Advances in Wetland Remote Sensing

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Typical Wetland Information

- Inventory (extent and location)
- Boundaries (legal, buffers, etc)
- Condition (stress, biomass, fragmentation, etc)
- Composition (species, invasives, etc)
- Cover change (watershed land use changes)
- Hydrology (stream network, etc)

Problems: Spatially complex (patchy, narrow, etc)
Species spectrally similar
Temporally variable (tidal, seasonal, annual)
Influenced by adjacent land cover/use

Advances in Wetland Remote Sensing

- Airborne digital cameras
- Hyper-spectral imaging systems (AVIRIS, CASI, Hyperion)
- High resolution satellite sensors (0.5 – 4 m)
- Image fusion (multi-resolution, multi-sensor, multi-temporal
- Classification algorithms (object-based, knowledge-based,etc)
- SAR and InSAR for structure & hydrology (water level change)
- Lidar topography and bathymetry
- GIS modeling and GPS location accuracy

SYSTEM & TECHNIQUE EVALUATION

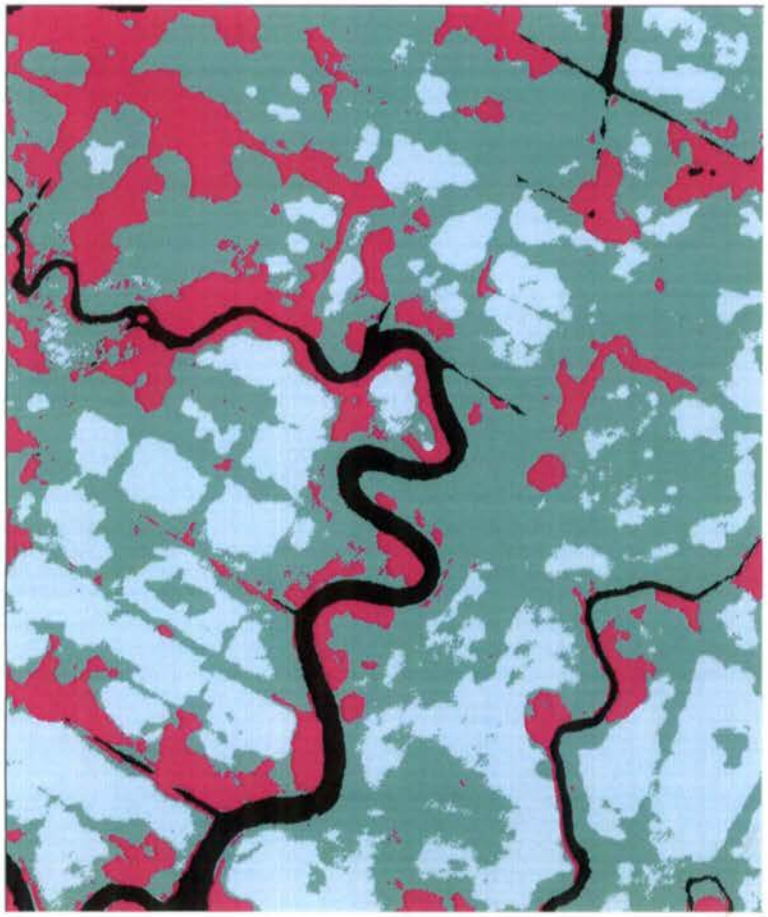
Working with NOAA/NERRS, USC, NOAA/CSC, DSU and Delaware DNREC, we evaluated estuarine habitat mapping and change detection techniques using imagery:

- aerial hyperspectral (AISA/CALMIT)
- aerial multispectral (digital camera)
- IKONOS multispectral (QuickBird)
- Landsat/TM multispectral

Tests were conducted on land cover, emergent wetlands and submerged vegetation at four NERRS sites:

- St. Jones River & Blackbird Creek, Delaware
- ACE Basin, South Carolina
- Grand Bay, Mississippi
- Padilla Bay, Washington

Coastal Wetlands



0.5m ADS-40 Imagery

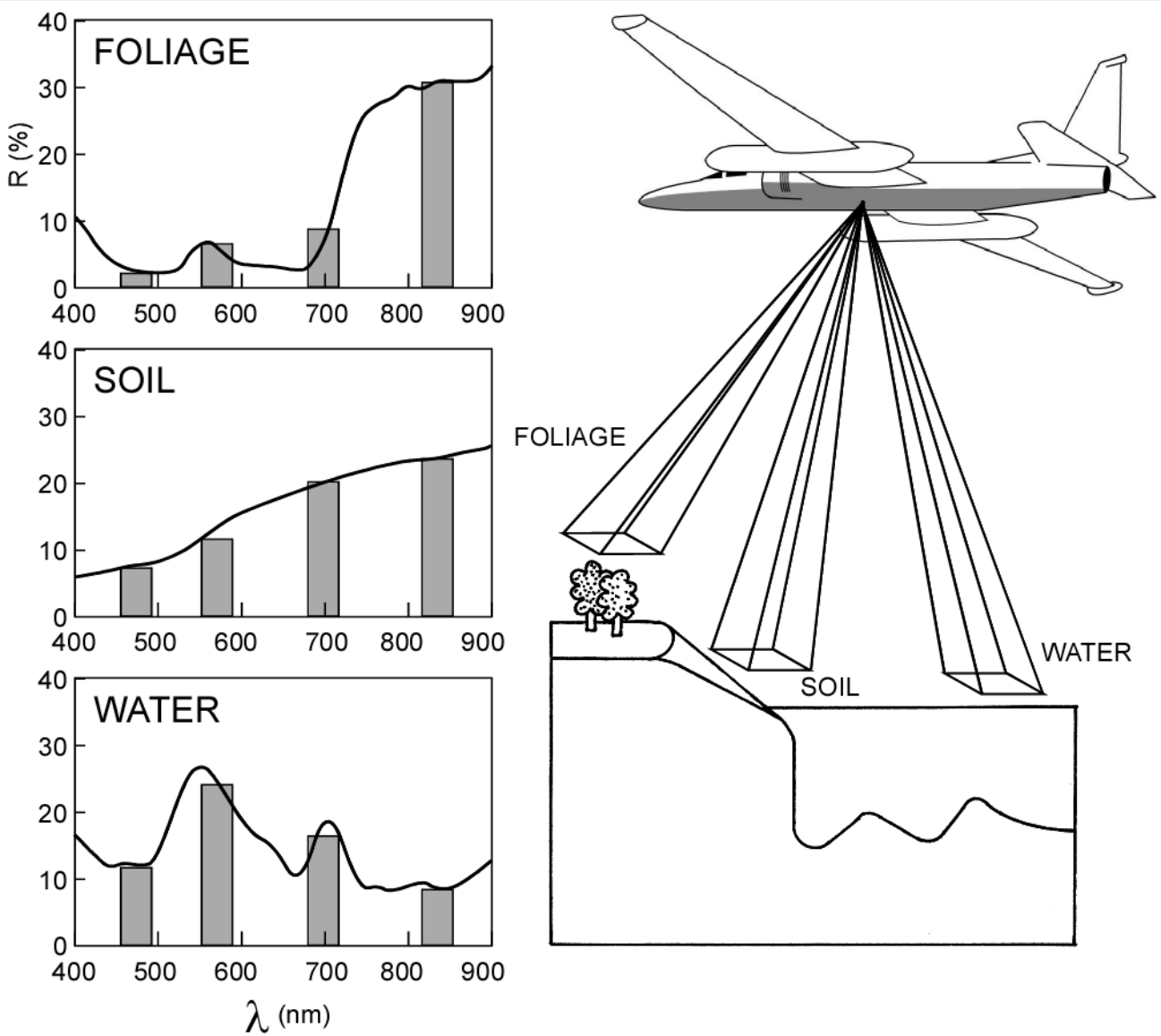
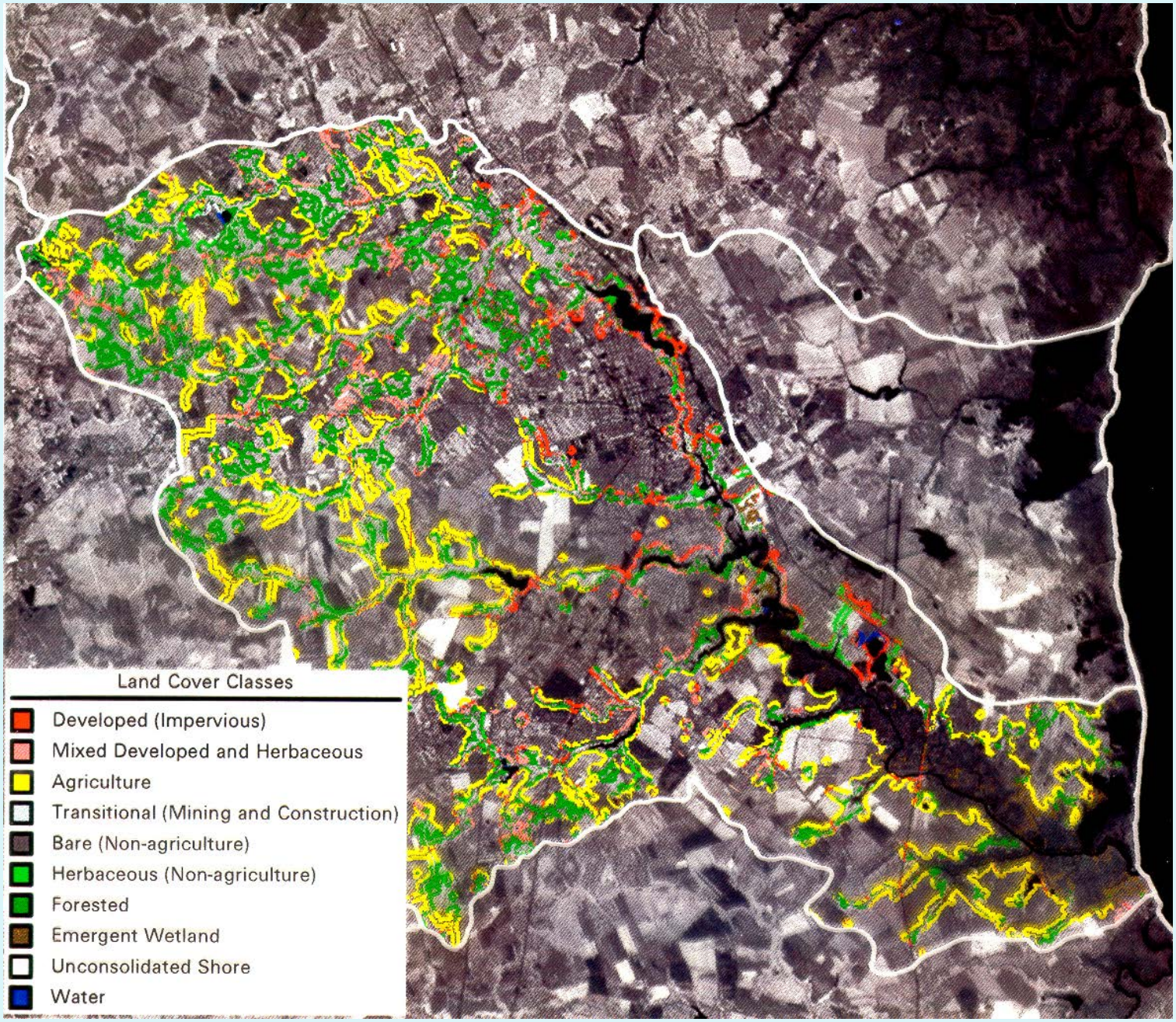


Fig. 2.5 Representative spectra for a terrestrial landscape as acquired using the hyperspectral AVIRIS sensor aboard the ER-2 platform (black lines), as compared to the crude spectral capability of a multispectral satellite (gray bars). In both cases the three land-cover types are separable

Table 1. High-resolution satellite parameters and spectral bands.

		IKONOS	QuickBird	OrbView-3	WorldView-1	GeoEye-1	WorldView-2
Sponsor		Space Imaging	DigitalGlobe	Orbimage	DigitalGlobe	GeoEye	DigitalGlobe
Launched		Sept. 1999	Oct. 2001	June 2003	Sept. 2007	Sept. 2008	Oct. 2009
Spatial Resolution (m)	Panchromatic	1.0	0.61	1.0	0.5	0.41	0.5
	Multispectral	4.0	2.44	4.0	n/a	1.65	2
Spectral Range (nm)	Panchromatic	525 – 928	450 – 900	450 - 900	400 – 900	450 - 800	450 – 800
	Coastal blue	n/a	n/a	n/a	n/a	n/a	400 – 450
	Blue	450 – 520	450 – 520	450 - 520	n/a	450 - 510	450 – 510
	Green	510 – 600	520 – 600	520 - 600	n/a	510 – 580	510 – 580
	Yellow	n/a	n/a	n/a	n/a	n/a	585 – 625
	Red	630 – 690	630 – 690	625 - 695	n/a	655 – 690	630 – 690
	Red edge	n/a	n/a	n/a	n/a	n/a	705 – 745
	Near-infrared	760 – 850	760 – 890	760 - 900	n/a	780 – 920	770 – 1,040
Swath width (km)		11.3	16.5	8	17.6	15.2	16.4
Off nadir pointing		±26°	±30°	±45°	±45°	±30°	±45°
Revisit time (days)		2.3 – 3.4	1 – 3.5	1.5 – 3	1.7 - 3.8	2.1 - 8.3	1.1 - 2.7
Orbital altitude (km)		681	450	470	496	681	770


Land Cover Classes
Developed (Impervious)
Mixed Developed and Herbaceous
Agriculture
Transitional (Mining and Construction)
Bare (Non-agriculture)
Herbaceous (Non-agriculture)
Forested
Emergent Wetland
Unconsolidated Shore
Water

Change Detection Problems

1. Interannual variation (dry vs. wet year)
2. Seasonal variation (leaf-off vs. leaf-on)
3. Atmospheric (scattering and absorption)
4. Tidal variation (within 1 ft. of LMT)
5. Clouds and shadows
6. Solar irradiance, angle, azimuth
7. Spatial misregistration
8. Resolution differences
9. Sensor radiometric drift

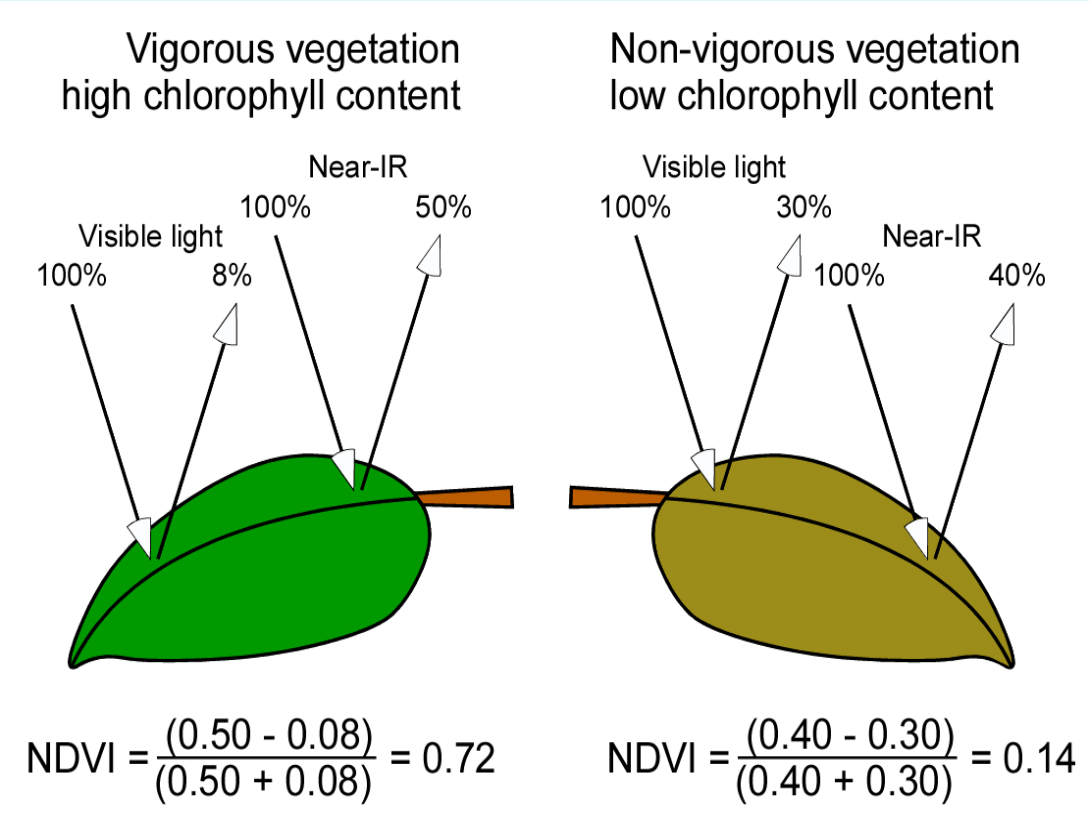


Figure 5.2 The NDVI algorithm capitalizes on the fact that green vegetation reflects less visible light and more near-IR, whereas sparse or less green vegetation reflects a greater portion of the visible and less near-IR. By combining these reflectance characteristics in a ratio, NDVI provides a useful index of photosynthetic capacity.

Biomass Change Analysis

1. The average biomass of a healthy wetland may vary greatly between years, but the <u>relative spatial distribution of biomass will remain essentially constant.</u>

2. Compute mean and standard deviation (SD) of MSAVI for each sub-basin.

3. Compute MSAVI deviation from sub-basin mean (Z-score) for each pixel where

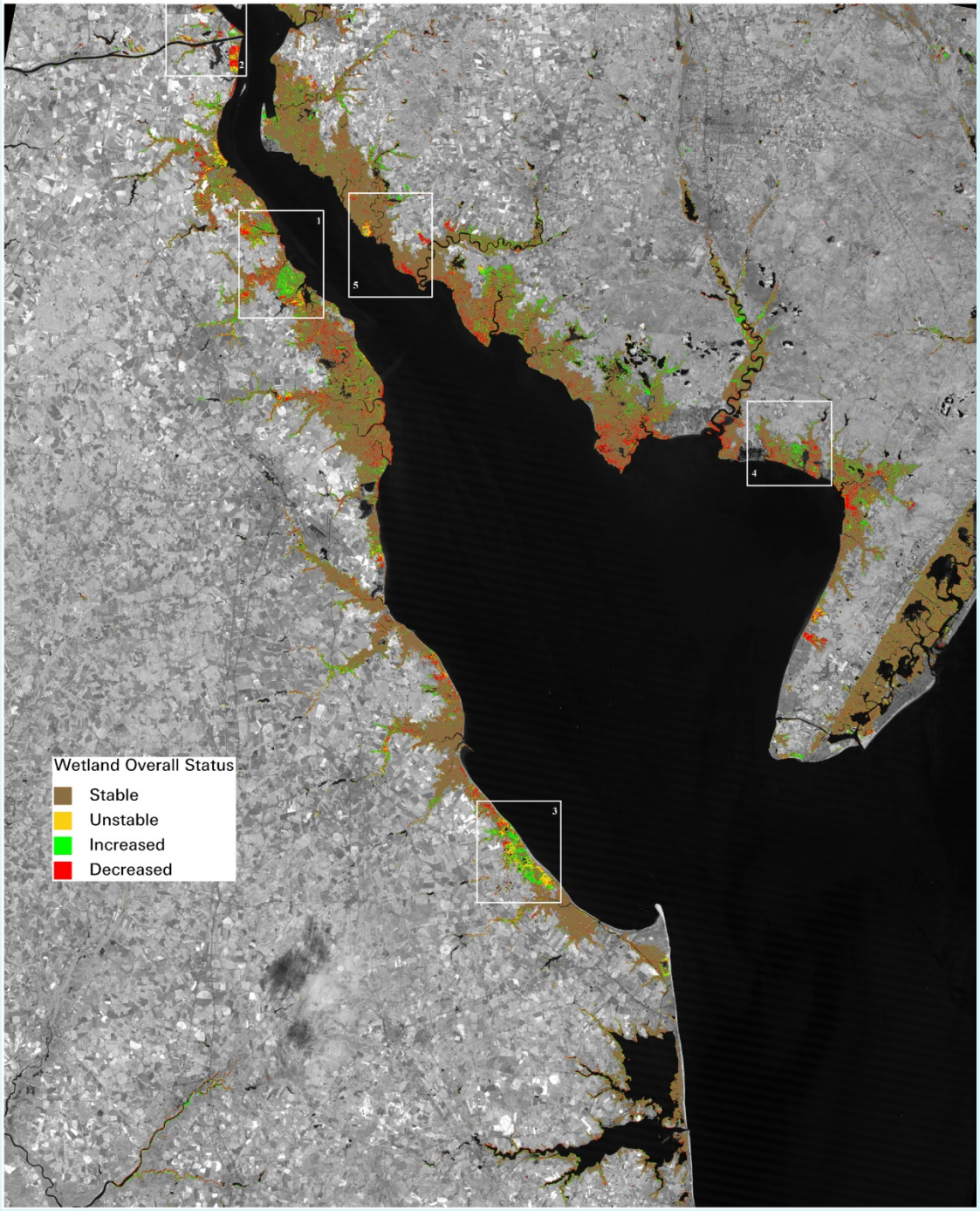
$$Z = \frac{MSAVI - \overline{X}_{MSAVI}}{(SD)_{MSAVI}}$$

4. Compute difference $Z_{before} - Z_{after}$ for each pixel.

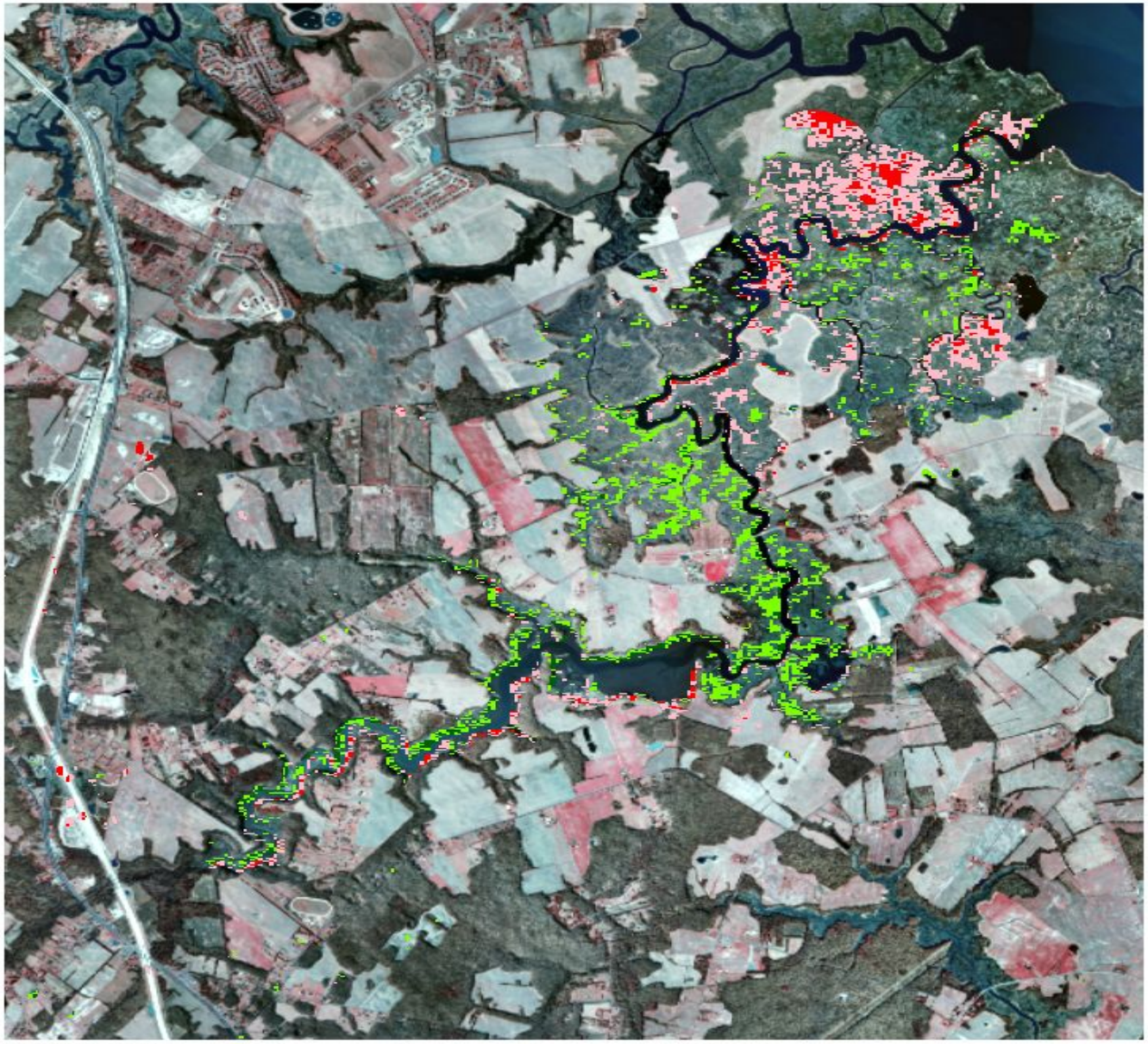
5. Select threshold for significant change (e.g. 2 SD).

6. Evaluate changes in flagged areas using high resolution imagery.

Delaware Bay Wetland Status (1984-1993)



Blackbird Creek Emergent LNBI Trend
1993-2002

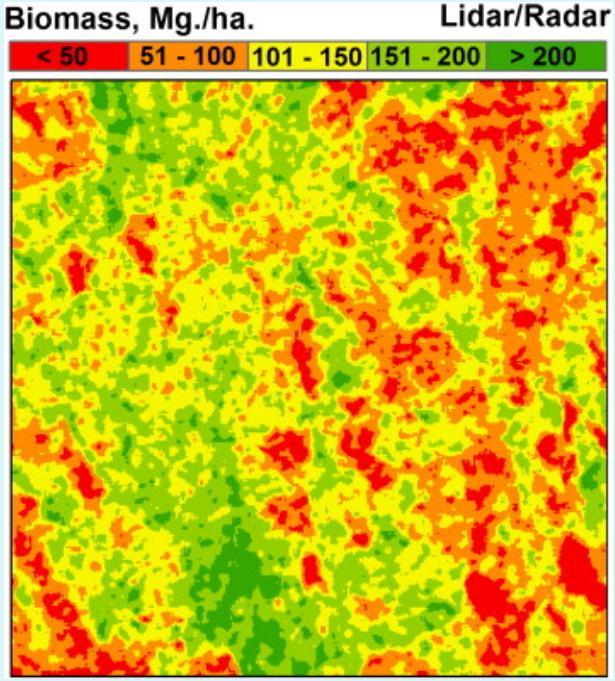


Zscore_diff_02-93_cl.img
Background
Loss > 3 sd
3 sd > Loss > 2 sd
2 sd > Loss > 1 sd
2 sd > gain > 1 sd
3 sd > gain > 2 sd
gain > 3 sd

1 0 1 2 Kilometers

N

Figure 1


Biomass, Mg./ha.
Lidar/Radar
< 50
51 - 100
101 - 150
151 - 200
> 200

Milford Neck Conservation Area

- Narrow barrier beach was breached during winter of 1985-86.

- Breach allowed direct exchange of tidal flow between Delaware Bay and Greco's Canal.
- Large areas of tidal marsh northwest of breach have become permanently inundated.
- Open water west of Greco's canal has increased from 40 ha to 160 ha. (with loss of Sp. alterniflora marsh)
- Gravel sill at mouth of canal at breach regulates interior marsh hydrology.
- Phragmites expanding.

- Sediment erosion/accretion not yet clear.

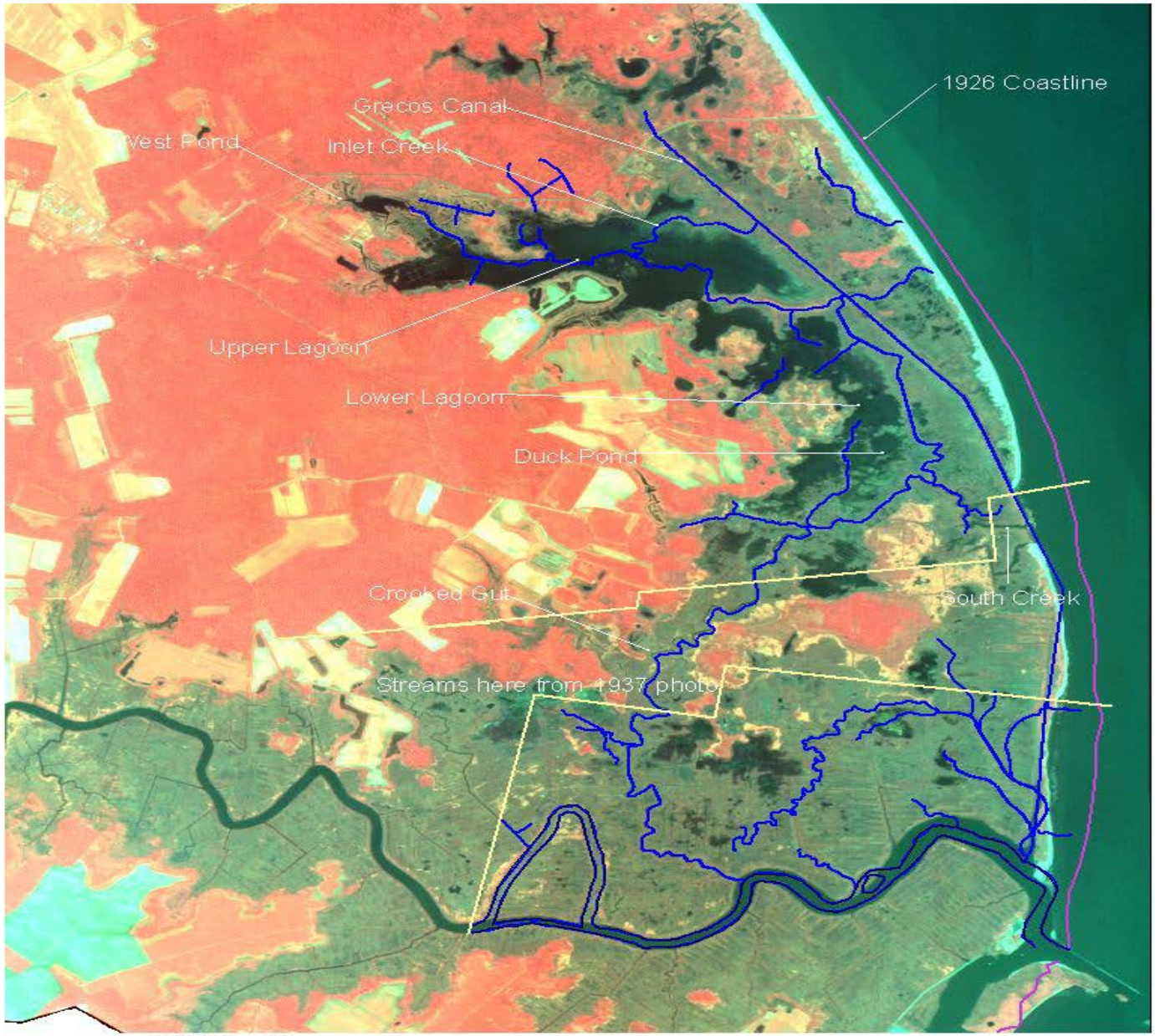
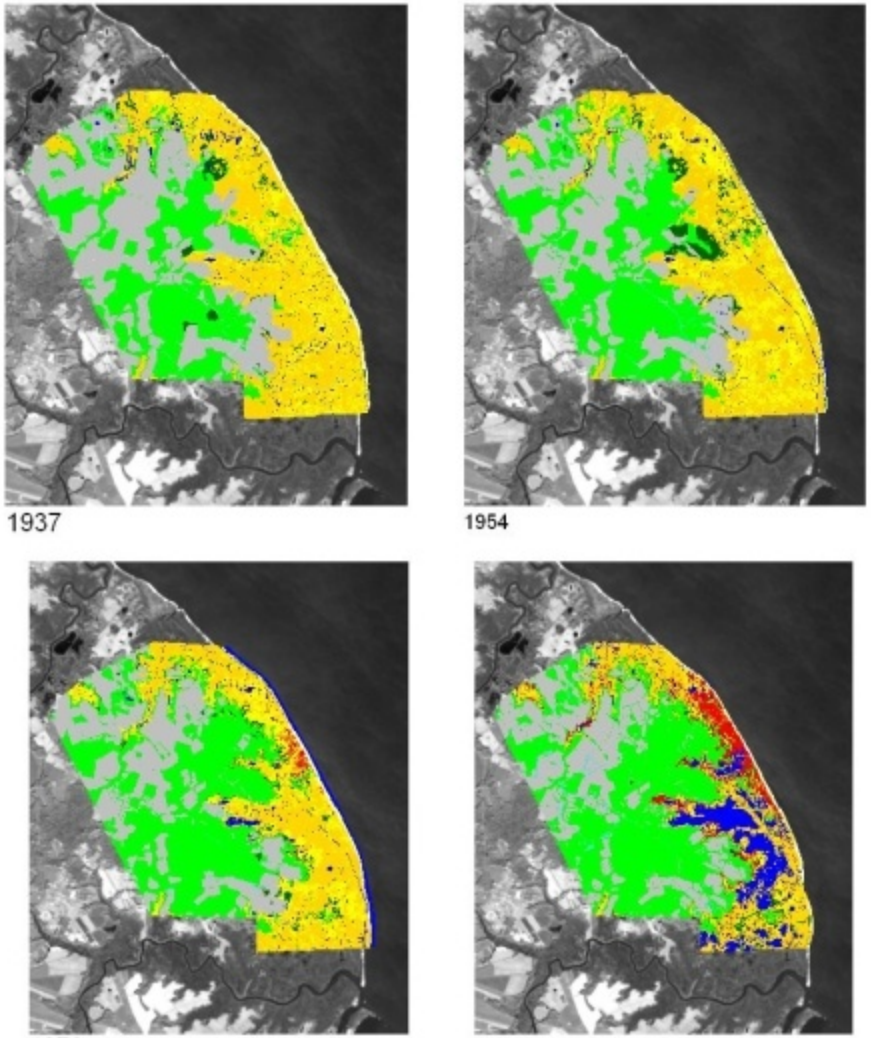


Figure 1

Milford Neck
1926 Coastline and Water Courses
Overlay on Inhanced 2004 IKONOS

500 0 500 Meters

N



Milford Neck Cover Change 1937-1999
Overlay on IKONOS 29 Oct 2000

Marsh Changes Due to New Inundation by Saltwater

Tidal flat → open water

Low marsh → tidal flat

High marsh → low marsh

Upland forest → high marsh

Milford Neck Canal Breach
18 September 1999
AISA Hyperspectral (1 m pixel size)

Both images
at low tide.

Milford Neck Canal Breach
24 August 2001
Ikonos Merged Image (1-4 m pixel size)

Pan Sharpened IKONOS Image
29 Oct 2000

Pan Sharpened IKONOS Image
2 July 2004

Summary & Conclusions

a). Large watersheds - use medium resolution (L/TM, SPOT),
only critical areas at high resolution (IKONOS, QuickBird).
(Image cost - Dig Cam = 332; Hyper = 174; IKONOS = 31; L/TM = 0.02 $/sq km)

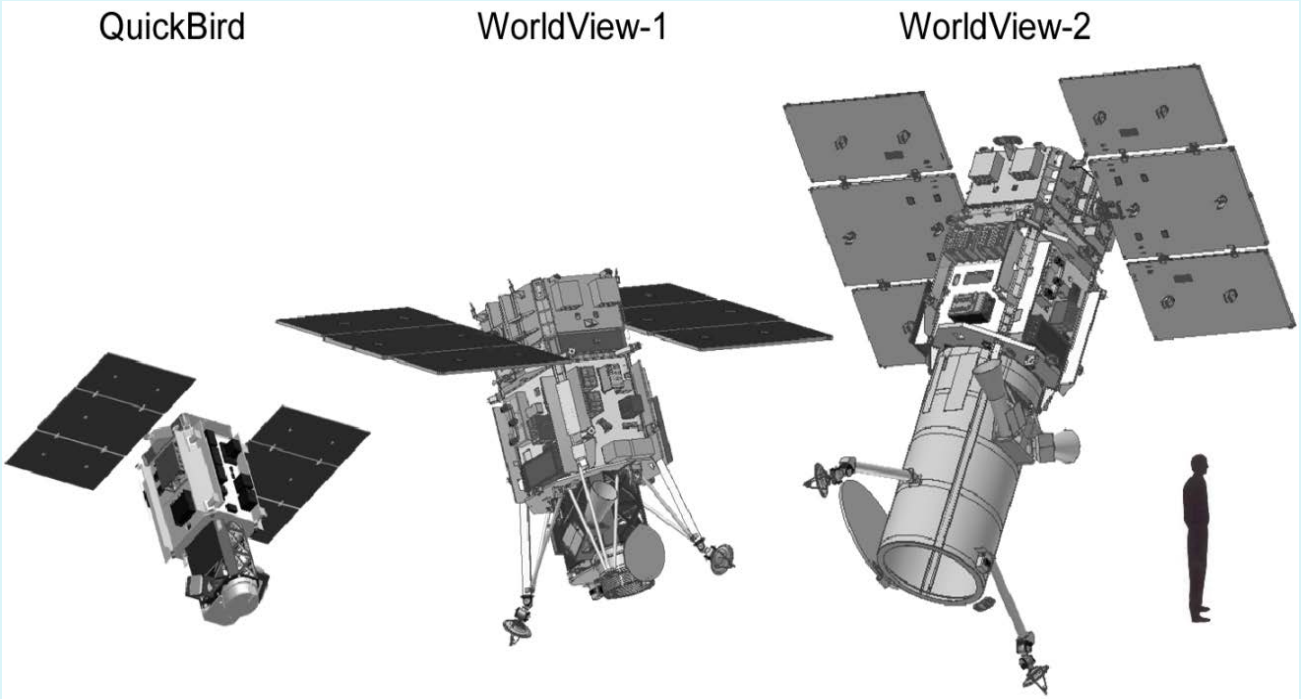
b). Hyperspectral - species ID, large budgets, experienced analysts.
Strips differ (sun angle, atmosph. correction,etc)
Aircraft roll gave uneven swath

c). Airborne digital camera - visual interpret & interpret satellite images.
Digital analysis difficult - color balance off, color brightness varies, etc.

d). Relative biomass change - wetland change detection.

e). Image fusion - multisensor, multiresolution, multitemporal
LiDAR, SAR & imagery - species ID, hydrology, bathymetry.

f). High resolution imagery - within-class spectral variance large.
Replace pixel-based by object-based analysis.



	QuickBird	**WorldView-1**	**Worldview-2**
Operational altitude	450 km	450 km	770 km
Weight class	2000 lbs	5700 lbs	5700 lbs
Panchromatic resolution at nadir	0.6 m	0.5 m	0.5 m
Multispectral resolution at nadir	2.4 m	2.0 m	2.0 m
Avg. revisit at 1m resolution (40°lat target)	2.5 days	1.7 days	1 day
Swath width	16.5 km	16 km	16 km
Operation schedule	Operational since 2001	Lofted Sept. 2007	Lofted Oct. 2009

$$\mathrm{NDVI} = \frac{\rho_{\mathrm{nir}} - \rho_{\mathrm{red}}}{\rho_{\mathrm{nir}} + \rho_{\mathrm{red}}}$$

$$\mathrm{NDII} = \frac{\rho_{\mathrm{nir}} - \rho_{\mathrm{mir}}}{\rho_{\mathrm{nir}} + \rho_{\mathrm{mir}}}$$

$$\mathrm{SAVI} = \frac{\rho_{\mathrm{nir}} - \rho_{\mathrm{red}}}{\rho_{\mathrm{nir}} + \rho_{\mathrm{red}} + \mathrm{L}} (1 + \mathrm{L})$$

$$\mathrm{MSAVI} = \frac{2\rho_{\mathrm{nir}} + 1 - \sqrt{(2\rho_{\mathrm{nir}} + 1)^2 - 8(\rho_{\mathrm{nir}} - \rho_{\mathrm{red}})}}{2}$$