Interdisciplinary approaches to assess the hydro-geomorphological effects of land use change on marine ecosystems of Puerto Rico and the U.S. Virgin Islands

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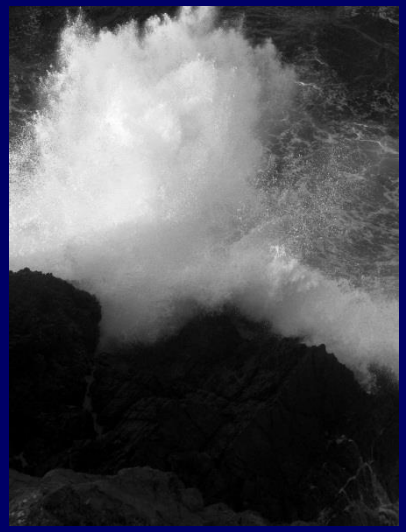
US Virgin Islands & Puerto Rico



Pt. Udall- St Croix

Esperanza-Vieques

Belvedere-Cabo Rojo

Trunk Bay-St. John

… below sea level

Tres Palmas Reserve-Rincon, PR

Culebra, PR

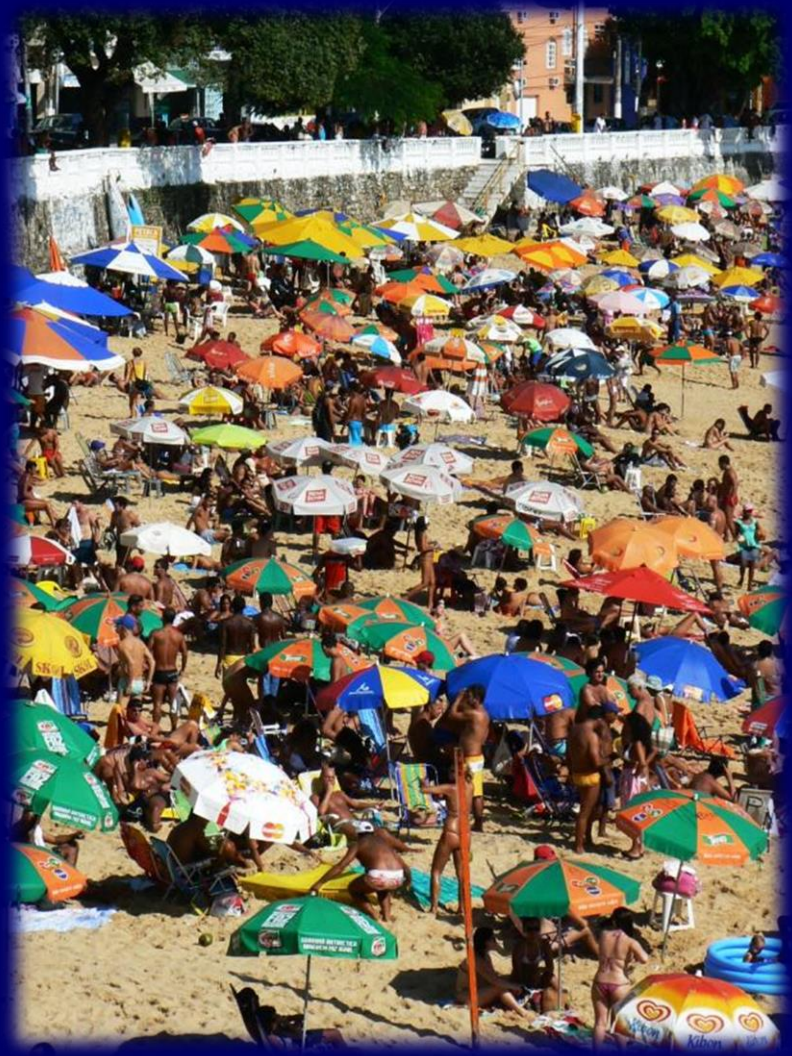
Parrott Fish, St. John

"Whenever I find myself growing grim about the mouth… and bringing up the rear of every funeral I meet… I account it high time to get to sea as soon as I can."

-H. Melville- Moby Dick

"… almost all men in their degree, some time or other, cherish very nearly the same feelings towards the ocean with me."

-H. Melville- Moby Dick



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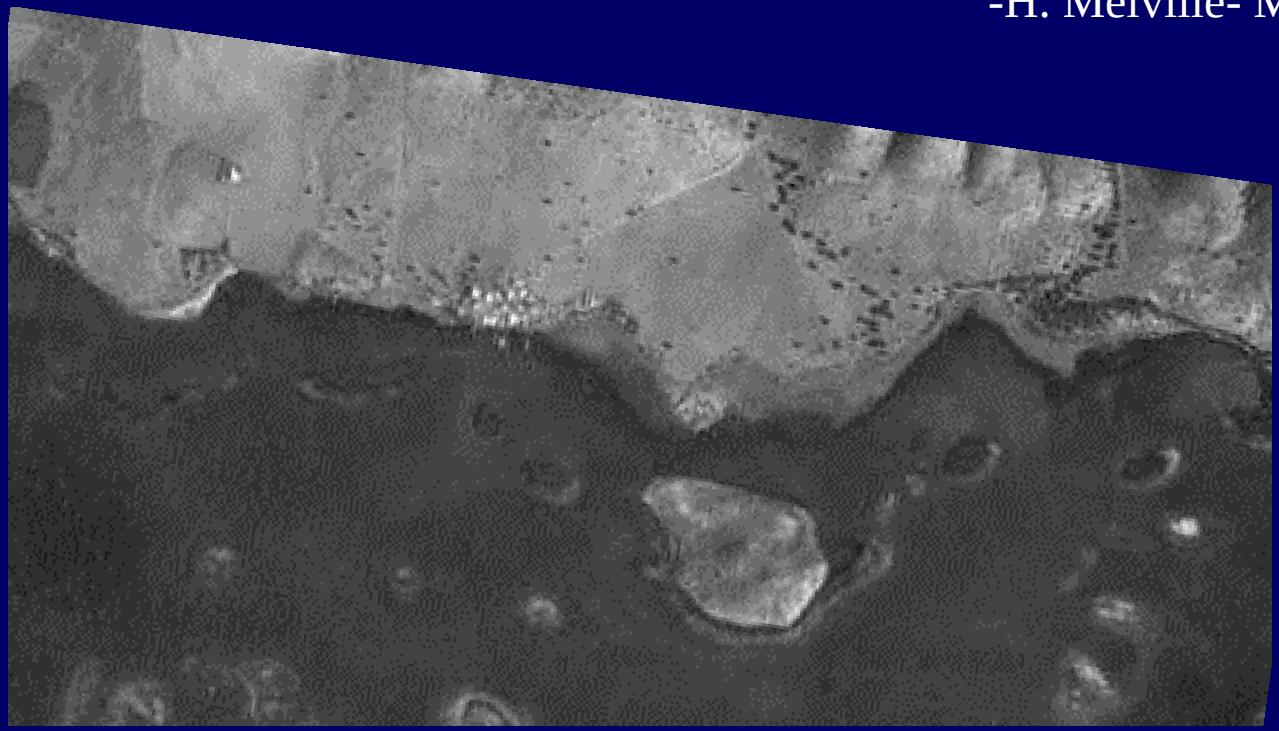
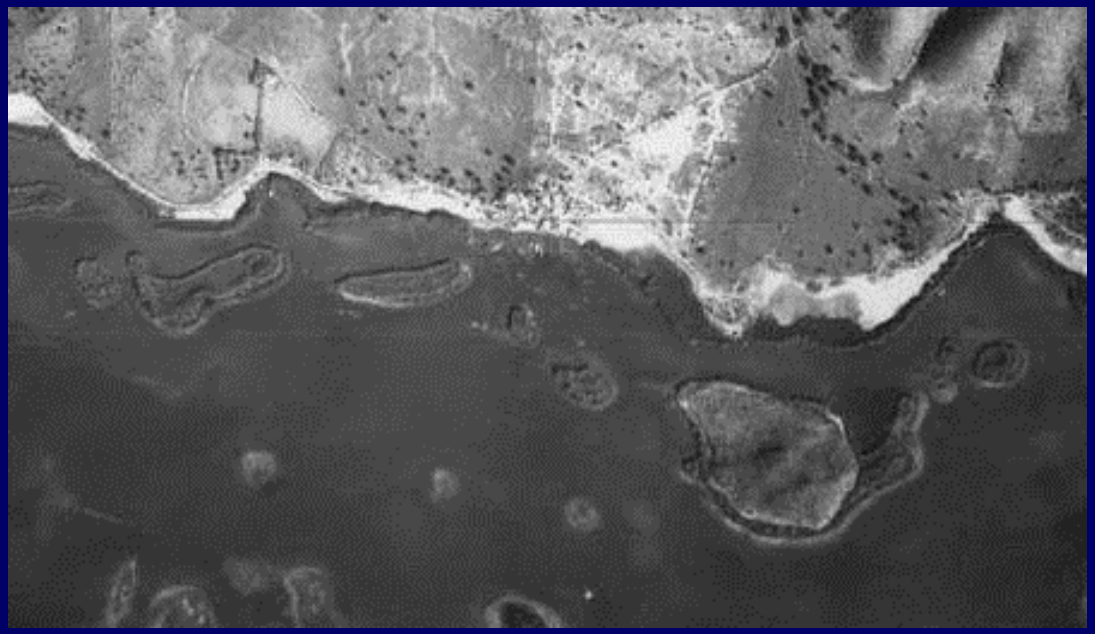


La Parguera-PR
(1936)

"… almost all men in their degree, some time or other, cherish very nearly the same feelings towards the ocean with me."

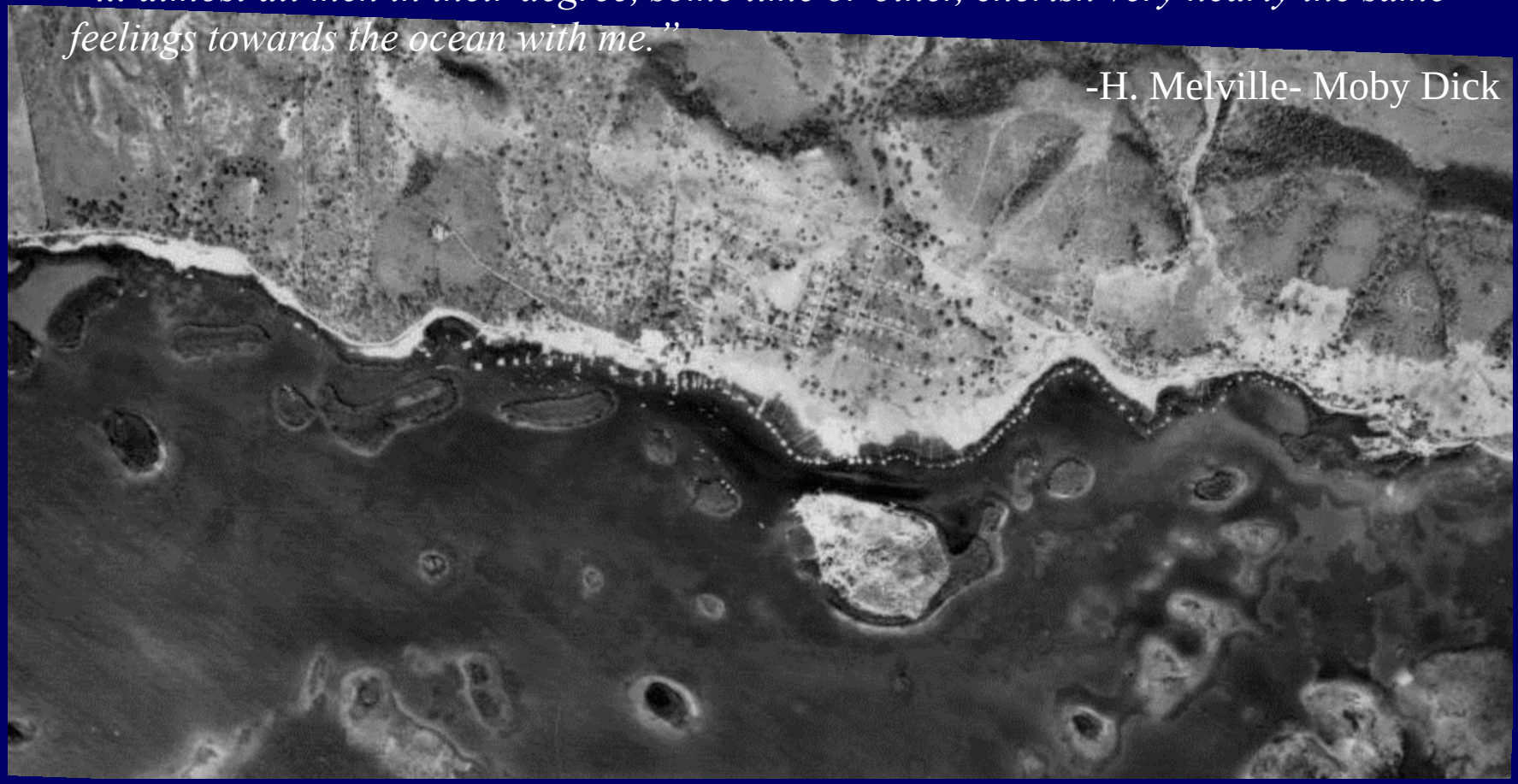
-H. Melville- Moby Dick



La Parguera-PR
(1950)

"... almost all men in their degree, some time or other, cherish very nearly the same feelings towards the ocean with me."

-H. Melville- Moby Dick

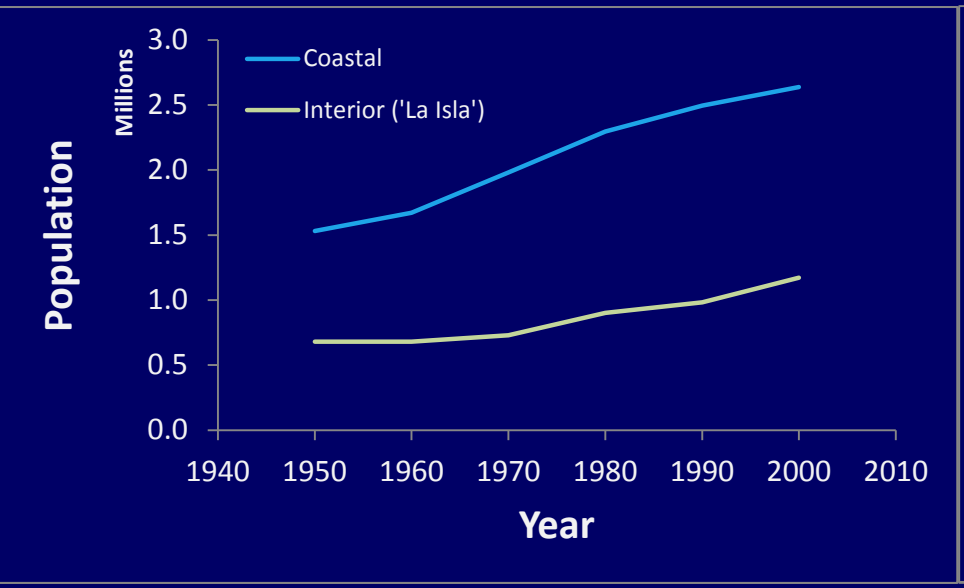


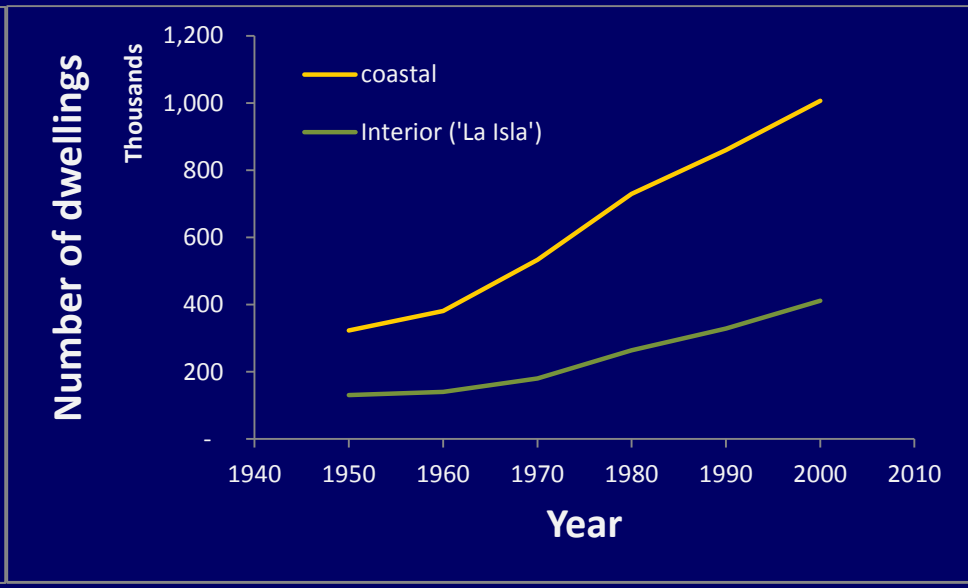
La Parguera-PR
(1963)

La Parguera-PR
(2005)

"… almost all men in their degree, some time or other, cherish very nearly the same feelings towards the ocean with me."

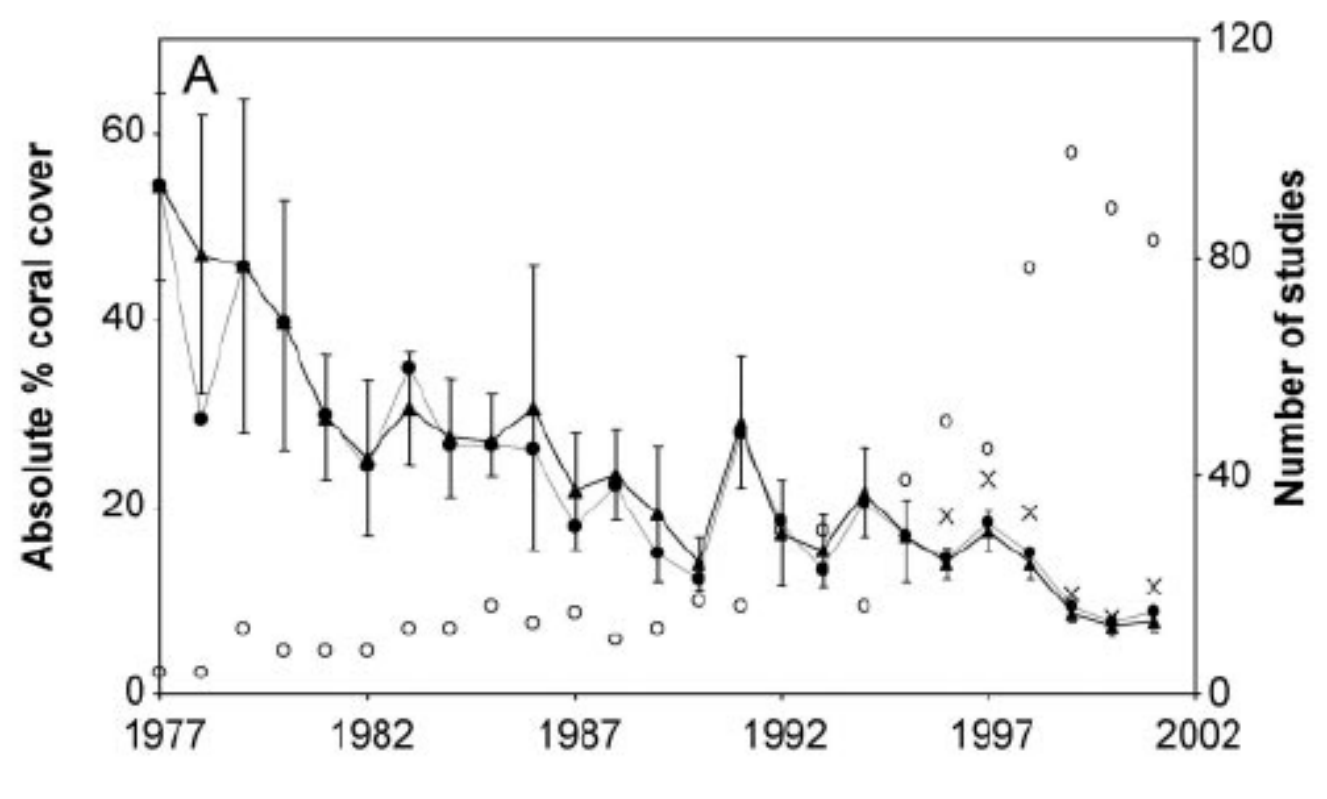
-H. Melville- Moby Dick





From Hernandez-Delgado et al. (2012)

Coral reefs throughout the Caribbean



Gardner et al. (2003)

Coral reefs throughout the Caribbean

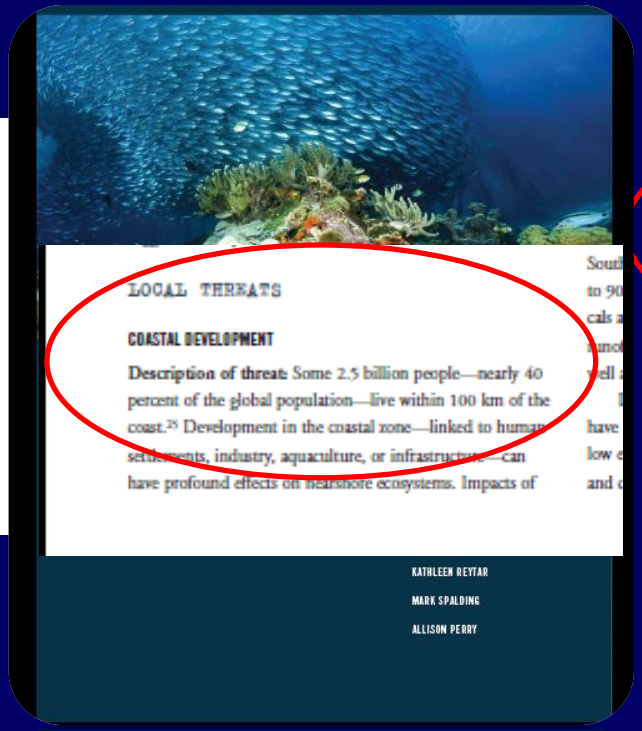
Gardner et al. (2003)

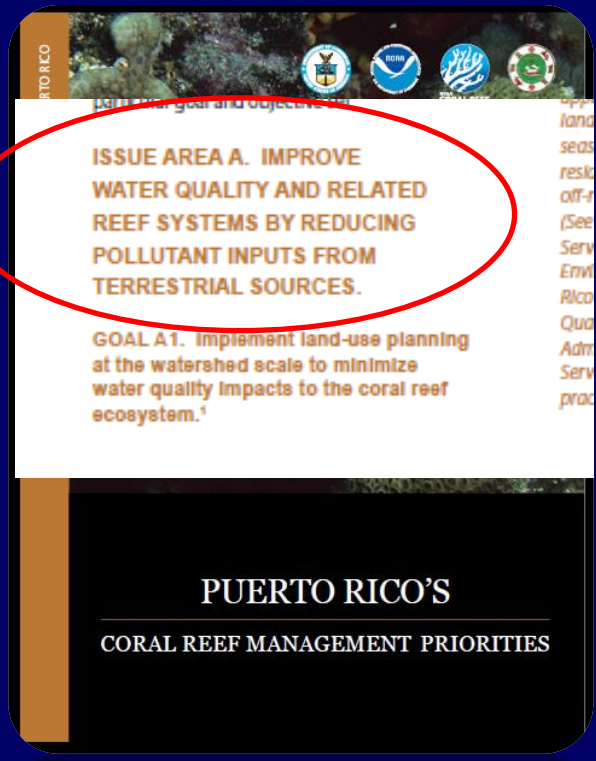
"…local causes have operated with some degree of synchrony on a region-wide scale. The ability of Caribbean coral reefs to cope with future local and global environmental change may be irretrievably compromised."

Mora (2007)

"…human activities related to agricultural land use, coastal development, overfishing, and climate change have created independent and overwhelming responses in fishes, corals, and macroalgae."

Coral reefs throughout the Caribbean





The repeating island… La isla que se repite

Fish Bay, St John
(Photo by CE Ramos-UT)

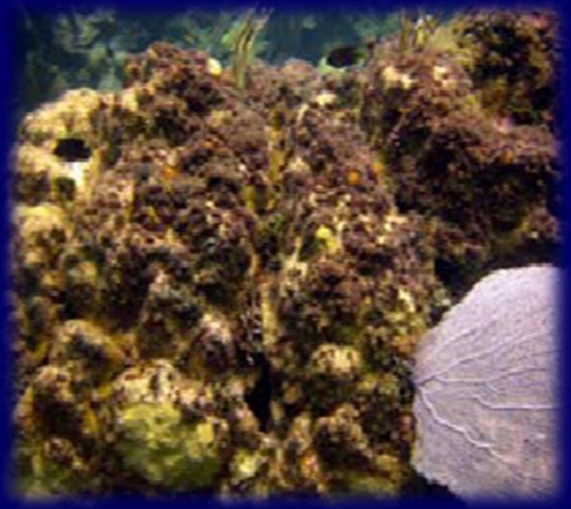
Coral Bay- USVI
(Photo by S. Coldren, CBCC)

Tortola- British Virgin Islands
(Photo by L. Jarecki)

Culebra- Puerto Rico
(Photo by E. Hernandez)

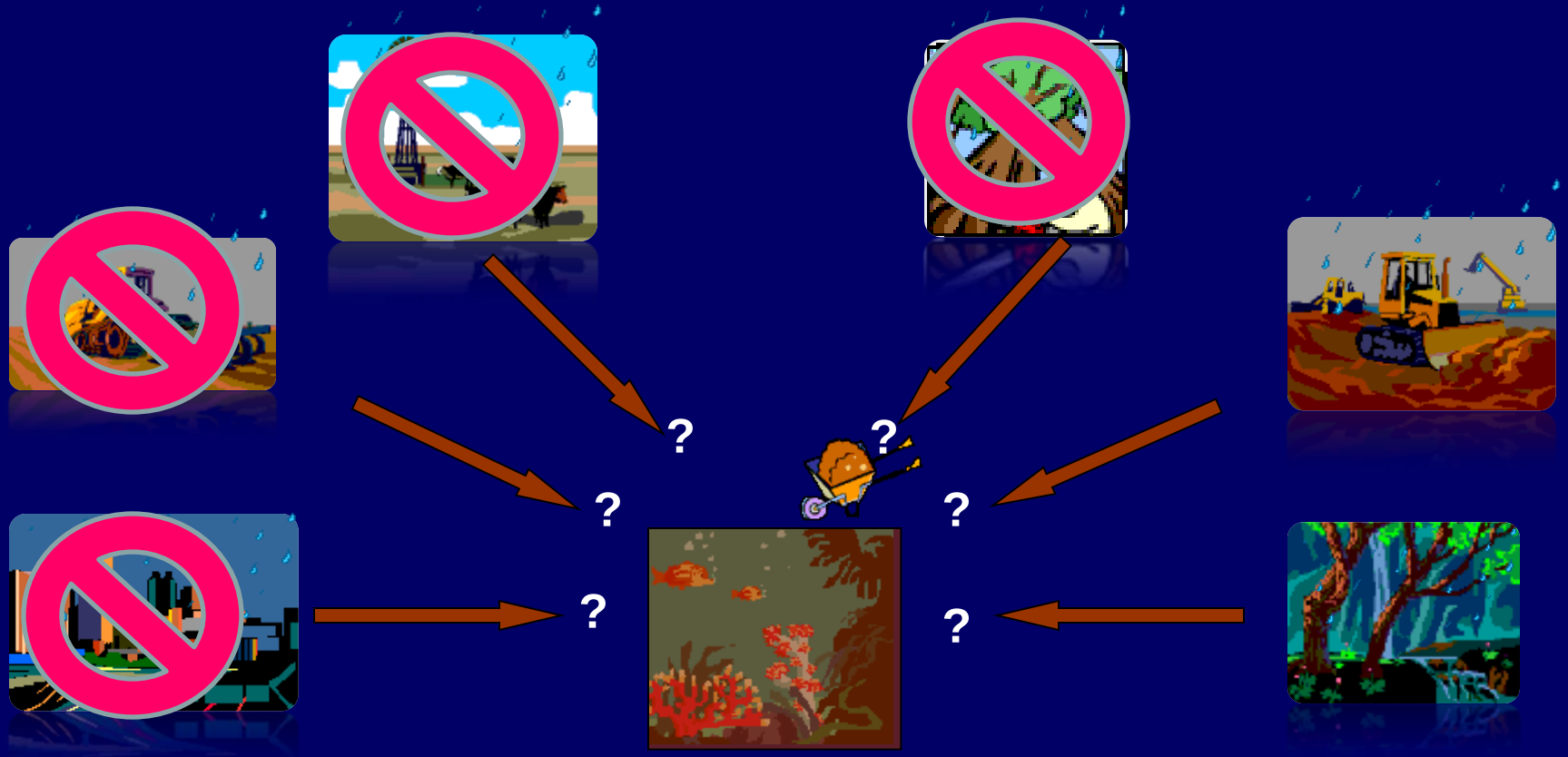
Effects of land disturbance: Downstream effects
Marine habitat- Increased nutrient/sediment input

Healthy reef system, Culebra-PR (2002)
(photo by E. Delgado, UPR)



Increased macroalgae cover, St John-USVI & Culebra-PR (2006)
(photos by E. Delgado-UPR & C Rogers-USGS)

Effects of land disturbance:
Approach #1: Very small coastal watersheds

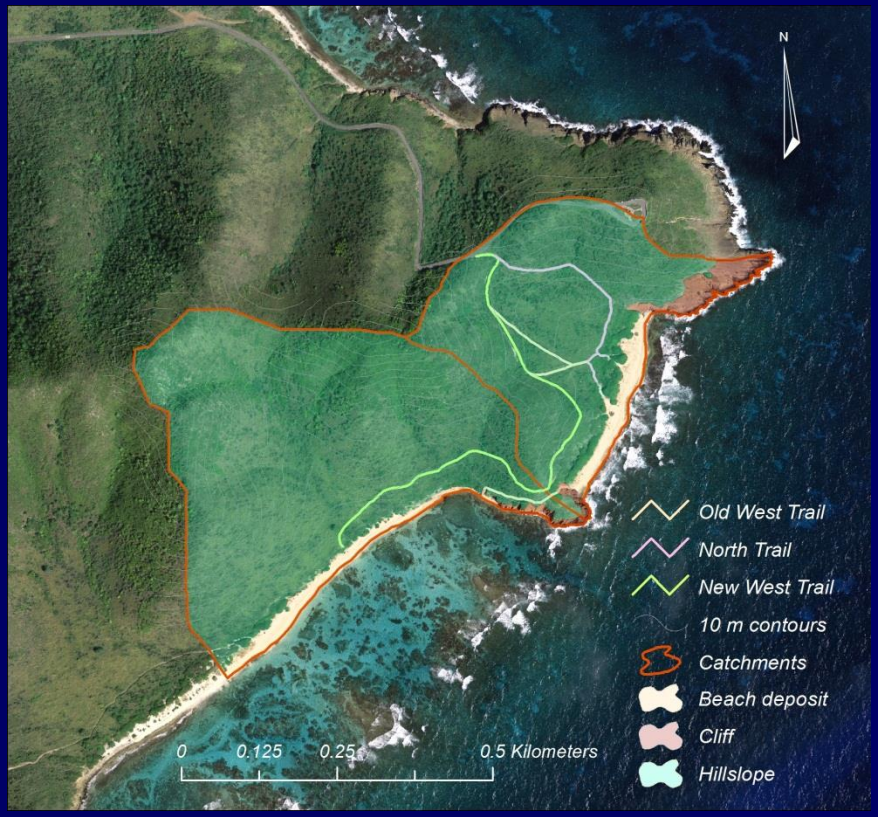


Non-Point Sources of Pollution

East End Bay-St Croix (USVI)

Study area:

- Bypassed all economic activities occurring on the island due to its "remote" location, low annual rainfall (725-940 mm yr^{-1}), and shallow soils
- One of the few land areas on island considered pristine
- Faces the East End Marine Reserve & turtle nesting beaches
- Two catchments (34 ha)
- ~ 2km long foot trail



East End Bay-St Croix (USVI)

Project (NOAA-Coral Reef Protection, ARRA Grant, 2009-2012):

- Implementation of erosion control measures along North Trail
- Construction of a new trail with erosion control provisions
- Terrestrial & marine monitoring to quantify effectiveness of restoration activities

East End Bay-St Croix (USVI)

Field methods:

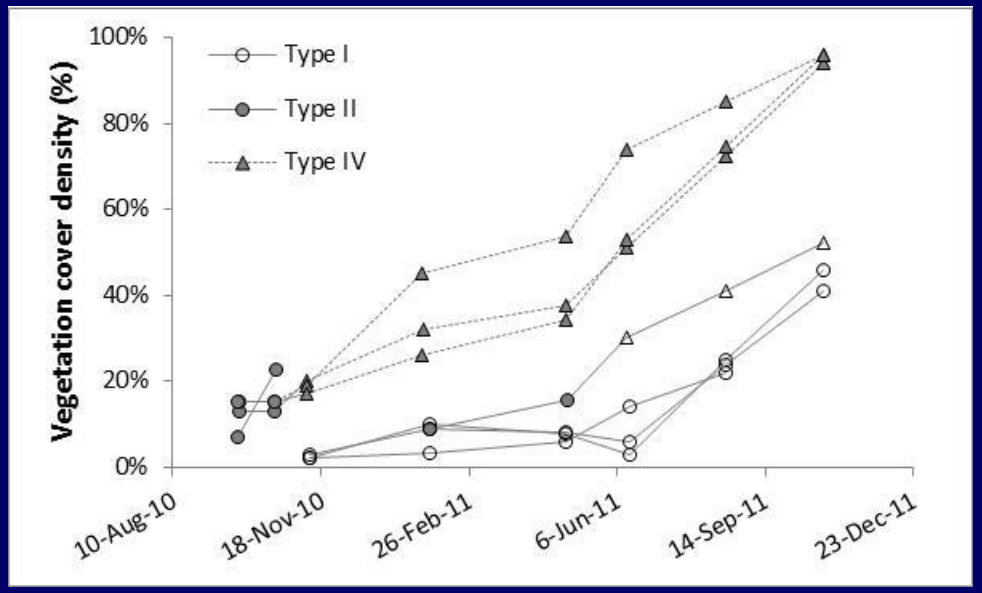
- Sediment traps to collect and measure the weight of the material being eroded from the trail surfaces
- Rainfall intensity
- Description of trail surfaces (dimensions, slope, vegetation cover)

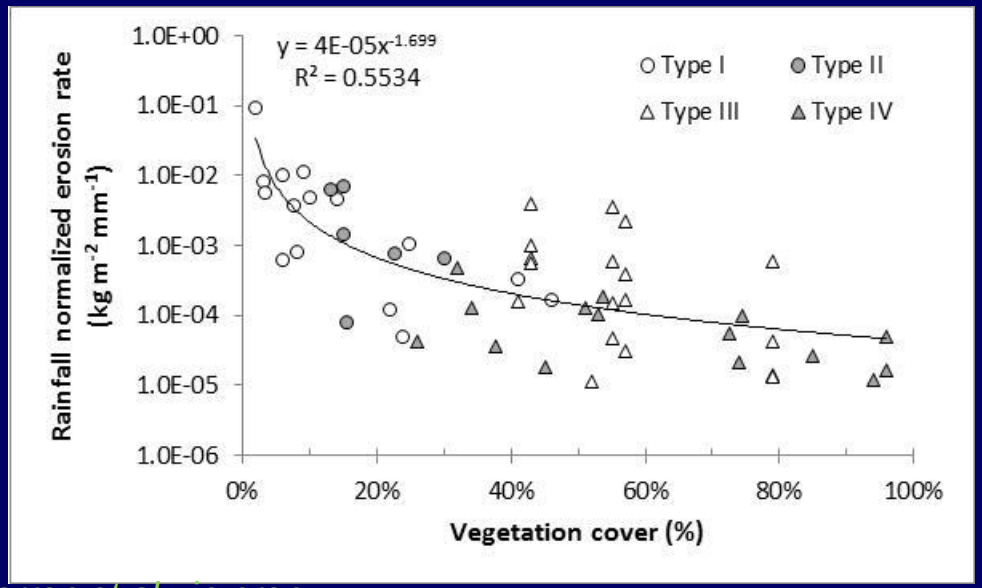
East End Bay-St Croix (USVI)

Results (trail-segment scale):

-How are erosion rates affected by:

- *Rainfall*
- *Vegetation cover*
- *Slope*





Ramos-Scharron et al., in prep.

East End Bay-St Croix (USVI)

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- ✓ *Rainfall*
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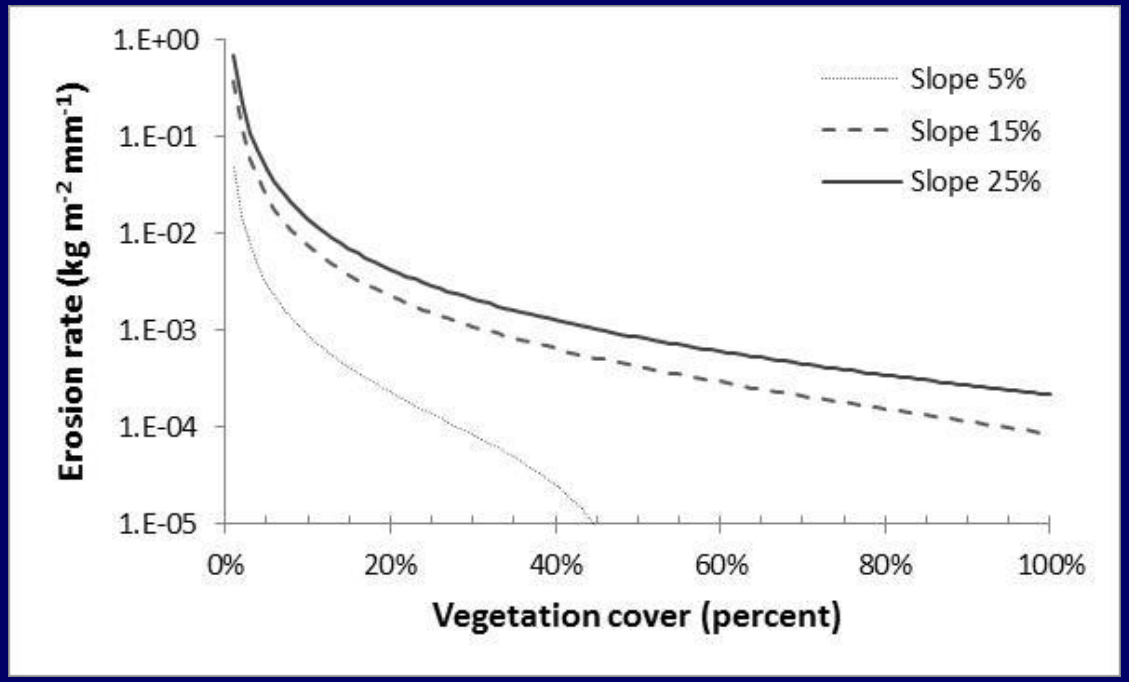


A numerical model:

$$E_r = -0.065 - (0.000046 * R * V^{-1.7}) + (0.00135 * R * S * V^{-1.7})$$

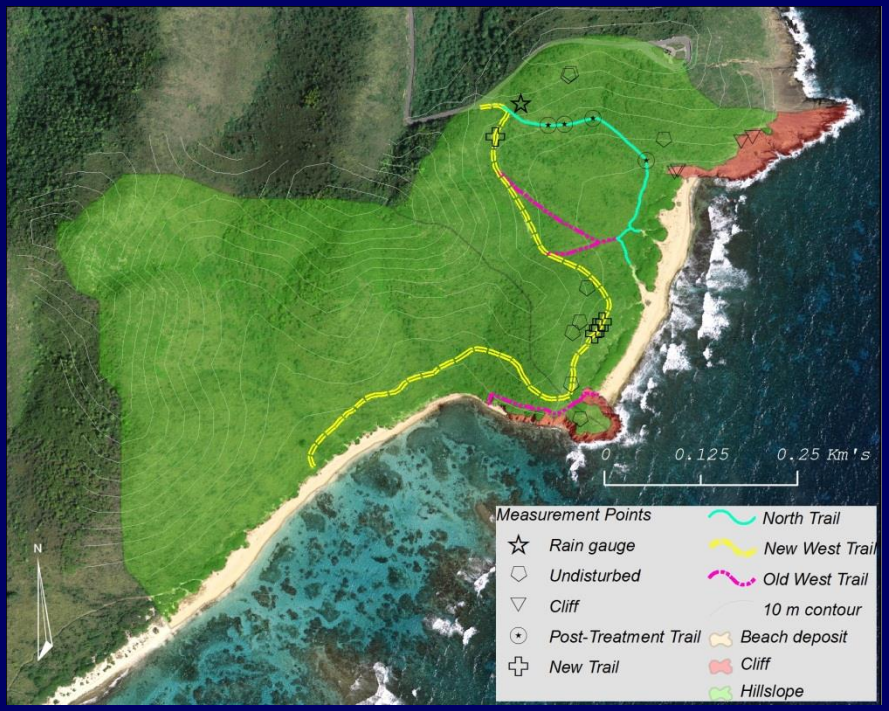
Ramos-Scharron et al., in prep.

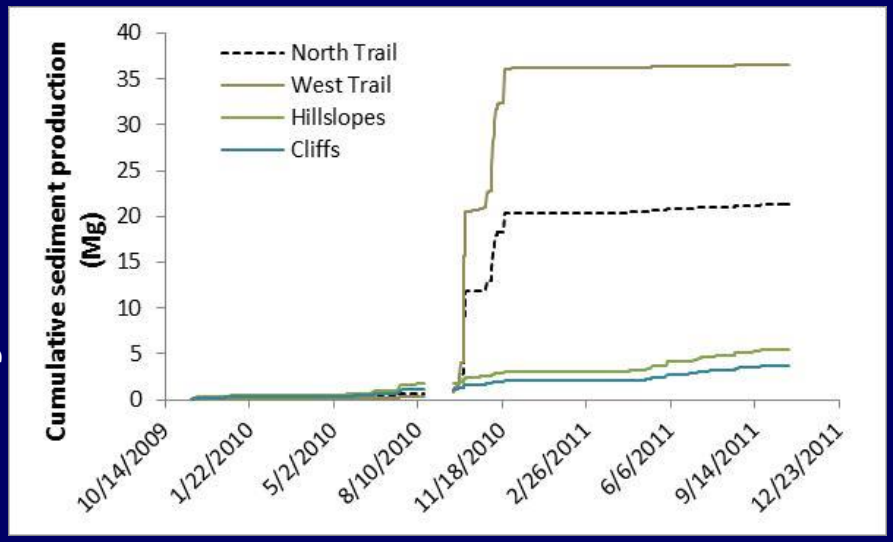
East End Bay-St Croix (USVI)

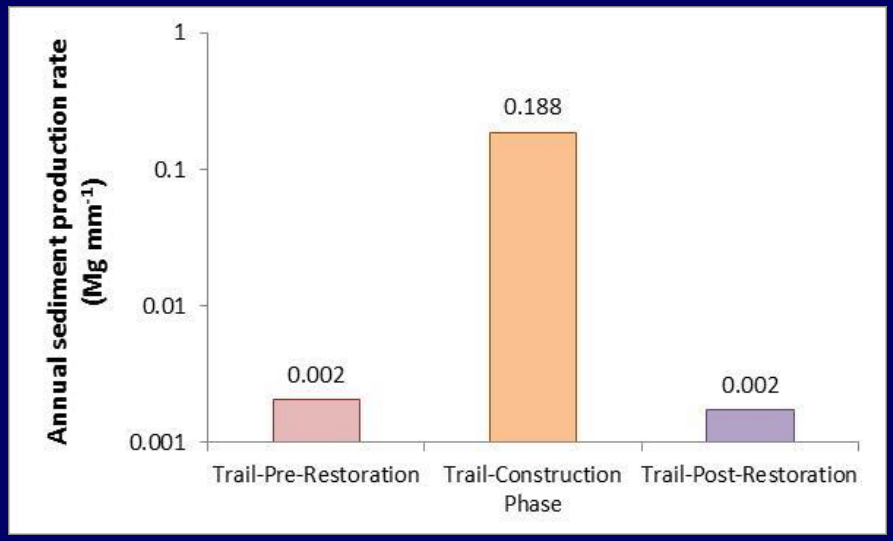
Results (Catchment-scale):

✓ *-How much sediment was produced by the entire trail network at different time periods?*

✓ *-What was the overall effectiveness of the project in reducing erosion rates?*

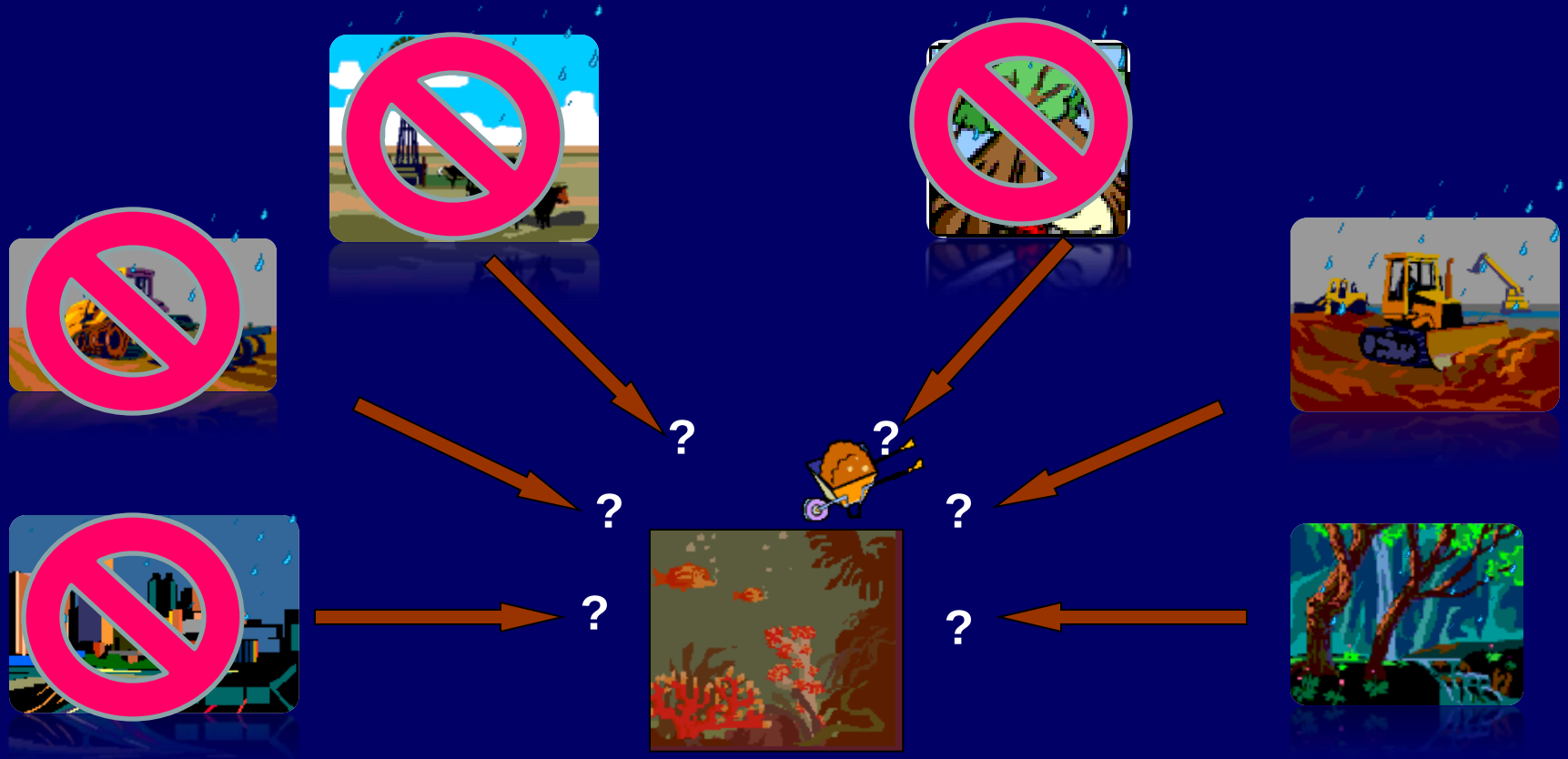






Ramos-Scharron et al., in prep.

Effects of land disturbance:
Approach #2: ~~Very~~ small coastal watersheds



Non-Point Sources of Pollution

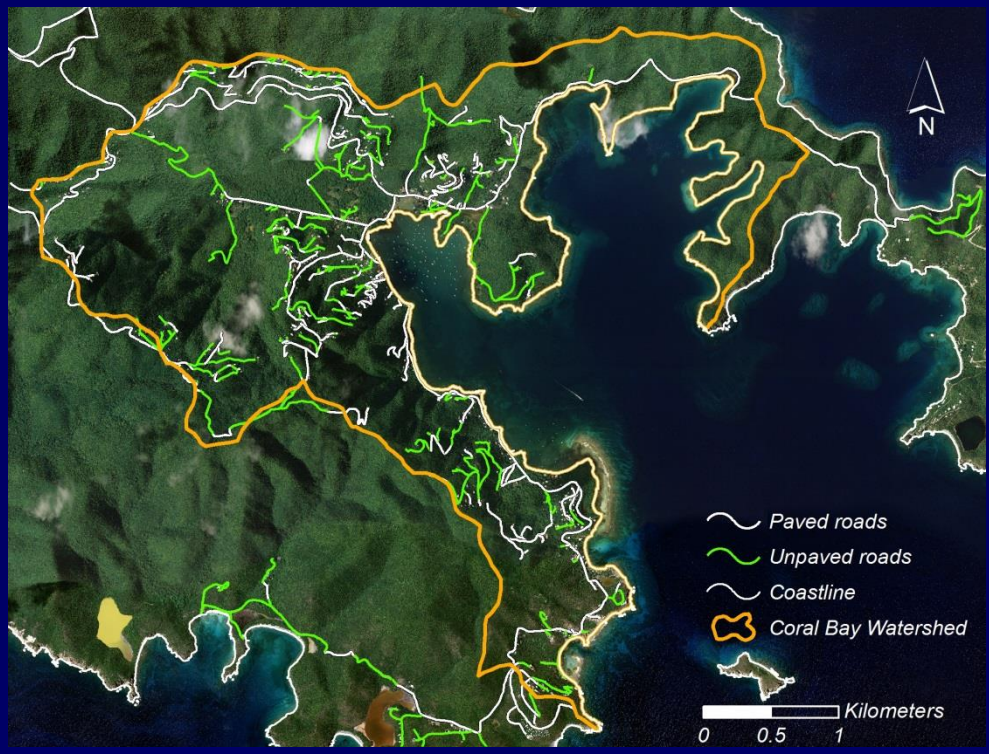
Effects of land disturbance:
Approach #2: ~~Very~~ small coastal watersheds

Vieques-PR

Culebra-PR

St. John-USVI

Coral Bay, St. John-USVI



- Watershed area = 10.7 km^2
- Steep topography (>50% slopes > 16 degrees)
- ~65 km of roads; ~25 km unpaved

Coral Bay, St. John-USVI

Project (NOAA-Coral Reef Protection, ARRA Grant, 2009-2012):

- Road drainage improvements
- Road Paving
- Sediment retention structures

Coral Bay, St. John-USVI

Assessment of road paving in reducing erosion rates:

- Rainfall
- Slope
- Road surface type (fine-textured, coarse-textured, paved)



Coral Bay, St. John-USVI

Assessment of road paving in reducing erosion rates:

- Rainfall
- Road surface type (fine-textured, coarse-textured, paved)
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Coral Bay, St. John-USVI

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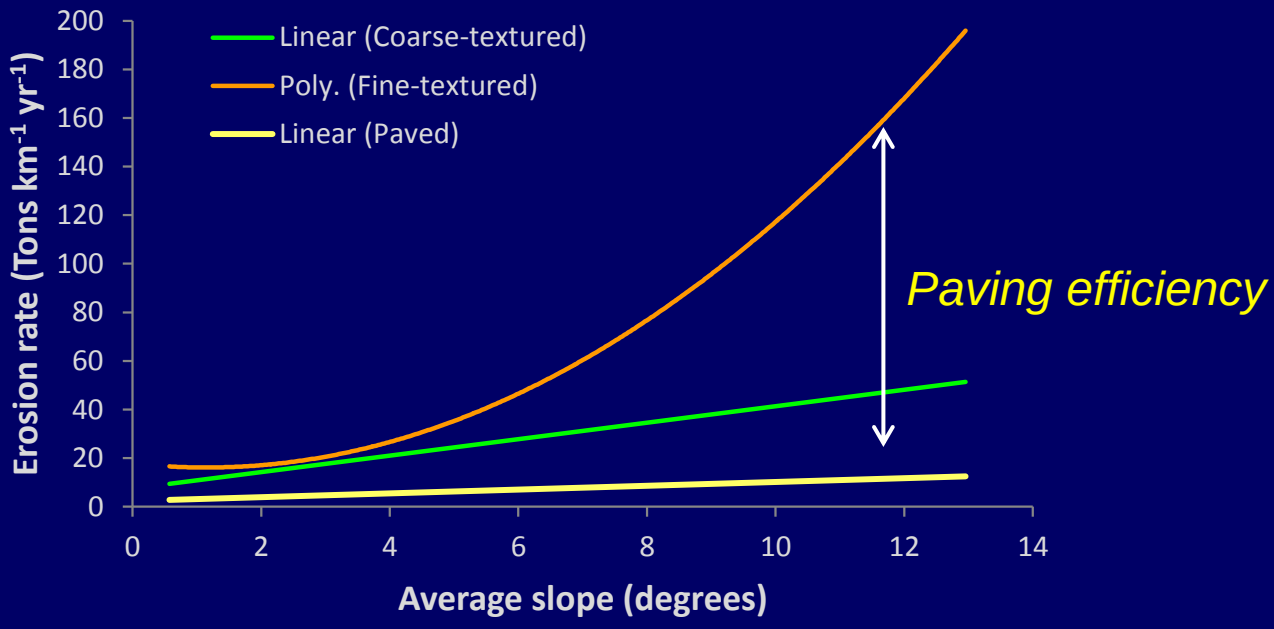
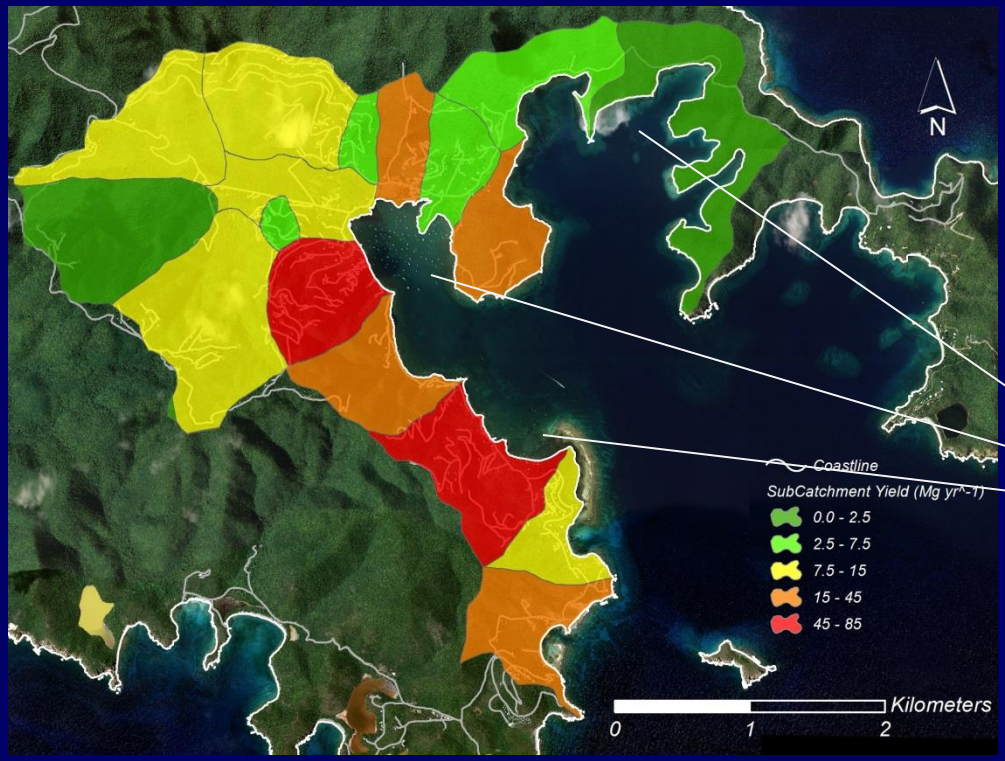


Ramos-Scharron et al., in prep.

Coral Bay, St. John-USVI

Watershed-scale assessment:

✓-Select priority catchments
✓-Comparison of terrestrial delivery & bay sediment settling rates

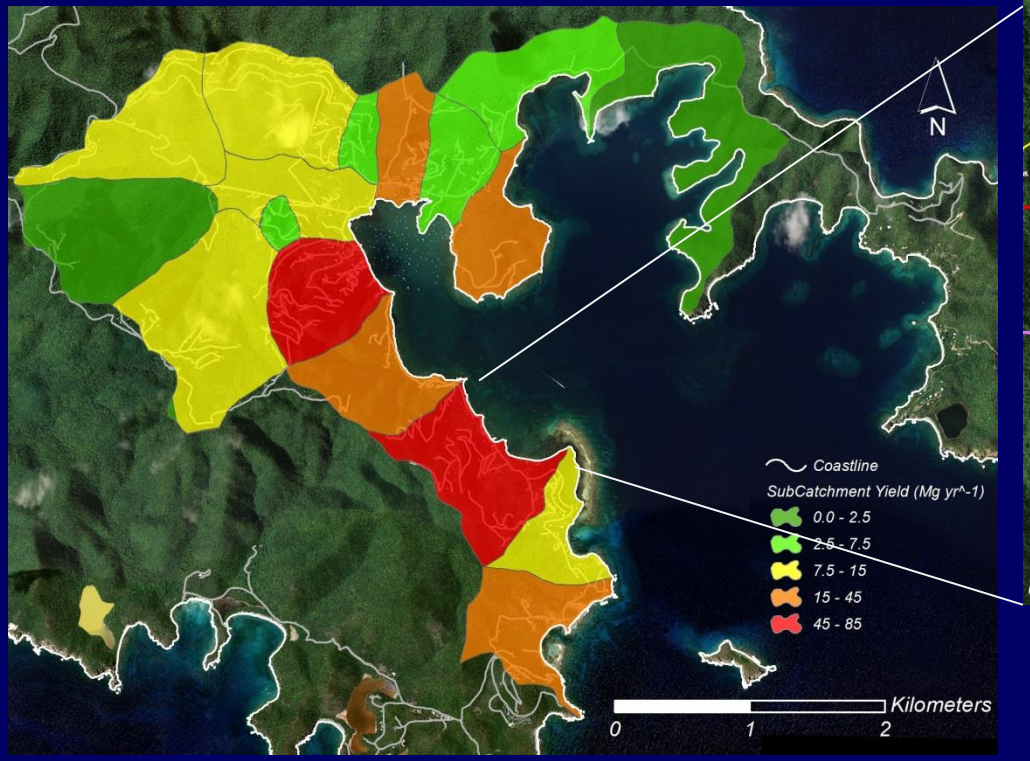


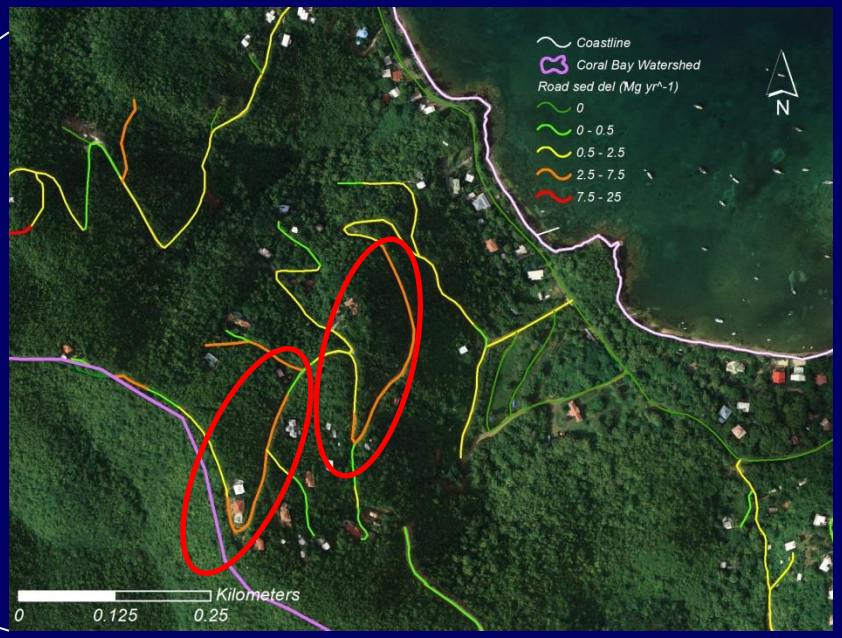
Univ of San Diego & UVI

Coral Bay, St. John-USVI

Watershed-scale assessment:

✓-Select priority catchments
✓-Comparison of terrestrial delivery & sediment settling rates
✓-Select priority sites





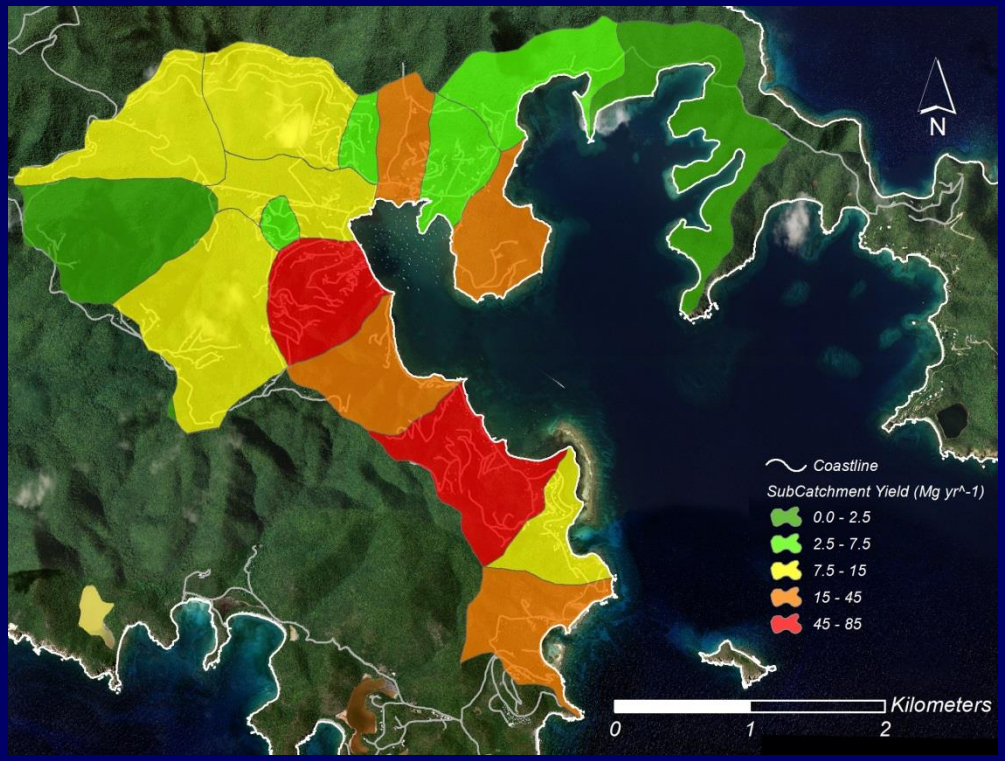
Calabash Boom

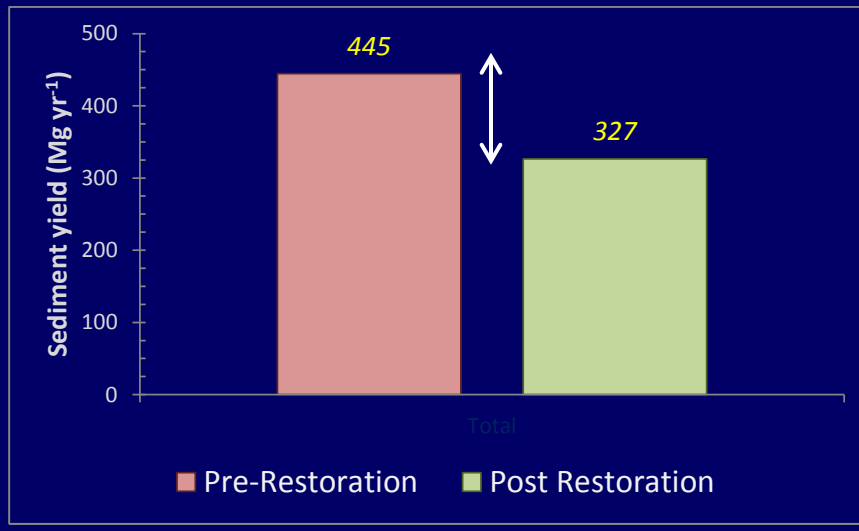
Ramos-Scharron et al., in prep.

Coral Bay, St. John-USVI

Watershed-scale assessment:

- ✓-Select priority catchments
- ✓-Terrestrial delivery rates & sediment settling rates
- ✓-Select priority sites
- ✓-Evaluate the effectiveness of sediment control strategies



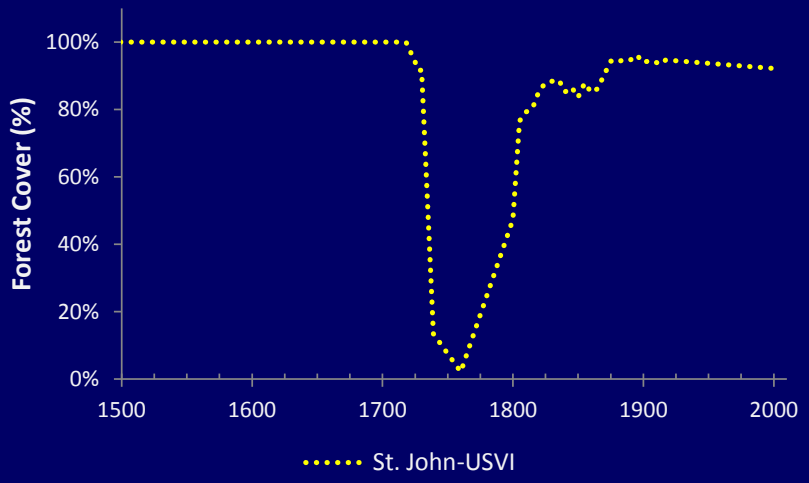


Coral Bay wide

Ramos-Scharron et al., in prep.

Coral Bay, St. John-USVI

Evaluating the overall strategy- Historical trends



Land use change scenario

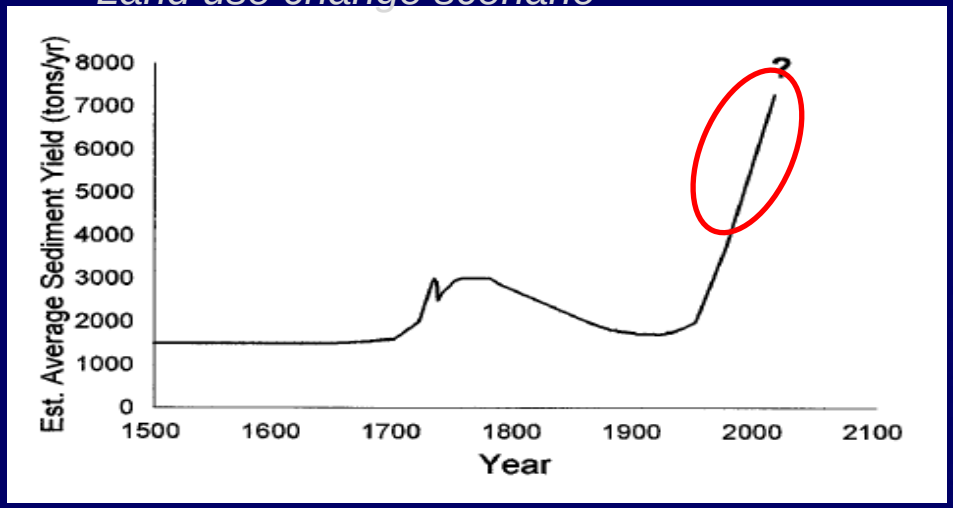
Long-term sedimentation studies bay/coastal environments

(Nichols & Brush, 1988; Brooks et al., 2007)

-No detectable impact on sedimentation rates from peak agricultural era

-Current sediment accumulation rates roughly 3 times higher than long-term average (~5,000 yrs BP)

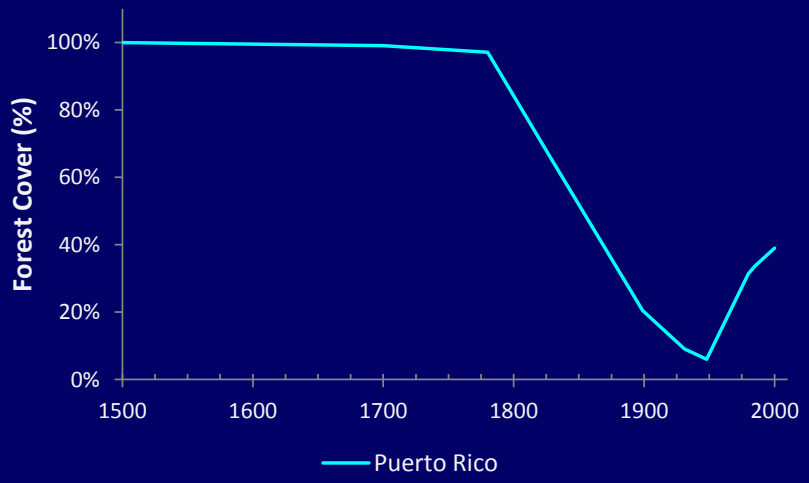
-Recognition of impacted sediment facies dating to the 1950s



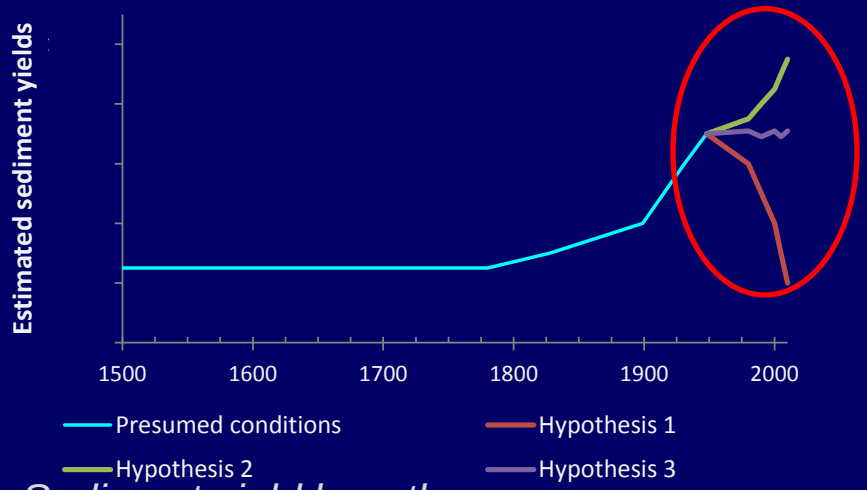
Sediment yield hypothesis (MacDonald et al., 1997)

Puerto Rico

Evaluating the overall strategy- Historical trends



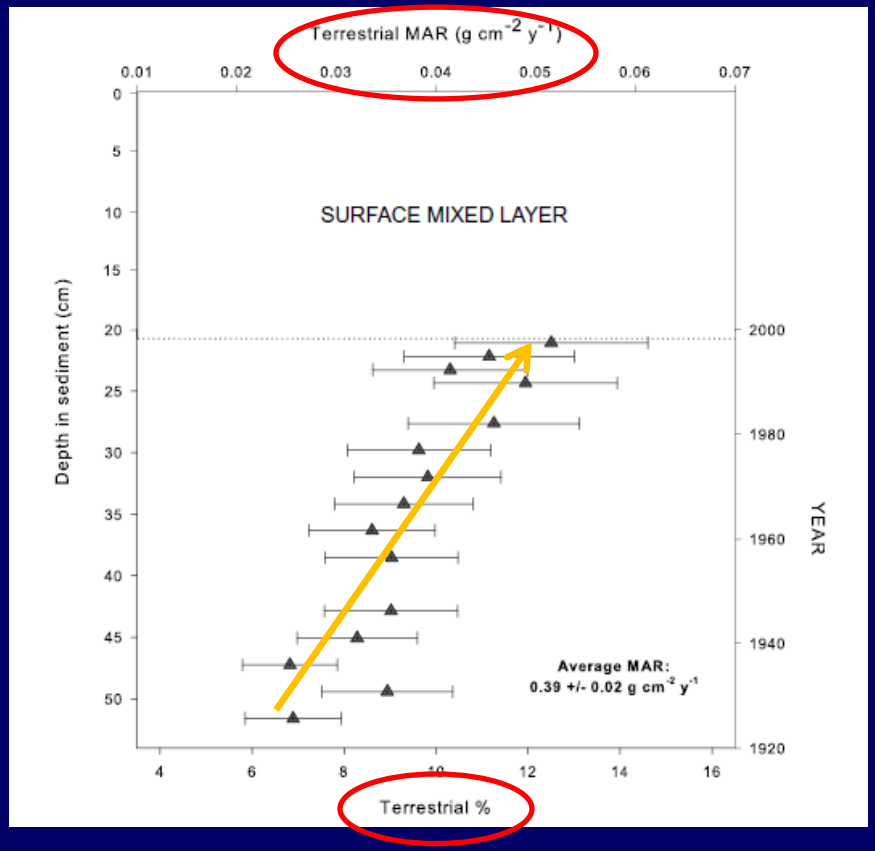
Land use change scenario



Sediment yield hypotheses

Long-term sedimentation studies bay/coastal environments

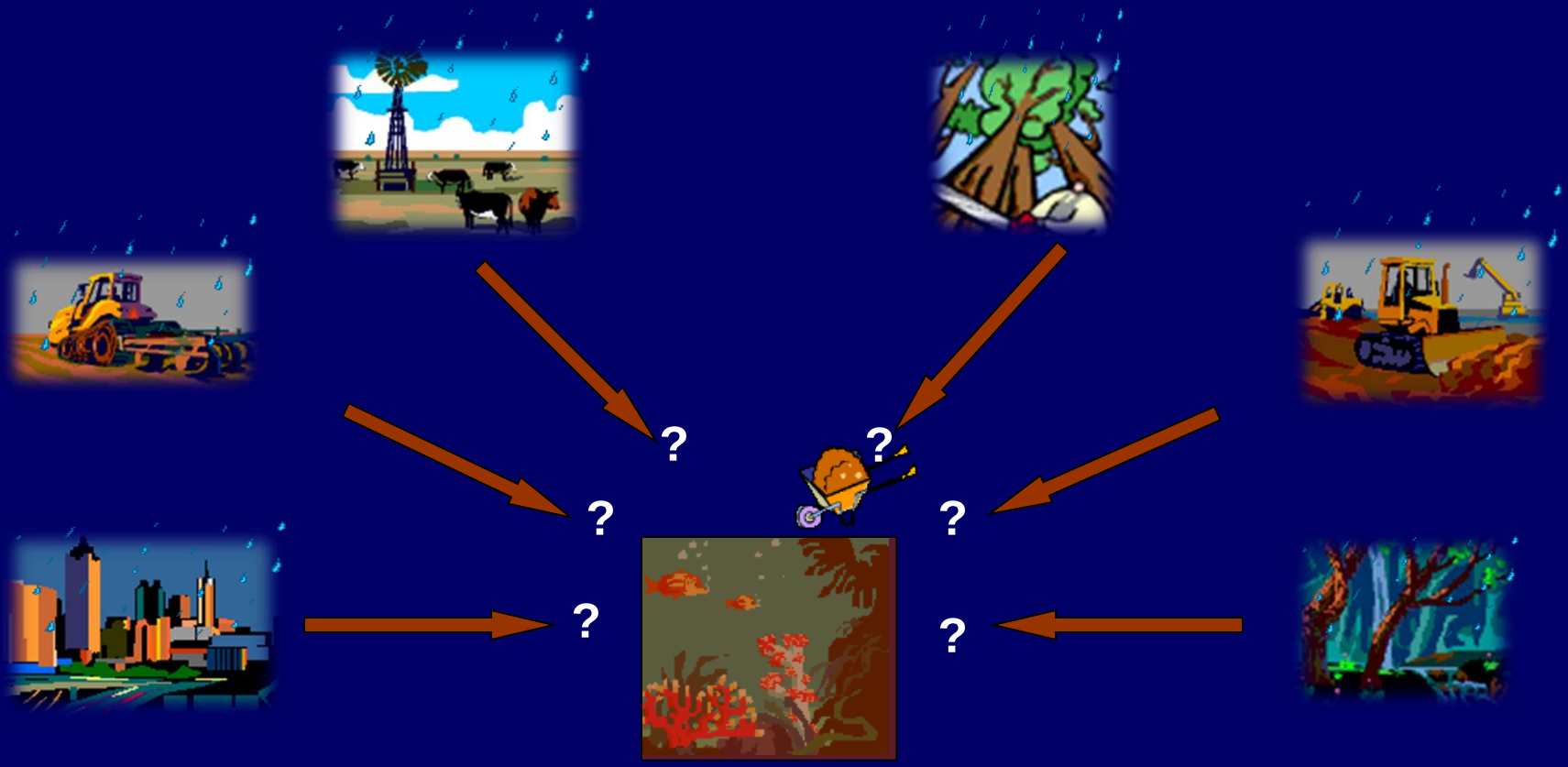
(Ryan et al., 2008; Parguera SW Puerto Rico)



Rio Fajardo Watershed (~ 60 km^2)

Effects of land disturbance:

Approach #3: Larger watersheds (10's to 100's km^2's)



Non-Point Sources of Pollution

Effects of land disturbance:
Approach #3: Larger watersheds

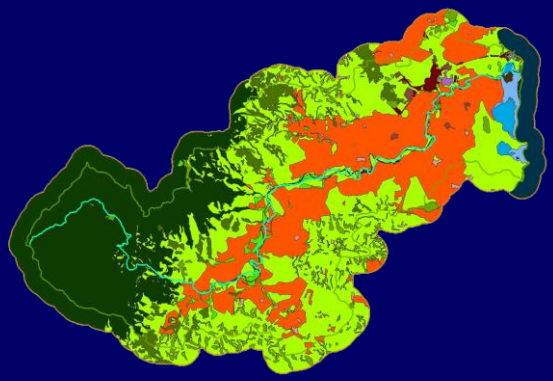
Construction

Landslides

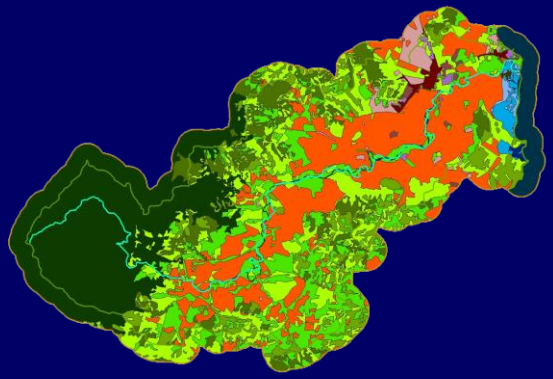
Streambanks

Agricultural activities

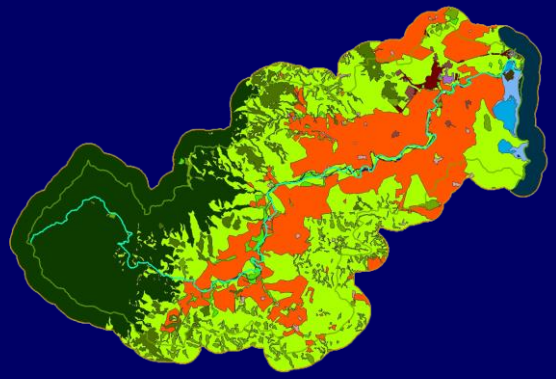
Rio Fajardo Watershed-Land Use Transitions



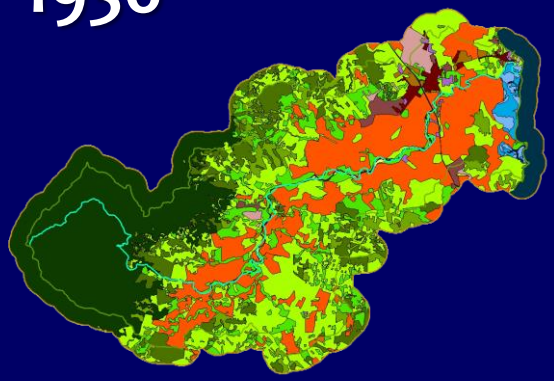
1936



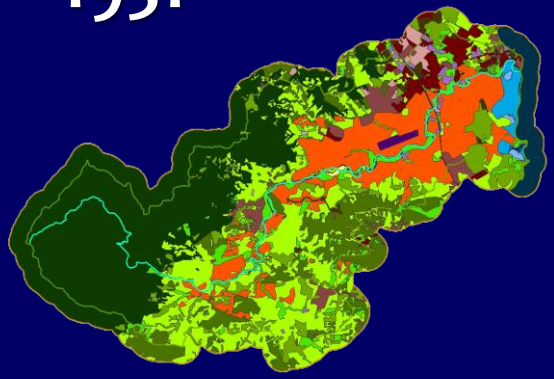
1951



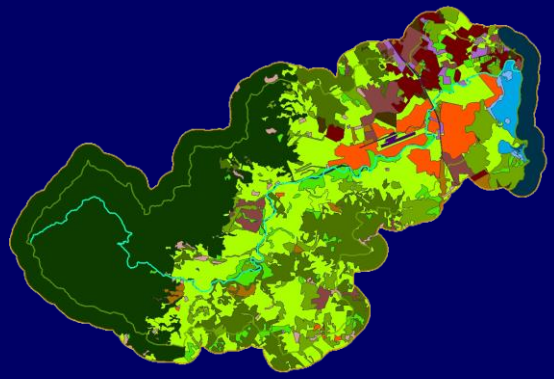
1963



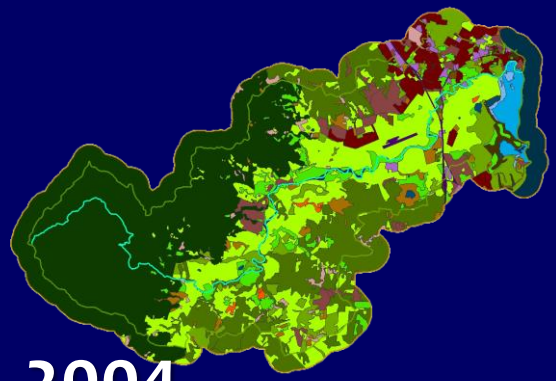
1971



1979



1983



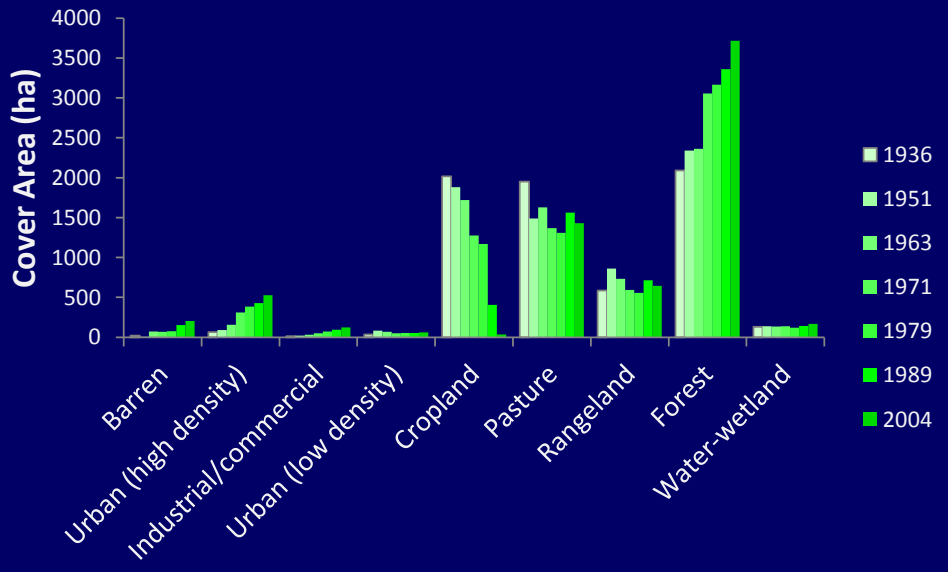
2004

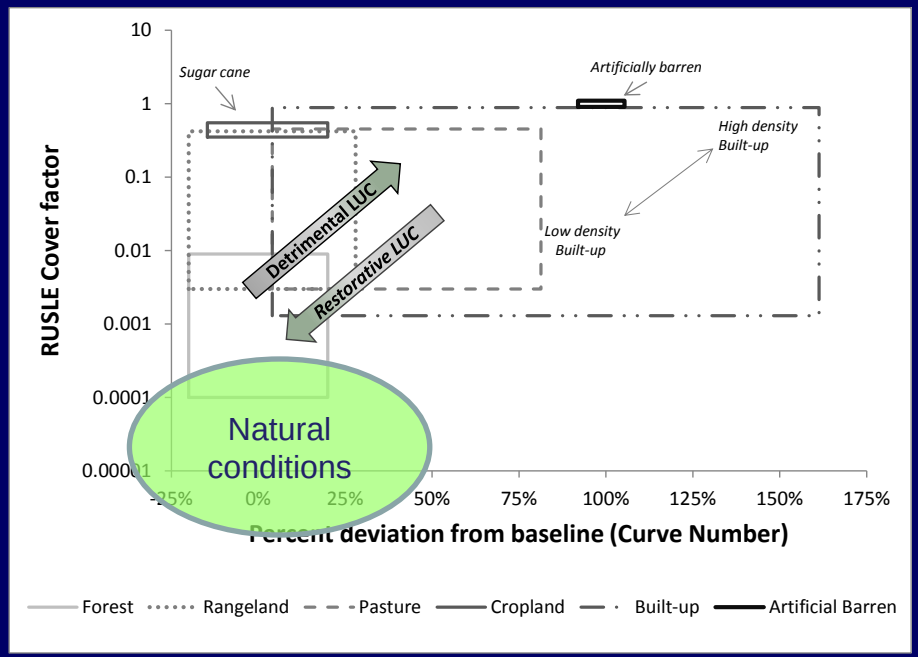
Ramos-Scharron et al., in prep.

Ramos-Scharron et al-GSA Southeastern Section Meeting, San Juan, March 2013

- Developed | Low Intensity
- Developed | Med Intensity
- Developed | High Intensity
- Developed | Commercial/Industrial
- Developed |Transportation
- Developed | Open Space/Bare
- Developed | Open Space/Impervious
- Developed | Open Space/Arificial Barren
- Cultivated Crops
- Grassland/Herbaceous
- Shrub/Scrub
- Forest | Low Density
- Forest | Medium Density
- Forest | High Density
- Wetlands | Shrub/Scrub/Artificial
- Wetlands | Forested
- Water | Reservoirs
- Water | Lake
- Water | Seawater
- Water | River
- Water | Pond
- Baren Land

Rio Fajardo Watershed



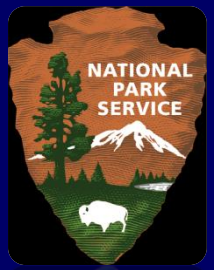


Interdisciplinary approach:

1. Reconstruct land use history
2. Reconstruct sediment yields through watershed modeling
3. Geomorphic mapping and quantification of active sources
4. Linking land sources with marine habitats through oceanographic observations
5. Sedimentation rates in coastal environments
6. Historical trends in coral growth rates (coral cores)
7. Geochemical proxies of land-bases sources of pollution in sediments and corals

Ramos-Scharron et al., in prep.

Collaborators



Sinoptica

University of San Diego

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