

Using Remote Sensing to Assess Climatic and Anthropogenic Impacts on Étange Saumâtre

Helenmary M. Hotz¹ and Alan D. Christian^{1,2}

¹School for the Environment, University of Massachusetts Boston

²Biology Department, University of Massachusetts Boston

ESRI UC – San Diego, CA

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Background

- ▶ Presently, Haitians are **protein deficient by 14 grams/day**
- ▶ Historically, Étang Saumâtre, the largest lake in Haiti, produced 90 metric tons fish/year
 - ▶ 1/3 of inland fishery production
 - ▶ a significant source of protein for the region's inhabitants
- ▶ **Communities:**
 - ▶ Eastern shore state owned
 - ▶ Western shore private ownership
- ▶ **Lake Level/Climate:**
 - ▶ At the beginning of the last decade, lake level was dropping
 - ▶ Since 2004, the frequency and magnitude of tropical storms have caused lake level to rise back to and exceed previous levels.
 - ▶ Specifically, 2004 and 2008 hurricane seasons significantly increased lake volume



Background

- ▶ Deforestation:
 - ▶ Dry subtropical forest – shrubs & cacti
 - ▶ In 1923, approximately 60% forested
 - ▶ In 2006, less than 2% forested
- ▶ Agriculture/Mining:
 - ▶ Use of fertilizer
 - ▶ Sand and gravel mining
- ▶ Geologic Hazards:
 - ▶ Located in closing Hispaniola rift valley
 - ▶ January 12, 2010 earthquake along along the Enriquillo-Plantain Garden transform fault that abuts the southeast coast of Etang Sumatre, resulting in an east/west movement along the fault of 30 centimeters (approximately 1 foot).



Background

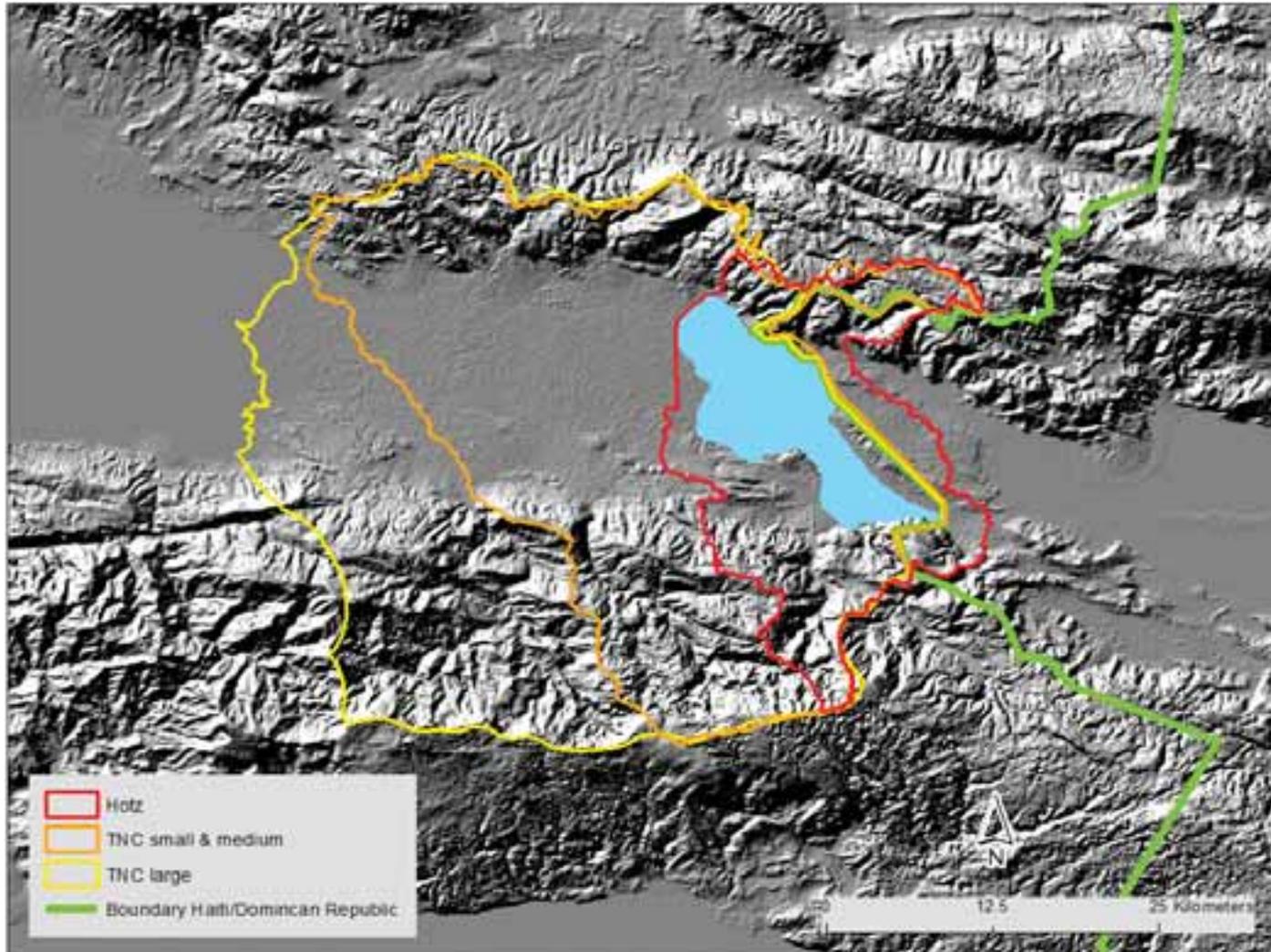
- ▶ Deforestation, increased storm frequency and increased storm intensity have resulted in:
 - ▶ slope failure
 - ▶ increased delivery of sediment to lake
 - ▶ lake level rise – shoreline flooding
 - ▶ decreased salinity of lake
 - ▶ 2007 = 15 ppt
 - ▶ 2010 = 10 ppt
 - ▶ 2011 = 8 ppt
- ▶ Thus, the impact of perturbations on the lake is not known



Watershed Scale Objectives

- ▶ To assess the impact of climatic perturbations on Étang Saumâtre and its fisheries by:
 - ▶ **Improved watershed delineation**
 - ▶ Developing the context of the relationship of the lake to land use/land cover, geology, and climate
 - ▶ **Documenting land cover/land use changes in the basin**
 - ▶ **Documenting changes in morphometry of ES from the 1980's to present**
- ▶ These objectives will be met doing spatial and temporal analysis using ESRI ArcGIS 10.2.2 and ENVI 5.1

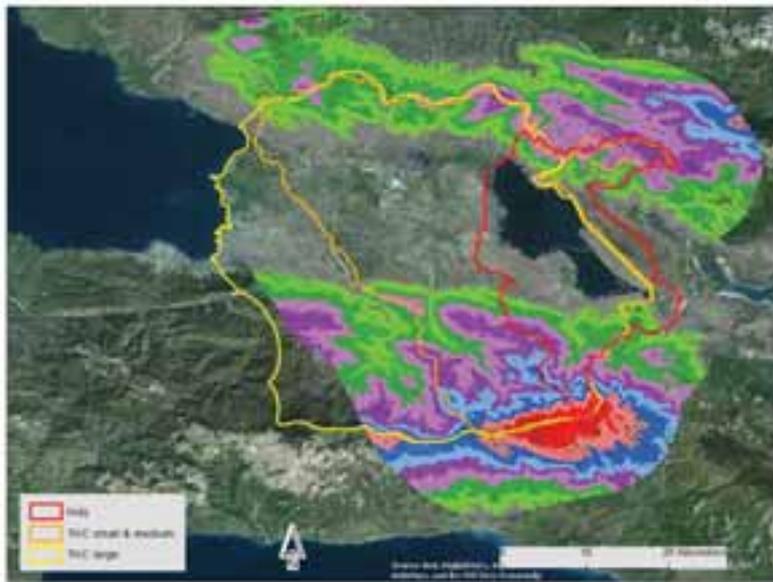
Cul de Sac & sub watersheds



- ▶ TNC's align with political boundary
- ▶ Pour points around ES give sub watersheds red – ES as pour point gives red

Difficult watershed to delineate

- ▶ No outlet stream/river
- ▶ Evaporation only loss
- ▶ Fed by precipitation and underground streams



- ▶ Using 20 m contours

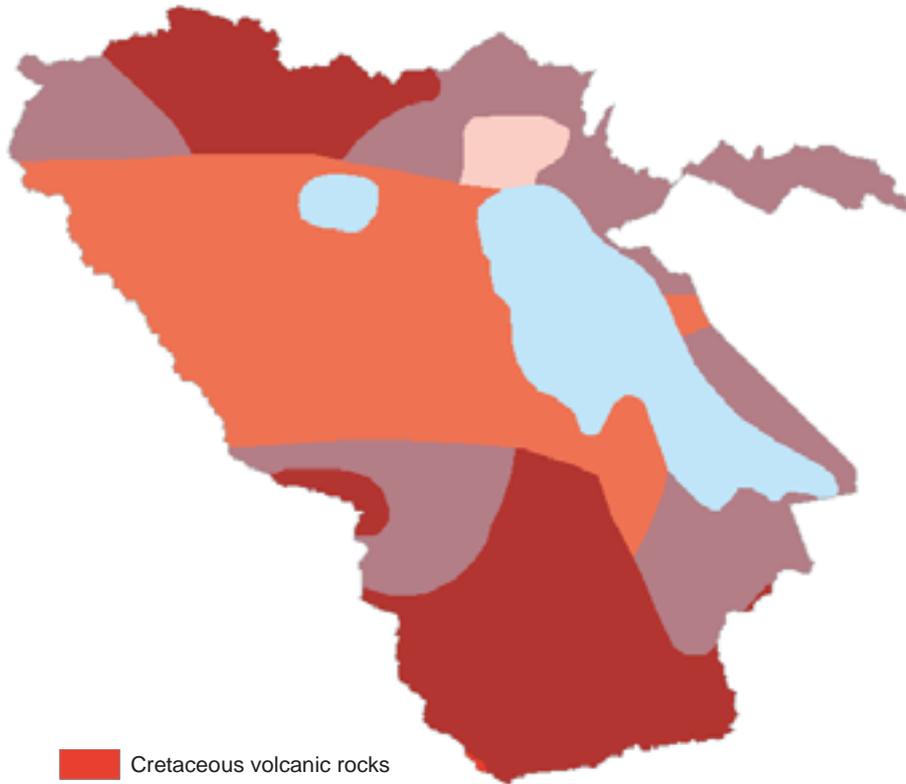


- ▶ Watersheds on basemap imagery

Cul de Sac & sub watersheds

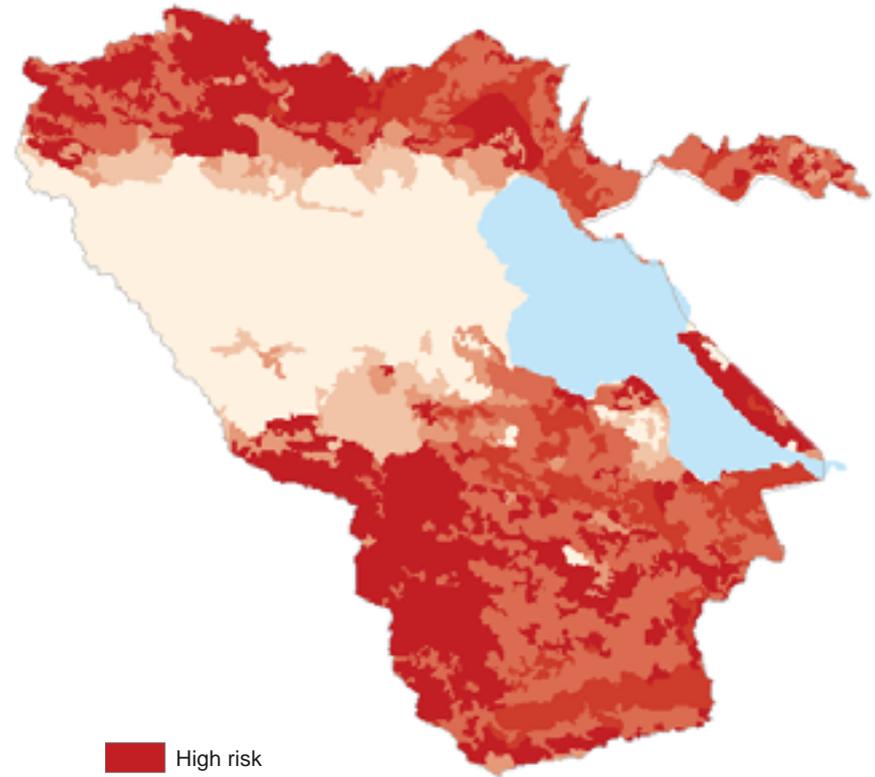


Geology and Erosion TNC 2006



- Cretaceous volcanic rocks
- Eocene and(or) Paleocene marine strata
- Post-Eocene marine strata
- Quaternary alluvium
- Quaternary and Tertiary volcanic edifices, flows, tuff, silicic pyroclastic
- Water

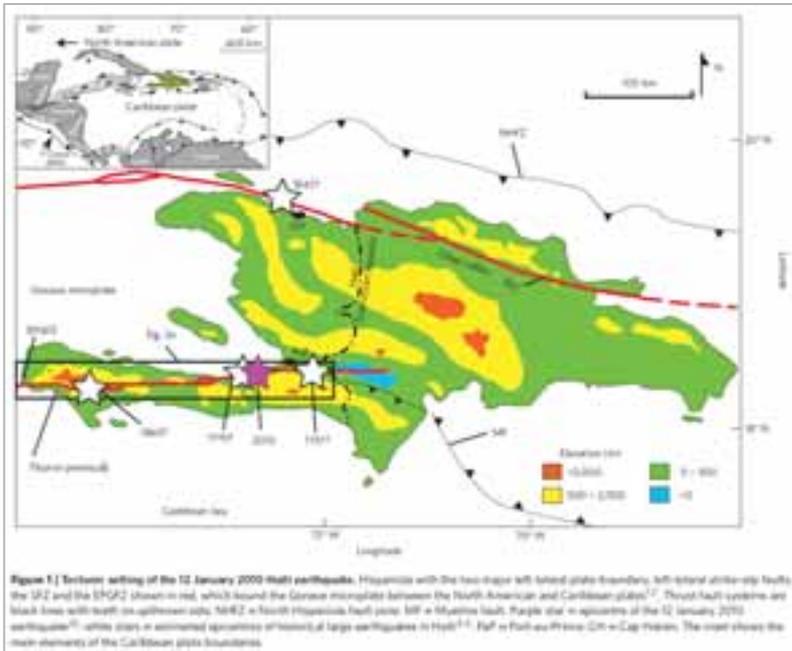
Uplifted marine strata - limestone



- High risk
- Very serious risk
- Serious risk
- Average risk
- Low risk
- Zero or very low risk

Serious to high risk of erosion

Geology

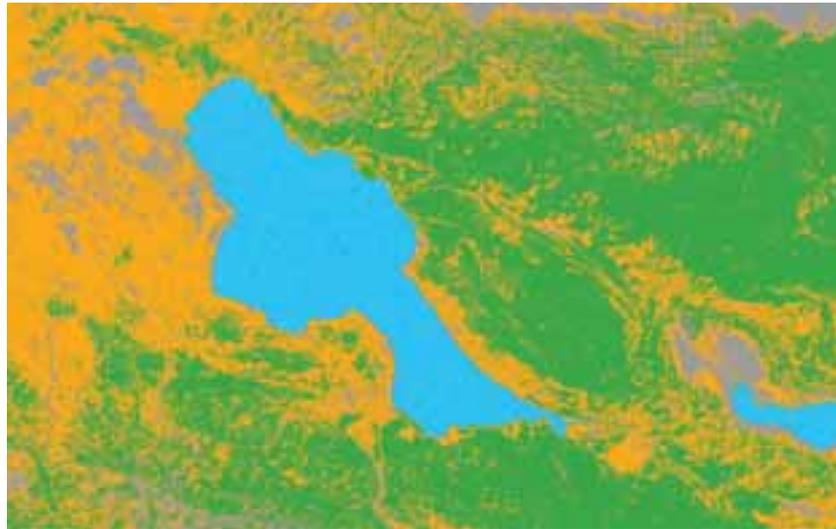


- ▶ January 12, 2010 30 cm shift east/west on Enriquillo-Plantain Garden (EPGF) fault
- ▶ Models suggest that most of the moment release was not on the EPGFZ
- ▶ Implies that considerable strain remains to be released on the EPGFZ
- ▶ EPGFZ remains a serious seismic hazard for Haiti, particularly for the Port-au-Prince area (Prentice 2010)

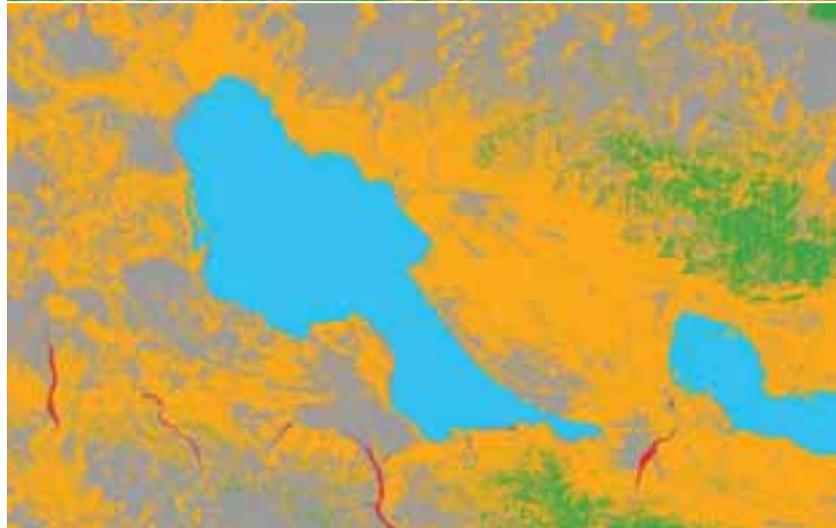
Geology and Erosion - 2013



Land cover - deforestation



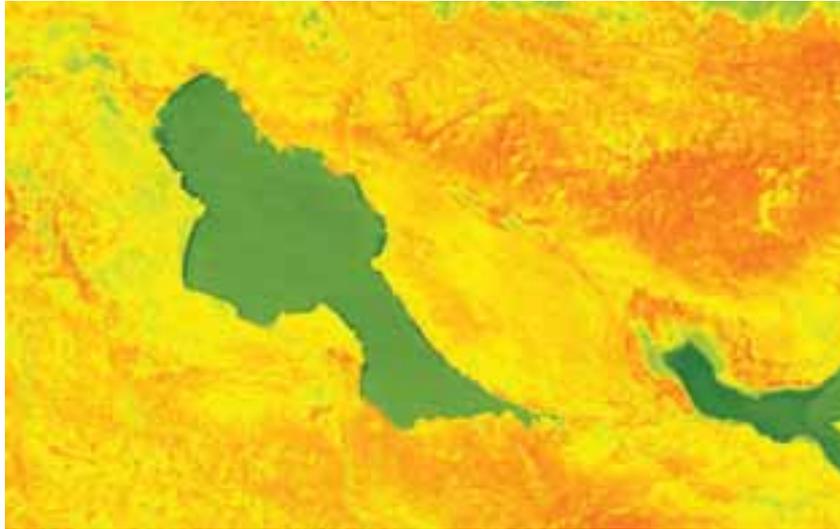
1984



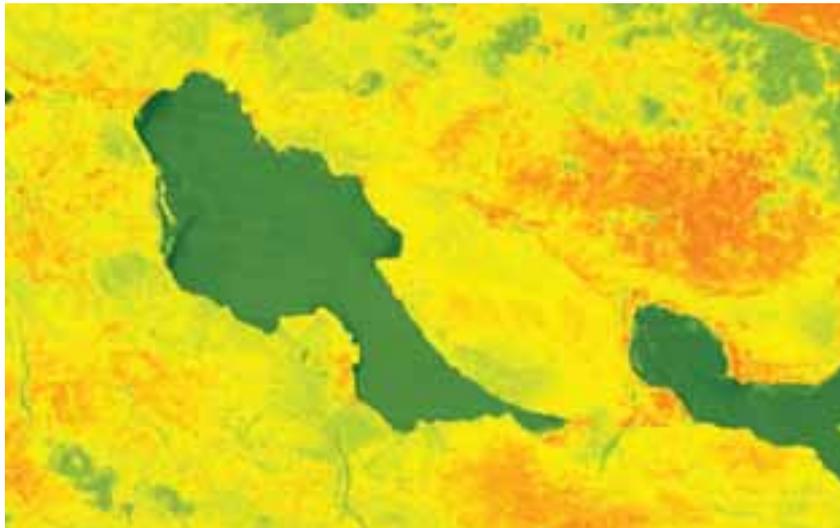
2011



NDVI



1984



2011

- Layers
 - NDVI_2011
 - Value
 - High : 1
 - Low : -1
 - LTS0080472011105CHM00_B3.TI
 - Value
 - High : 255
 - Low : 0
 - LTS0080472011105CHM00_B4.TI
 - Value
 - High : 255
 - Low : 0
 - ndvi_1984
 - Value
 - High : 1
 - Low : -1
 - LTS0080471984351XXX02_B3.TIF
 - Value
 - High : 255
 - Low : 0
 - LTS0080471984351XXX02_B4.TIF
 - Value
 - High : 255
 - Low : 0

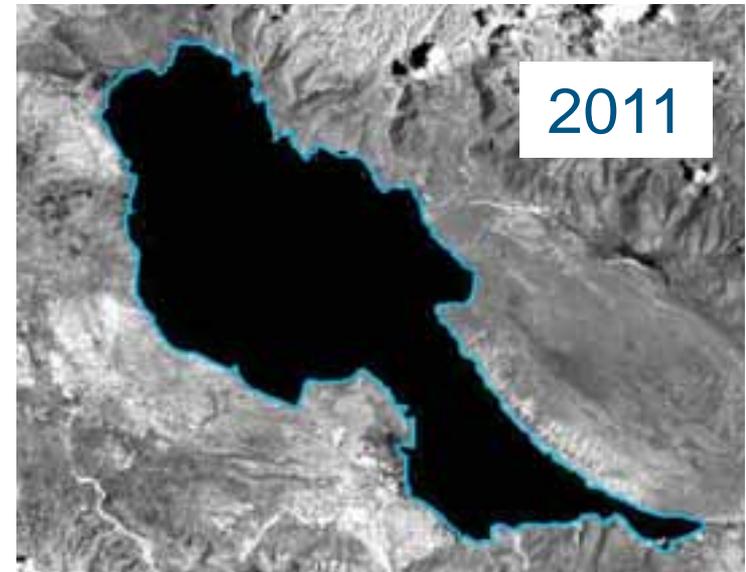
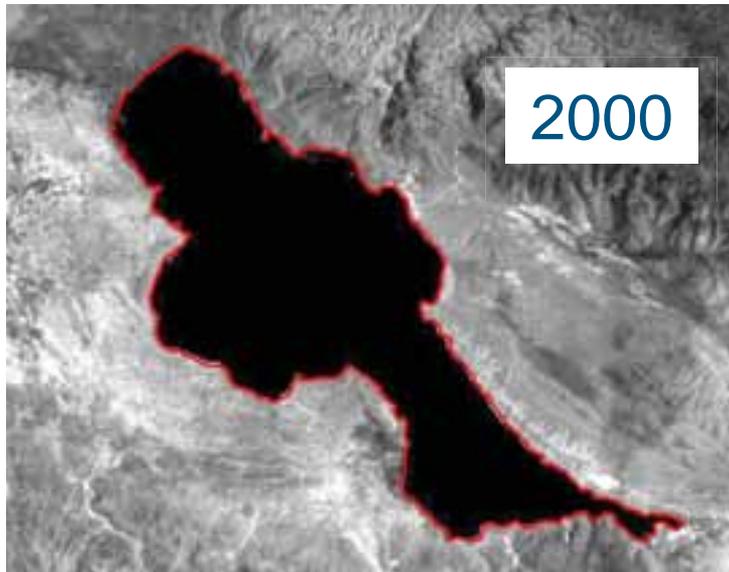
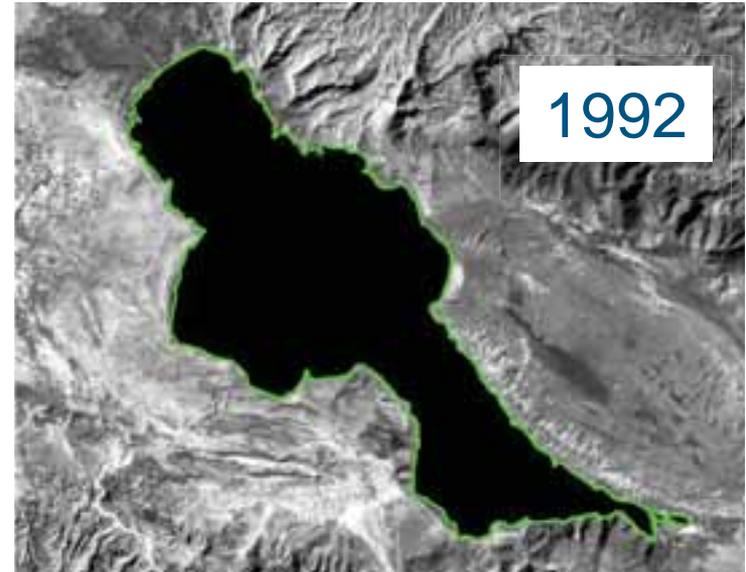
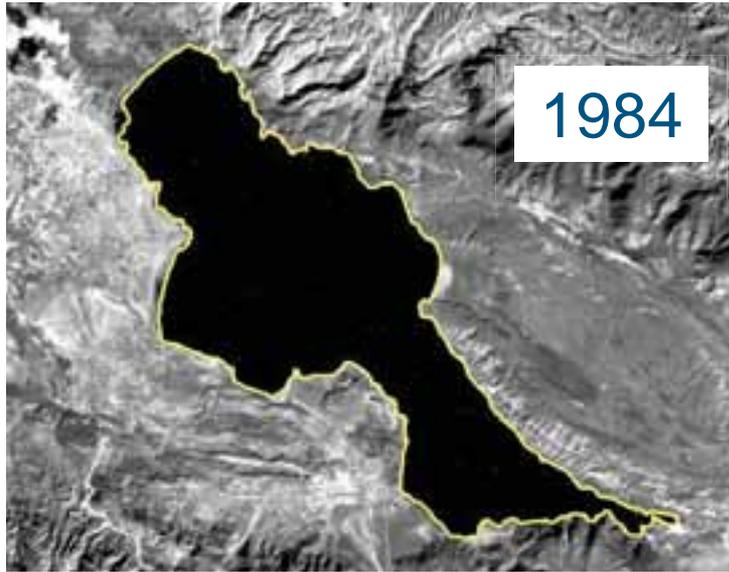
Lake level rise – Étange Saumâtre

- ES lake level has been rising since 2004
- Fed by rain and underground springs
- Island is primarily up thrust marine strata – limestone
- The lake expansion:
 - ✓ large area on south side of major road from Port au Prince to DR – threatens to overtake road
 - ✓ Flooding homes
 - ✓ Flooding agricultural fields, etc.
- Lake level rise also due to sediment flow to lake:
 - ✓ Deforestation
 - ✓ Steep slopes
 - ✓ Rift valley is an arid climate

Quantifying lake level rise

- Using ArcGIS 10.1 and ENVI tools:
 - ✓ Landsat 5 – band 4 – 1984-2011
 - ✓ Landsat 8 – band 7 2014
 - ✓ Digitize lake shore for area and shore length

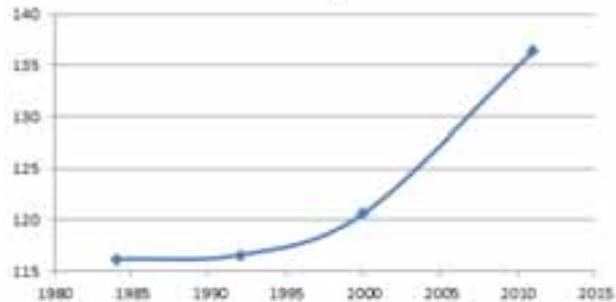
ES Shoreline/Area Change 1984-2011



Lake Area Results

Year	Area_sq_km
1984	116.178345
1992	116.58066
2000	120.63993
2011	136.373701

Area sq km

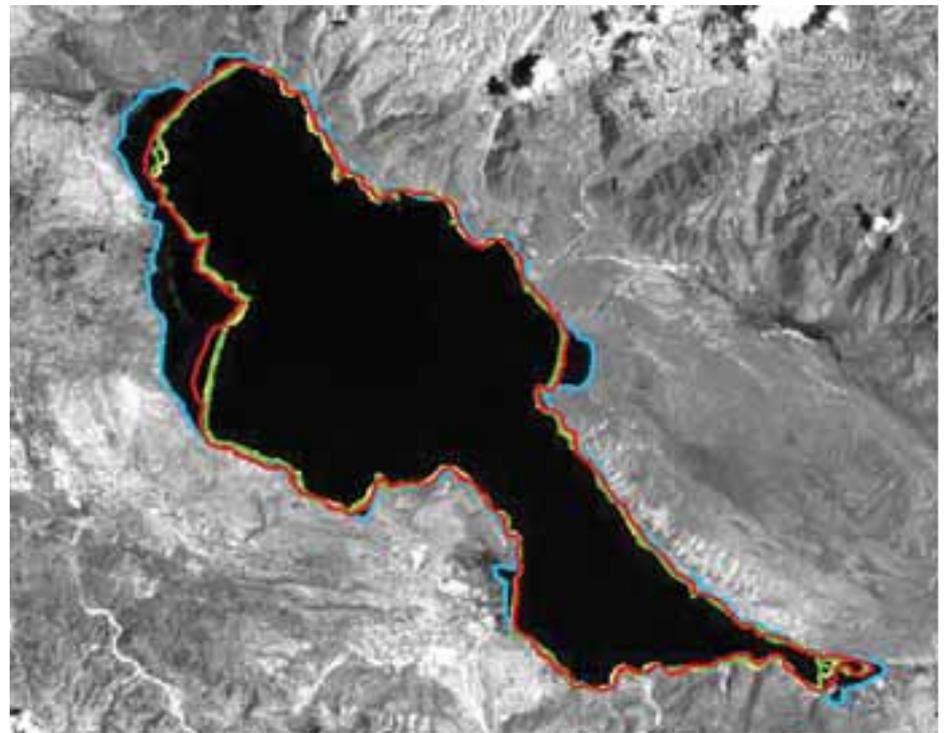
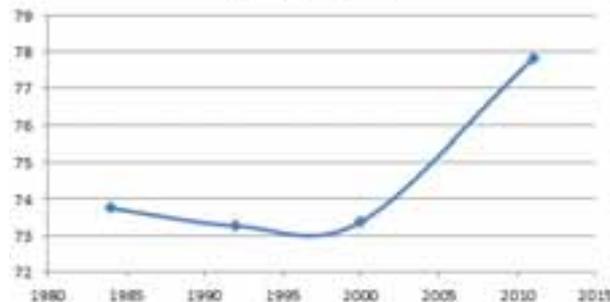


- ▶ 17.4% increase over 17 years
- ▶ 1984 to 2000 = 3.9% increase
- ▶ 2000 to 2011 = 13%

Lake Perimeter

Year	Perimeter km
1984	73.75
1992	73.27
2000	73.38
2011	77.82

Perimeter km



- ▶ 5.5% increase over 17 years



Discussion

- ▶ Seismic region – tectonic activity
- ▶ Global climate change exerting impact
 - ▶ **Erosion – sediment transport**
 - ▶ **Lake level rising - area increasing**
 - ▶ **Marked decrease in salinity**
- ▶ Decreased positive/productive use of land

Look toward the future...

- ▶ Spatial and temporal analysis of land use will provide insight towards identifying and understanding cause and effect relationships between the watershed and ES
 - ▶ **Analysis Landsat images**
- ▶ Develop accurate bathymetric and morphometric profiles of lake via Landsat and marine on board instrumentation
- ▶ Facilitate management and mitigation efforts

Future work

- Use ArcGIS 10.2.2 and ENVI 5.1:
 - ✓ Continue Landsat analysis for lake level rise
 - ✓ NDVI vegetation
 - ✓ Land cover
- Haiti ground collection of point training sites:
 - ✓ For NDVI vegetation and Land cover analysis
- Grant for equipment for data collection:
- Trimble GPS

Acknowledgements

- ▶ Dr. Alan Christian
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- ▶ The Nature Conservancy
- ▶ ESRI