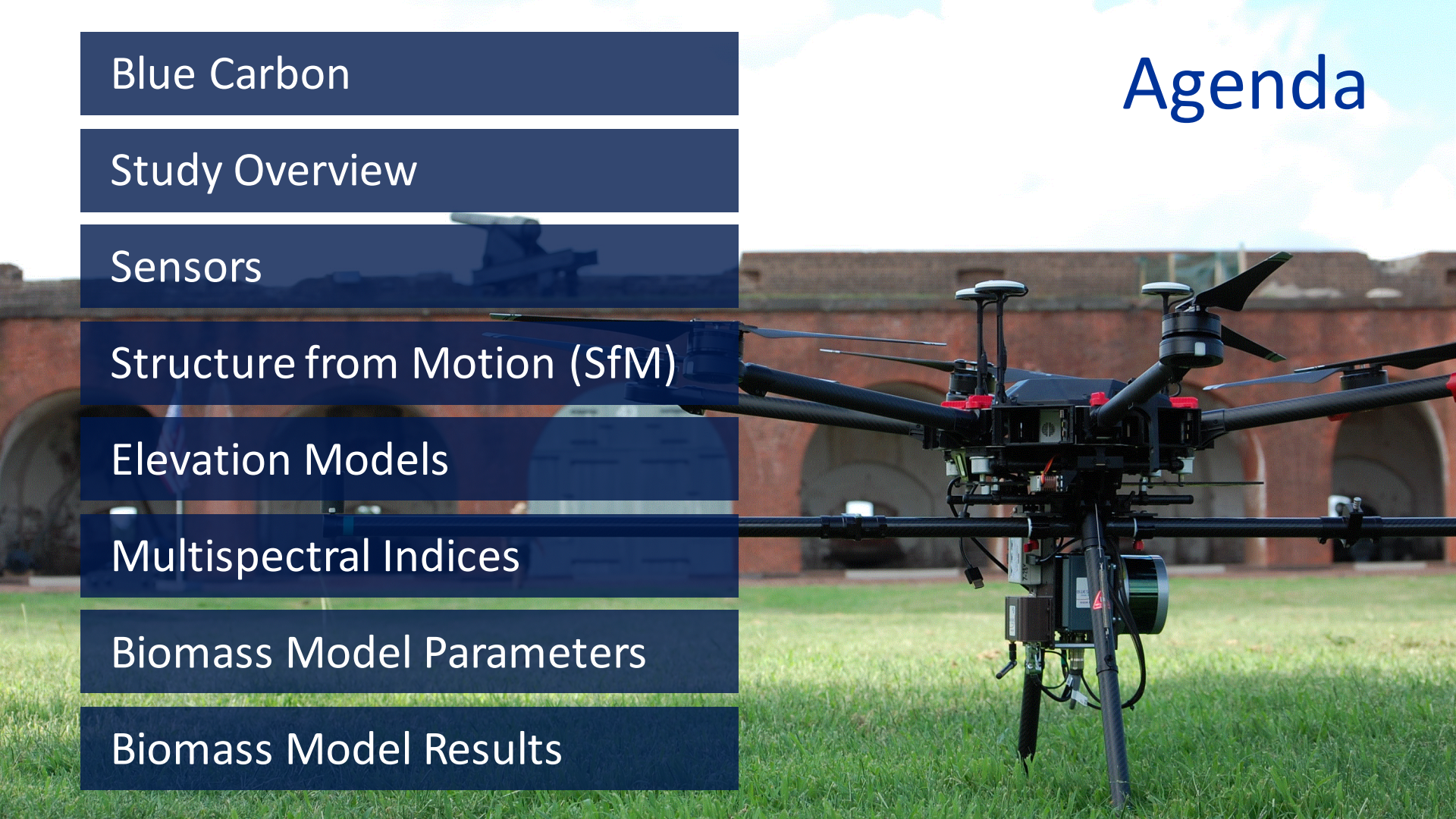
- Elevation Models
- Multispectral Indices
- Biomass Model Parameters
- Biomass Model Results



Blue Carbon

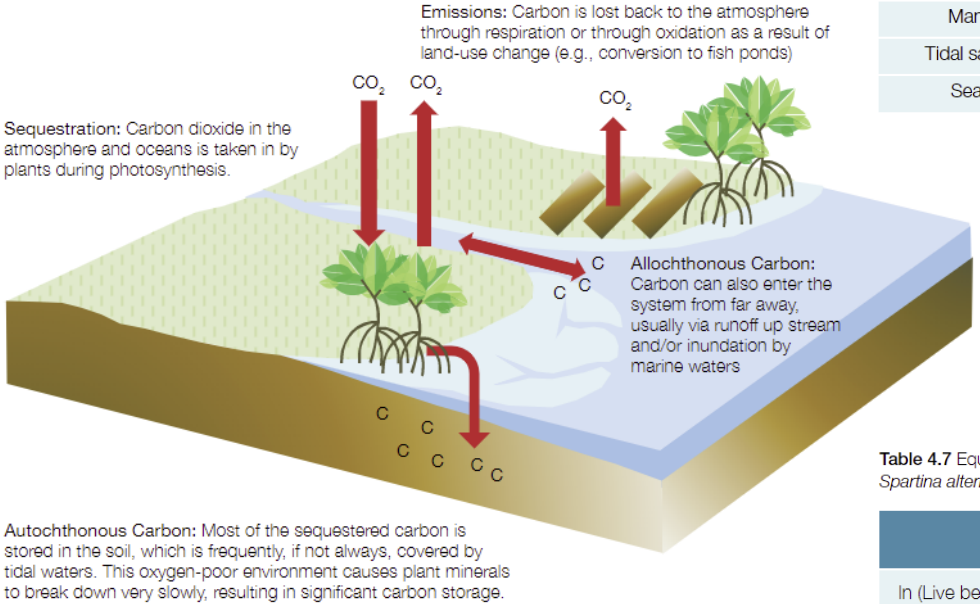


Table 1.2 Mean and range values of soil organic carbon stocks (to 1 m depth) for mangrove, tidal marsh, and seagrass ecosystems and CO_2 equivalents. Examples of how carbon is distributed amongst the different ecosystems and the variation within each ecosystem (IPCC 2013)

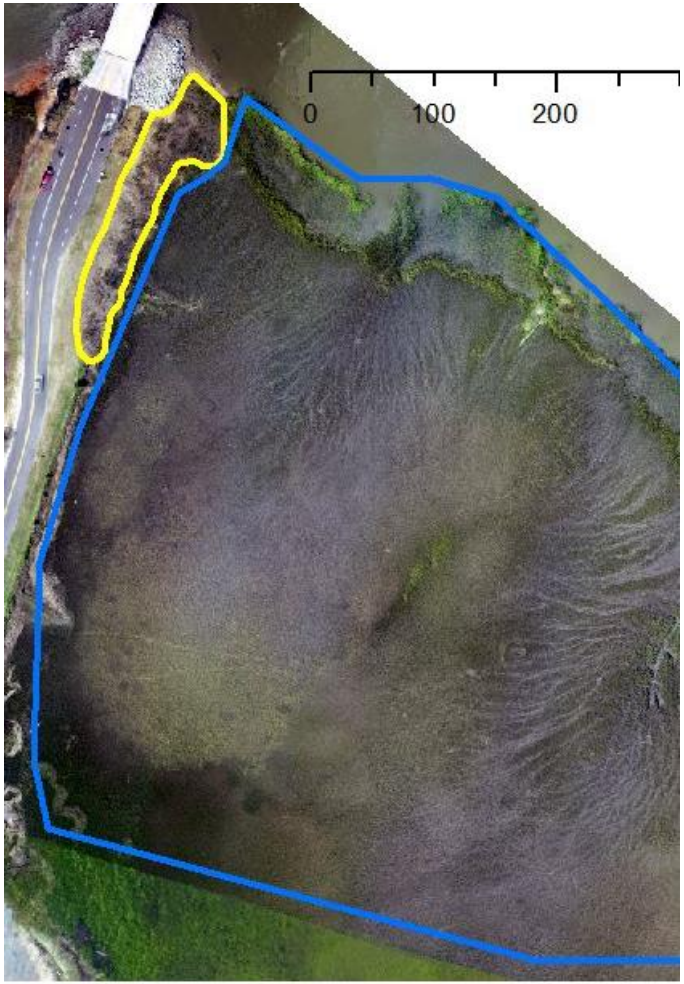
ECOSYSTEM	CARBON STOCK Mg/ha	RANGE Mg/ha	CO_2Mequiv/ha
Mangrove	386	55 – 1376	1415
Tidal salt marsh	255	16 – 623	935
Seagrass	108	10 – 829	396

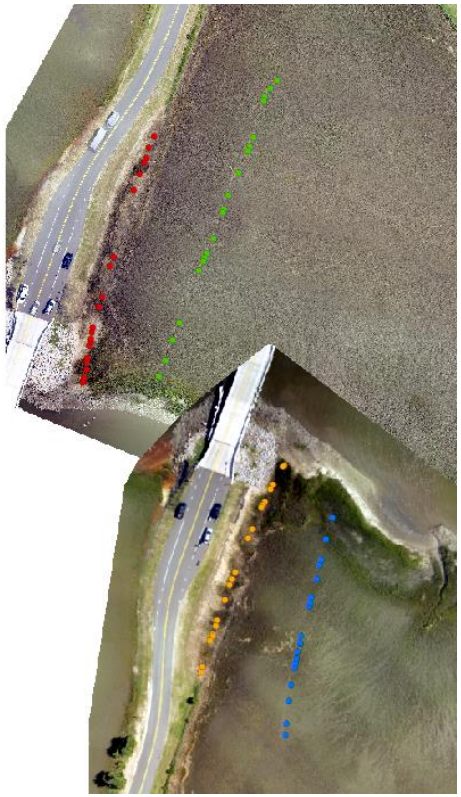
Table 4.7 Equations to predict belowground root and rhizome biomass on the basis of aboveground biomass of *Spartina alterniflora* (Gross *et al.* 1991)

EQUATION	ABOVE-GROUND COMPONENTS INCLUDED (FOR AN ENTIRE PLOT)	r^2
ln (Live belowground biomass, g) = 0.718 x ln (Live Aboveground biomass, g) + 2.646	Living leaves and stems	0.86
ln (Live Belowground biomass, g) = 0.700 x ln (Live Aboveground biomass, g) + 3.051	Living leaves only	0.85
ln (Live Belowground biomass, g) = 0.713 x ln (Total Aboveground biomass, g) + 2.235	All live and dead aboveground	0.86

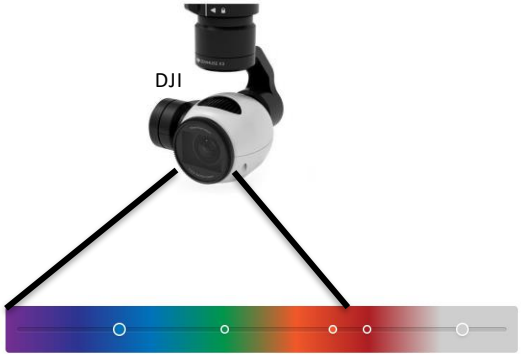
Source: the BLUE CARBON initiative
COASTAL BLUE CARBON methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrass meadows

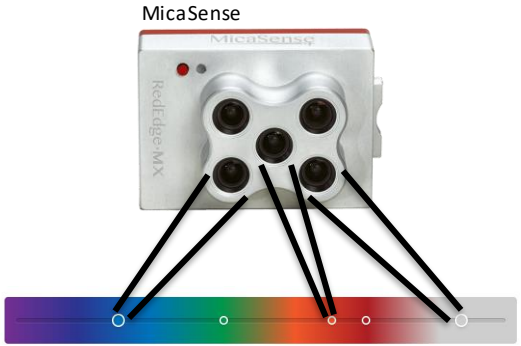
Study Overview

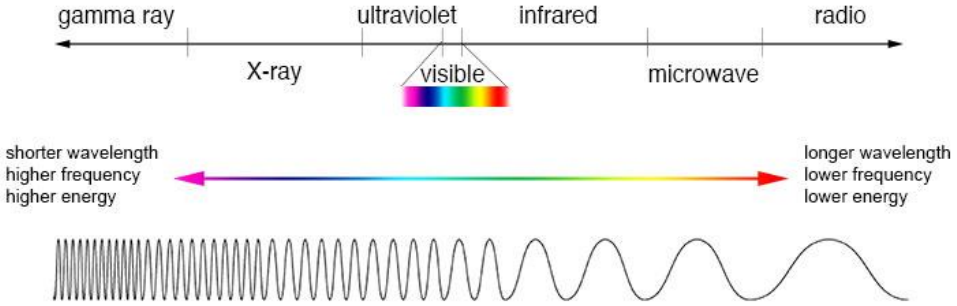


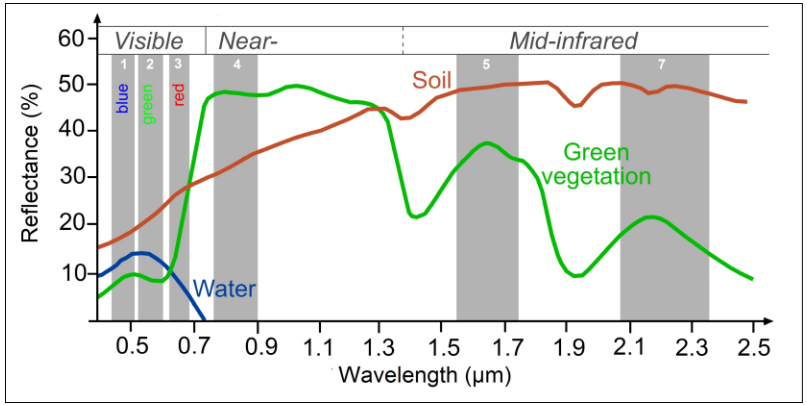


Sensors

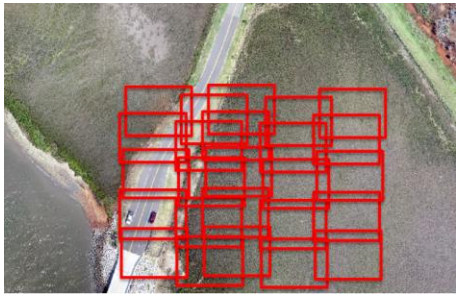

DJI

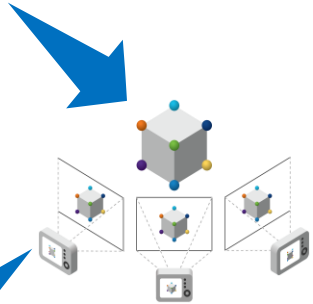

MicaSense
RedEdge-MX

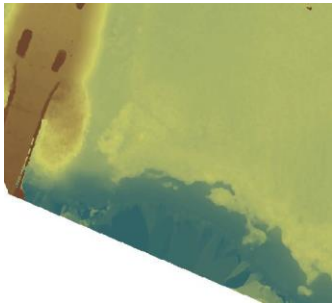

gamma ray
ultraviolet
infrared
radio
X-ray
visible
microwave
shorter wavelength
higher frequency
higher energy
longer wavelength
lower frequency
lower energy

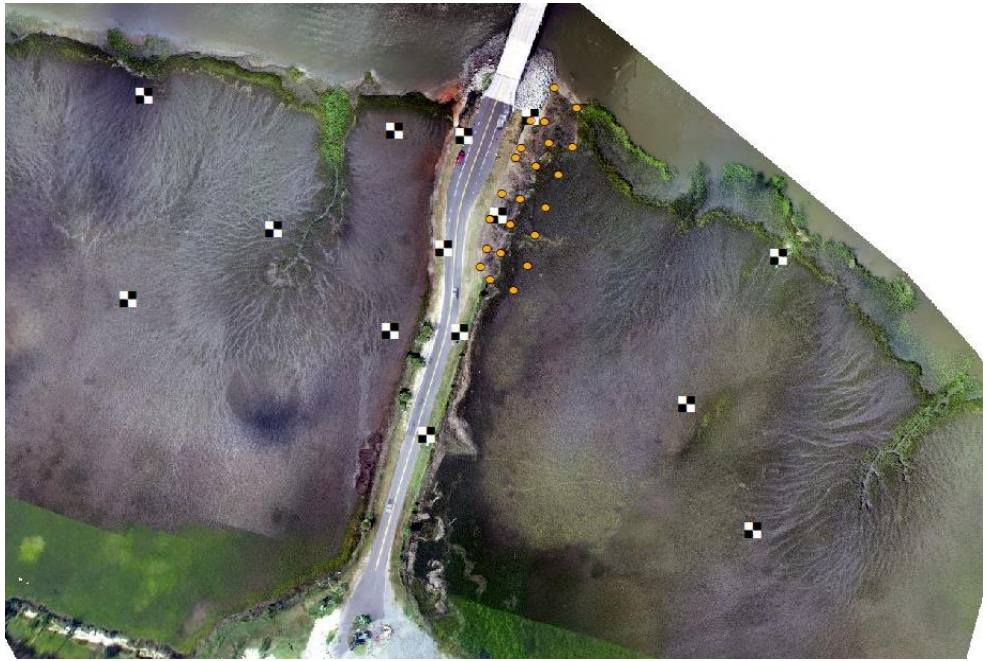

Visible
Near-
Mid-infrared
1
2
3
4
5
7
blue
green
red
Soil
Green vegetation
Water
Reflectance (%)
60
50
40
30
20
10
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
2.1
2.3
2.5
Wavelength (μm)

Structure from Motion (SfM)

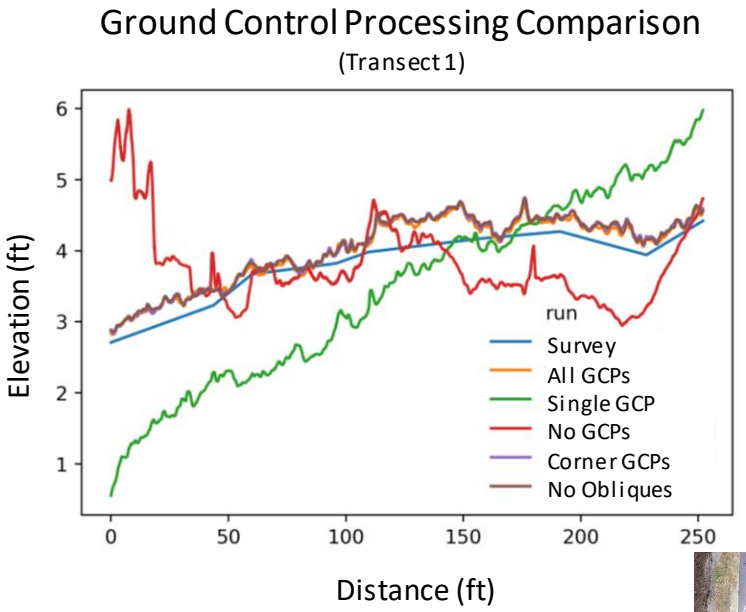




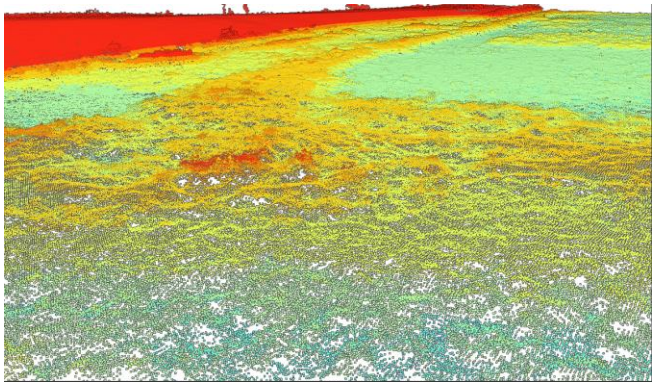




Elevation Models



SfM Point Cloud Density	
Flight Height (ft)	Density (pts/0.25m*0.25m)
125	40
400	4



Multispectral Indices

Normalized Difference Vegetation Index (NDVI)

$$\frac{NIR - Red}{NIR + Red}$$

Fractional Vegetation Coverage (FVC)

$$\frac{NDVI - NDVI_{soil}}{NDVI_{veg} - NDVI_{soil}}$$

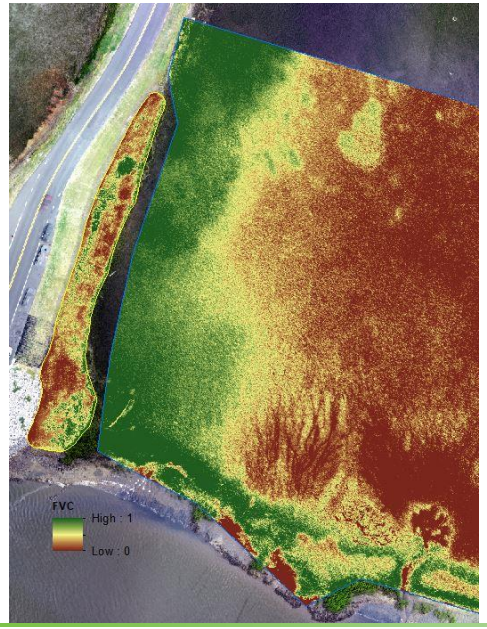
Normalized Difference Red Edge (NDRE)

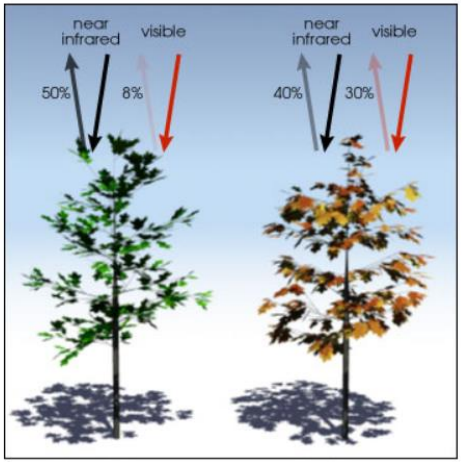
$$\frac{NIR - Red\ Edge}{NIR + Red\ Edge}$$

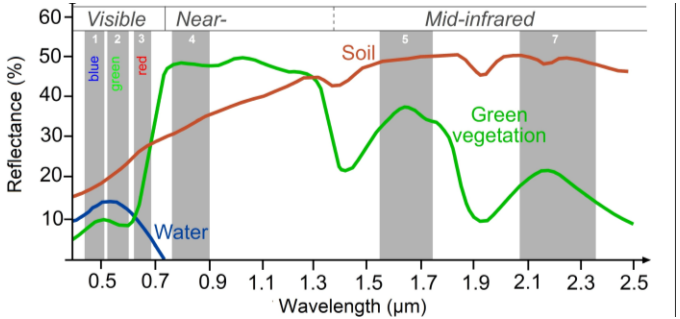
Normalized Difference Water Index (NDWI)

$$\frac{Green - NIR}{Green + NIR}$$

FVC

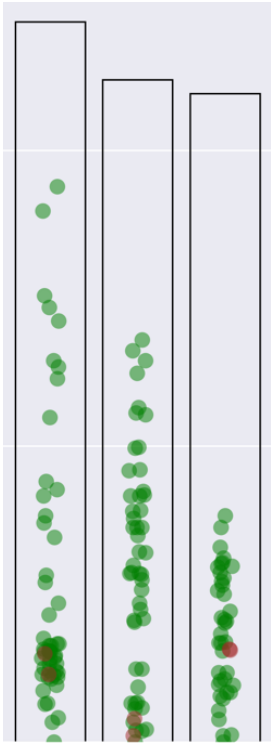


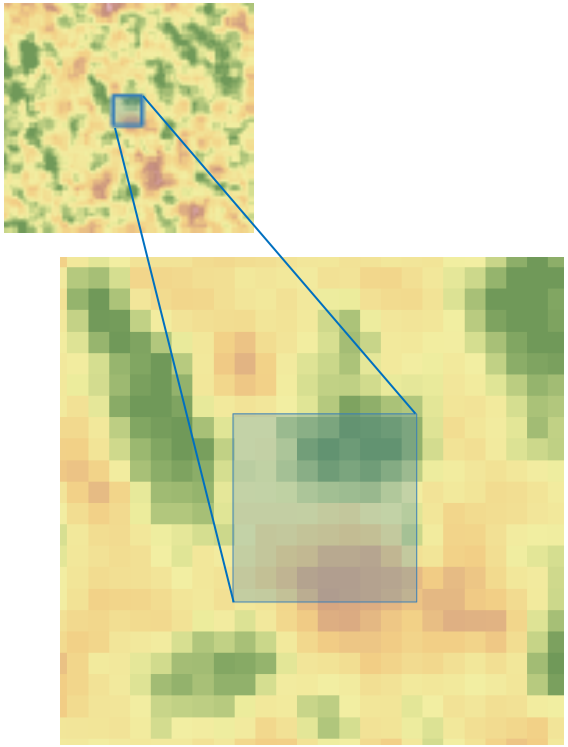




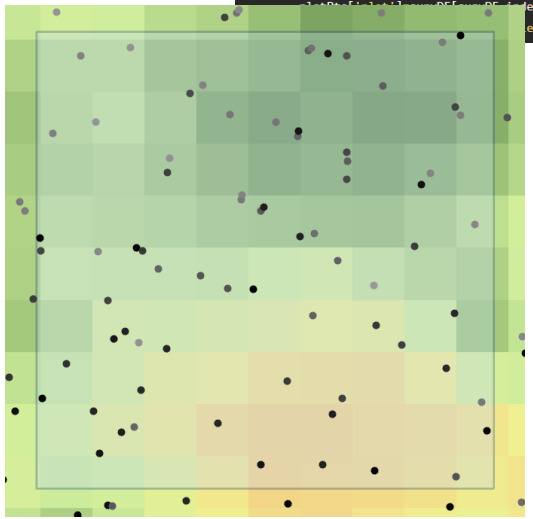
FVC: Estimating Spartina alterniflora fractional vegetation cover and aboveground biomass in a coastal wetland using SPOT6 satellite and UAV data
Zaiming Zhou, Yanming Yang, Benqing Chen

Biomass Model Parameters

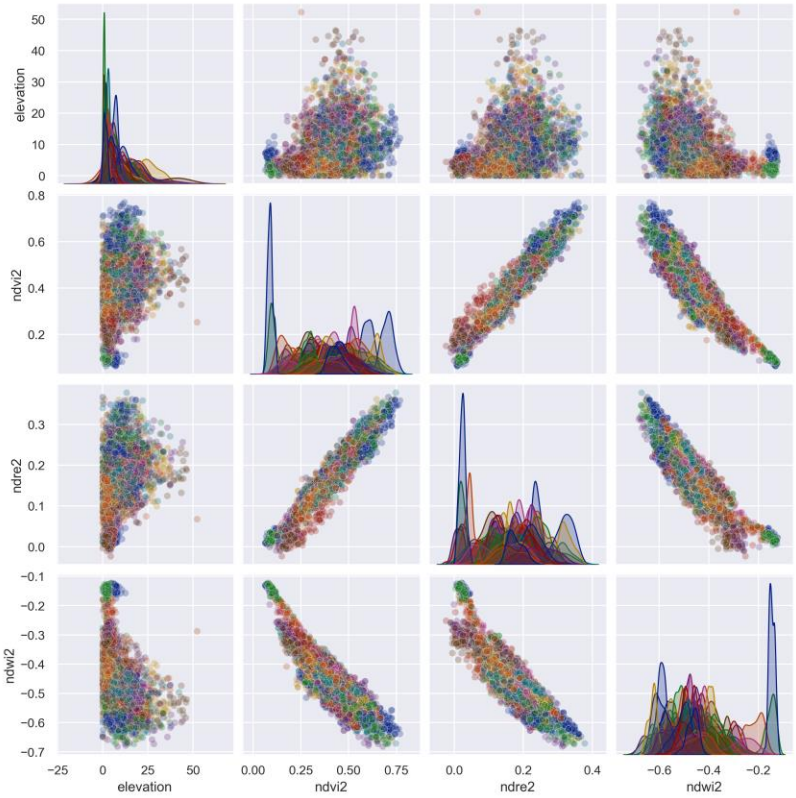




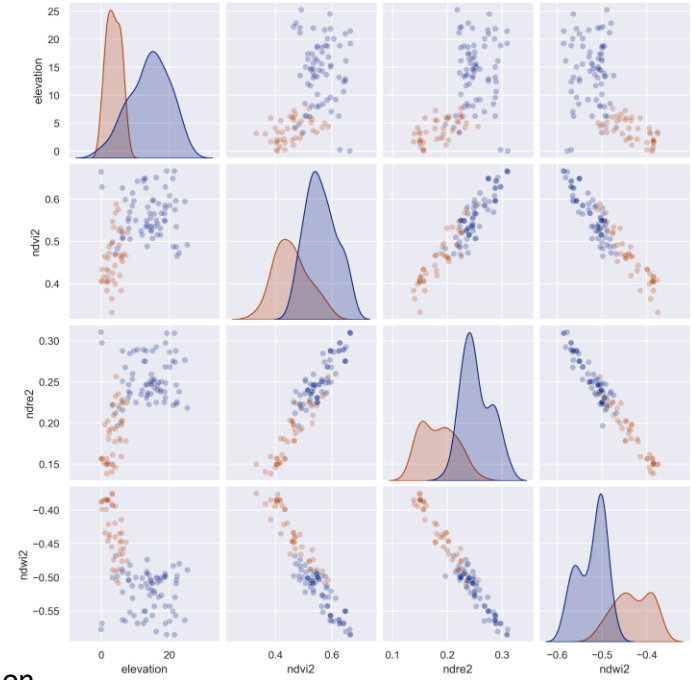
```
for plot in survDF.index:
    print("processing plot: {}".format(survDF[survDF.index==plot]['plot_id'].values))
    ptx=survDF[survDF.index==plot]['x_coord'].values[0]
    pty=survDF[survDF.index==plot]['y_coord'].values[0]
    #get plot extents
    yma=pty+ps
    ymi=pty-ps
    xma=ptx+ps
    xmi=ptx-ps
    #list of all elevations
    plotPts=pcDF[(pcDF['x']<xma)&(pcDF['x']>xmi)&(pcDF['y']<yma)&(pcDF['y']>ymi)][['x',
    #normalize against plot minimum and convert to cm
    plotPts['elevation']=(plotPts['z']-min(list(plotPts['z'].values)))*30.48
    #get corresponding raster values
        #iterate point elevs and pull NDVI values
    for i2 in range(0, len(idx)):
        with rasterio.open(os.path.join(inP, idx[i2][i])) as src:
            plotPts[cols[i2]]=plotPts.apply(lambda x: cellVal(x.x, x.y, src), axis=1)
    plotPts['plot_id']=survDF[survDF.index==plot]['plot_id'].values[0]
    plotPts=plotPts[['plot_id','x','y','z','elevation']+cols]
```



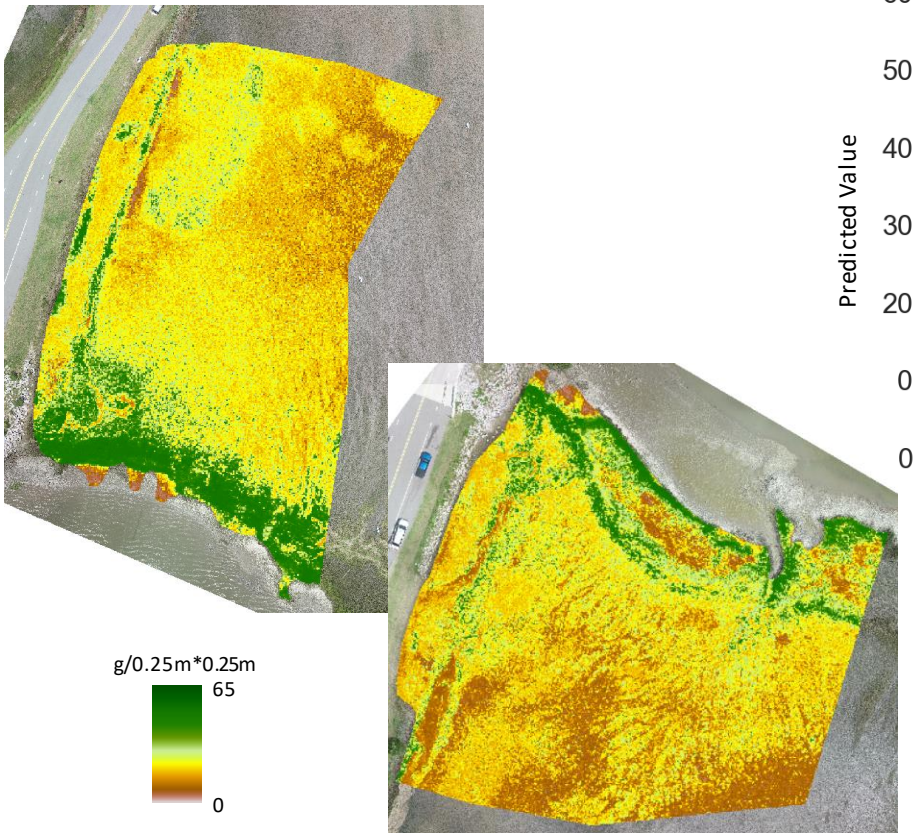
Biomass Model Parameters

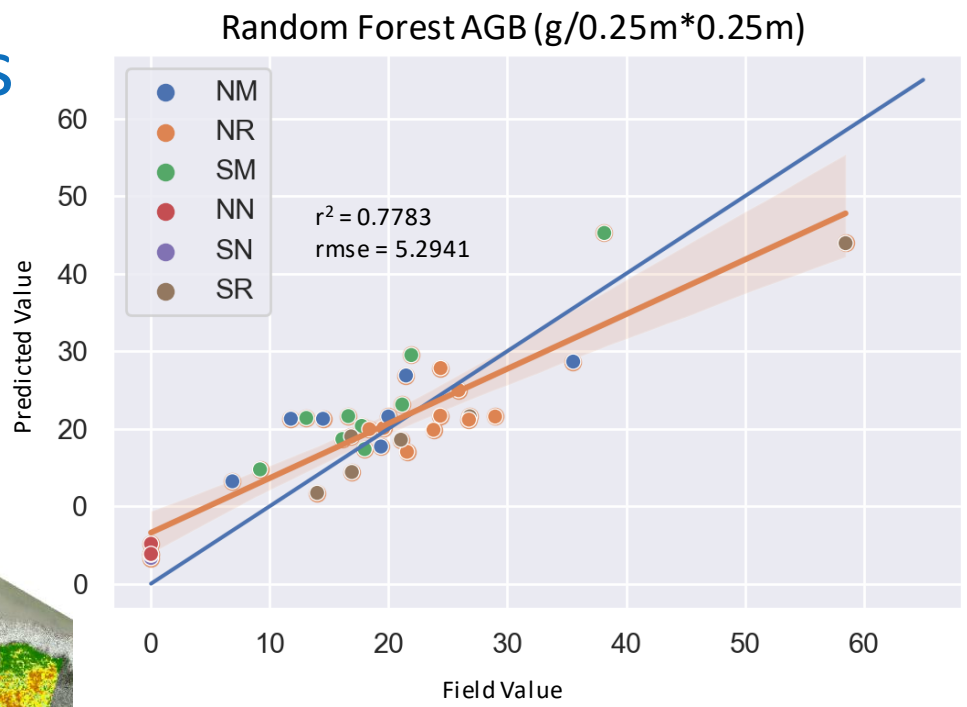


- Minimum
- 5th percentile
- 25th percentile
- 50th percentile
- 75th percentile
- 90th percentile
- Maximum
- Mean
- Standard Deviation
- Interquartile Range
- Kurtosis
- Skewness
- Variance
- Coefficient of Variation
- Mean Absolute Deviation (AAD)
- Median Absolute Deviation (MAD)
- Standard Deviation/Mean



Biomass Model Results





- scikit-learn
  - random forest
- Training/Testing
  - 60%/40%