Using Remotely Sensed Data to Study Possible Effects of Land Cover/Land Use Change on Water Quality in Tampa Bay

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Outline

- Background – Public Health
- Hypothesis
- Objectives
- Land Cover/Land Use change (LC/LU) analysis on Tampa Bay (TB) using Coastal Change Analysis Program (C-CAP) - NOAA product
- Water Quality (WQ) analysis with emphasis on Turbidity - Analysis of relationship between Remotely Sensed (RS) data from MODIS and *in situ* data from the Environmental Protection Commission of Hillsborough County (EPCHC) on turbidity on TB
- Analysis of relationship between LC/LU and WQ on TB
- Preliminary conclusions

http://www.networkedblogs.com/p22486755 http://www.brennanbail.com/images/tampa-bail-bond.jpg

Tampa Bay Watershed

The 5,700 Km^2 Tampa Bay watershed (TBW) lies within the Counties of Hillsborough, Pinellas, and Manatee and extends to parts of Sarasota, Pasco, and Polk Counties.

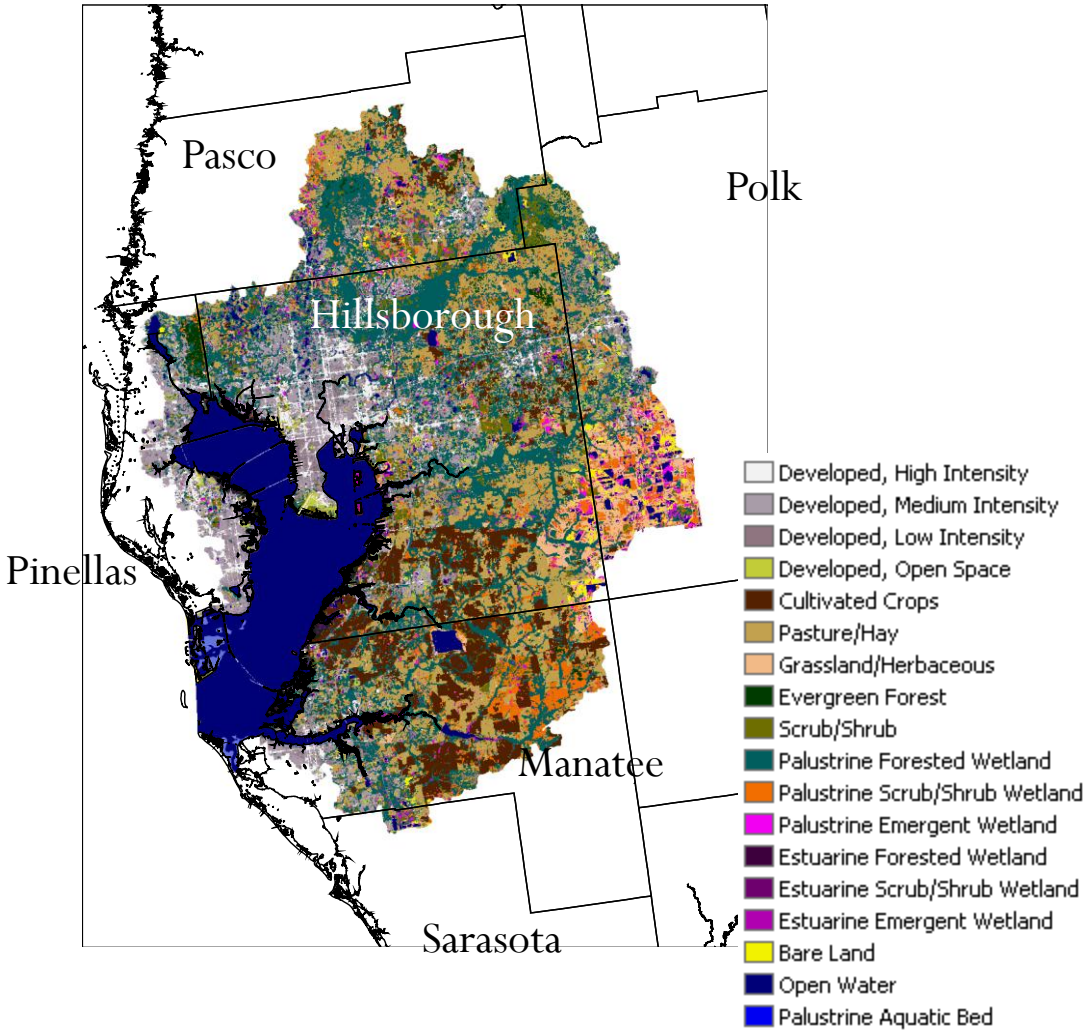
Tampa Bay (TB), is the largest open-water estuary in Florida. Stretches 1,030.81 km^2 at high tide.

Average depth: 3.4 m

More than 128.75 km of deep-water shipping channels –

the largest 13 m deep.

Three ports: $15 billion to the local economy and support 130,000 jobs.



Water Quality

- Improving since the early 80's - effective environmental management strategies - upgrade to tertiary level in the waste water treatment plant
- Ecological importance allowing the supportive function of ecosystems
- Sport fishing, boating, kayaking, and wildlife watching support tourism and leisure of locals
- Public health

Hypotheses

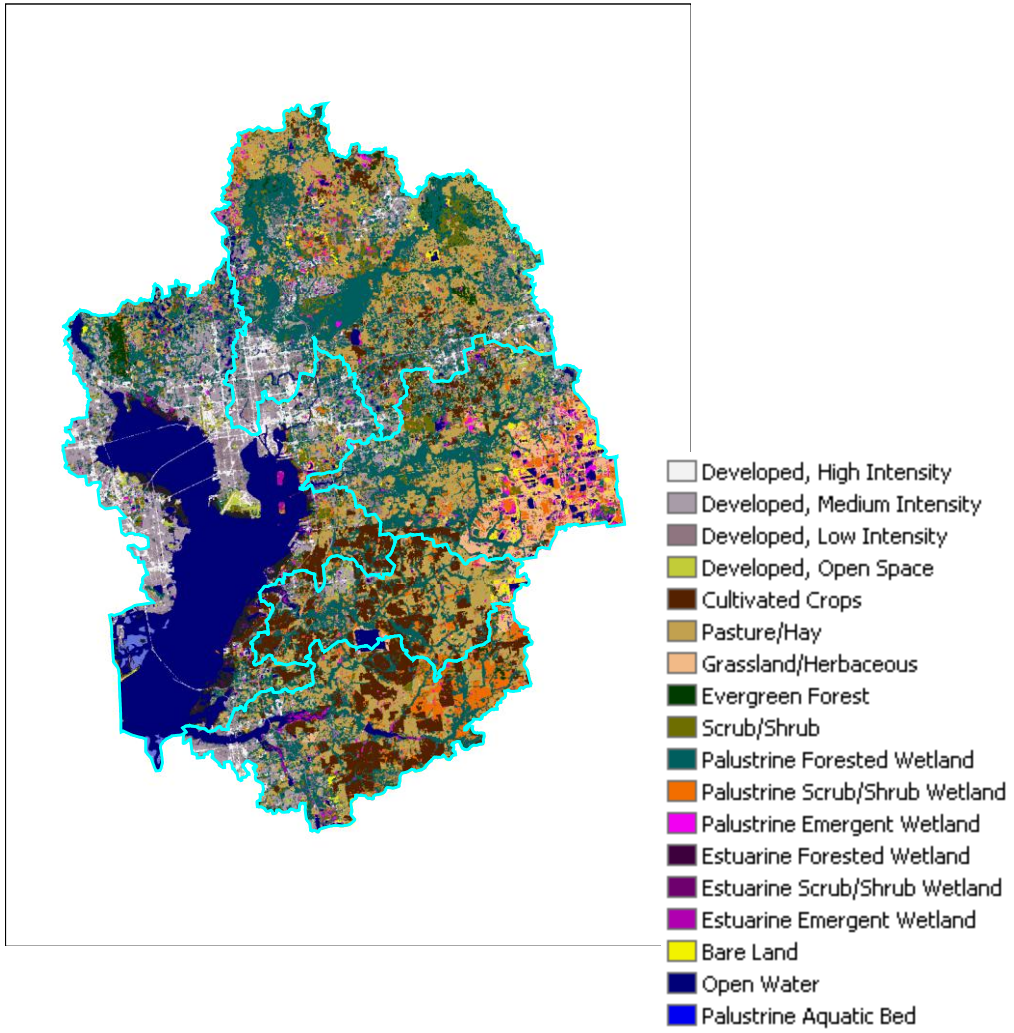
- Change in LC/LU affects the WQ of Tampa Bay
- Both the LC/LU and WQ can be estimated well with RS as well as the effect of their interaction

Objectives

- Analyze for possible effects that LC/LU changes may cause in WQ of TB
  - Evaluate LC/LU change in TB using RS
  - Estimate turbidity in TB water using RS
  - Estimate association between LC/LU and WQ

5 Sub-watersheds

1. Hillsborough River
2. Alafia River
3. Little Manatee River
4. Manatee River
5. Tampa Bay watershed



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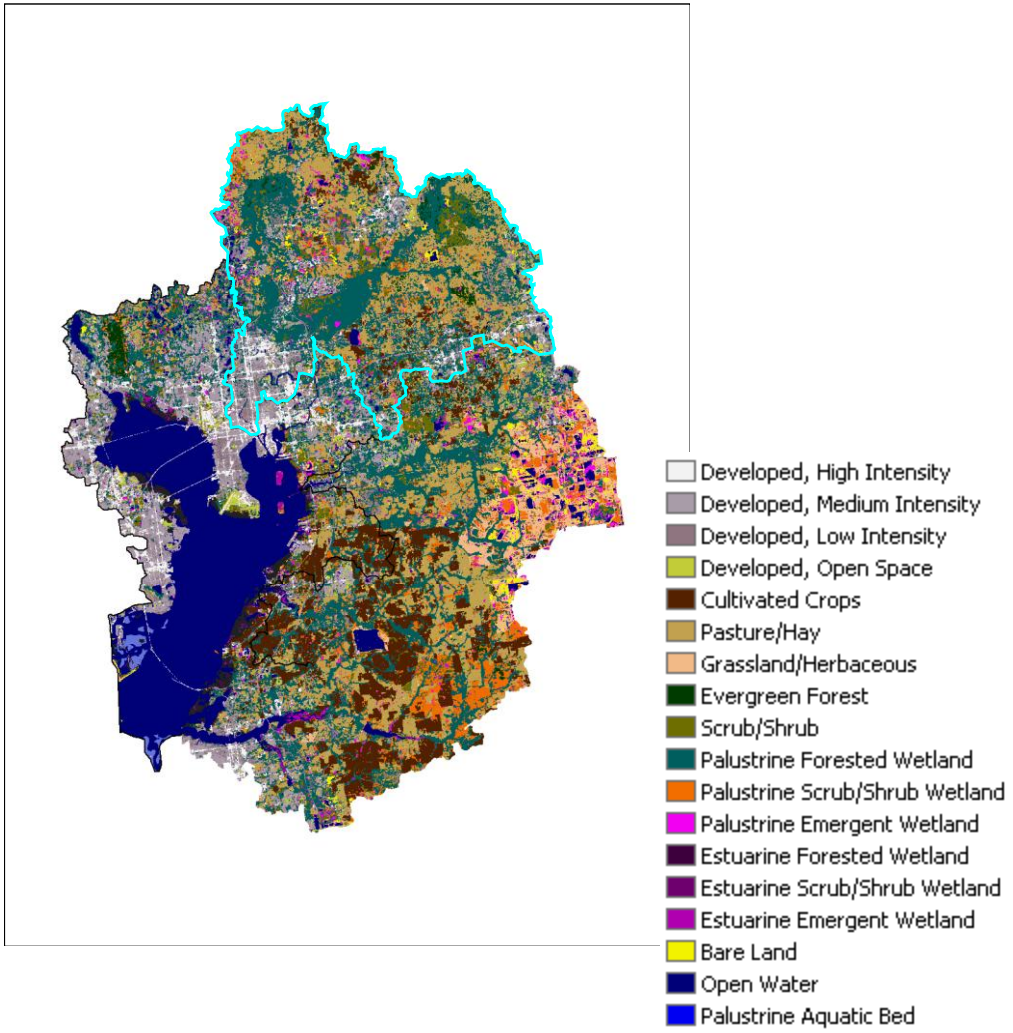

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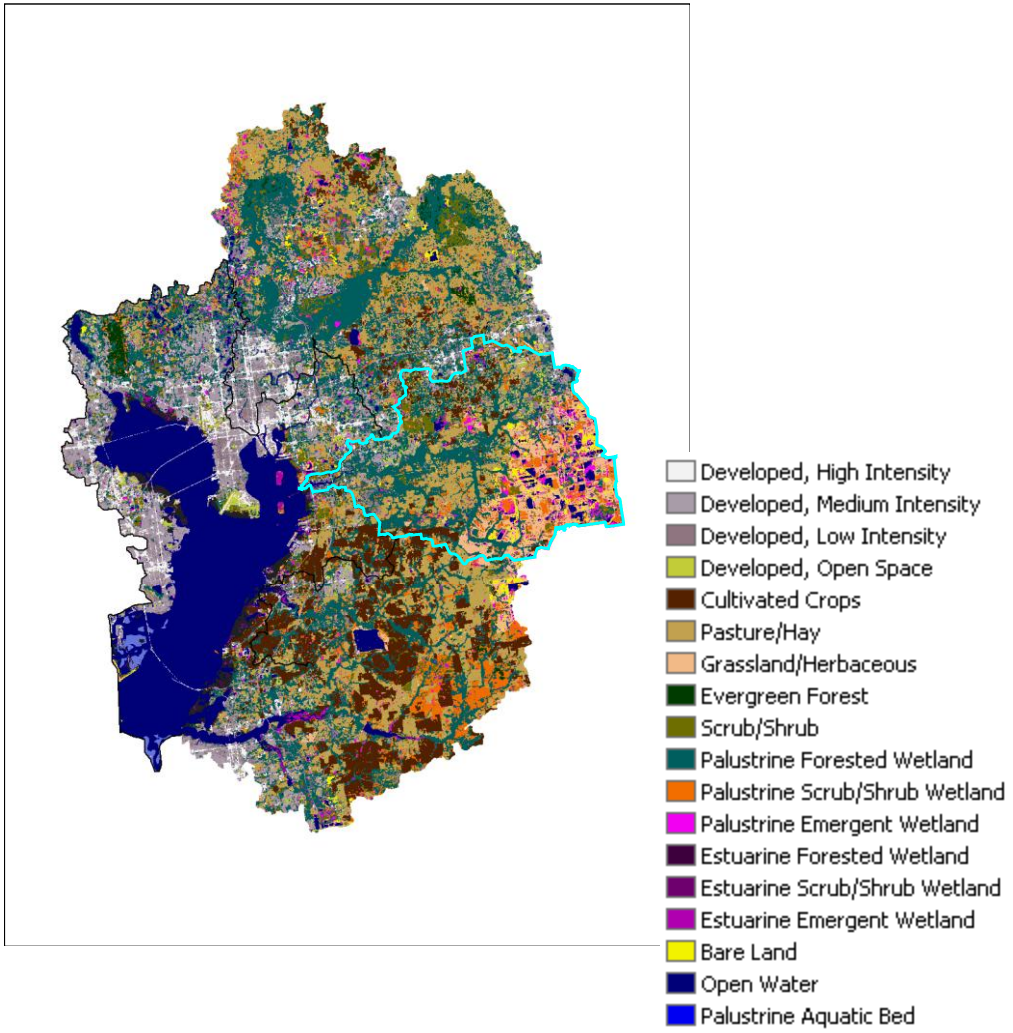

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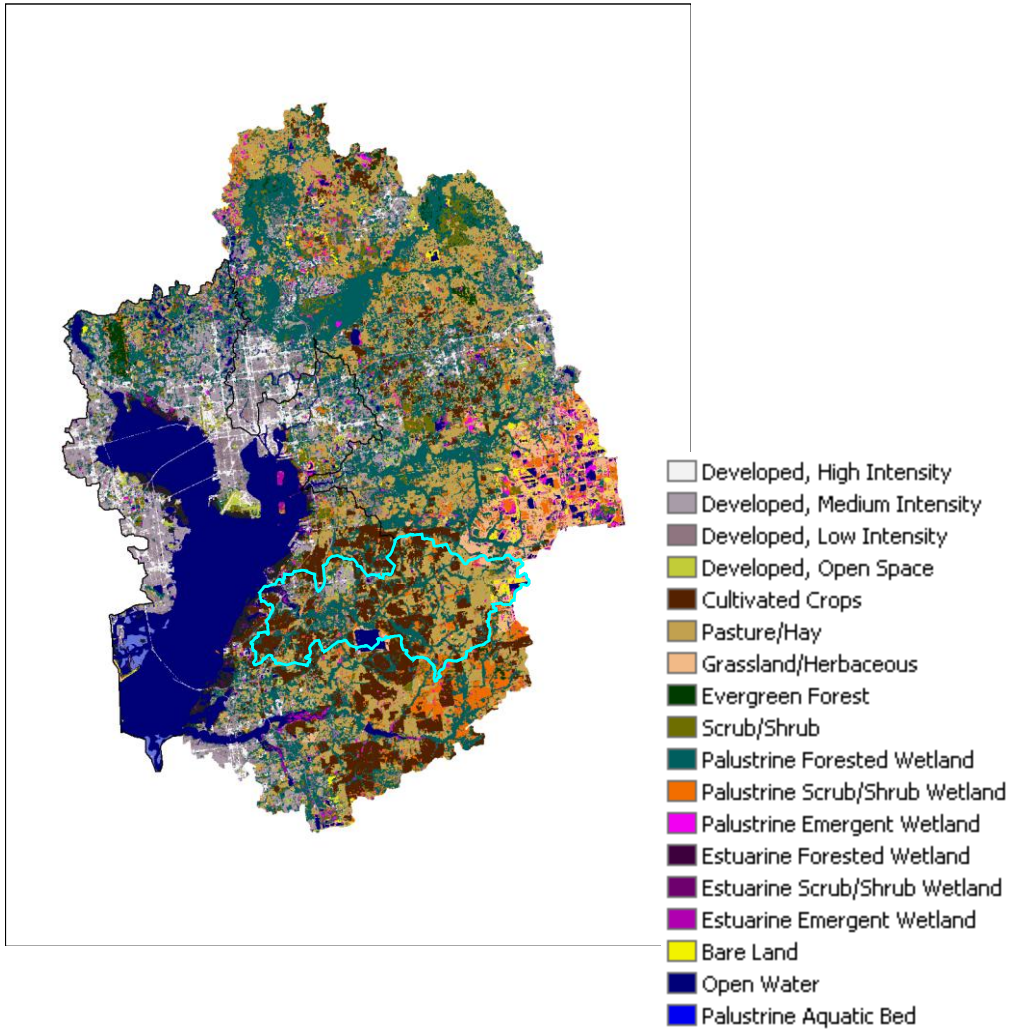

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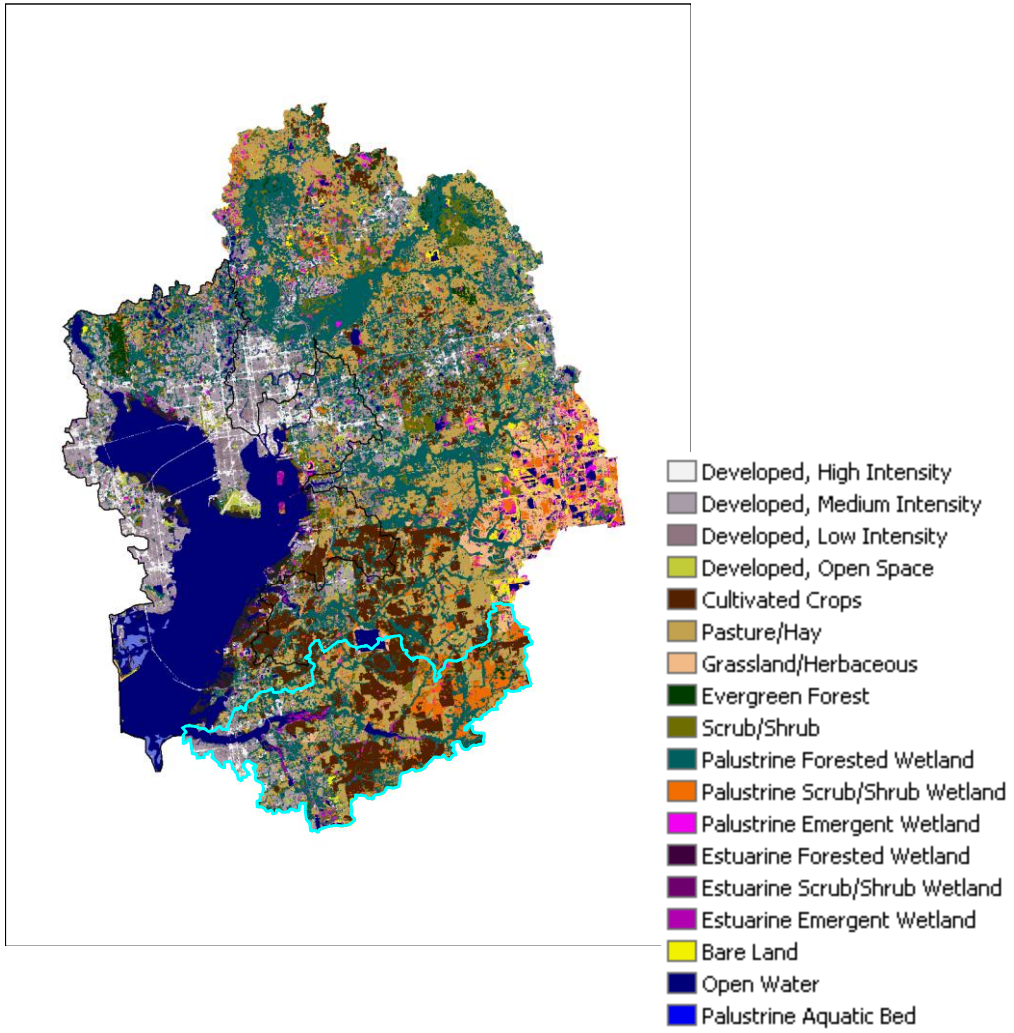
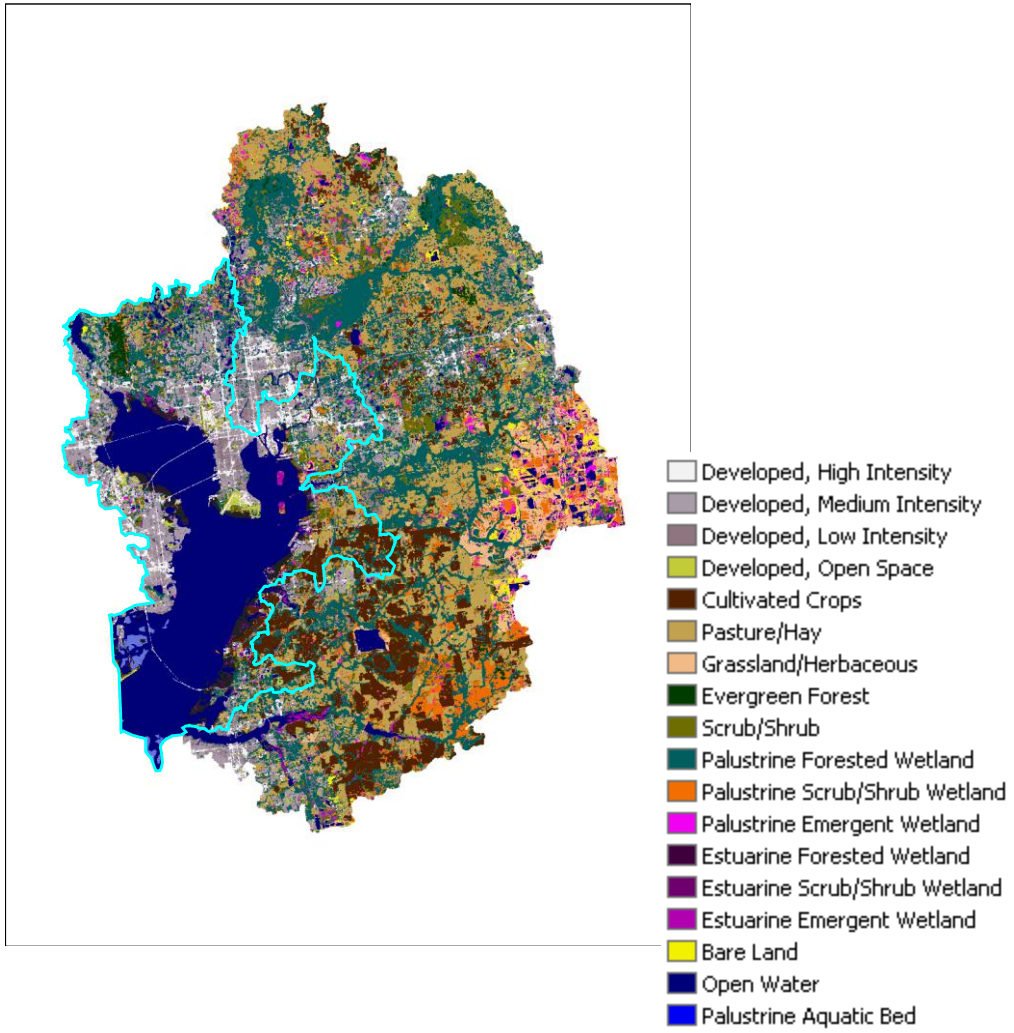


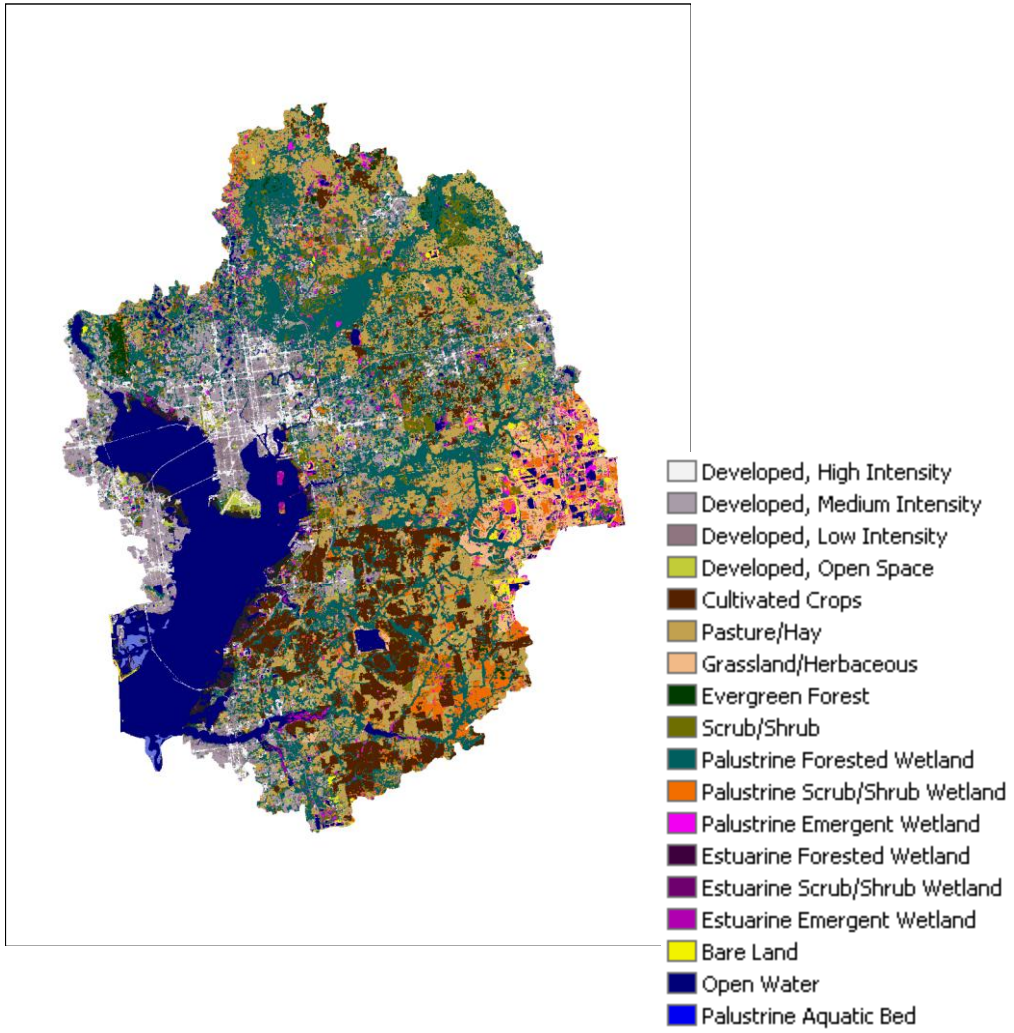
5 Sub-watersheds

1. Hillsborough River
2. Alafia River
3. Little Manatee River
4. Manatee River
5. Tampa Bay tributary



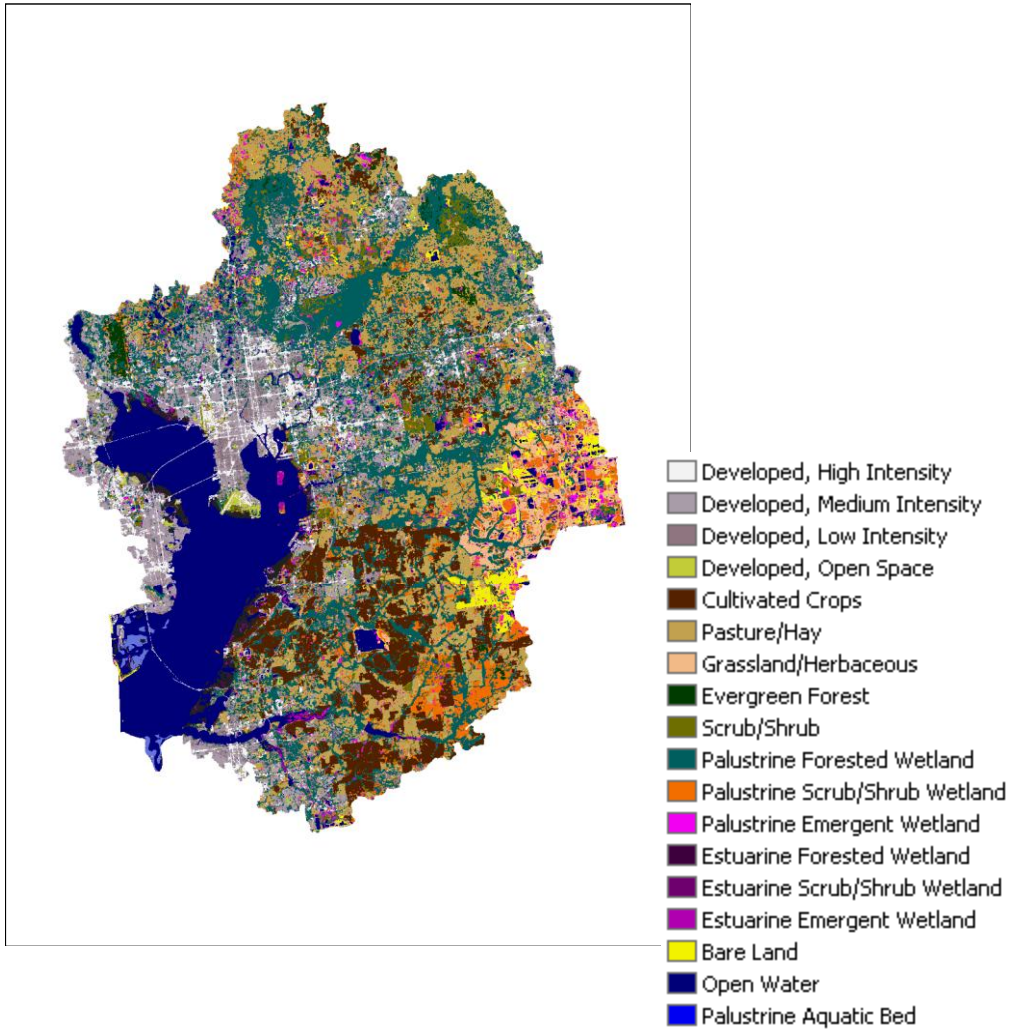
C-CAP 1996

	Area in all TBW in Km^2
	1996
Develop.	1264
Agricult.	1617
Forest	48
Scrub	247
Wetland	2348
Uncons.	0.5
Bare Land	67
Water	1056



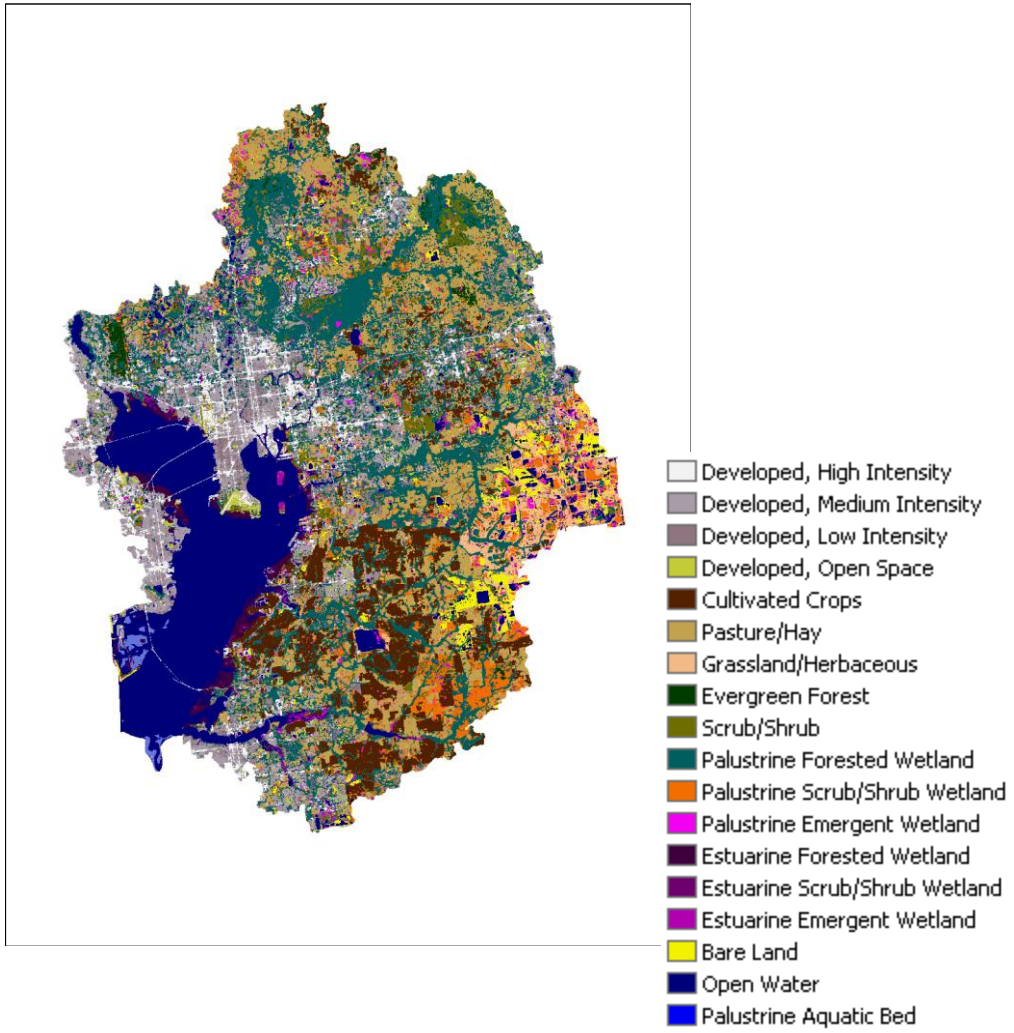
C-CAP 2001

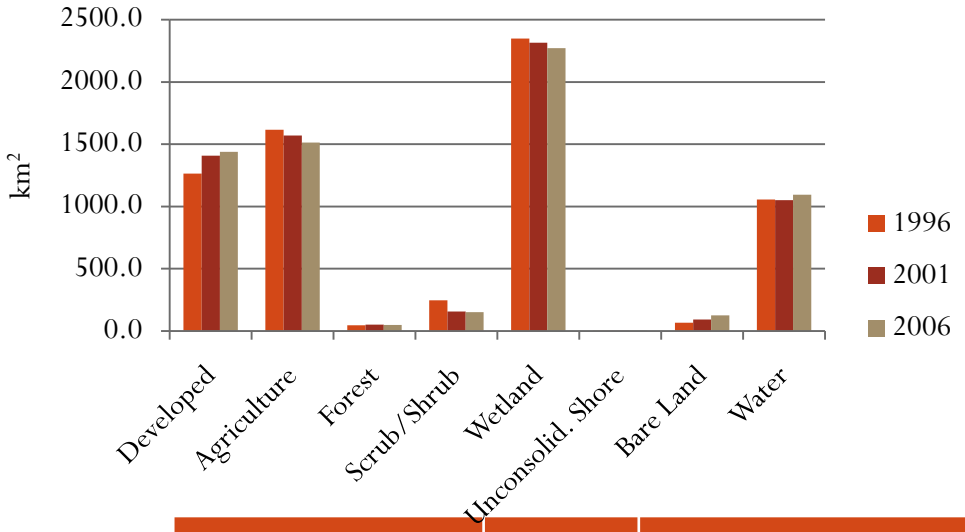
	Area in all TBW in Km^2		Change	
	1996	2001	Km^2	Percent
Develop.	1264	1410	146	11.5
Agricult.	1617	1517	-46	-2.9
Forest	48	51	3.5	7.3
Scrub	247	156	-9.1	-36.8
Wetland	2348	2314	-34.4	-1.5
Uncons.	0.5	0.4	-0.1	-19.5
Bare Land	67	94	27	39
Water	1056	1052	-4	-0.4



C-CAP 2006

	Area in all TBW in Km^2		Change	
	2001	2006	Km^2	Percent
Develop.	1410	1439	29	2.1
Agricult.	1517	1513	-58	-3.7
Forest	51	50	-1	-2.9
Scrub	156	152	-4	-2.4
Wetland	2314	2272	-41	-1.8
Uncons.	0.4	0.4	0.0	1.7
Bare Land	94	126	32	34.5
Water	1052	1095	44	4.1

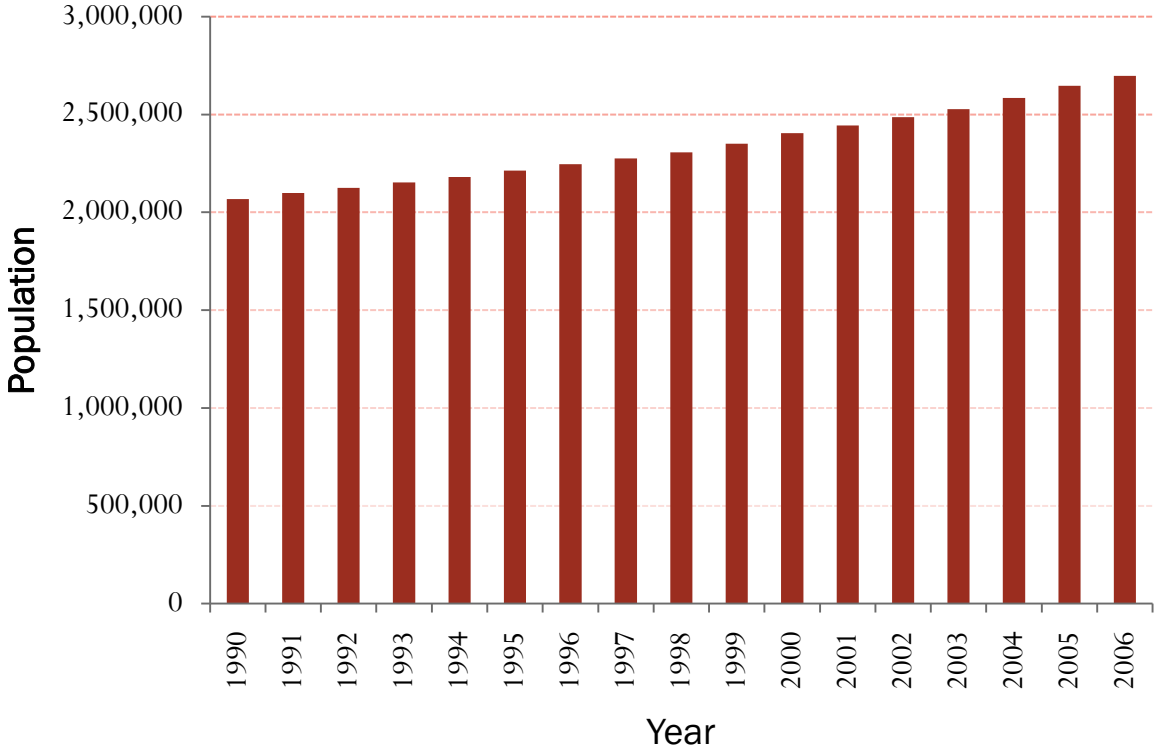




Change in Land Cover/Land Use (LC/LU)

	Area in all TBW in Km²		Change Km²	Pct. Change					
	1996	2006	Entire TBW	Entire TBW	HR	AR	LMR	MR	TB
Develop.	1264	1439	175	13.8	16	13.5	11.2	31.1	9.5
Agricult.	1617	1513	-105	-6.5	-3	-4.3	-10.4	-8.1	-10
Forest	48	50	2	4.2	7.1	-4.7	-17.1	8.9	0
Scrub	247	152	-94	-38.2	-33.4	-35.2	-53.4	-42.2	-43.5
Wetland	2348	2272	-76	-3.2	-2.2	-4.3	-4.4	-2.5	-4
Uncons.	0.5	0.4	-0.1	-18.1					-18.8
Bare Land	67	126	59	87.3	86	56.2	356.6	92.7	-20.8
Water	1056	1095	39	3.7	23.7	28.5	23.5	16.0	0.5

Population Growth in the Tampa Bay Metropolitan Area



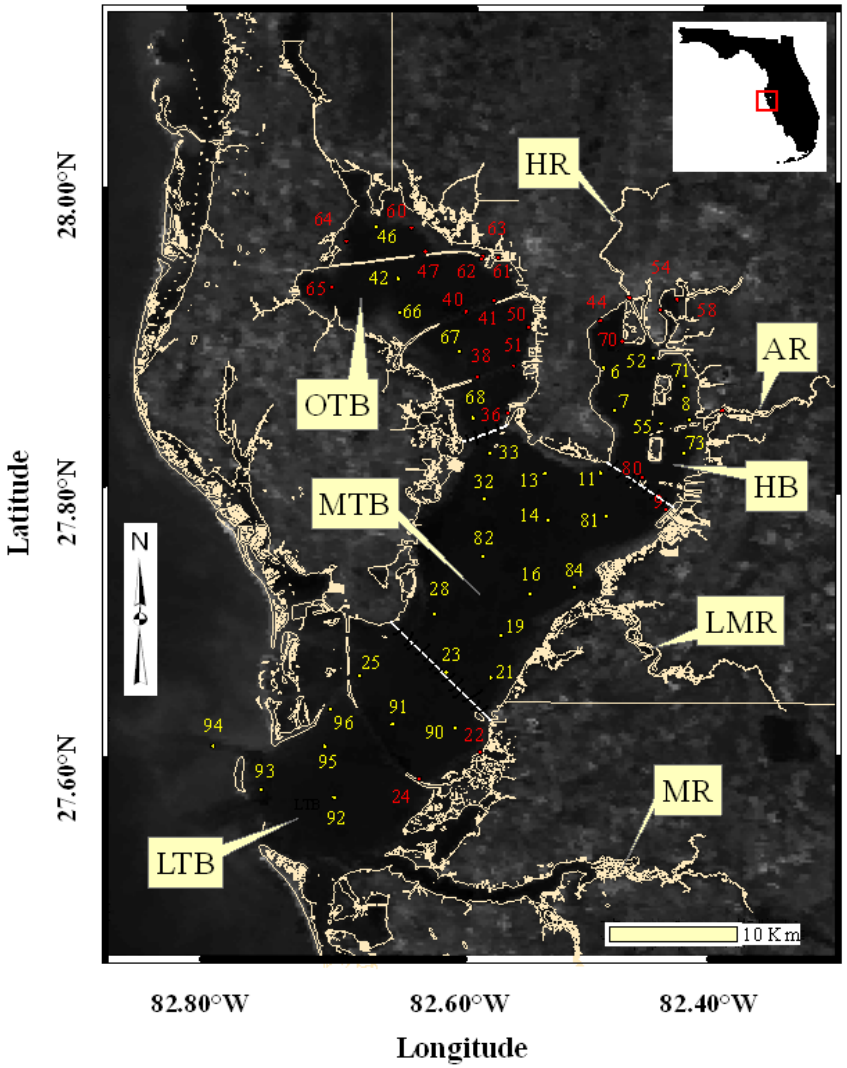
That number is expected to grow by nearly 19 percent by the year 2015, as approximately 500 people move to one of the three counties each week.

http://www.tbep.org/estuary.html

US Bureau of the Census (1990 – 2000)

http://www.census.gov/popest/metro/CBSA-est2006-annual.html

Water Quality



- Surface reflectance MODIS Terra daily product (MOD09GQ) Band 1 (620 – 670 nm) 250 m
- Corrected for atmospheric effect
- Turbidity
- Criteria:

1. Matching with a good quality satellite image of the same day
2. No mixed pixels
3. Water depth ≥ 2.4 m to avoid bottom reflectance contamination.

- Ultimately, 294 data values from 33 stations (in red) out of 5,262 from 56 stations (red and yellow)
- In situ data provided by the Environmental Protection Commission of Hillsborough County (EPCHC)

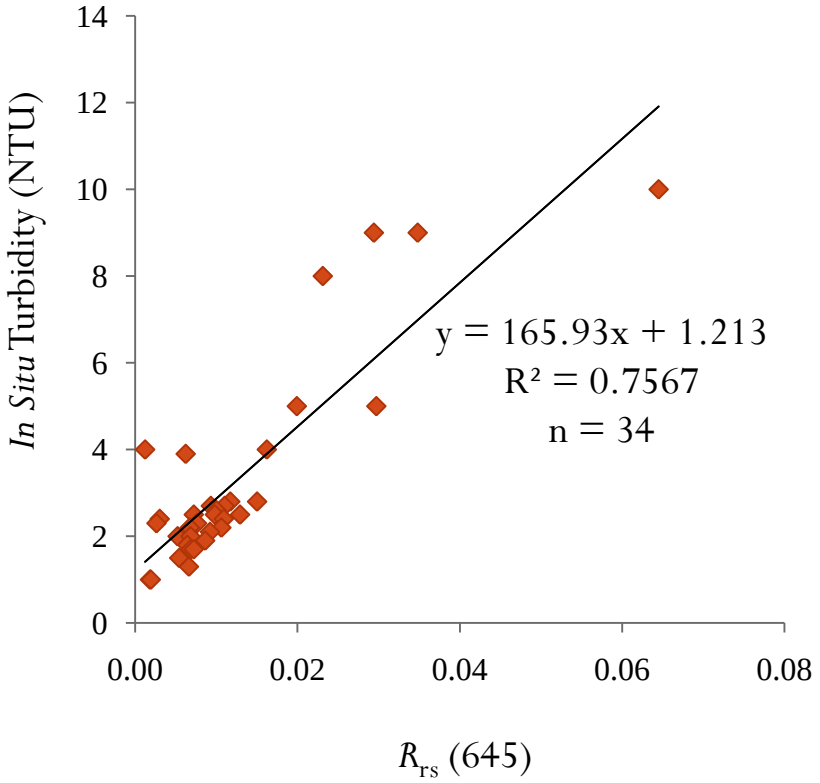
Relationships between *in situ* turbidity (NTU) and R_{rs} from MOD09GQ

Number of Days	R^2	Equation	n
8	0.76	$165.93 \times R_{rs} + 1.213$	34
7	0.69	$157.96 \times R_{rs} + 1.4746$	60
6	0.55	$161.43 \times R_{rs} + 1.6089$	87
5	0.48	$160.42 \times R_{rs} + 2.1492$	114
4	0.47	$162.94 \times R_{rs} + 1.9947$	133
3	0.35	$143.39 \times R_{rs} + 1.9064$	195
2	0.35	$144.19 \times R_{rs} + 1.8696$	222
1	0.32	$143.64 \times R_{rs} + 1.8413$	260
0	0.32	$142.28 \times R_{rs} + 1.7944$	294

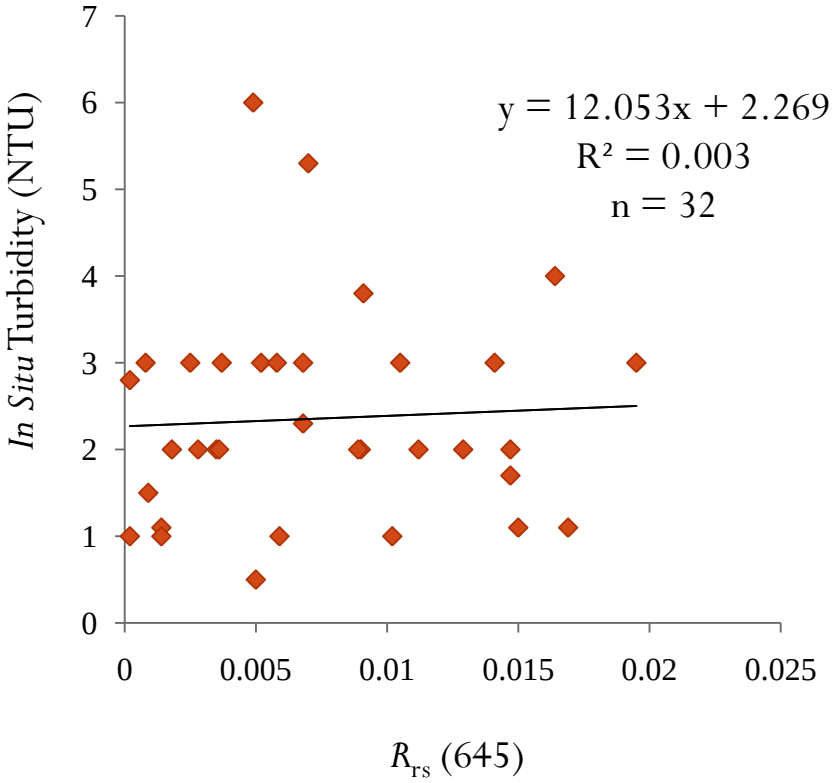
Cumulative analysis starting with all the matching pairs of data available according to the criteria and gradually decreasing the data set by increasing one day after rain event until eventually having only the matching pairs with 8 days or more after a rain event. All relationships were significant ($P<0.0001$).

Relationships between *in situ* turbidity (NTU) and R_{rs} from MOD09GQ (cont'd)

8 days after rain event

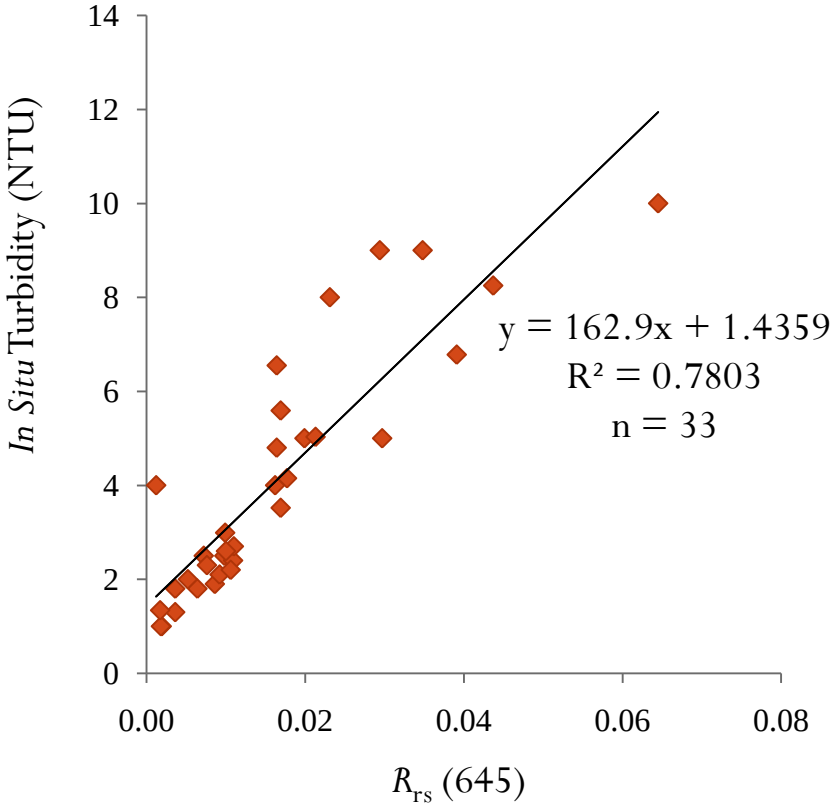


Same day of a rain event (cloud free sky)



Relationships between *in situ* turbidity (NTU) and R_{rs} from MOD09GQ (cont'd)

7 days after a rain event - color reading ranging between 4 and 7 Pt-Co units



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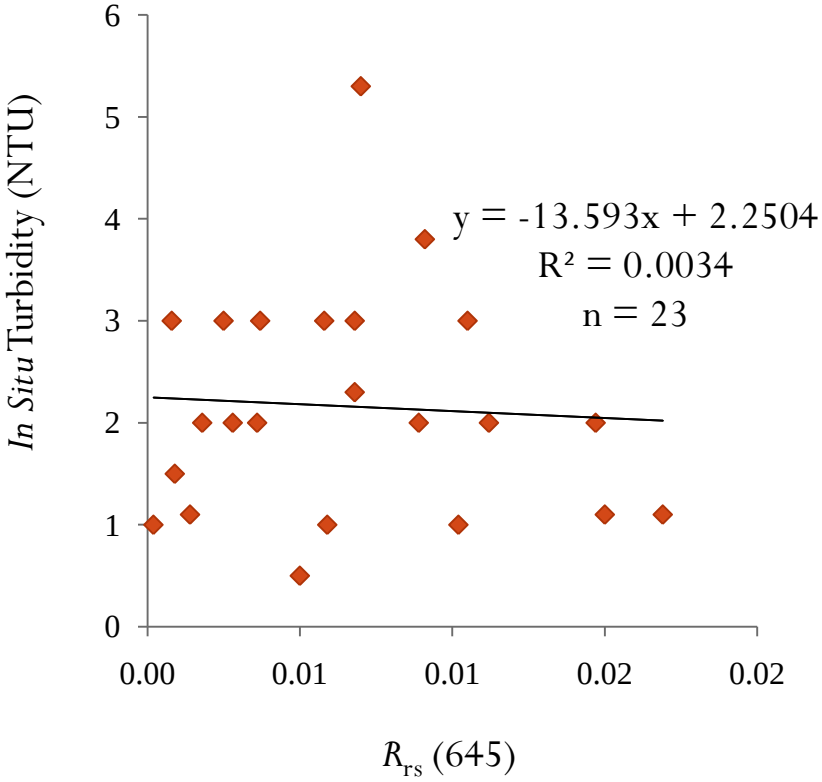


Summary Table of Time Series from 2000 to 2007 in Tampa Bay water

	Slopes of the Trends	
	≥ 8 days after rain	Same day of rain
Reflectance	-0.000003	-0.000002
In situ Turbidity (NTU)	-0.001	-0.00004
In situ Chlorophyll-α (mg/L)	-0.0004	-0.0006
In situ Total Nitrogen (TN)(mg/L)	-0.0003	-0.0002
In situ Total Phosphorus (TP) (mg/L)	-0.00003	0.00005

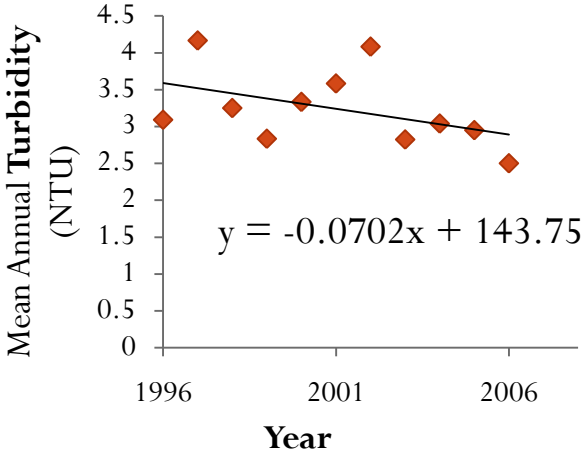
These trends were calculated using both RS and *in situ* data from the same dates.

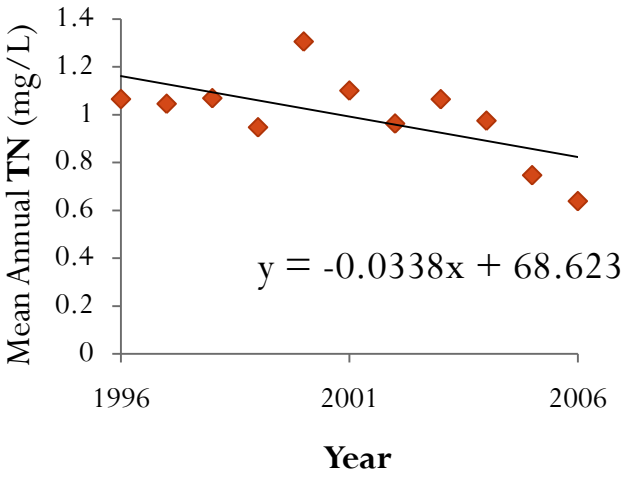
Summary statistics for Time Period 2000-2007

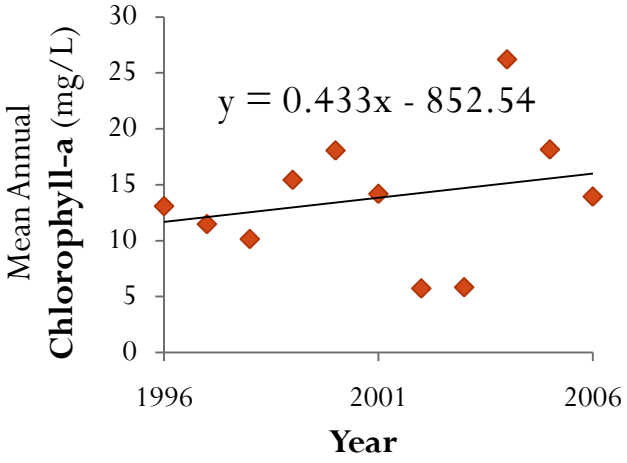
Sub-Regions	Average Turbidity (NTU)	SD-Turbidity (NTU)	Average Bottom Depth (m)	SD - Bottom Depth (m)	Average Color (Pt-Co Units)	SD - Color (Pt-Co Units)	n
Hillsborough Bay	4.8	3.0	3.8	1.0	10.0	5.4	38
Old Tampa Bay	2.9	2.2	3.5	1.0	8.7	3.7	37
Middle Tampa Bay	3.2	1.9	6.2	2.0	7.9	4.4	135
Low Tampa Bay	3.9	2.7	6.4	2.6	4.4	2.0	84

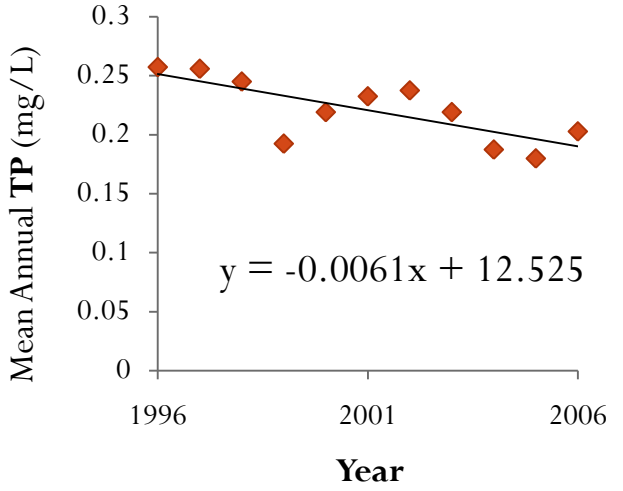
Summary statistics of *in situ* data variables for the time period 2000-2007 by sub-regions of the Tampa Bay and using only data matched up with Remotely Sensed Data

Mean Annual Concentration of Four Parameters of WQ in Water from Hillsborough River from 1996 to 2006









The same procedure was followed with each one of the other 4 tributaries of TB

Relationship between Increase in Developing Land and Trend of Water Quality in Tributaries (cont'd)

Watershed	Change km^2 1996-2006	Pct. Change 1996-2006	Change Area times Precipit. m^3	Regression Slope Turbidity	Regression Slope Chlo.-α	Regression Slope TN	Regression Slope TP
Hillsborough River	53.1	16	3507416832	-0.07	0.433	-0.034	-0.006
Alafia River	18.4	13.5	292776153	-0.237	0.015	-0.015	0.009
Little Manatee River	4.8	11.2	66756506	-0.143	-0.243	-0.034	-0.009
Manatee River	38.9	31.1	425579746	-0.073		-0.056	-0.004
Tampa Bay tributary	59.8	9.5	515451903	-0.111	-0.435	-0.005	-0.010

Percent change in developing land in the 5 tributaries of TB (5 sub-watersheds within the TBW) and their associated trend in mean annual WQ variables.

Preliminary Conclusions

- Areas covered with developed land, bare land, and open water increased in the TBW for the time period 1996-2006.
- The Sub-watershed with the greater percentage of increase in developed land was Manatee River followed by Hillsborough River, Alafia River, Little Manatee River, and Tampa Bay tributary.
- Areas covered with agriculture, wetlands, and scrub/shrub decreased for the same time period.
- The sub-watershed with the greater decrease in wetlands was Little Manatee River followed by Alafia River, Tampa Bay tributary, Manatee River, and Hillsborough River.
- Turbidity is better estimated with RS with more days after rainfall.
- Turbidity and concentration of TN, TP, and chlorophyll-α slightly decreased in TB water for the time period 2000- 2006.

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Presenter:

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