Potential Relationships between Urban Development and the Trophic Status of Tampa Bay Tributaries and Lake Thonotosassa, Further the Potential Effect on Public Health

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Presenter Disclosures

<Max Jacobo Moreno Madriñán>

(1) The following personal financial relationships with commercial interests relevant to this presentation existed during the past 12 months:

< “No relationships to disclose” >

Outline

- Background – Public Health
- Hypothesis
- Objectives
- Land Cover/Land Use change (LC/LU) 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
- 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.

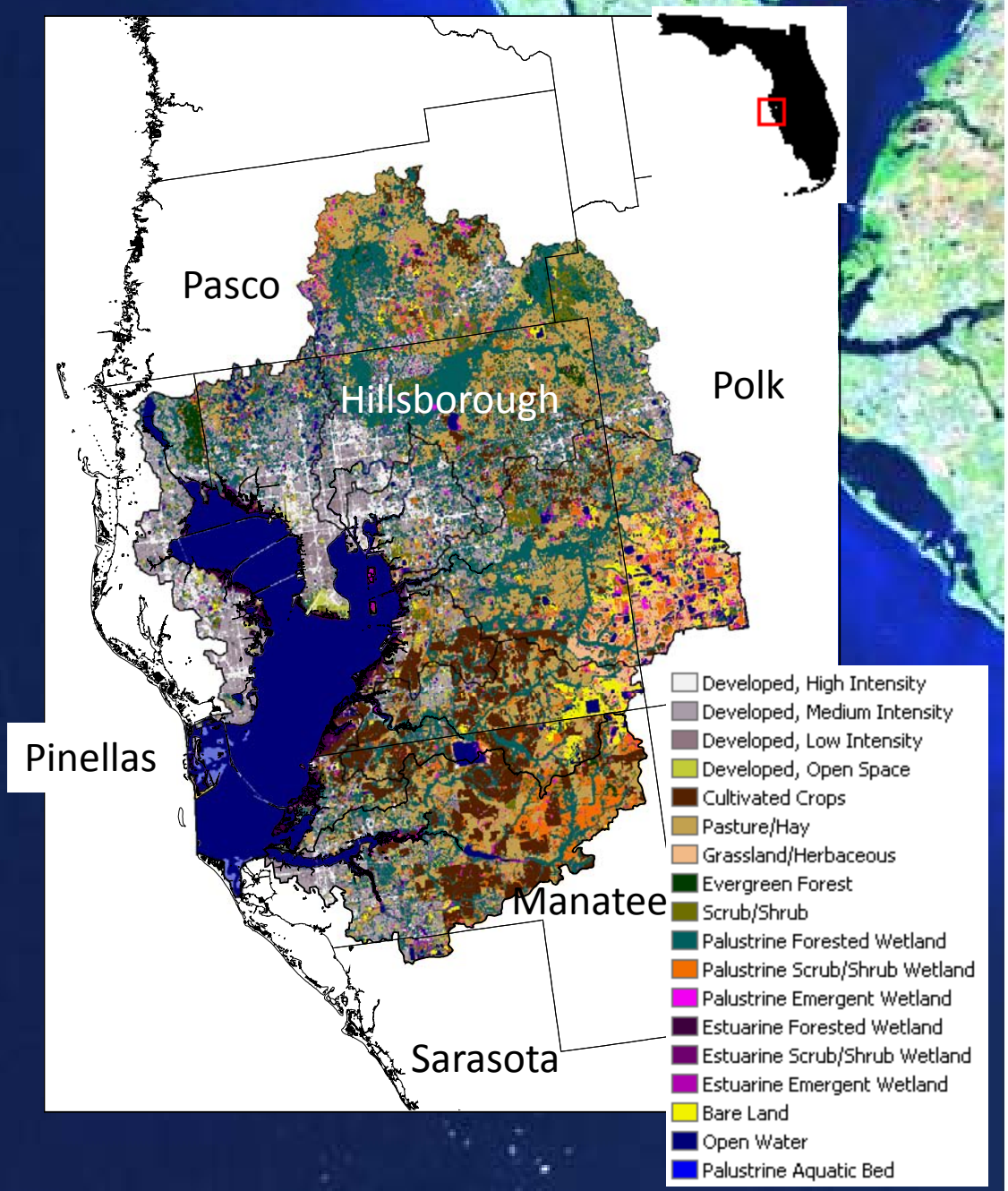
Tampa Bay (TB), is the largest open-water estuary in Florida. Stretches 1,030.81 km^2 at high tide.

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

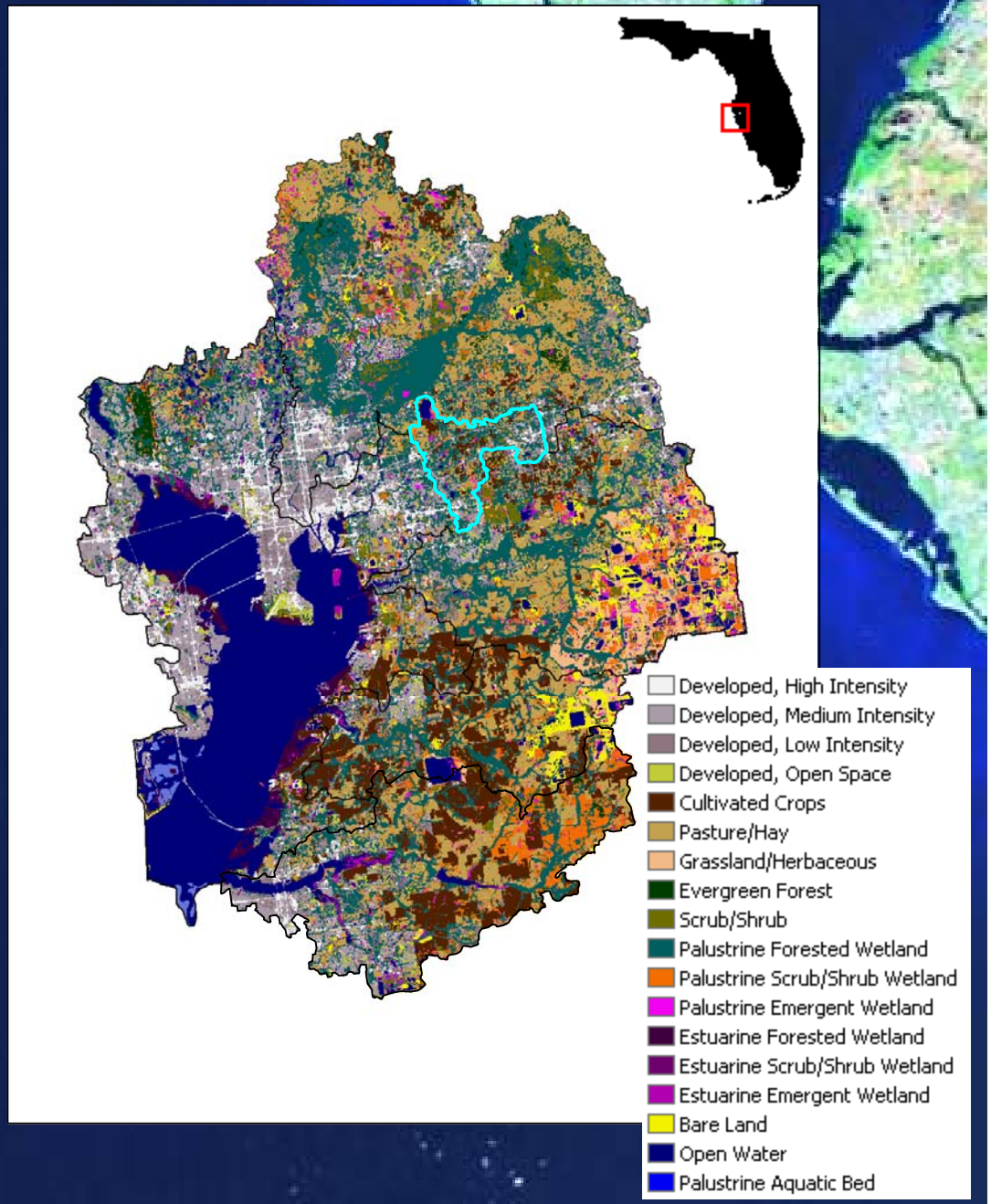
- Change in LC/LU affects the WQ of Tampa Bay tributaries, Lake Thonotosassa and the Bay itself
- Both the LC/LU and WQ can be estimated with RS as well as the effect of their interaction

Objectives

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

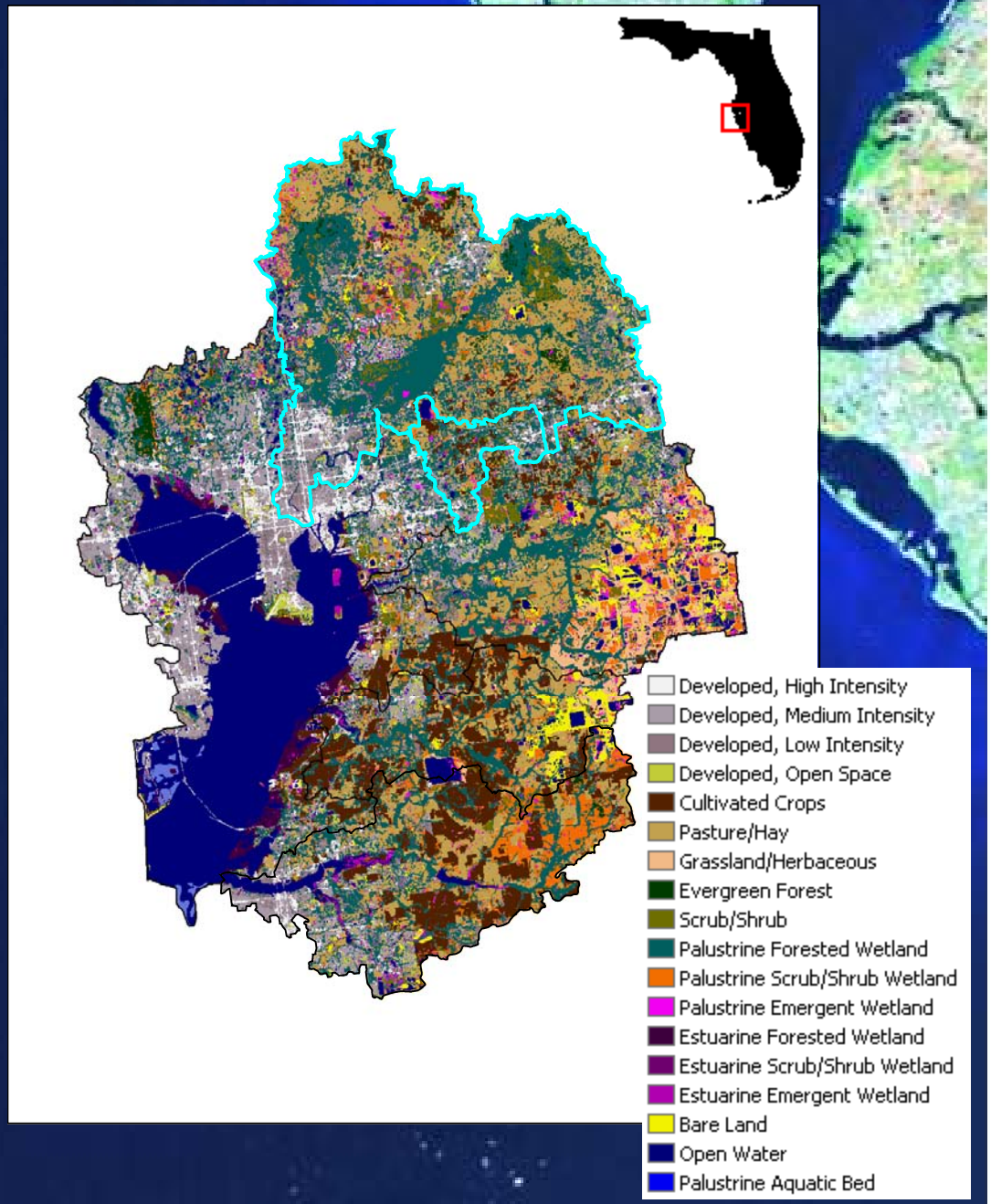
5 Sub-watersheds

- Lake Thonotosassa Watershed (LTW)
- Lake Thonotosassa (LT)



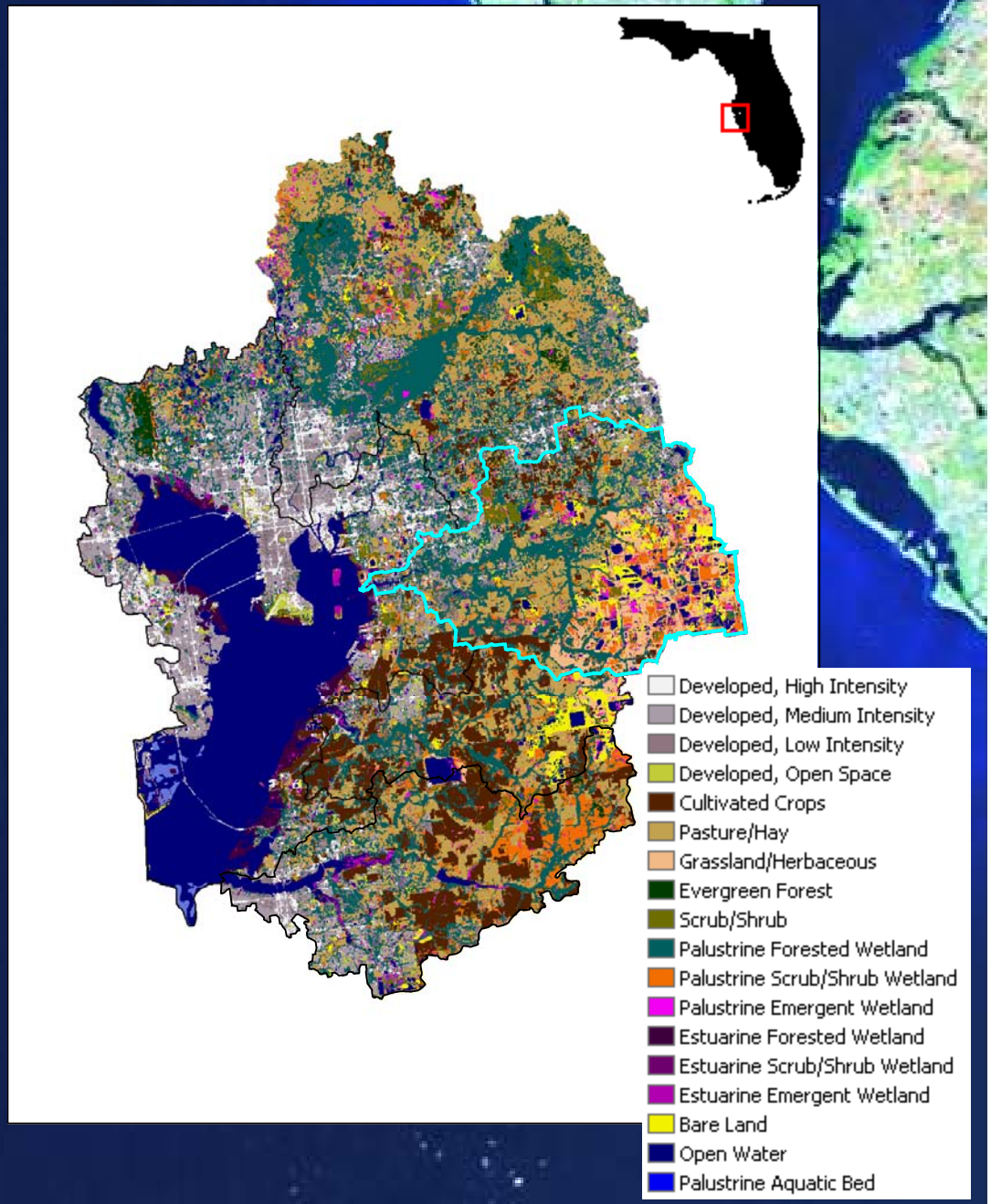
5 Sub-watersheds

1. Hillsborough River (HR)
   - Lake Thonotosassa Watershed (LTW)



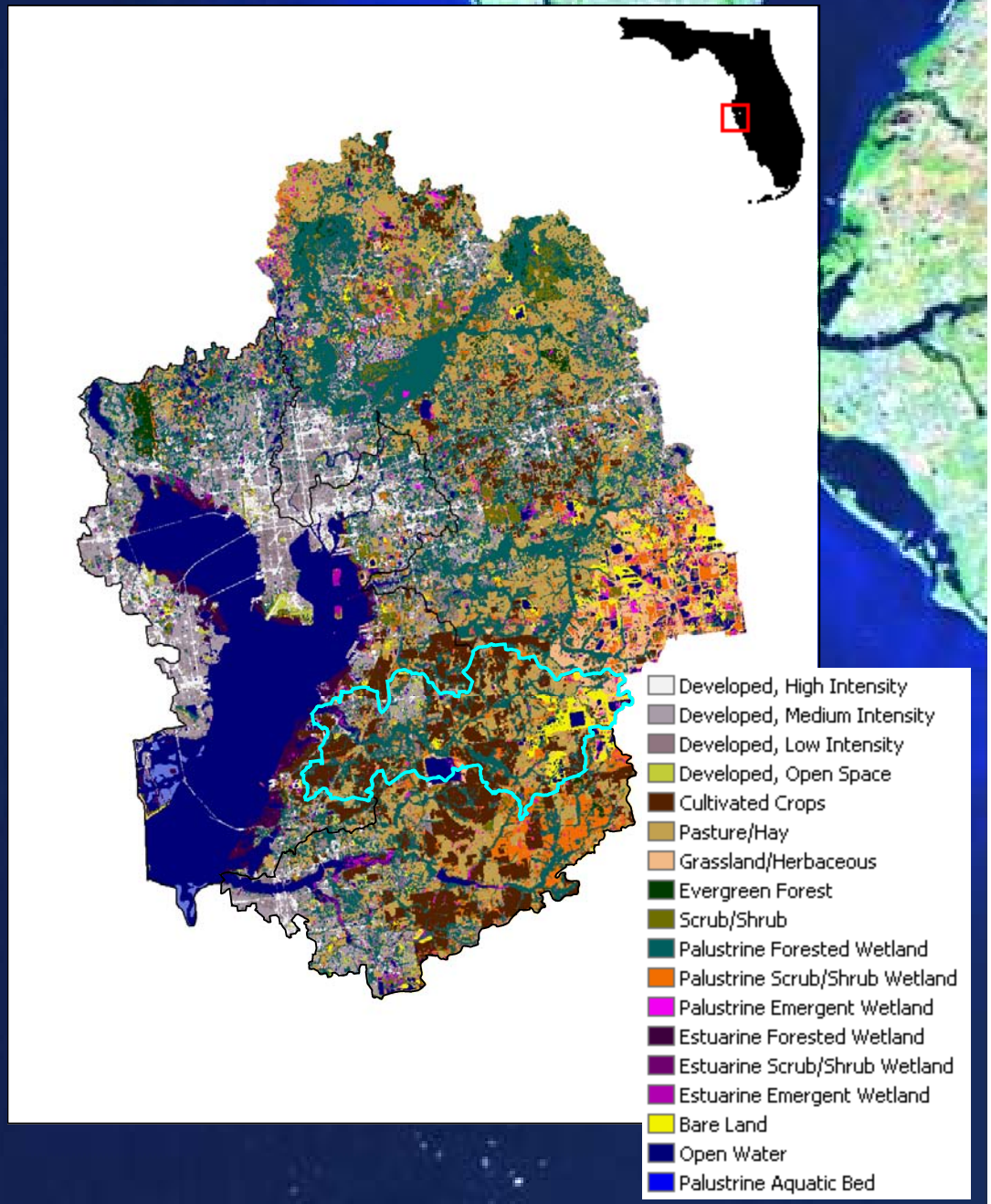
5 Sub-watersheds

1. Hillsborough River (HR)
   - Lake Thonotosassa Watershed (LTW)
2. Alafia River (AR)



5 Sub-watersheds

1. Hillsborough River (HR)
   - Lake Thonotosassa Watershed (LTW)
2. Alafia River (AR)
3. Little Manatee River (LMR)



5 Sub-watersheds

1. Hillsborough River (HR)
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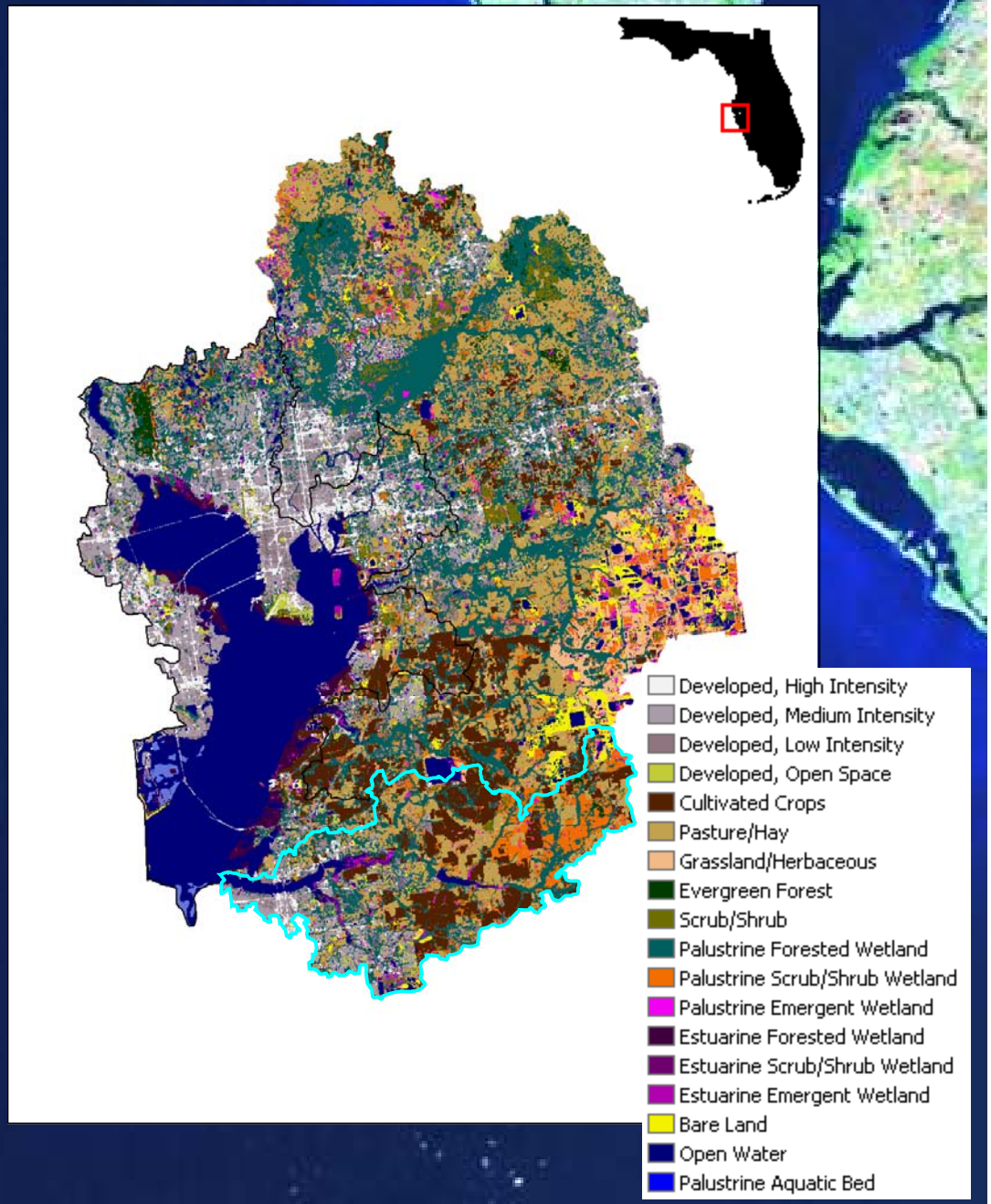
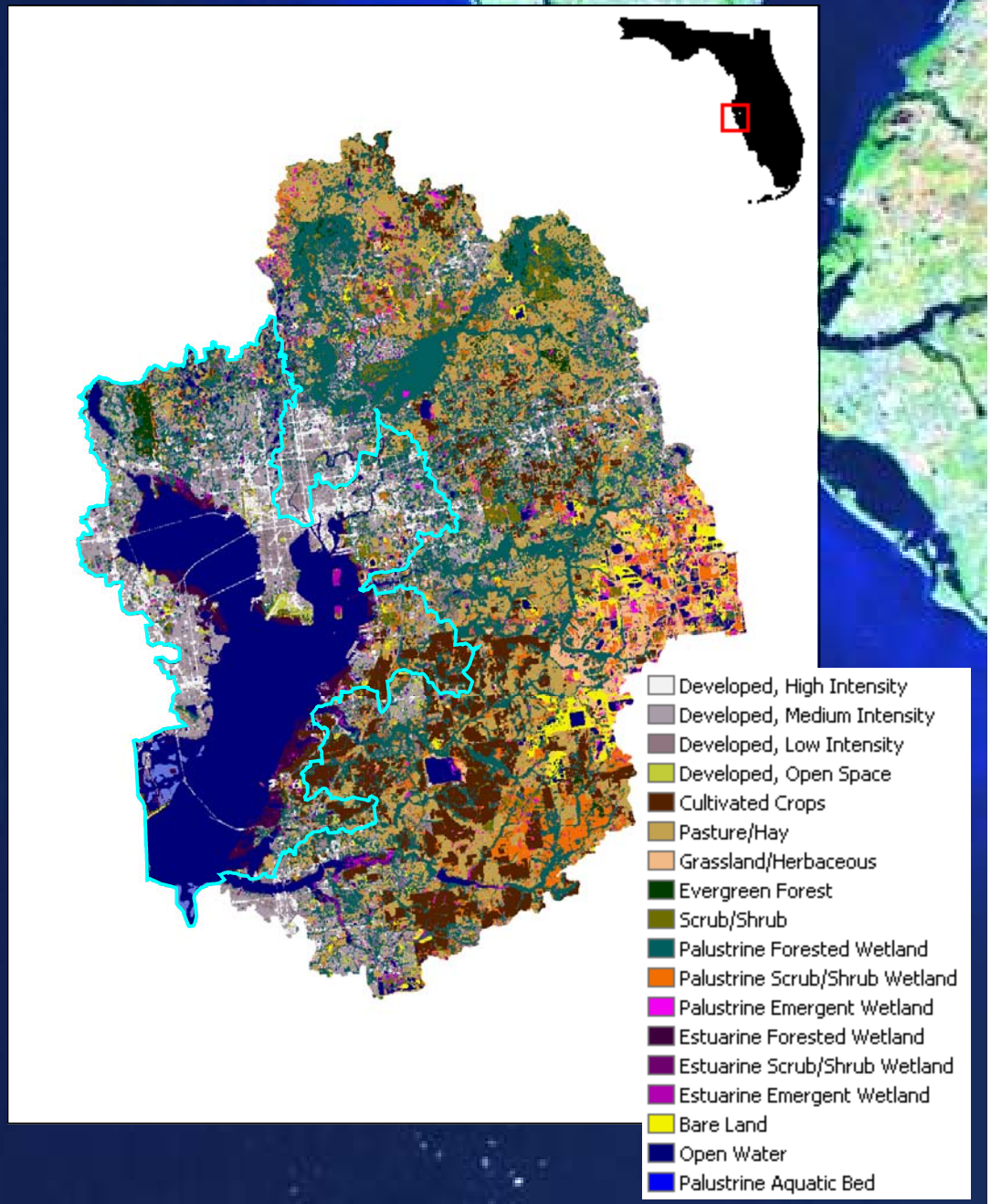
2. Alafia River (AR)
3. Little Manatee River (LMR)
4. Manatee River (MR)



5 Sub-watersheds

1. Hillsborough River (HR)
   - Lake Thonotosassa Watershed (LTW)
2. Alafia River (AR)
3. Little Manatee River (LMR)
4. Manatee River (MR)
5. Tampa Bay watershed (TBw)
   - TB West
   - TB N. East
   - TB. East
   - TB. S. East
   - TB



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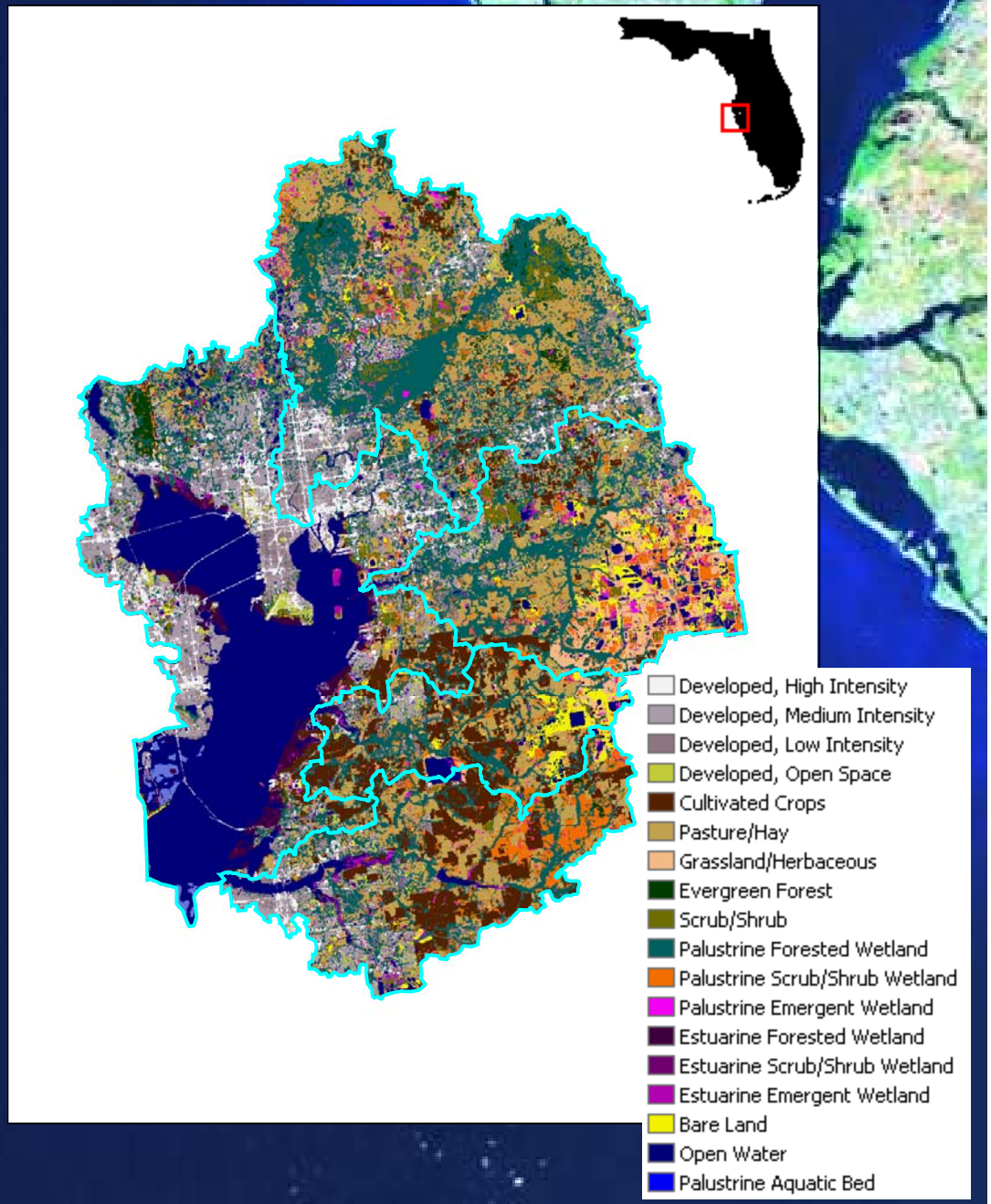
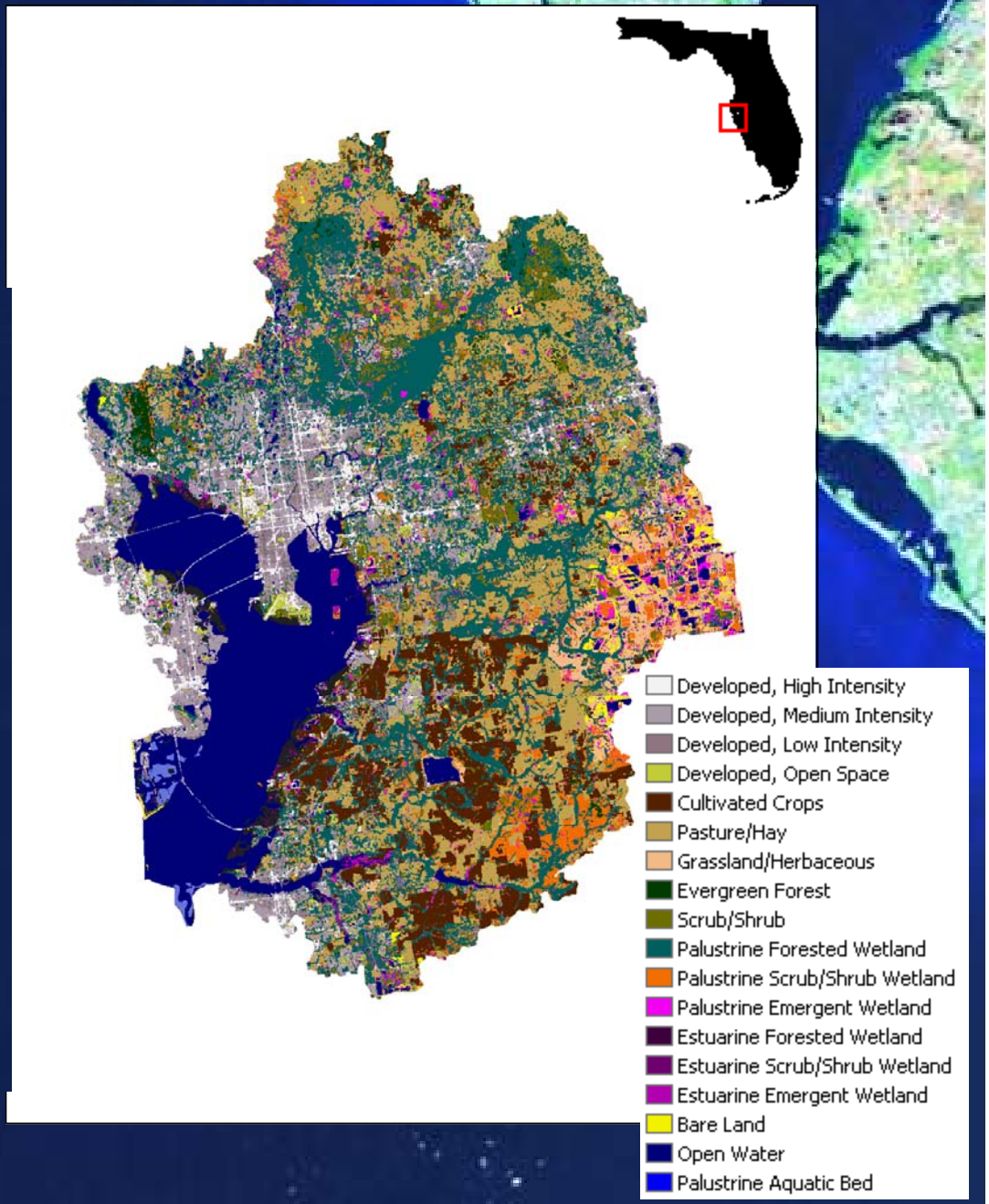


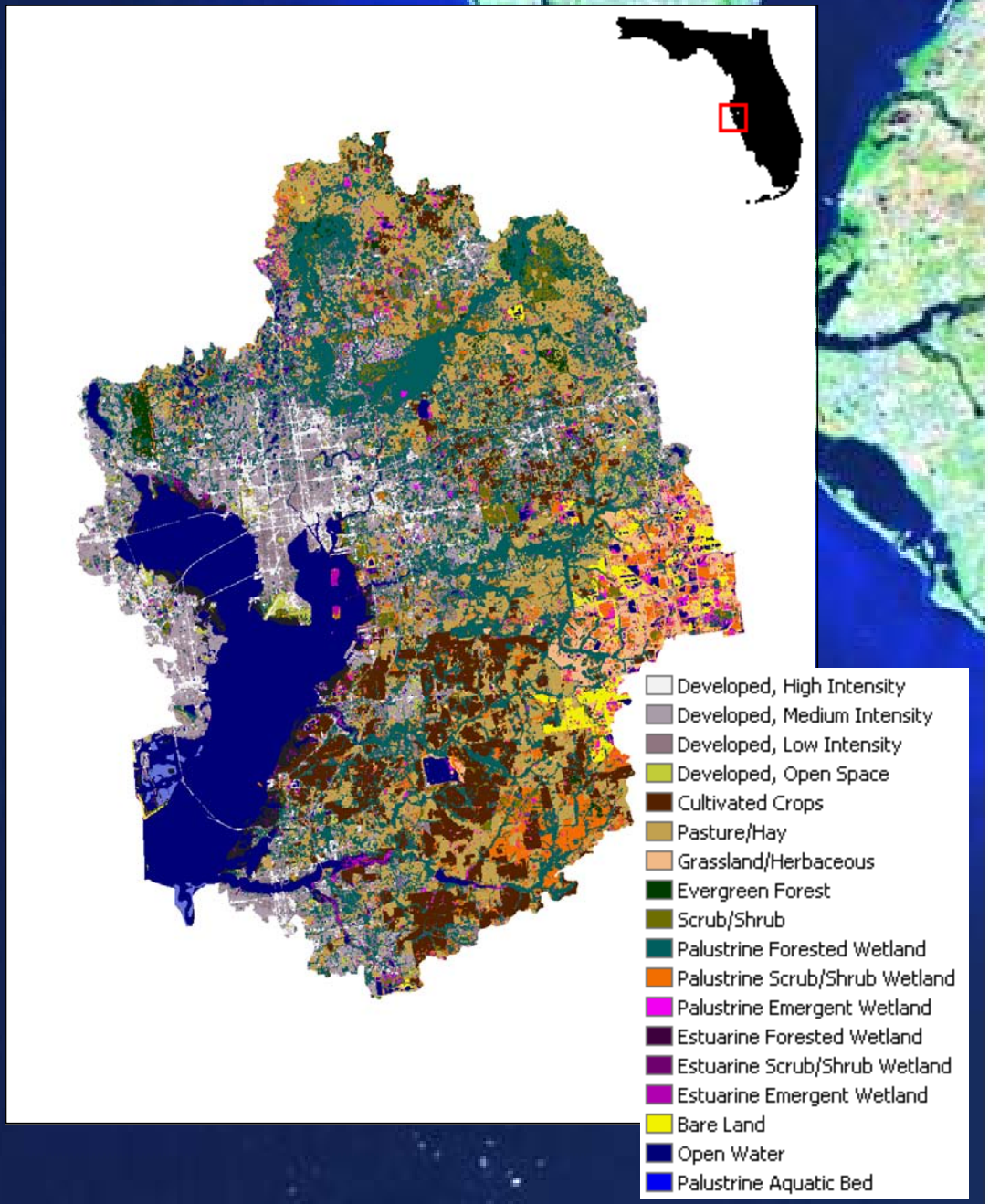
C-CAP 1996: TBW

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



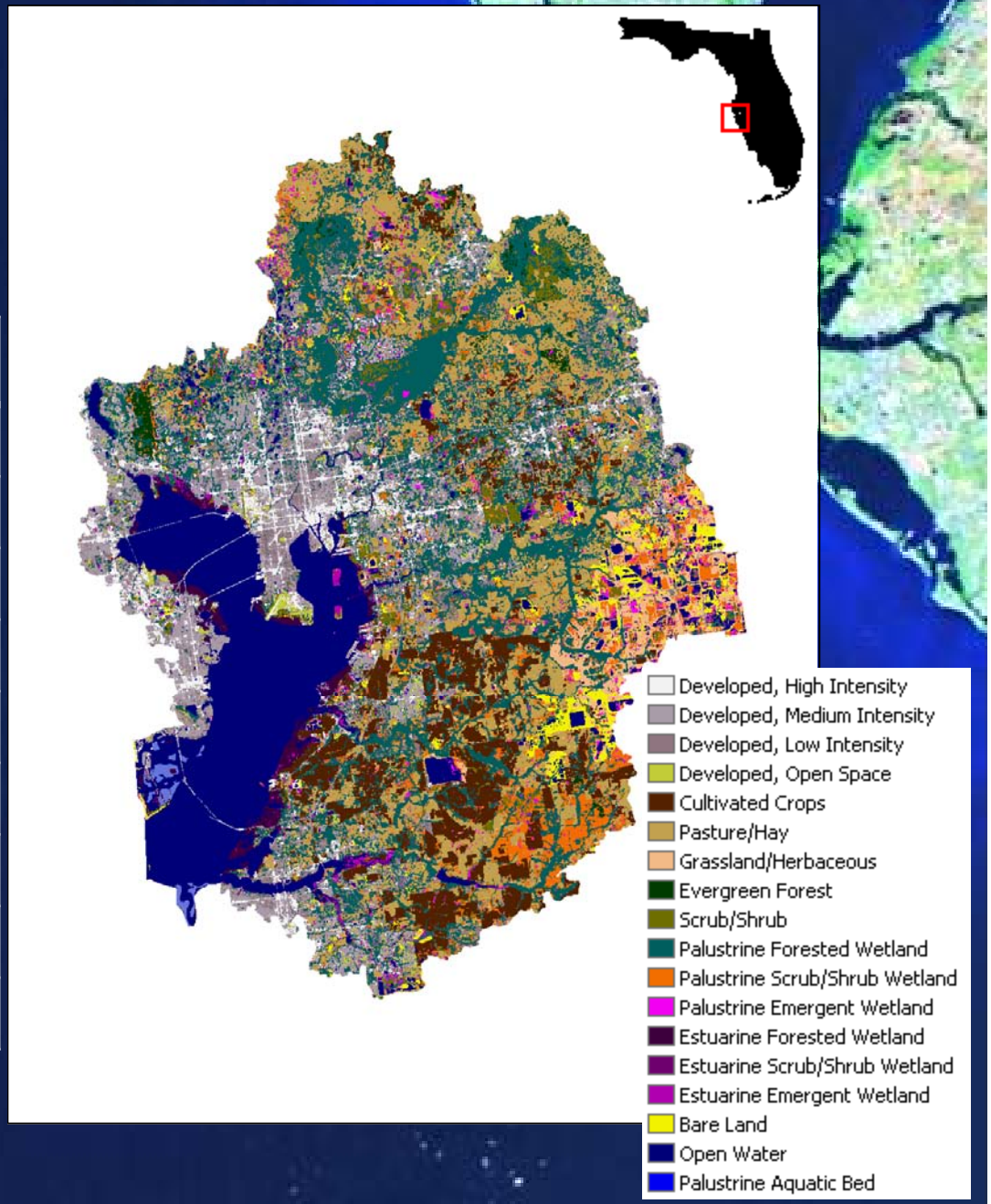
C-CAP 2001: TBW

Class name	Area in all TBW in Km^2		Change	
	1996	2001	Km^2	Percent
Develop.	1264	1410	146	11.5
Agr./Grass	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



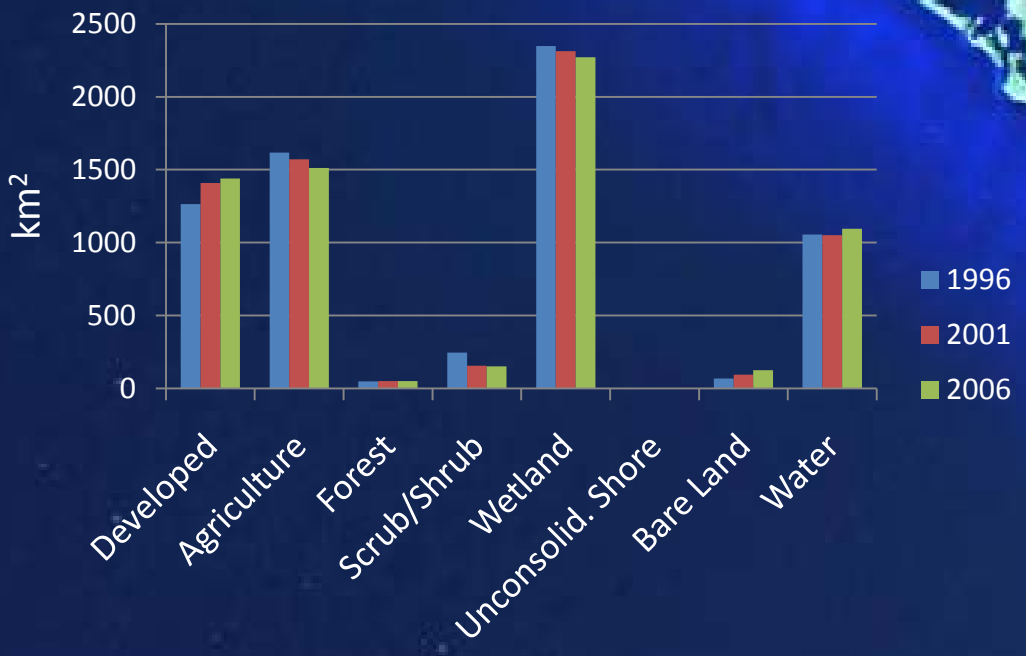
C-CAP 2006: TBW

Class name	Area in all TBW in Km^2		Change	
	2001	2006	Km^2	Percent
Develop.	1410	1439	29	2.1
Agr./Grass	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) in the Tampa Bay Watershed

Class name	Area in Tampa Bay Watershed in Km²		Change in Km²	Pct. Change
	1996	2006		
Develop.	1264	1439	175	13.8
Agr./Grass	1617	1513	-105	-6.5
Forest	48	50	2	4.2
Scrub	247	152	-94	-38.2
Wetland	2348	2272	-76	-3.2
Uncons.	0.5	0.4	-0.1	-18.1
Bare Land	67	126	59	87.3
Water	1056	1095	39	3.7

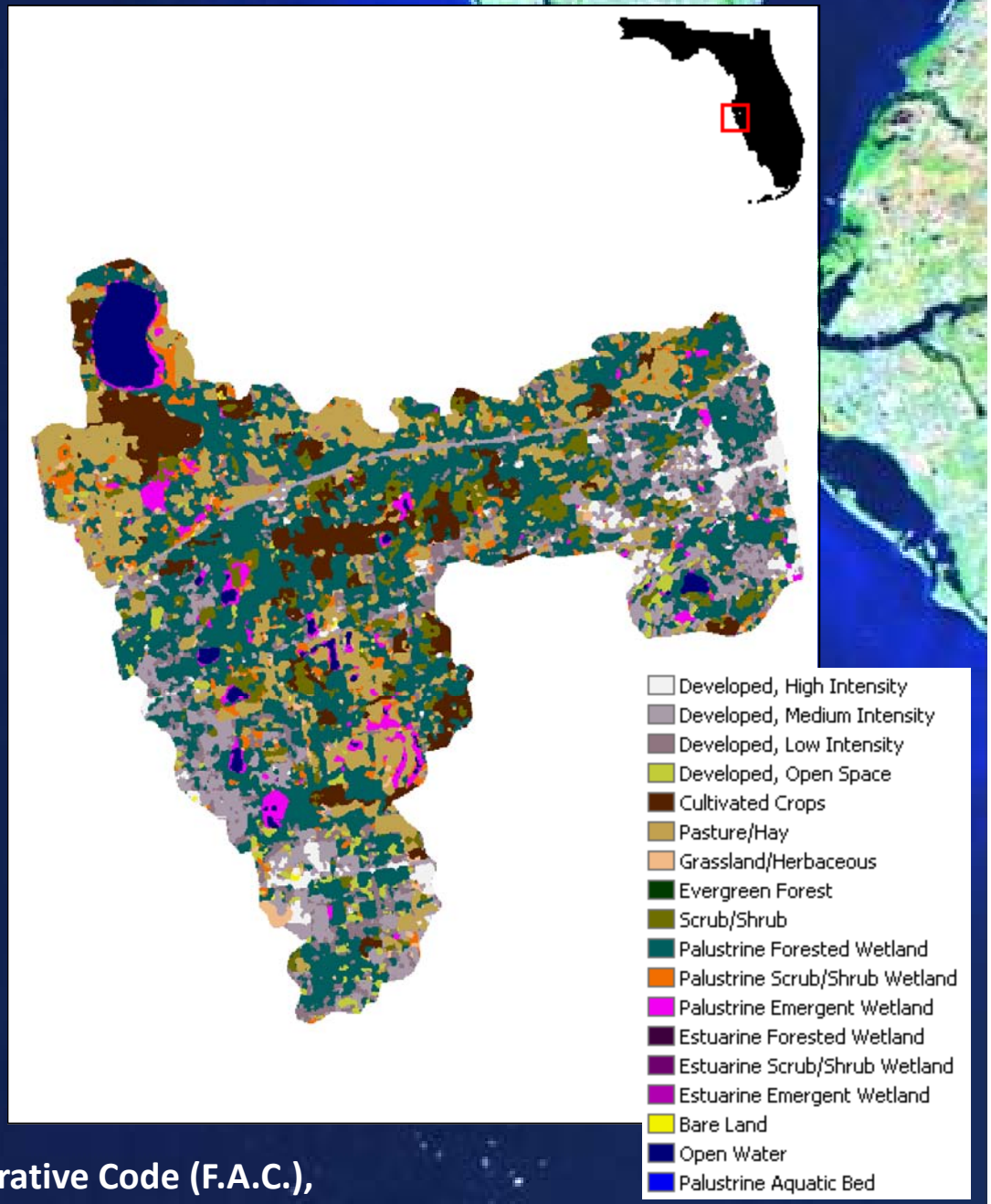


Change in LC/LU in Tampa Bay Watershed by Tributaries

Class name	Pct. Change from 1996 to 2006								
	HR	AR	LMR	MR	TB-West	TB-N.East	TB-East	TB-S.East	TB
Develop.	16	13.5	11.2	31.1	6.8	13.2	41.4	11.1	2.1
Agr/Grass	-3	-4.3	-10.4	-8.1	-16.2	-23.2	-8.7	0	-0.3
Forest	7.1	-4.7	-17.1	8.9	-0.1	11.1	-100	0	0
Scrub	-33.4	-35.2	-53.4	-42.2	0	-45.0	0	-49.1	-20.5
Wetland	-2.2	-4.3	-4.4	-2.5	-4.2	-5.3	-4.8	-2.6	1.2
Uncons.					0	0	-9.0	-100	-47.4
Bare Land	86	56.2	356.6	92.7	-47.5	-100	149.4	65.2	-9.0
Water	23.7	28.5	23.5	16.0	1.7	15.6	43.5	25.2	0

C-CAP 1996: LTW

Class name	Area in LTW in Km²
	1996
Develop.	37.7
Agr./Grass	34.4
Forest	0.1
Scrub	10.1
Wetland	61.9
Bare Land	0.7
Water	4.6

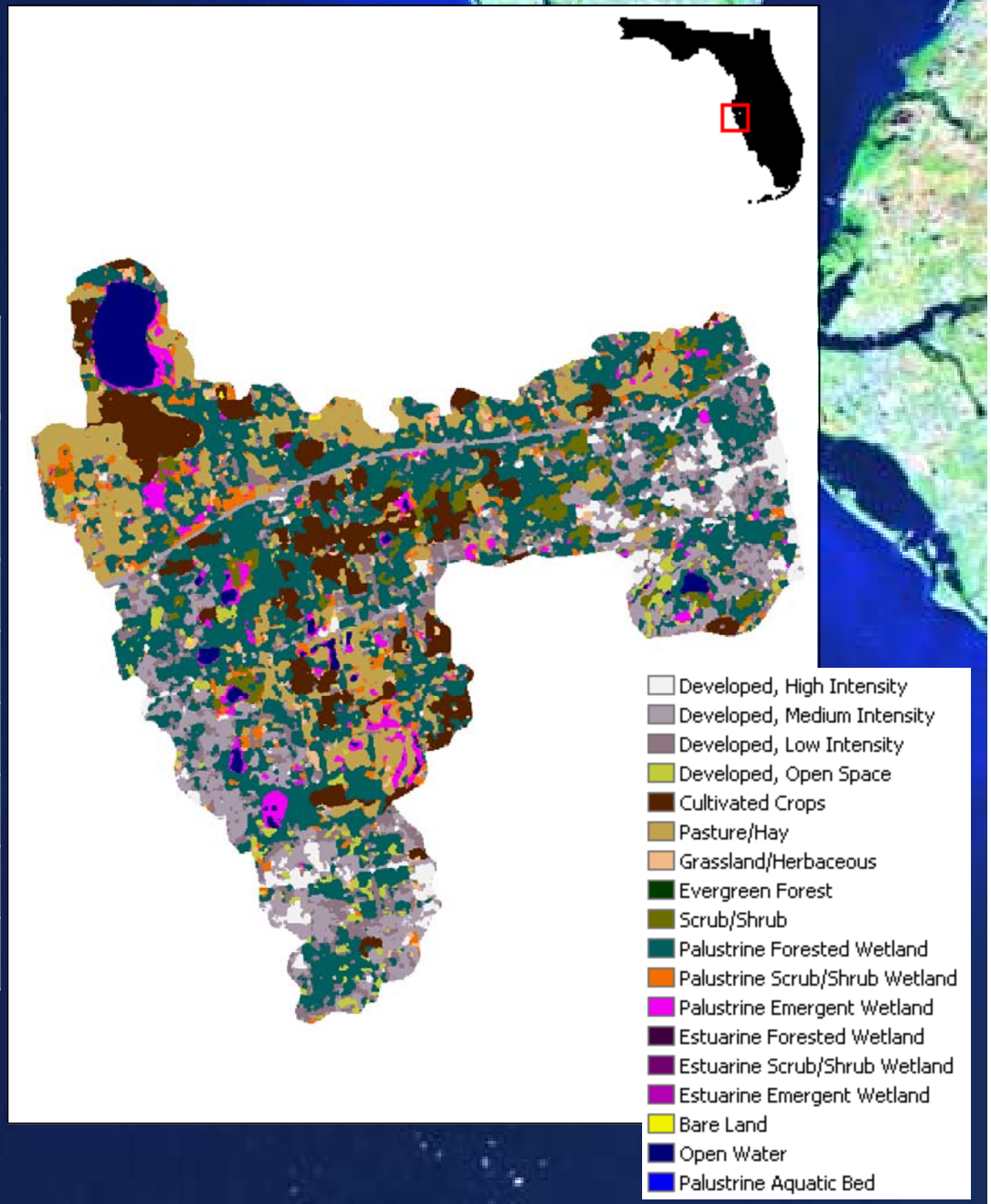


Watershed: 150 Km²
Lake: 2.5 km long, 1.5 km wide, and 2.5 m depth

Class III: Rule **62-302.400, Florida Administrative Code (F.A.C.),** human recreation and propagation of fish and wildlife.

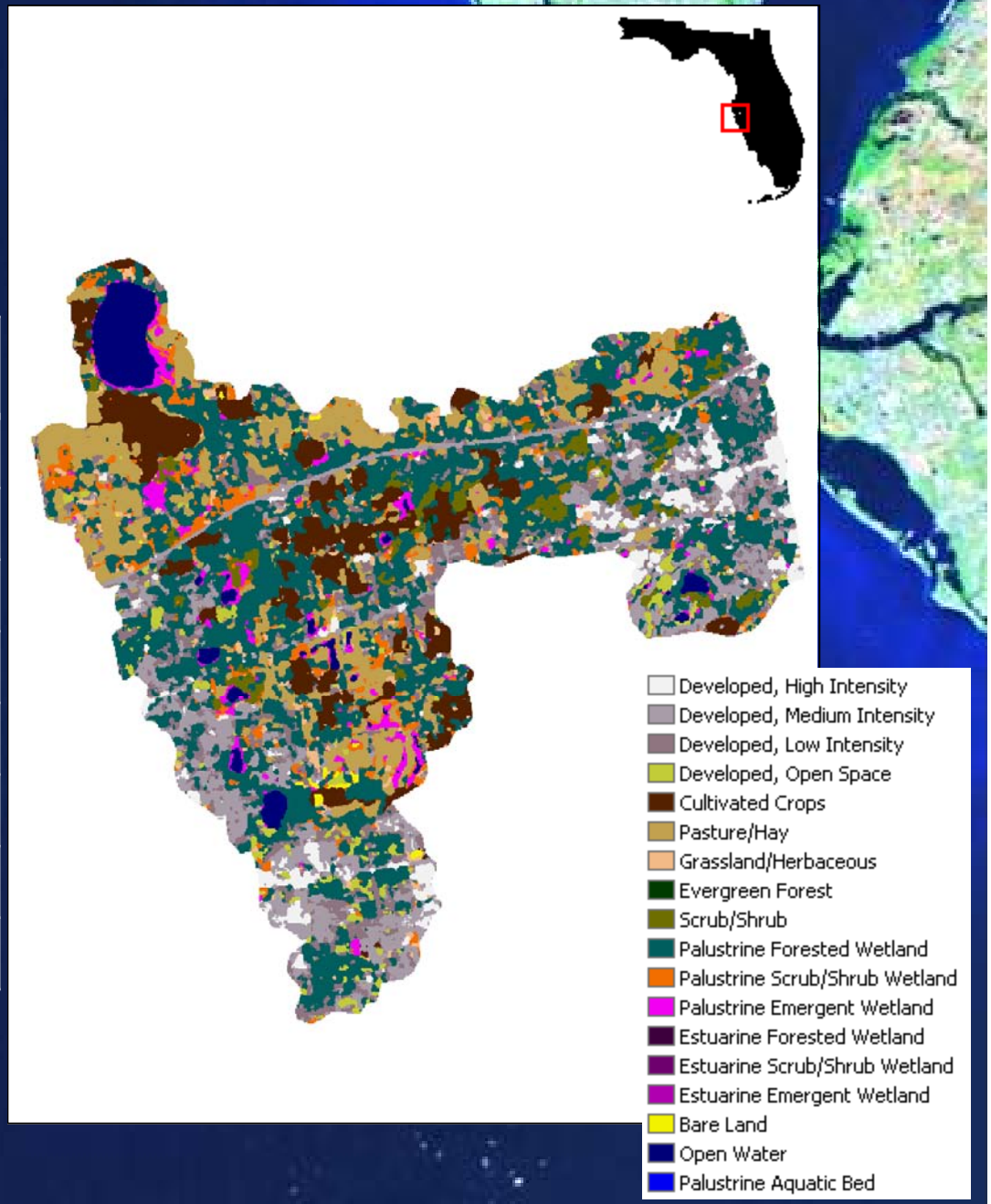
C-CAP 2001: LTW

Class name	Area in LTW in Km²		Change	
	1996	2001	Km²	Percent
Develop.	37.7	44.8	7.1	18.7
Agr./Grass	34.4	34.4	0	-0.1
Forest	0.1	0.1	0	-1.4
Scrub	10.1	4.9	-5.1	-50.9
Wetland	61.9	60.5	-1.4	-2.2
Bare Land	0.7	0.2	-0.5	-77.5
Water	4.6	4.6	0	0.1



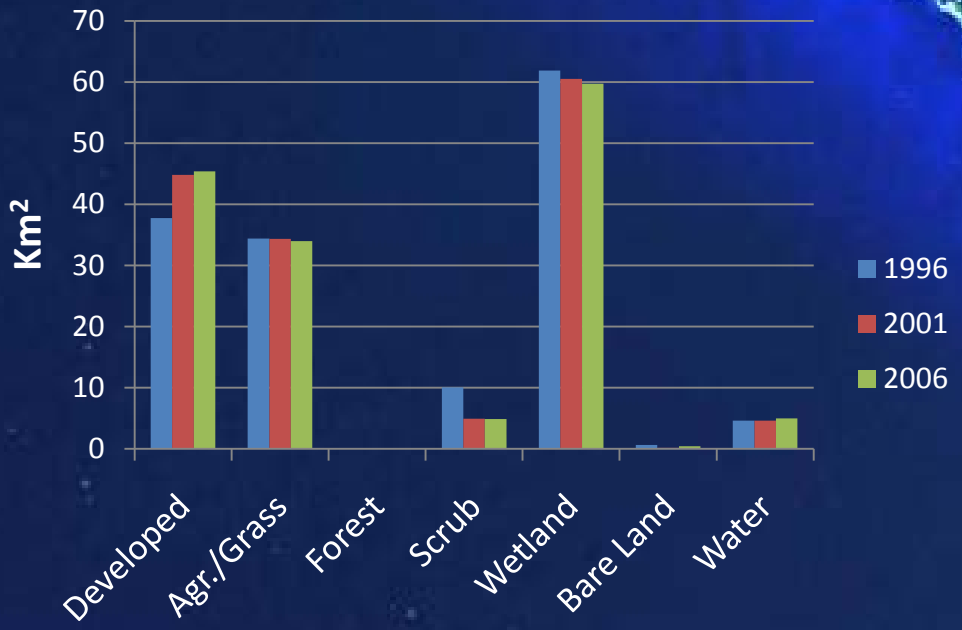
C-CAP 2006: LTW

Class name	Area in LTW in Km²		Change	
	2001	2006	Km²	Percent
Develop.	44.8	45.4	0.6	1.4
Agr./Grass	34.4	34	-0.4	-1.1
Forest	0.1	0.1	0	-10.3
Scrub	4.9	4.9	-0.1	-1.5
Wetland	60.5	59.7	-0.8	-1.3
Bare Land	0.2	0.4	0.3	174.9
Water	4.6	5.0	0.4	8



Change in Land Cover/Land Use (LC/LU) in Lake Thonotosassa Watershed

Class name	Area in Thonotosassa Watershed in Km^2		Change in Km^2	Pct. Change
	1996	2006		
Develop.	37.7	45.4	7.7	20.3
Agr./Grass	34.4	34	-0.4	-1.2
Forest	0.1	0.1	0	-11.6
Scrub	10.1	4.9	-5.2	-51.6
Wetland	61.9	59.7	-2.2	-3.5
Bare Land	0.7	0.4	-0.3	-38.1
Water	4.6	5.0	0.4	8.1



Population Growth in the Tampa Bay Metropolitan Area

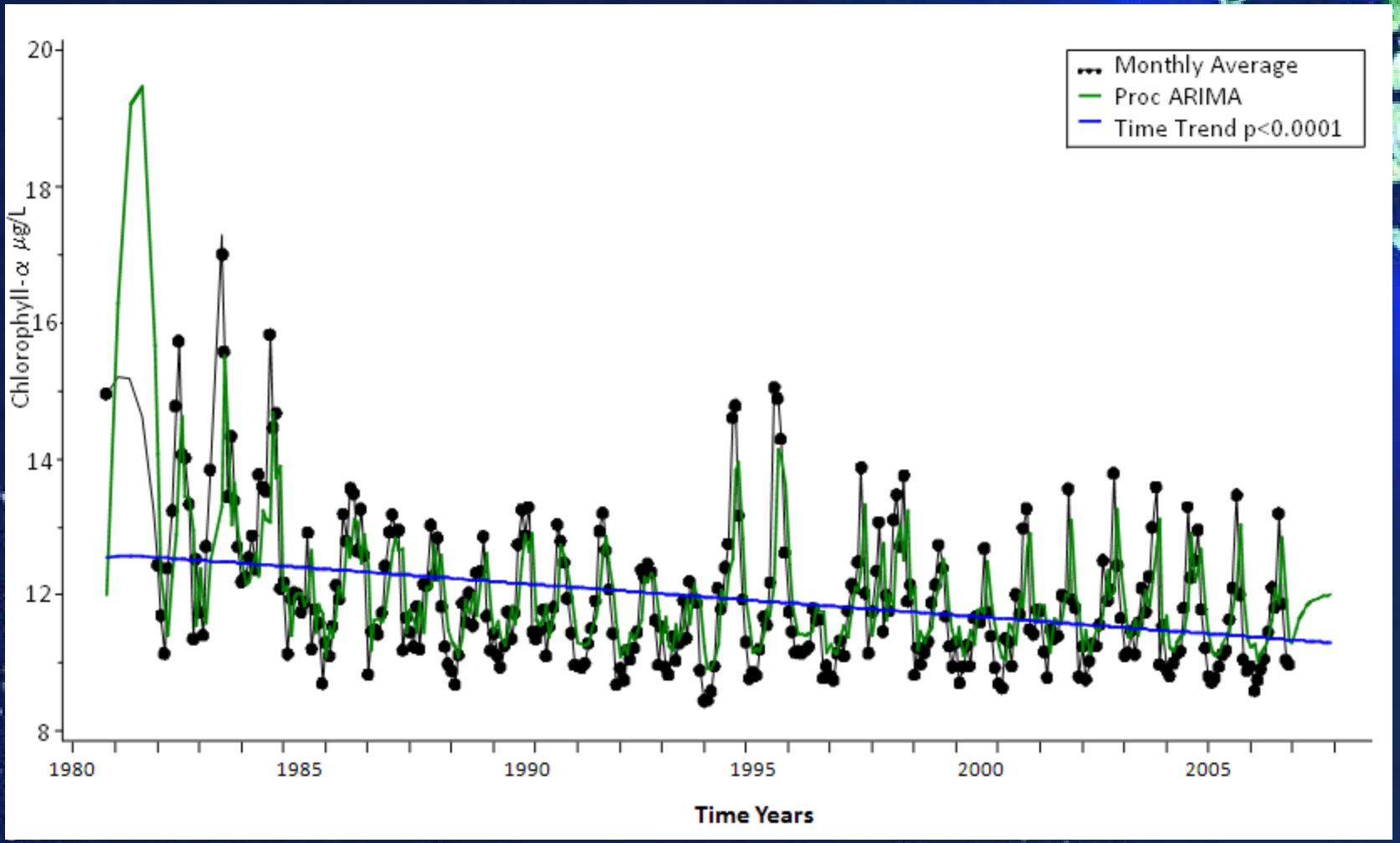
That number is expected to grow by nearly 19 percent by the year 2015, as approximately 500 people move to one of the three counties each week.

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

US Bureau of the Census (1990 – 2000)

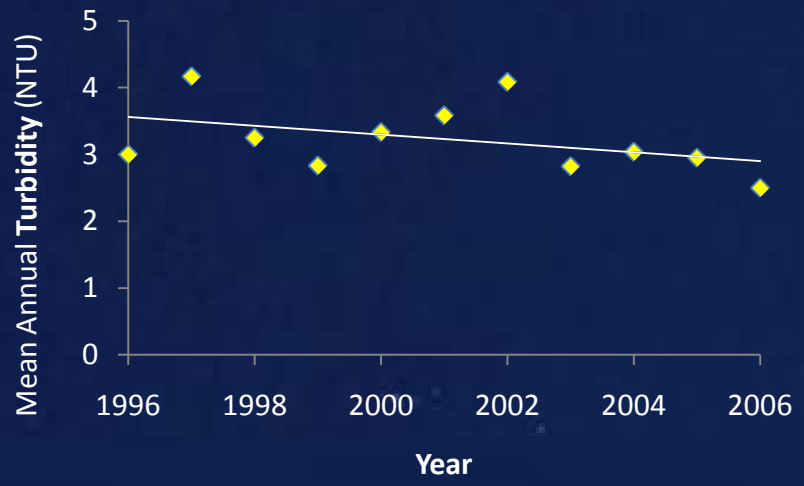
http://www.census.gov/popest/metro/CBSA-est2006-annual.html

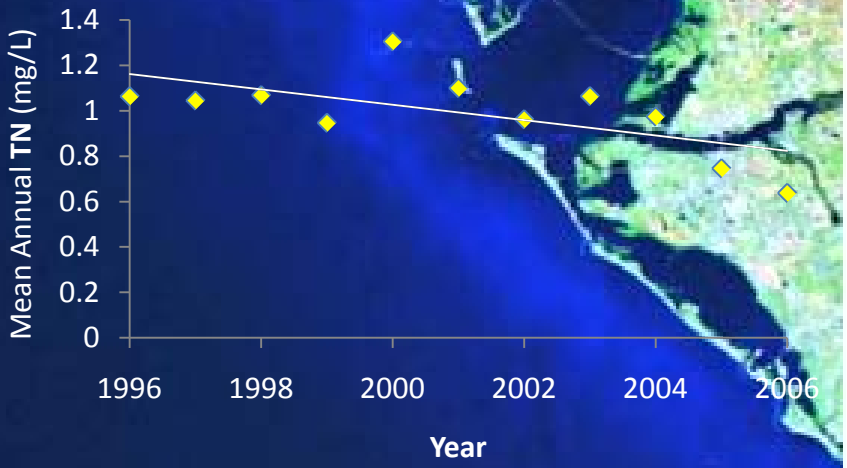
Chlorophyll-α concentration in Tampa Bay Water (1981- 2007)

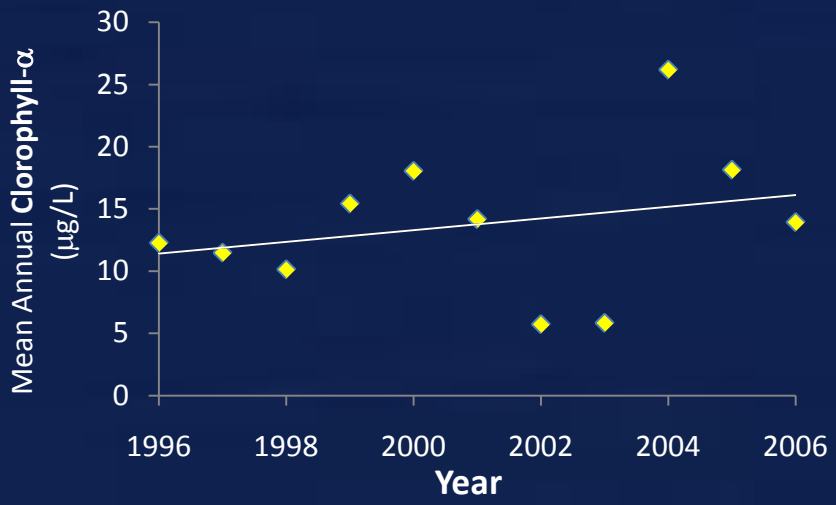


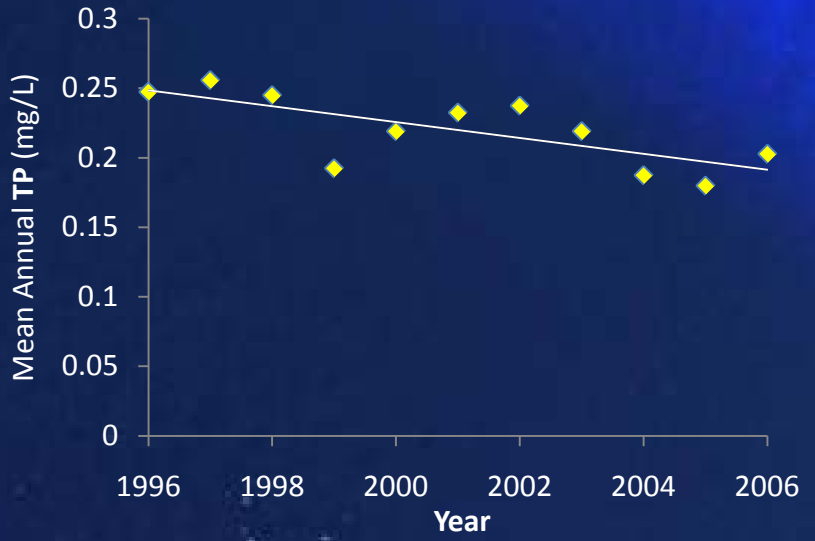
Data from the Environmental Protection Commission of Hillsborough County

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





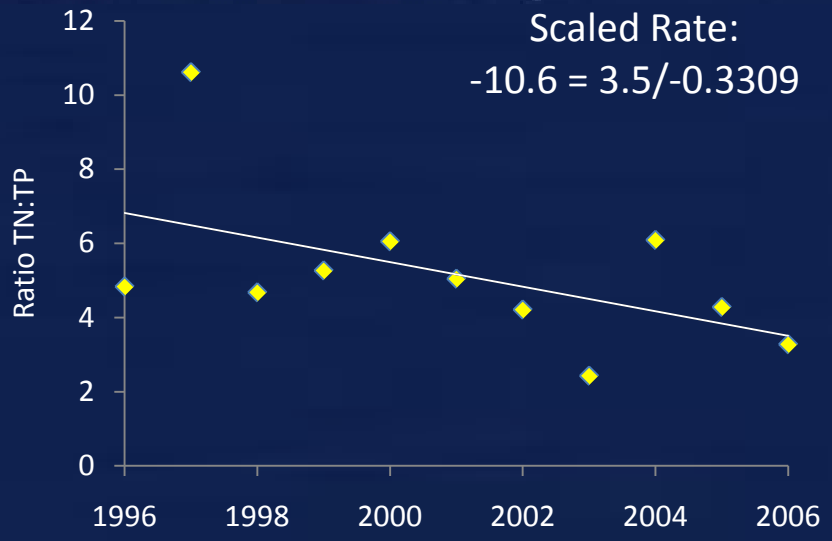




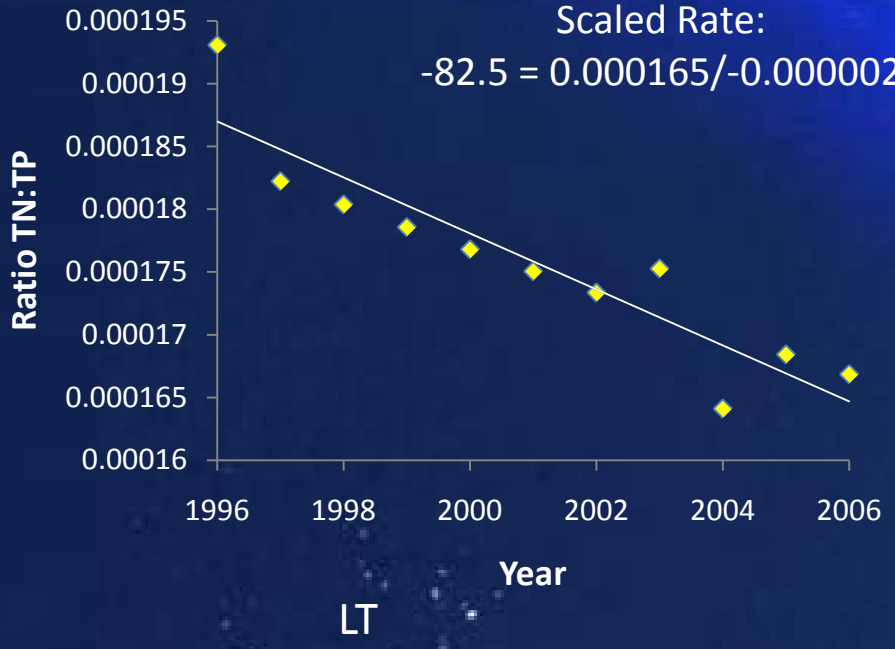
The same procedure was followed with each one of the other 4 tributaries of TB

Mean Annual Ratio of TN:TP in Water from Hillsborough River and Lake Thonotosassa from 1996 to 2006

Decreasing ratios of TN:TP in inflow water may be a concern for potential favorable conditions leading to abundance of cyanobacteria in receiving water bodies



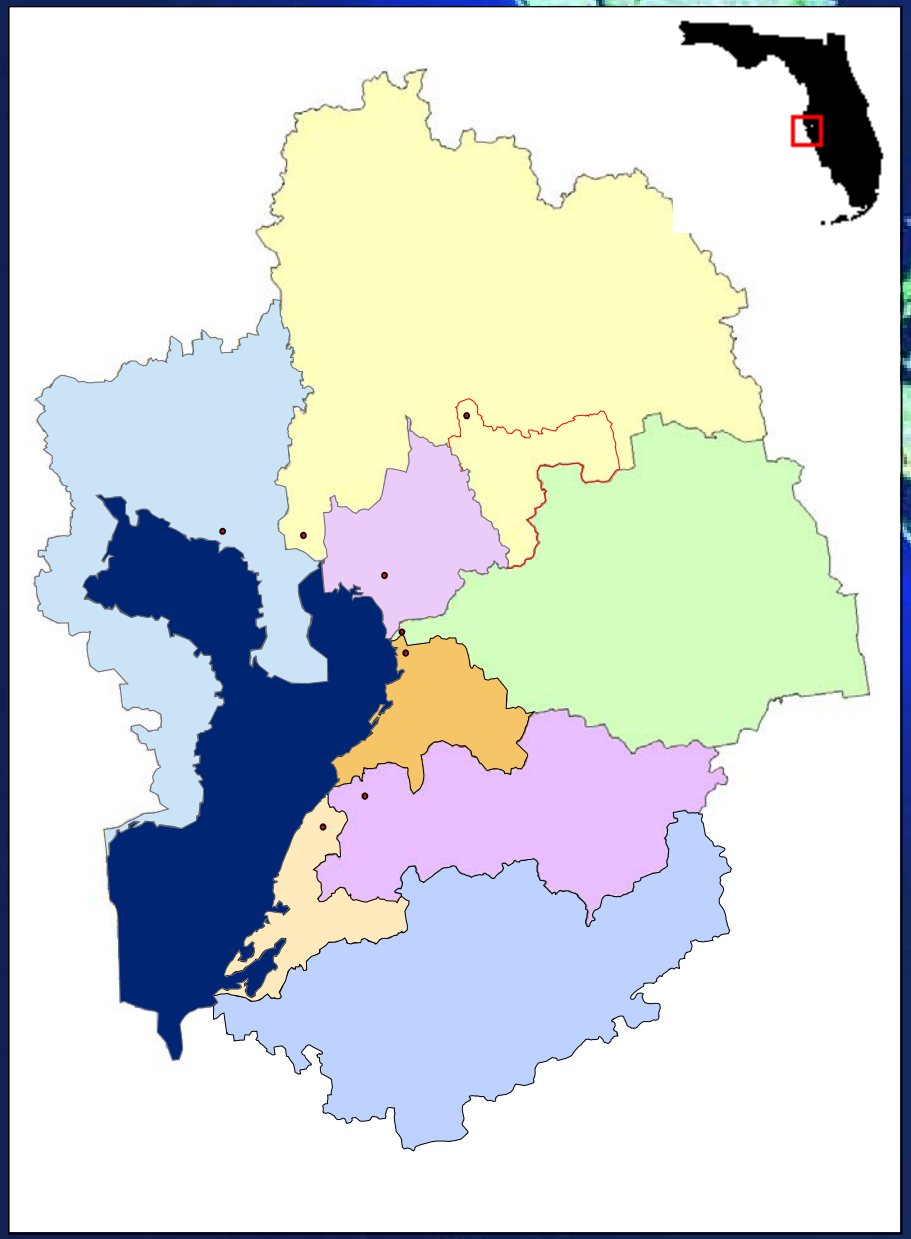
HR



LT

In Situ Water Quality

Water quality monitoring sites in tributaries

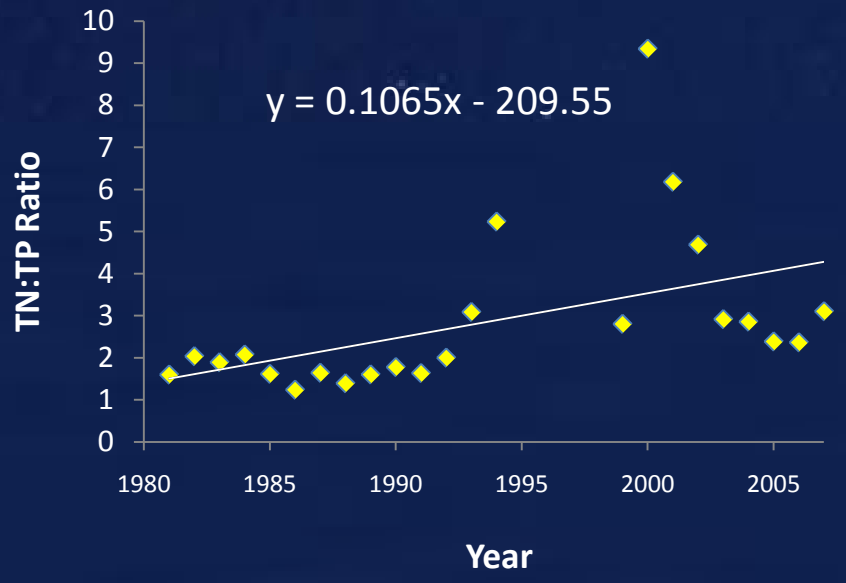


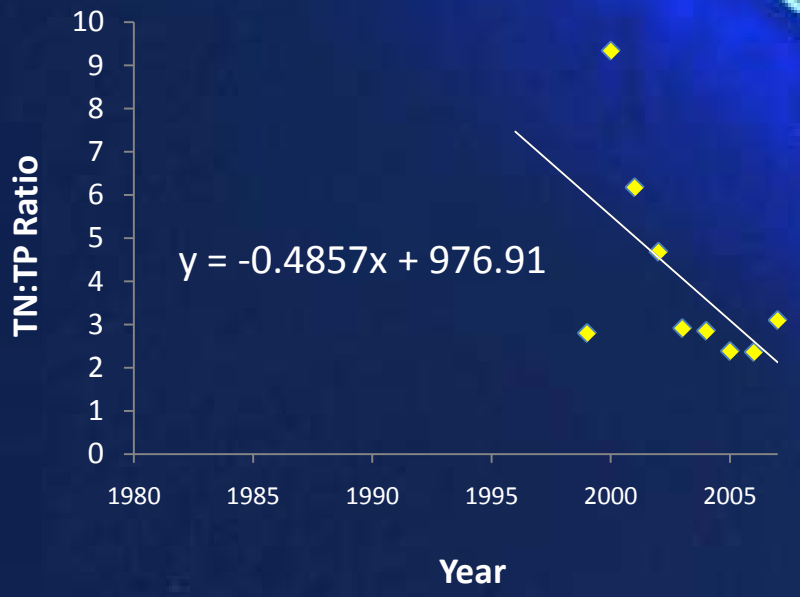
Change in Developing Land and Regression Slopes of Water Quality in Tampa Bay Tributaries

Watershed	Change km^2 1996-2006	Pct. Change 1996-2006	Scaled Rate: Range/Slope		
			Turbidity	Chlorophyll-α	TN:TP Ratio
HR	53.1	16	-43.9	34	-10.6
AR	18.4	13.5	-18	2343	-19.2
LMR	4.8	11.2	-16.8	-21.8	-25.4
MR	38.9	31.1	-71.2		25.7
TB West	30.8	6.8	-24.7	-7.2	-13.3
TB N. East	15.6	13.2	30.7	9.9	31.7
TB East	11.1	41.1	-260	-657	-29.7
TB S. East	2.9	11.1	-44.6	-48.6	-1714
TB	0.2	2.1	-13.7 (Site 14)	6875 (Site 14)	-4 (Site 14)
LT	7.7	20.3	-42.4	118.7	-82.5

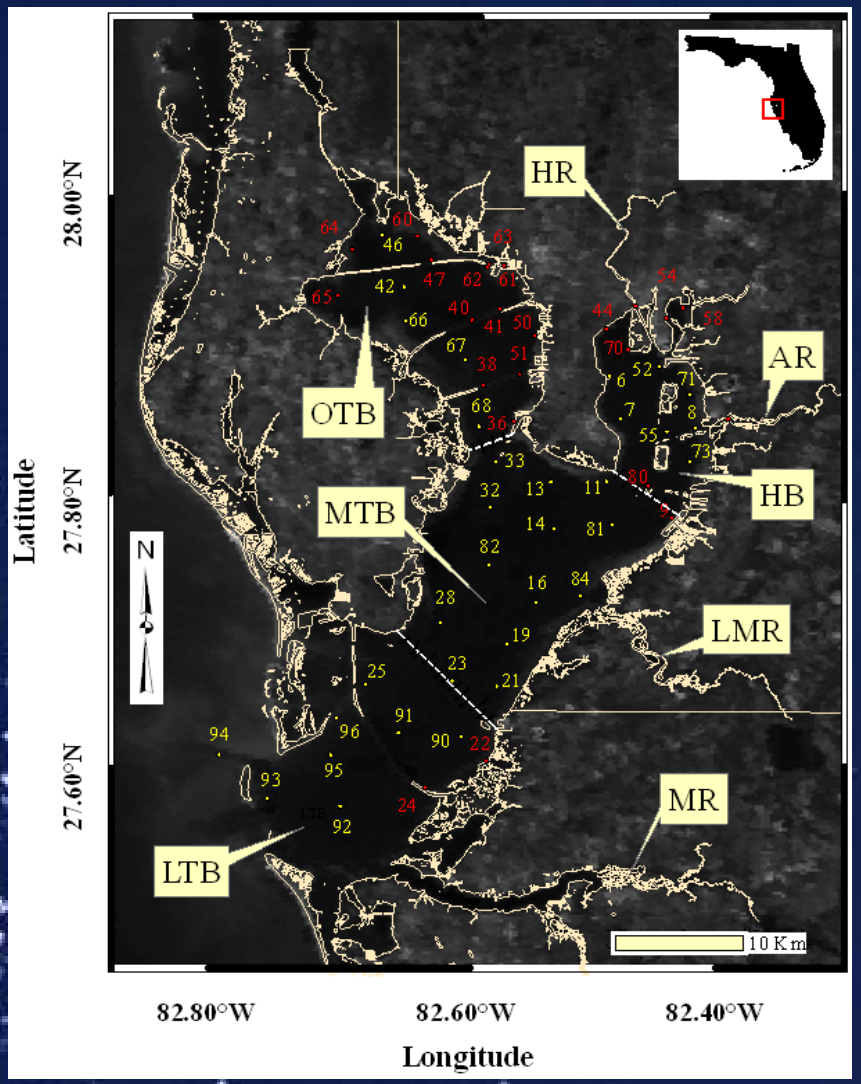
Percent change in developing land in watersheds of TB tributaries and their corresponding trend in mean annual WQ variables. Trends are obtained from plotting annual means

Trends of Mean Annual Ratios of TN:TP in Water from Site 14 in Tampa Bay for the time periods 1981-2007 and 1999 - 2007





Estimating Turbidity with Remotely Sensed Data



- 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)

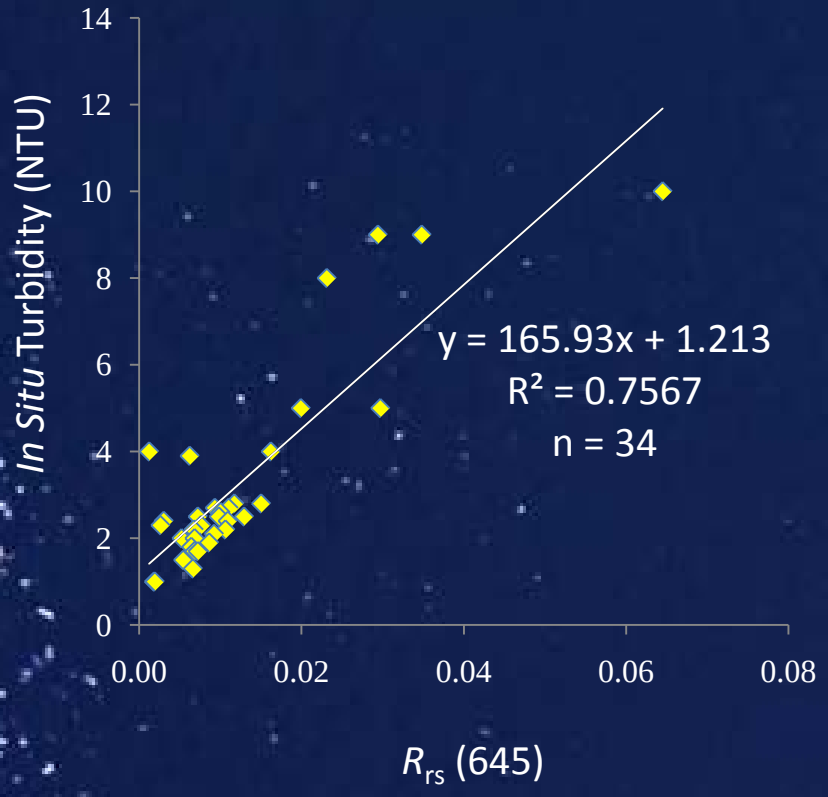
Relationships between *in situ* turbidity (NTU) and R_{rs} from MOD09GQ

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

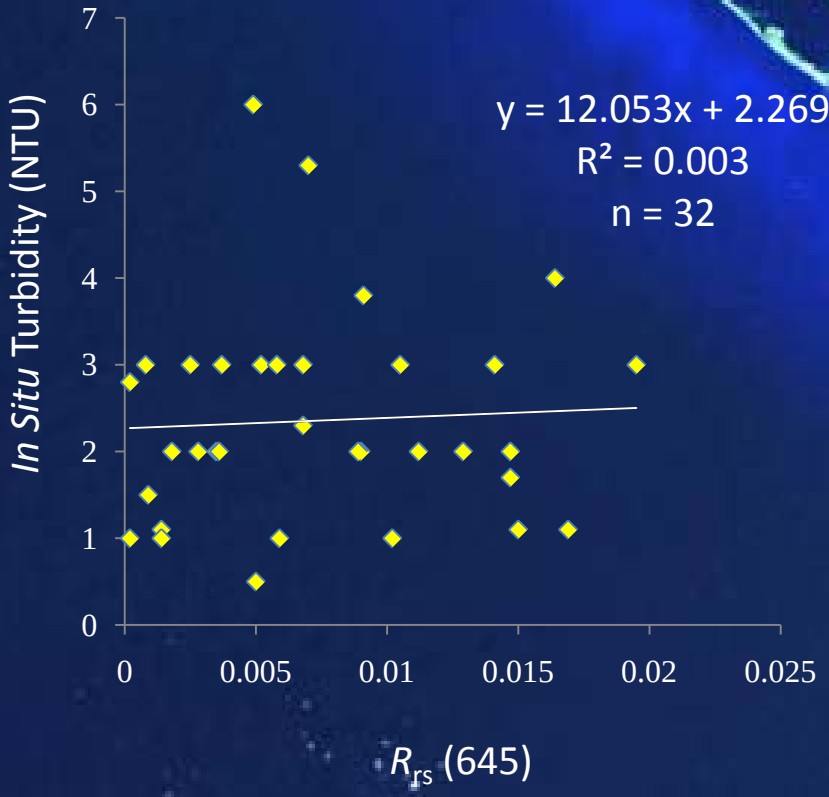
Cumulative analysis starting with all the matching pairs of data available according to the criteria and gradually decreasing the data set by increasing one day after rain event until eventually having only the matching pairs with 8 days or more after a rain event. All relationships were significant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

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)



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

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

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

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.
- Lake Thonotosassa watershed showed an increase in developed land and a decrease in land classes agriculture, scrub, and wetland.

Preliminary Conclusions

- Except for Manatee River and few minor tributaries within the Tampa Bay watershed, ratios of TN to TP in the remaining tributaries suggest a decreasing trend. This may be a concern in regard to potential for cyanobacteria abundance.
- 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.
- The Surface reflectance MODIS Terra daily product (MOD09GQ) showed to be operable to estimate turbidity in TB but not in Lake Thonotosassa.

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