Mapping tropical forest habitats with Landsat satellite image time series: tree species and associations, foliage height profiles, age, disturbance type, and rates of forest regrowth

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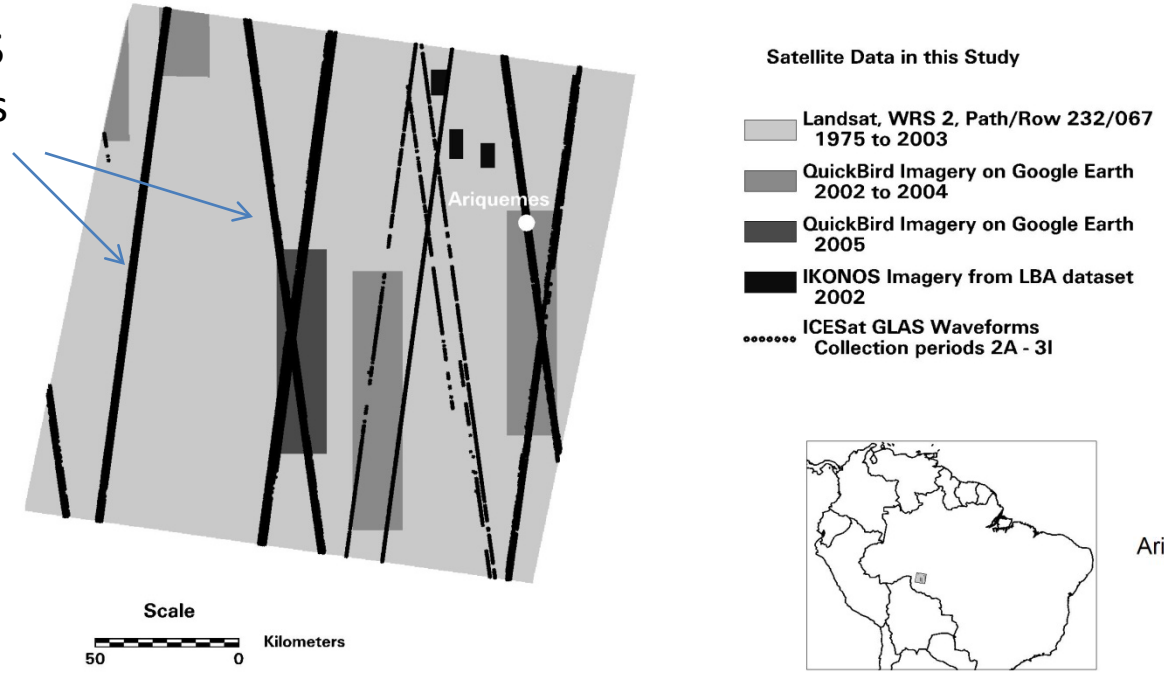
Studies with Long Landsat Image Time Series including Cloud-gap-filled Series

- **Amazonian** forest regrowth: biomass accumulation rates from space borne lidar
- **Bahamian** forest vertical structure and disturbance – Kirtland's warbler habitat
- **Puerto Rico** tree species distributions and stand variables
- **Trinidad and Tobago** forest tree species associations

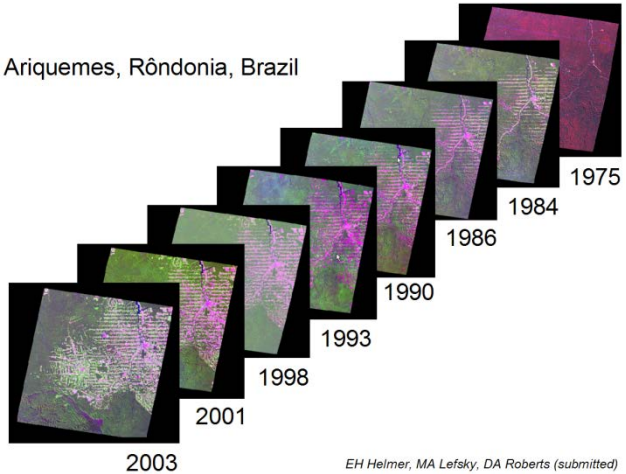
Rates of forest biomass accumulation in young tropical forest regrowth from Landsat time series and GLAS

GLAS shots



EH Helmer, MA Lefsky, DA Roberts (submitted)

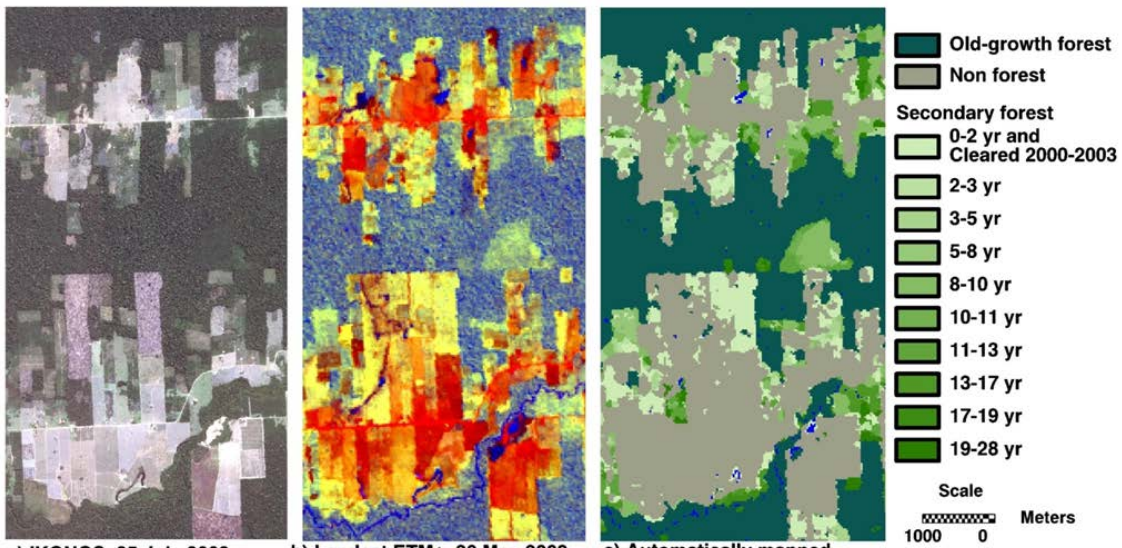
Ariquemes, Rôndonia, Brazil



EH Helmer, MA Lefsky, DA Roberts (submitted)

EH Helmer, MA Lefsky, DA Roberts, 2009, Journal of Applied Remote Sensing Vol 3:033505

Lowland forest age from TAMA algorithm and Landsat time series; biomass from GLAS

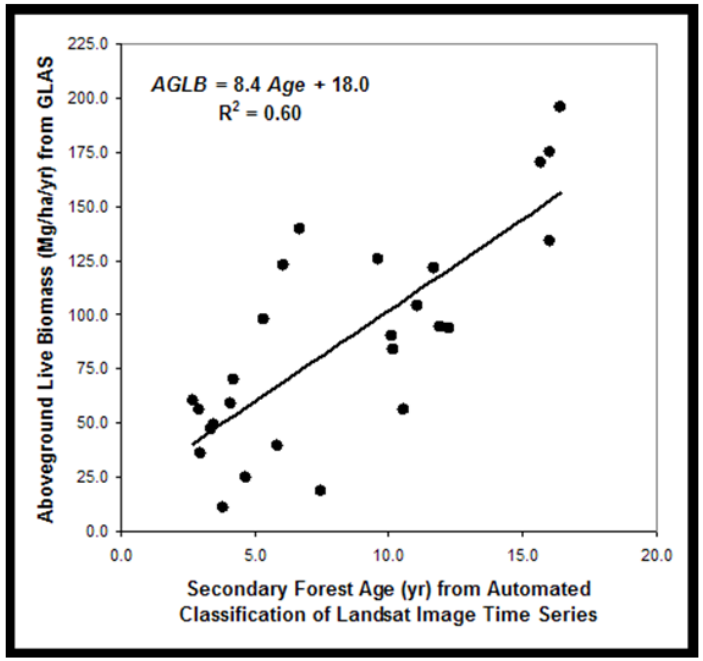


a) IKONOS, 25 July 2002 Red, Green, Blue

b) Landsat ETM+, 20 May 2003 Brightness, Greenness, Wetness

c) Automatically mapped lowland forest age in 2003

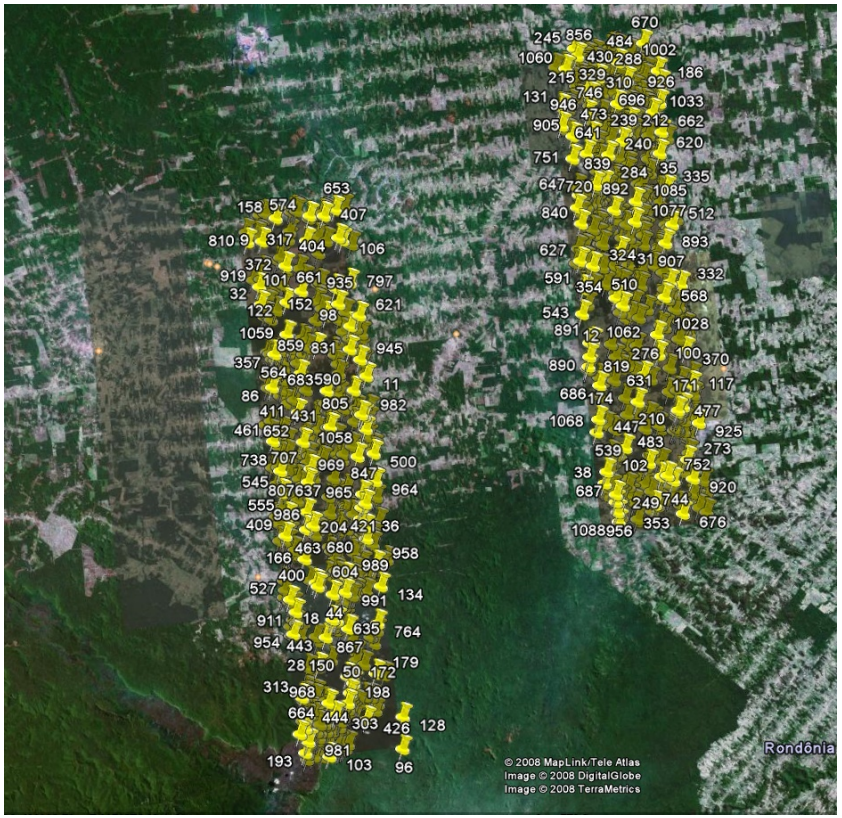
EH Helmer, MA Lefsky, DA Roberts, 2009, Journal of Applied Remote Sensing Vol 3:033505

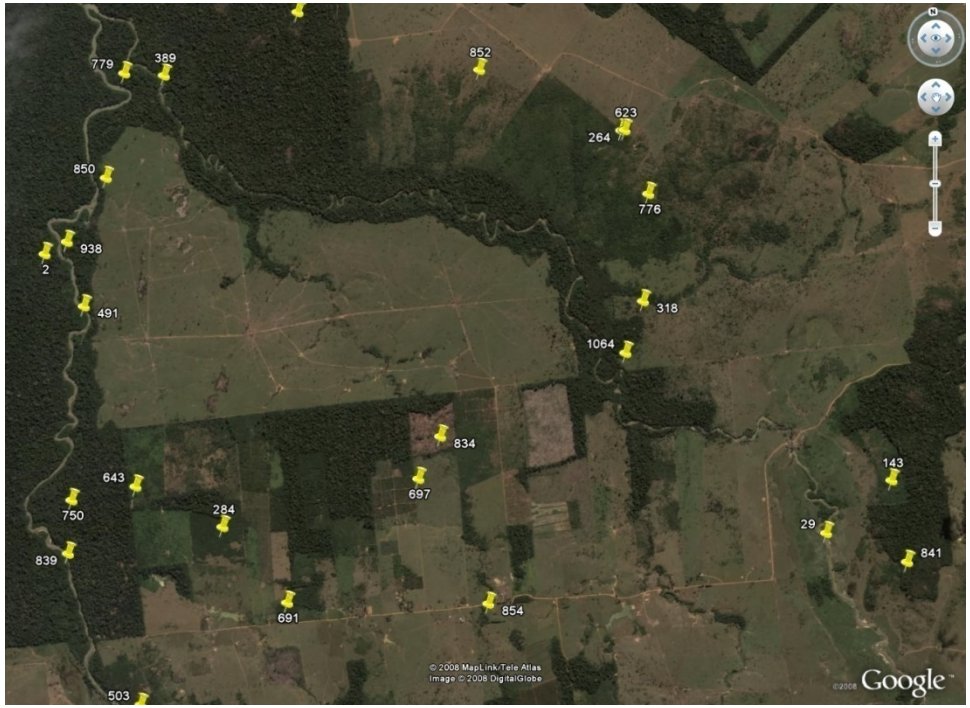


EH Helmer, MA Lefsky, DA Roberts, 2009, Journal of Applied Remote Sensing Vol 3:033505

Rondönia, Brazil is moist – now beginning work on wetter and drier Amazonian sites)

Reference data from Google Earth



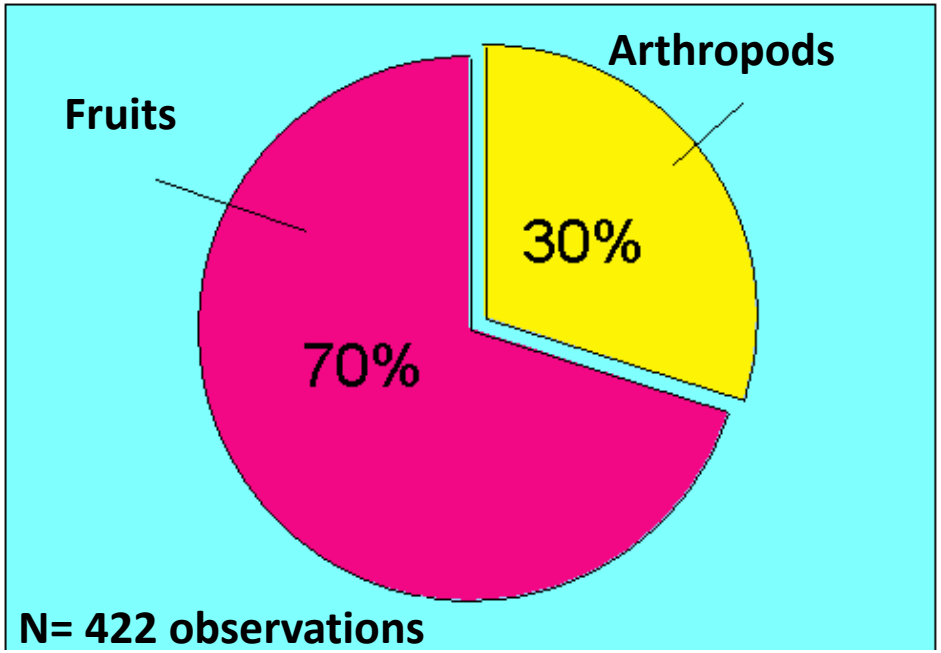


EH Helmer, MA Lefsky, DA Roberts, 2009, Journal of Applied Remote Sensing Vol 3:033505

Forage species more common in disturbed habitats

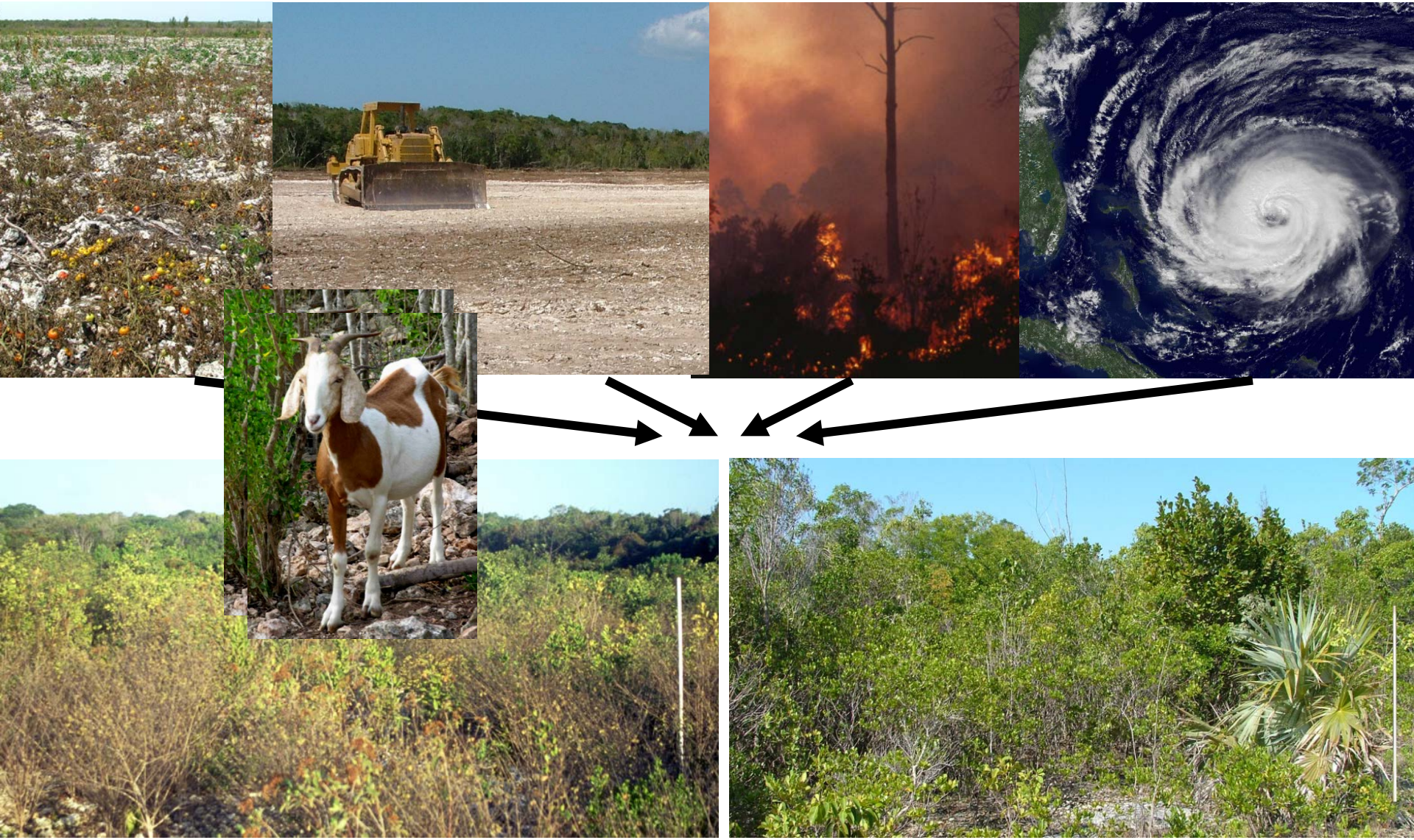
Chiococca alba

Erithalis fruticosa

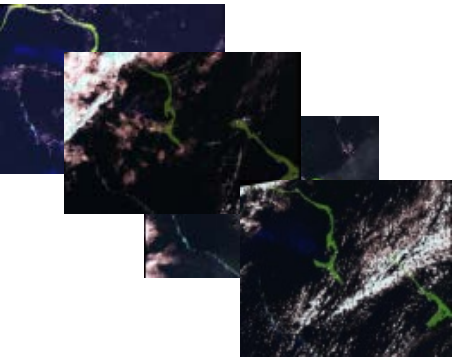


Lantana involucrata; L. bahamensis

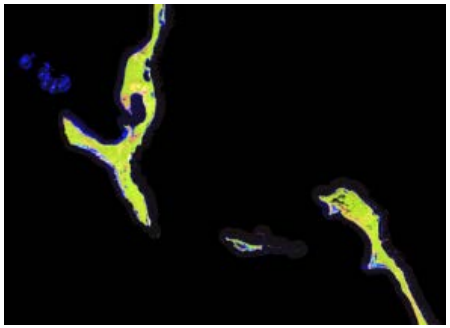
Different sources of forest disturbance



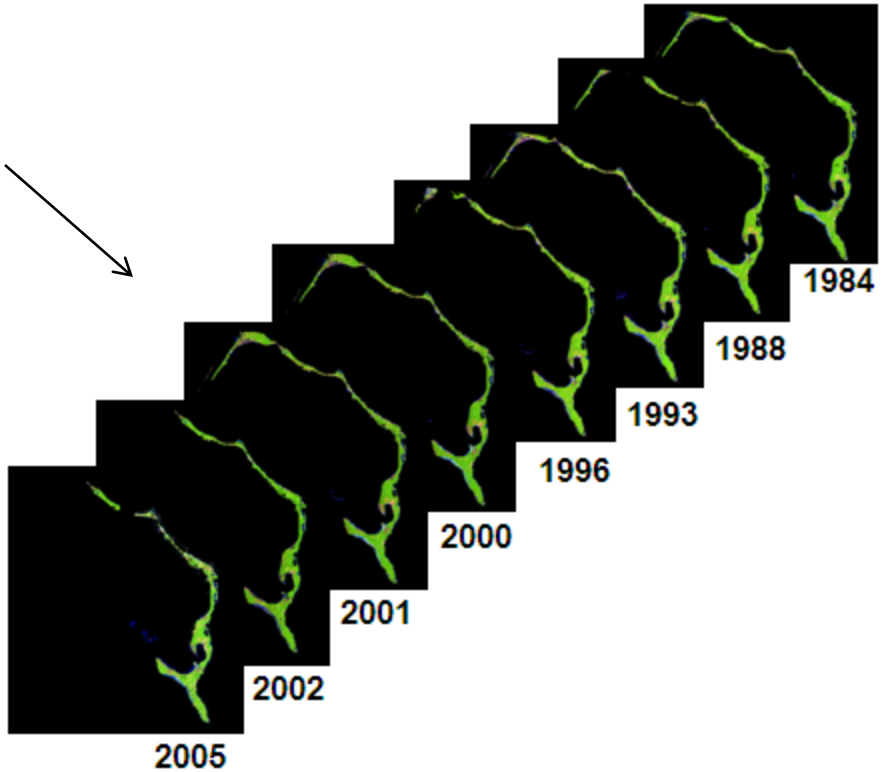
Created time series of cloud-gap-filled Landsat



Cloudy scenes

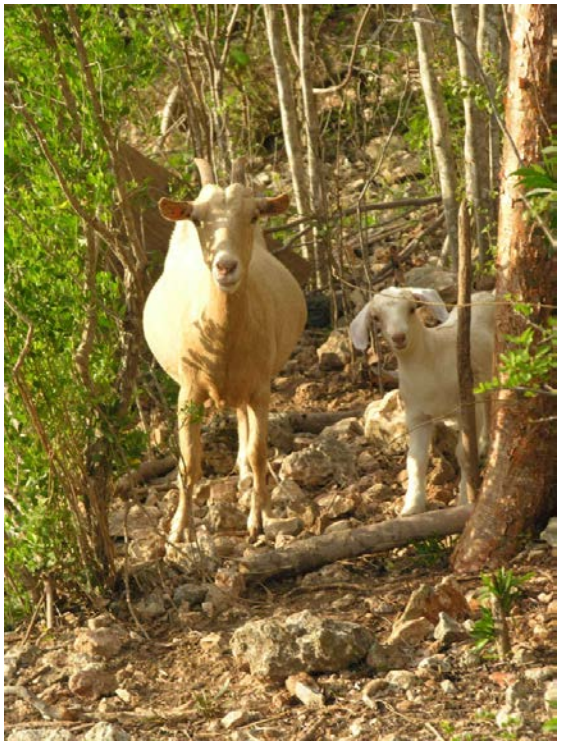


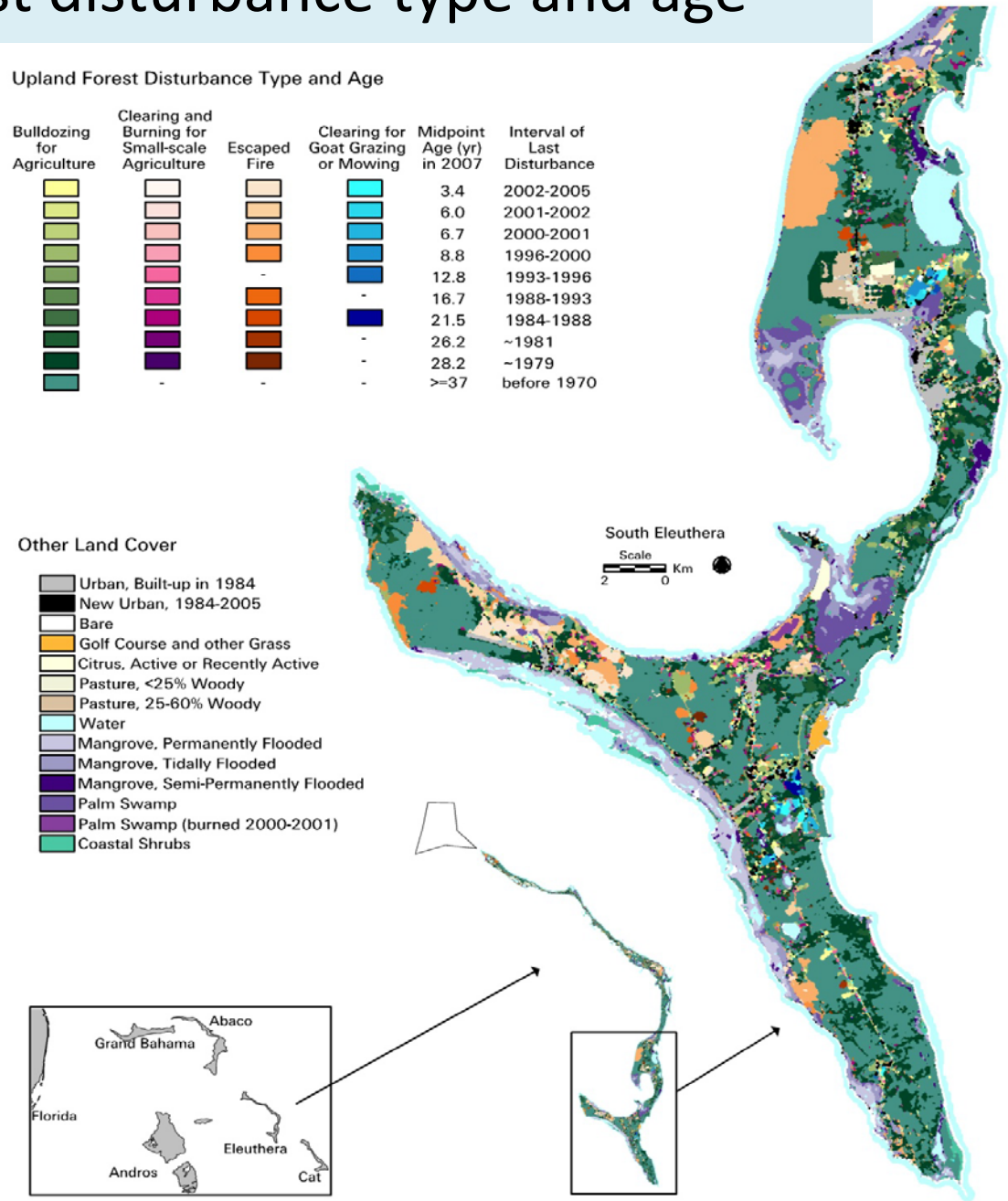
Cloud-gap-filled scene



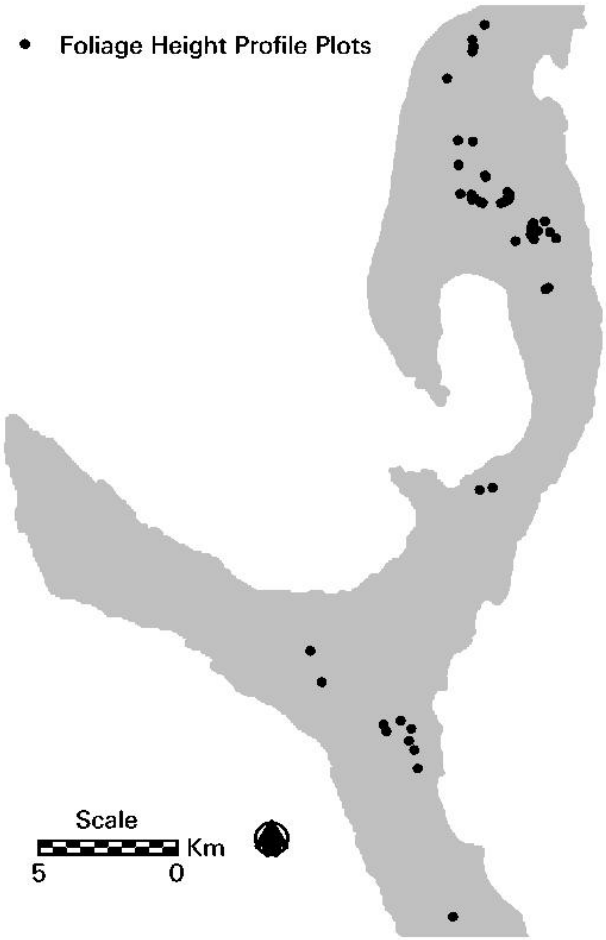
Time series of cloud-gap-filled scenes

Mapped forest disturbance type and age



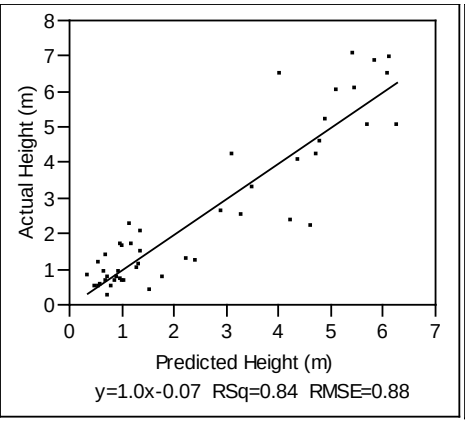


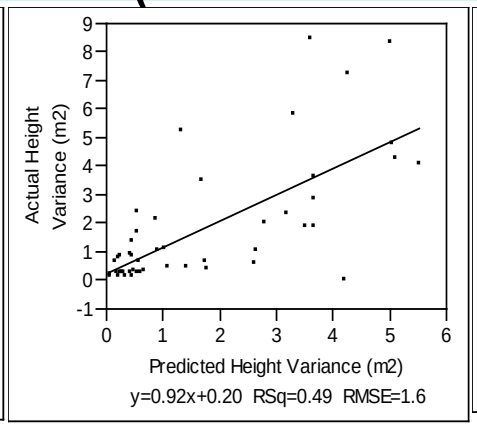
Measured foliage height profiles at 48 plots selected via a random sample of patches stratifed by forest disturbance type and age

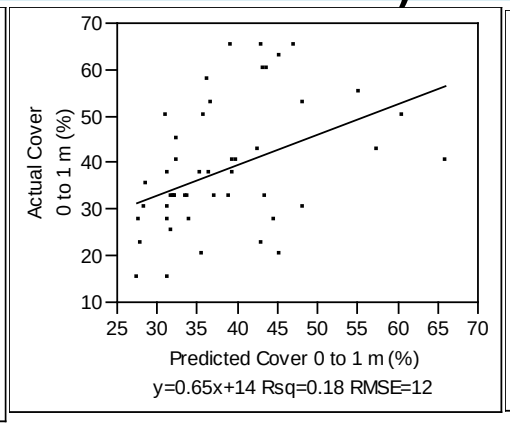


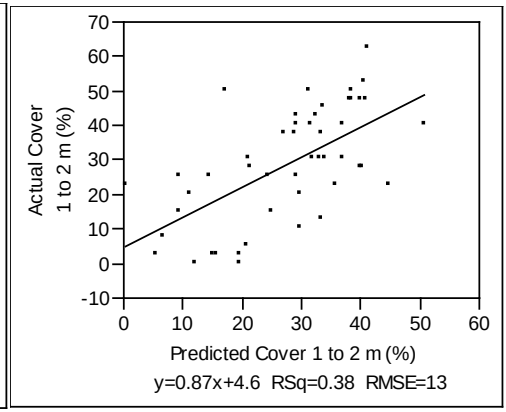
Clustered points tend to be goat-grazed patches of different ages

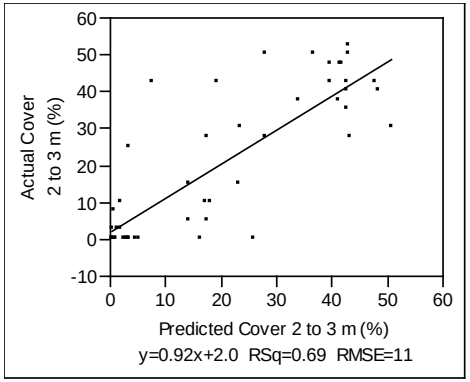
Regression tree mapping models of forest vertical structure, predicted vs. observed (10-fold cross-validation)

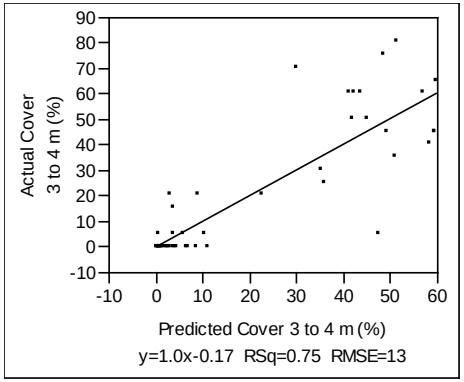


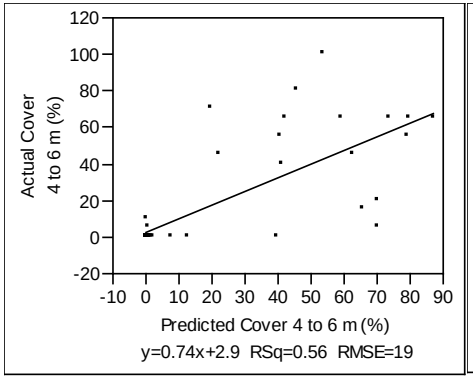


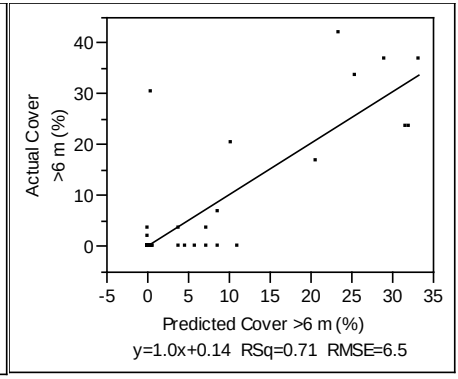












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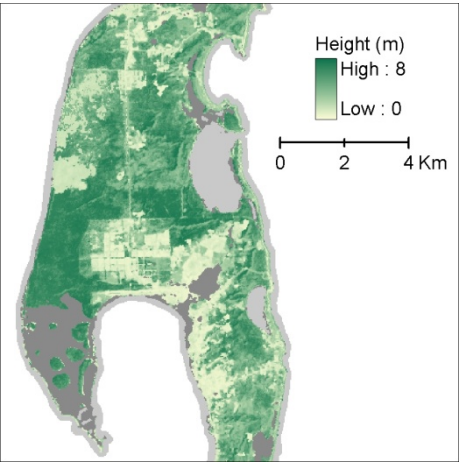
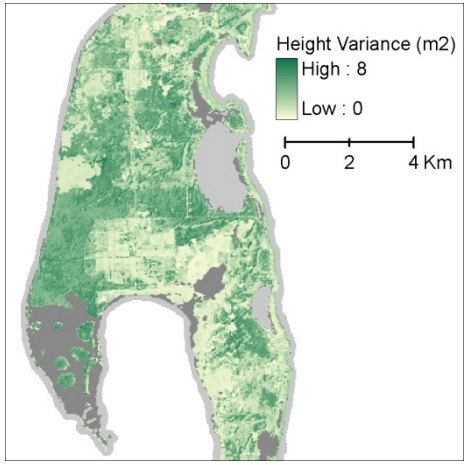
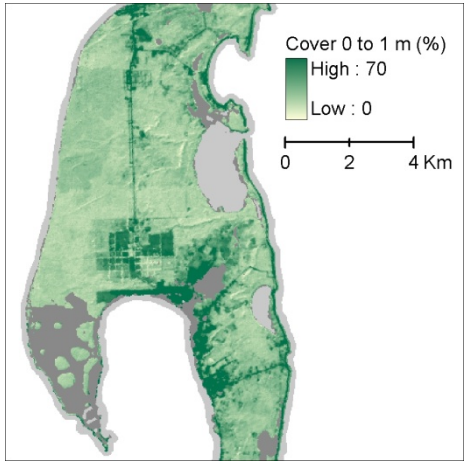
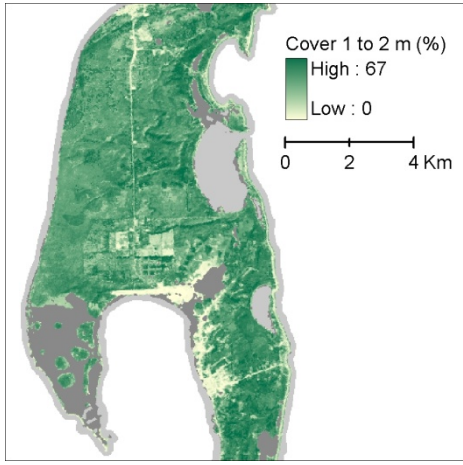
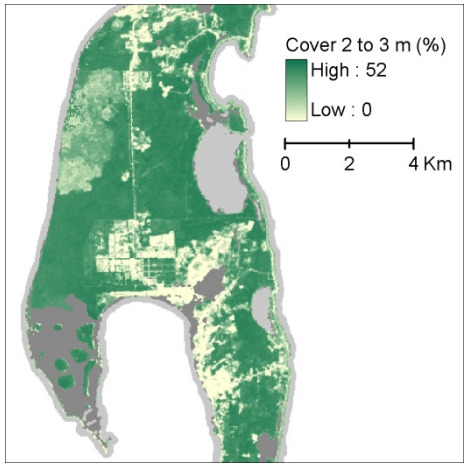
Tropical dry forest height and foliage height profiles mapped from a time series of cloud-cleared Landsat and ALI images

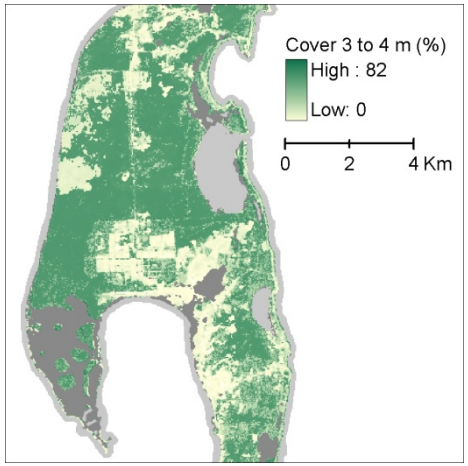


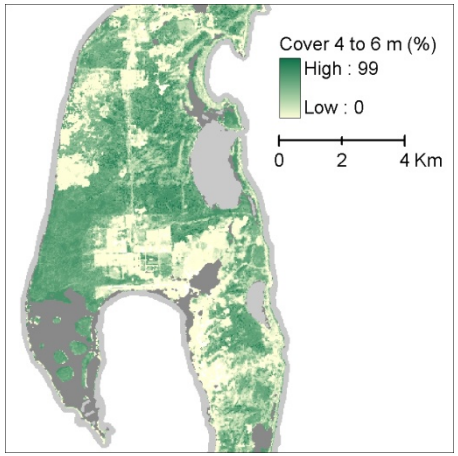


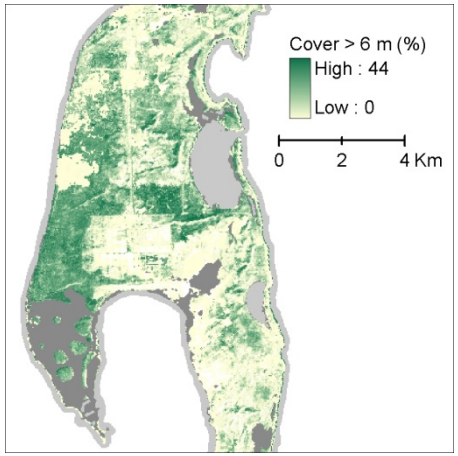






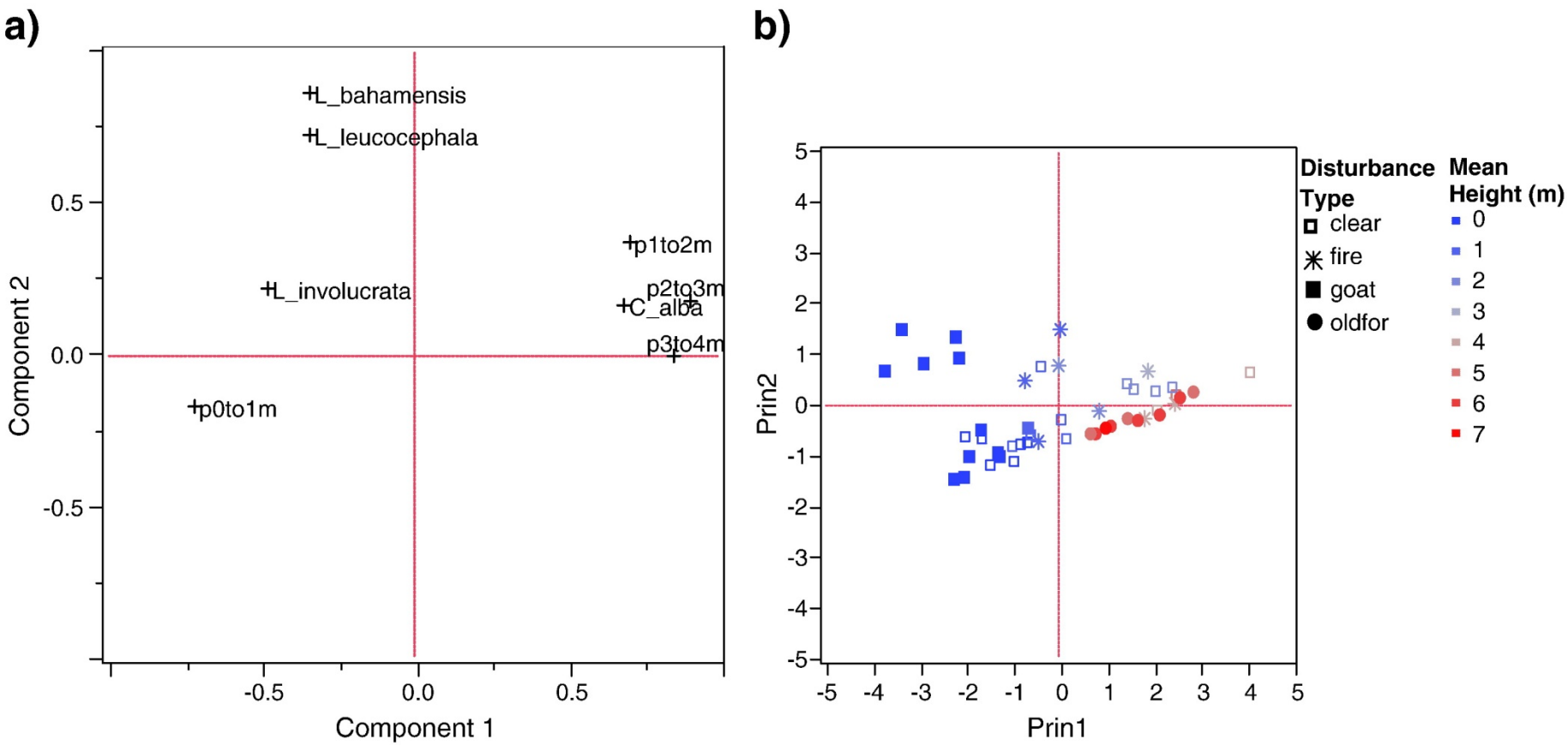






Remote Sensing of Environment 114 (2010) 2457–2473

Counts of Kirtland's Warbler forage species related to vertical structure (and disturbance type)



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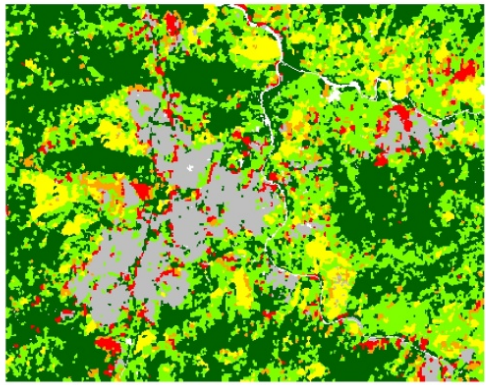
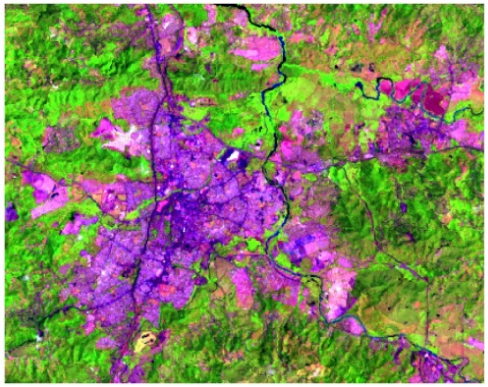
Puerto Rico Urban Change Detection

Urban Change

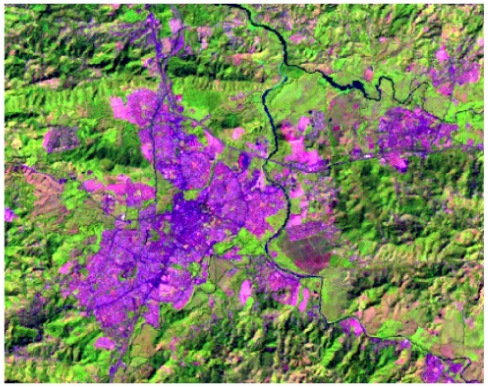


- Water
- Urban throughout time series
- Forest throughout time series
- Agriculture, including pasture and grass, throughout time series
- Agriculture to Urban: 1980-1985
- Agriculture to Urban: 1985-1990
- Agriculture to Urban: 1990-2000

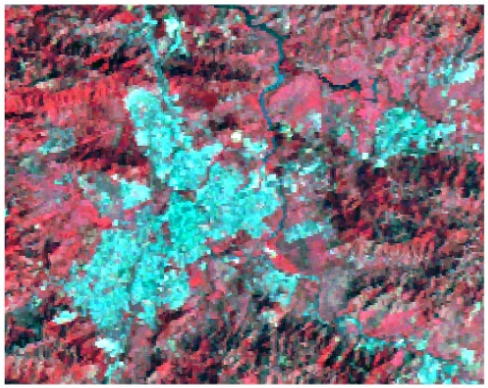
2000 Landsat mosaic



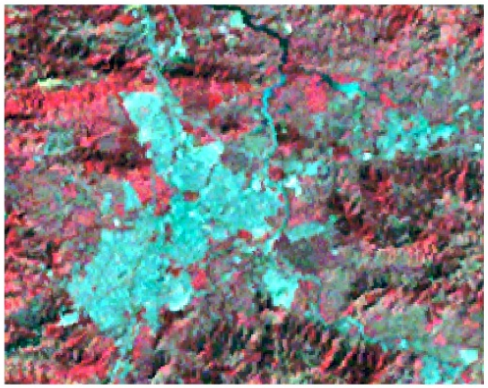
1990 Landsat mosaic

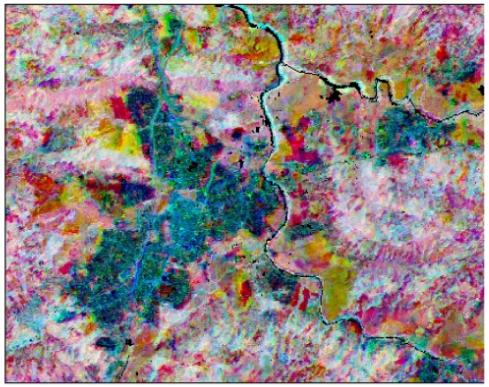


1985 Landsat mosaic



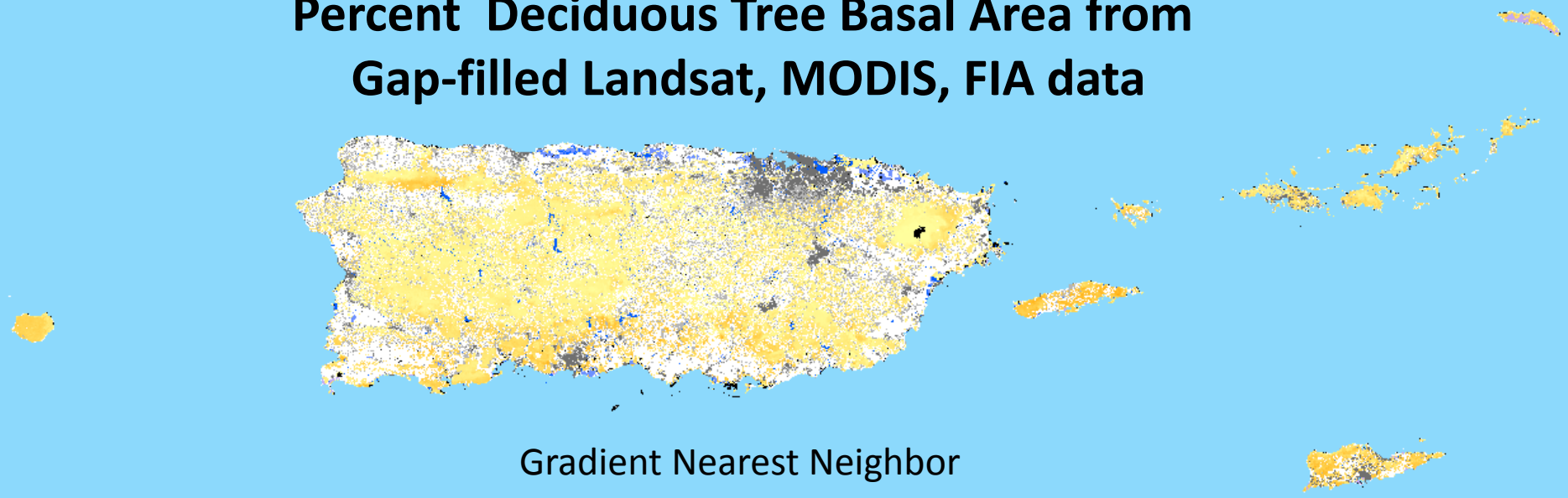
1980 Landsat mosaic



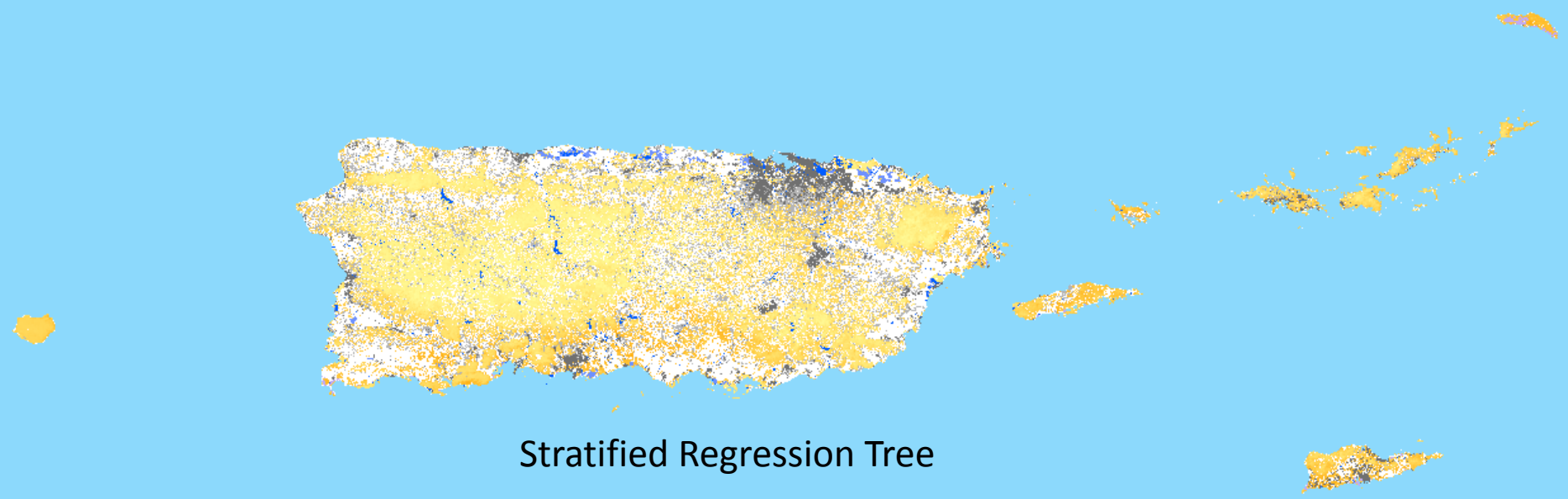


Band 1: 1980 NDVI
Band 2: 1985 NDVI
Band 3: 1990 Tasseled Cap Wetness
Band 4: 2000 Tasseled Cap Wetness
(displayed as bands 2,3,4)

Percent Deciduous Tree Basal Area from Gap-filled Landsat, MODIS, FIA data

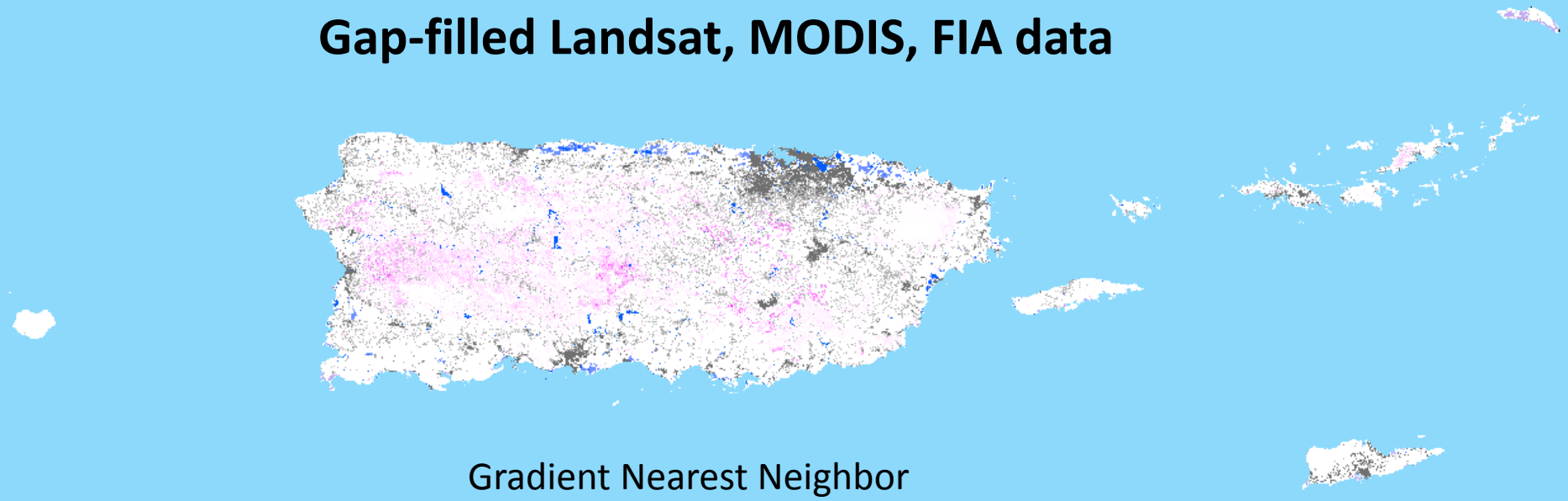


Gradient Nearest Neighbor

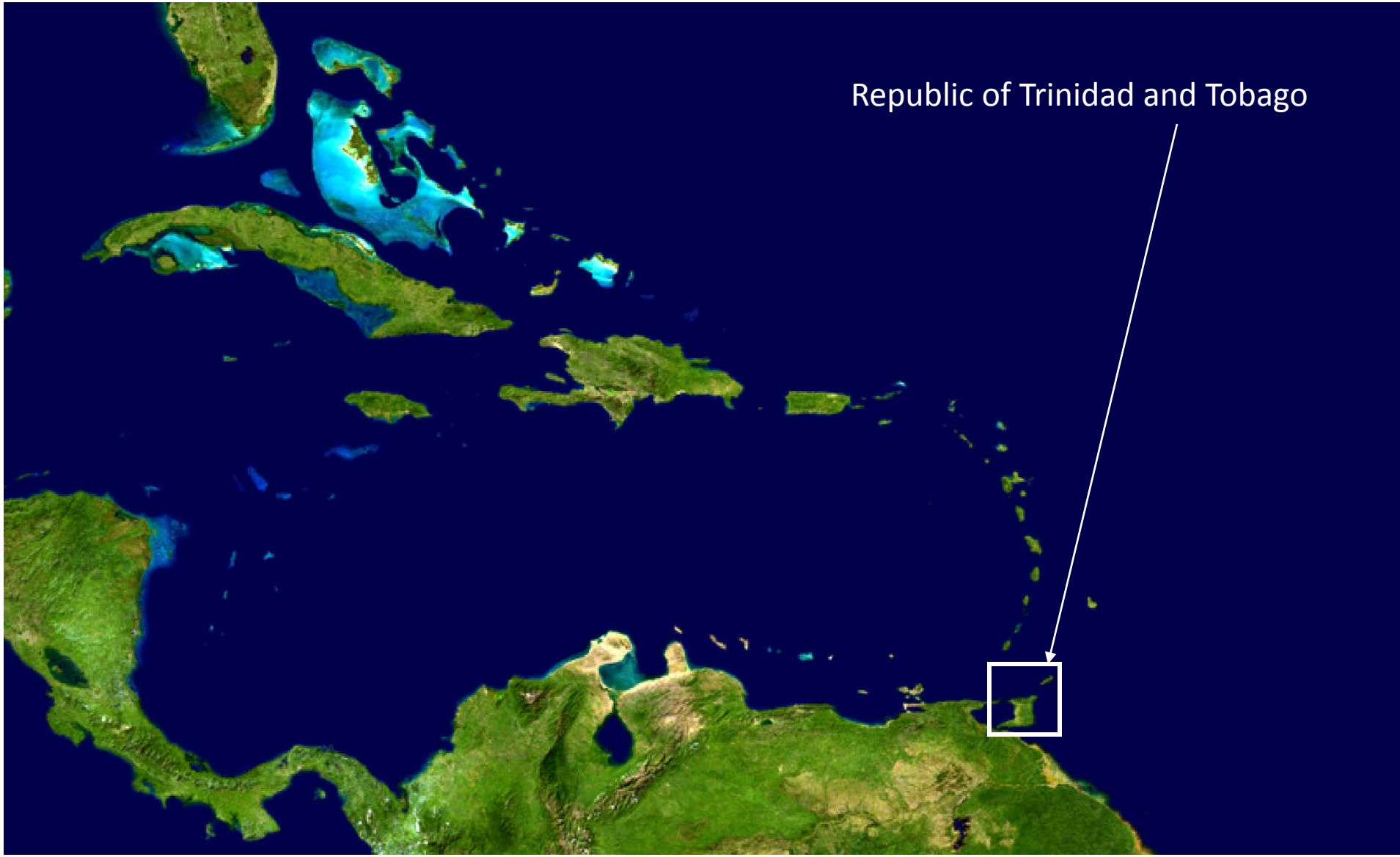


Stratified Regression Tree

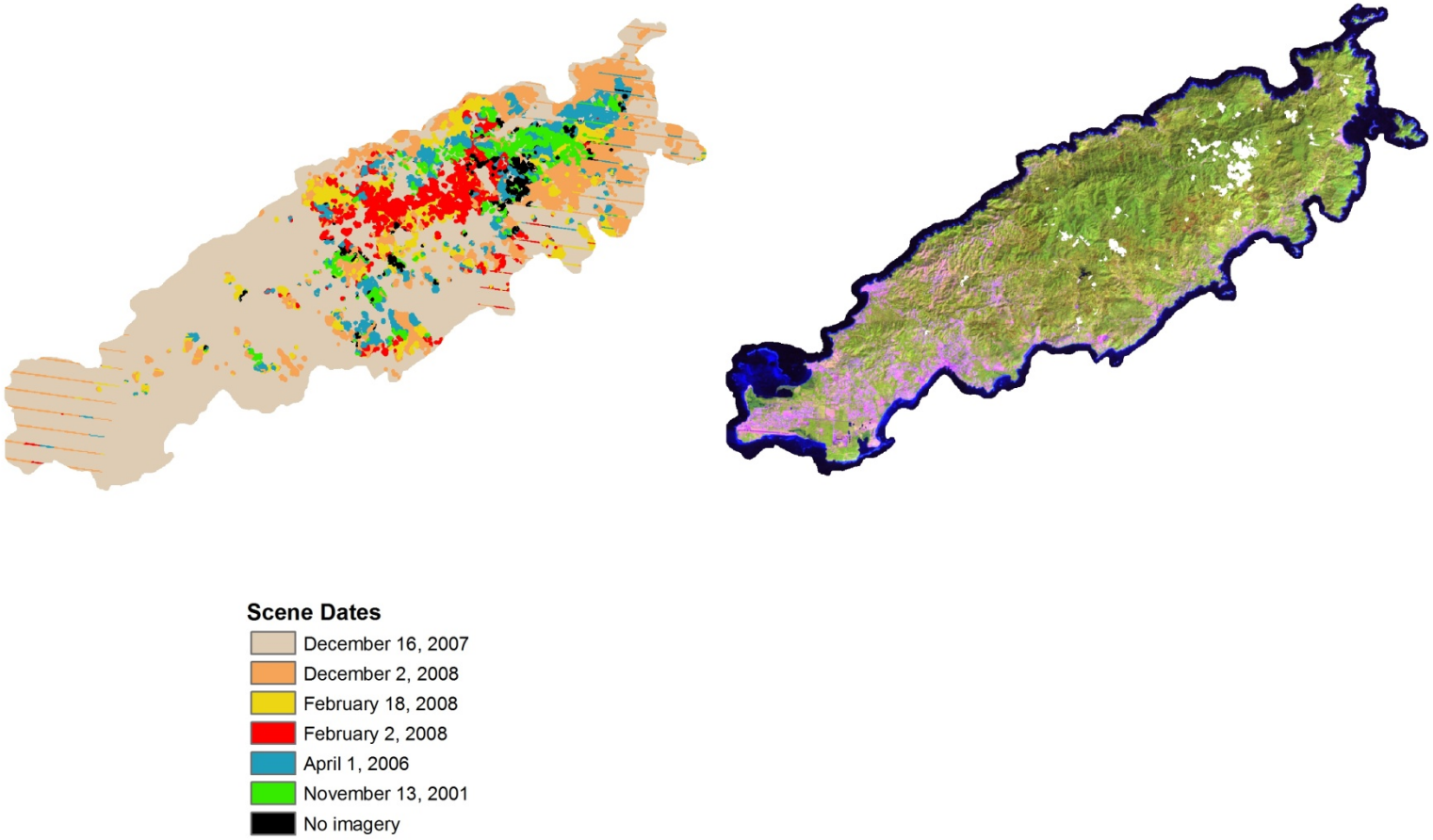
Percent *Syzigium jambos* Basal Area from Gap-filled Landsat, MODIS, FIA data



Gradient Nearest Neighbor


Republic of Trinidad and Tobago

Dates of Landsat scenes in gap-filled imagery



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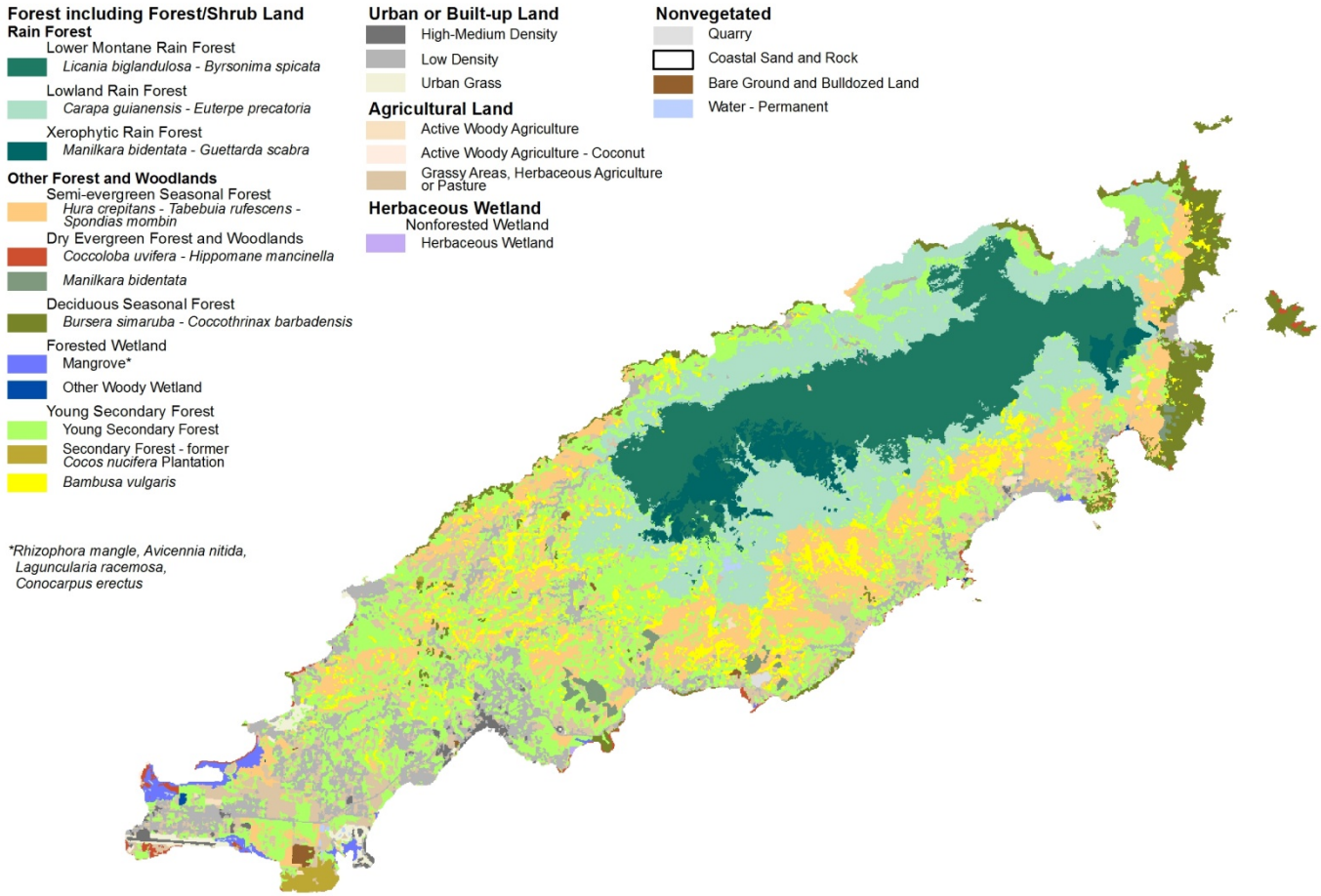
Forest associations and land cover of Tobago from gap-filled Landsat



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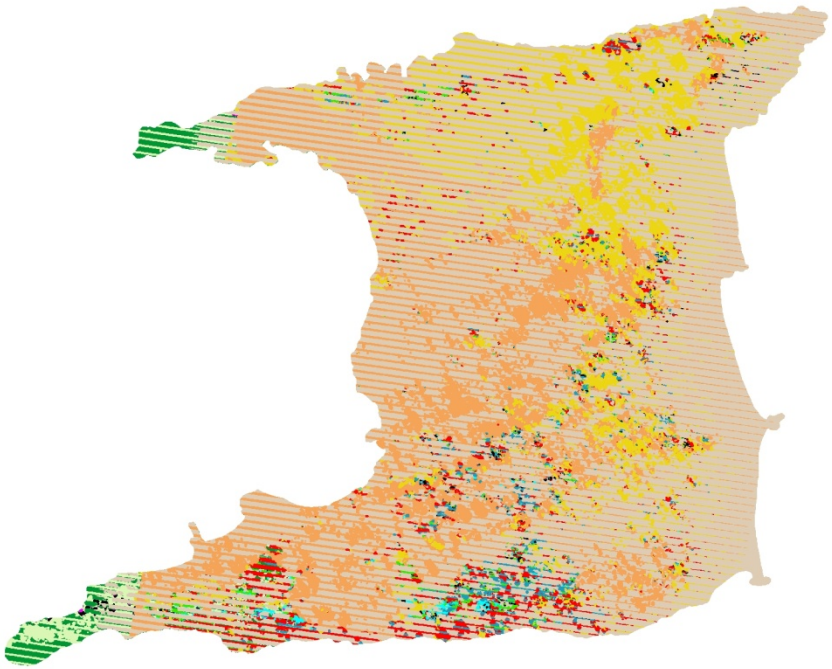
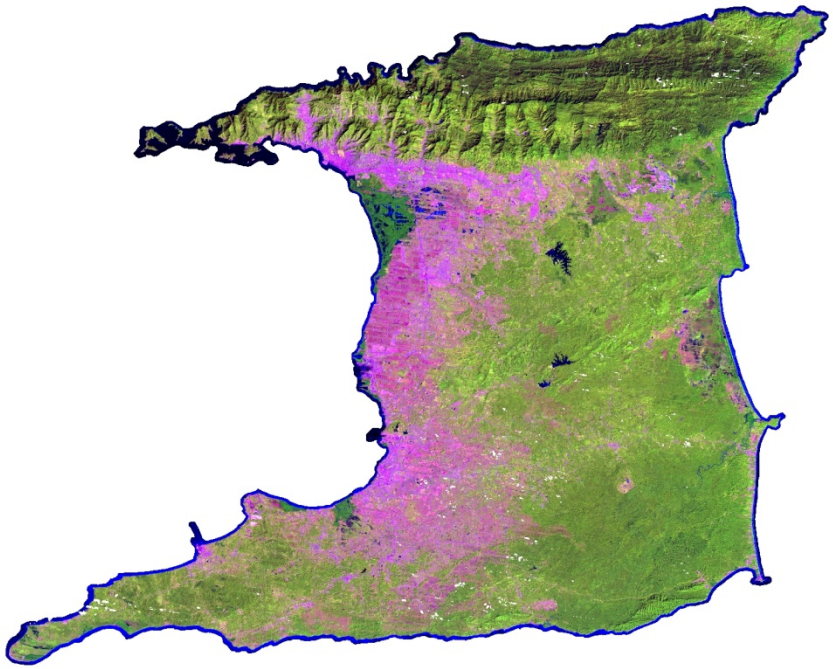
Dates of Landsat scenes in gap-filled imagery





Scene Dates

- December 16, 2007
- March 5, 2002
- January 29, 2001
- April 17, 2006
- January 30, 2007
- March 21, 2008
- February 3, 2006
- February 11, 2003
- January 24, 2008
- October 25, 2000
- No imagery

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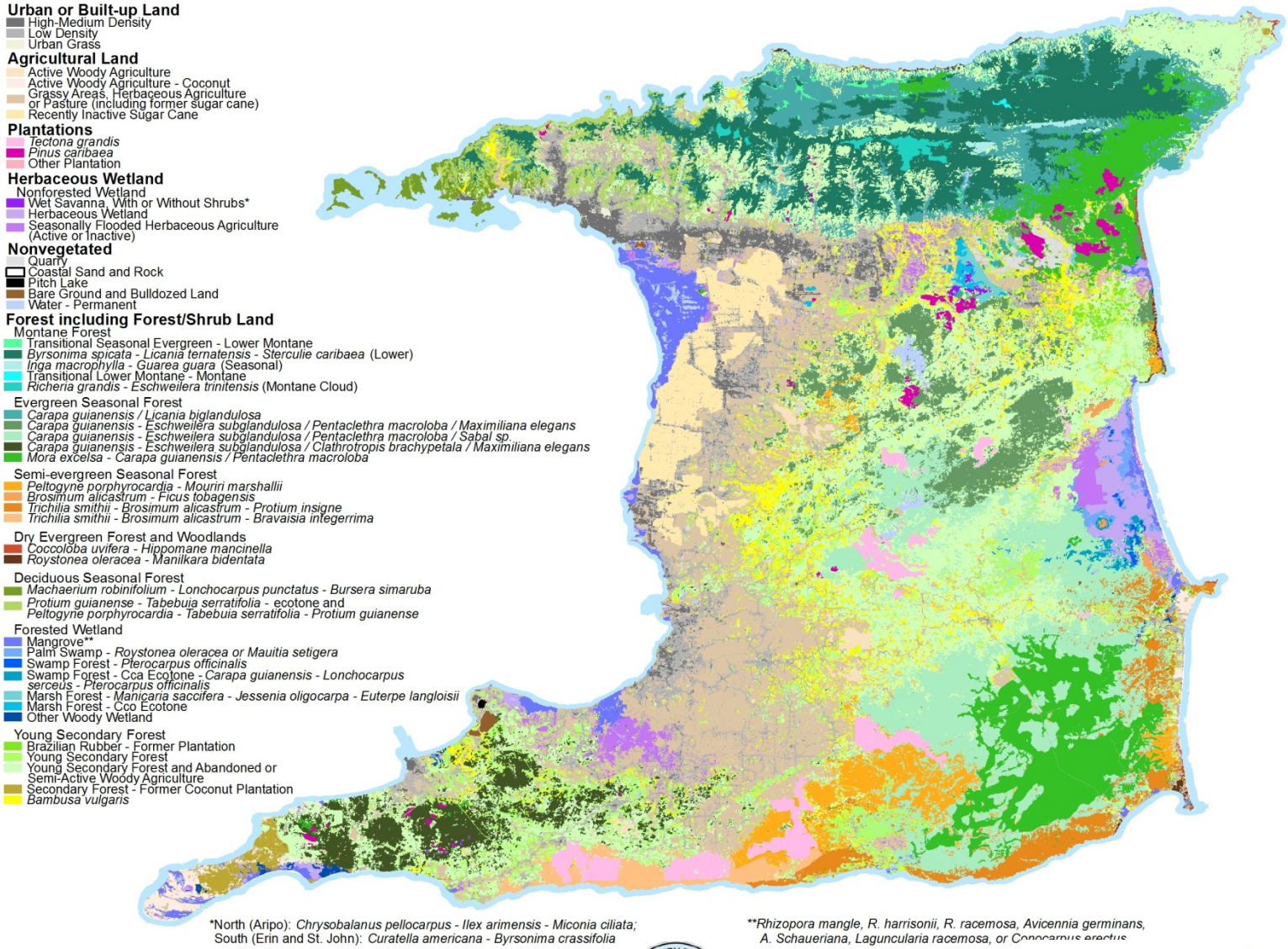
Forest associations and land cover of Trinidad from gap-filled Landsat



*North (Aripo): *Chrysobalanus pellocarpus - Ilex arimensis - Miconia ciliata;*
South (Erin and St. John): *Curatella americana - Byrsonima crassifolia*

***Rhizopora mangle, R. harrisonii, R. racemosa, Avicennia germinans, A. Schaueriana, Laguncularia racemosa, or Conocarpus erectus*

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Many lowland tree species associations of seasonal evergreen forests in Trinidad identifiable in fine resolution imagery viewable on Google Earth[1]

Carapa guianensis - Eschweilera subglandulosa / Pentaclethra macroloba / Maximiliana elegans

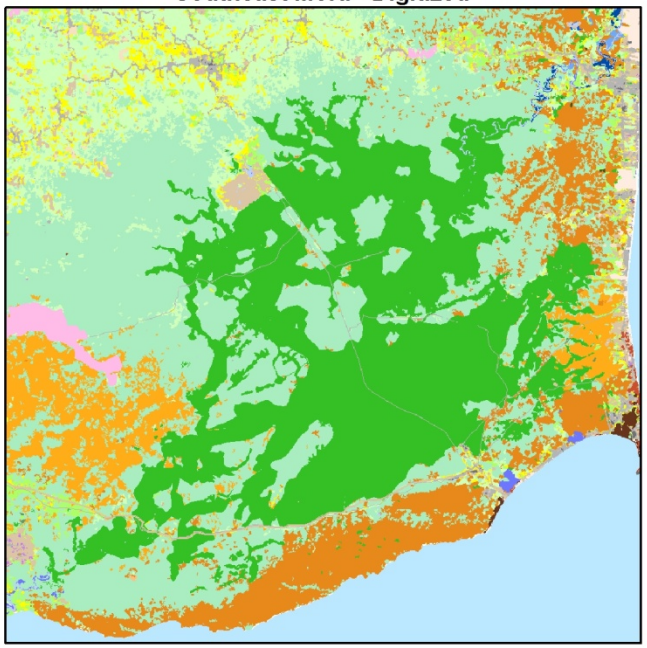
1:3,0000

C.guianensis – E.subglandulosa / P. macroloba / Sabal sp.

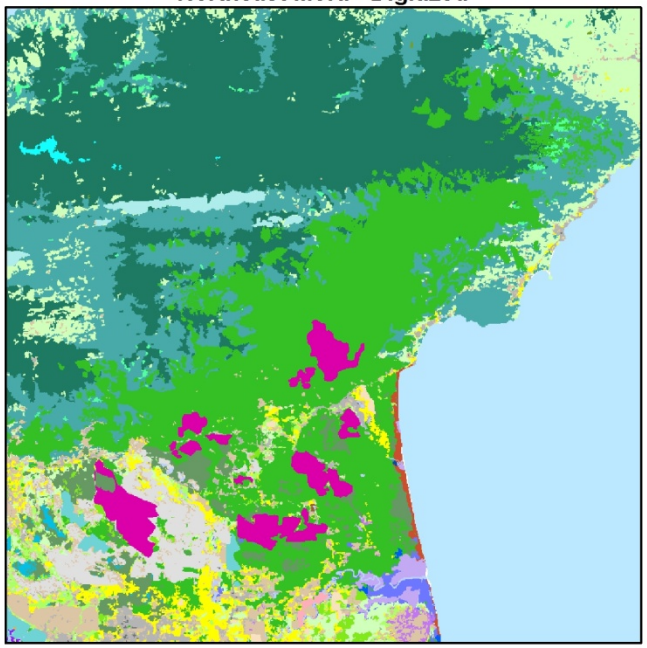
1:15,0000

Mora Classification

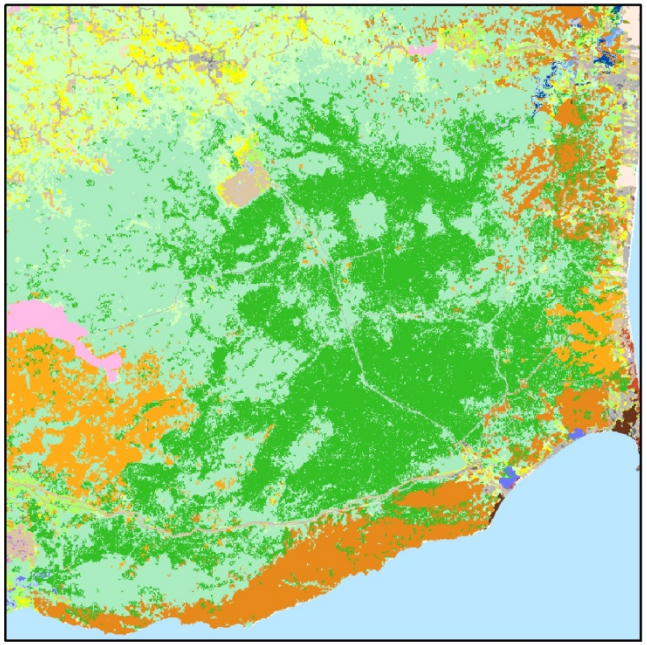
Southeast Mora - Digitized



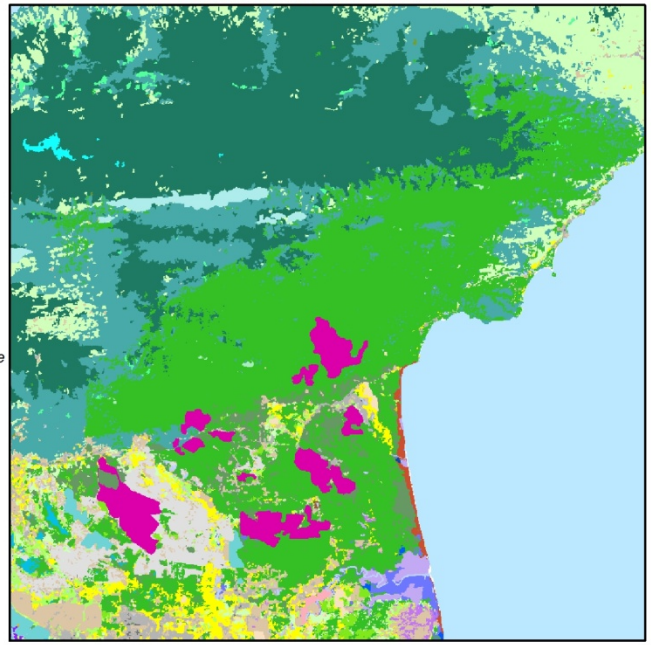
Northeast Mora - Digitized



Southeast Mora - Modeled



Northeast Mora - Modeled



Urban or Built-up Land
- High-Medium Density
- Low Density
- Urban Grass

Agricultural Land
- Active Woody Agriculture
- Active Woody Agriculture - Coconut
- Grassy Areas, Herbaceous Agriculture or Pasture (including former sugar cane)
- Recently Inactive Sugar Cane

Plantations
- *Tectona grandis*
- *Pinus caribaea*
- Other Plantation

Herbaceous Wetland

Nonforested Wetland
- Wet Savanna, With or Without Shrubs*
- Herbaceous Wetland
- Seasonally Flooded Herbaceous Agriculture (Active or Inactive)

Nonvegetated
- Quarry
- Coastal Sand and Rock
- Pitch Lake
- Bare Ground and Bulldozed Land
- Water - Permanent

Forest including Forest/Shrub Land

Montane Forest
- Transitional Seasonal Evergreen - Lower Montane
- *Byrsonima spicata - Licania ternatensis - Sterculie caribaea* (Lower)
- *Inga macrophylla - Guarea guara* (Seasonal)
- Transitional Lower Montane - Montane
- *Richeria grandis - Eschweilera trinitensis* (Montane Cloud)

Evergreen Seasonal Forest
- *Carapa guianensis / Licania biglandulosa*
- *Carapa guianensis - Eschweilera subglandulosa / Pentaclethra macroloba / Maximiliana elegans*
- *Carapa guianensis - Eschweilera subglandulosa / Pentaclethra macroloba / Sabal sp.*
- *Carapa guianensis - Eschweilera subglandulosa / Clathrotropis brachypetala / Maximiliana elegans*
- *Mora excelsa - Carapa guianensis / Pentaclethra macroloba*

Semi-evergreen Seasonal Forest
- *Peltogyne porphyrocardia - Mouriri marshallii*
- *Brosimum alicastrum - Ficus tobagensis*
- *Trichilia smithii - Brosimum alicastrum - Protium insigne*
- *Trichilia smithii - Brosimum alicastrum - Bravaisia integerrima*

Dry Evergreen Forest and Woodlands
- *Coccoloba uvifera - Hippomane mancinella*
- *Roystonea oleracea - Manilkara bidentata*

Deciduous Seasonal Forest
- *Machaerium robinifolium - Lonchocarpus punctatus - Bursera simaruba*
- *Protium guianense - Tabebuia serratifolia* - ecotone and *Peltogyne porphyrocardia - Tabebuia serratifolia - Protium guianense*

Forested Wetland
- Mangrove**
- Palm Swamp - *Roystonea oleracea or Mauitia setigera*
- Swamp Forest - *Pterocarpus officinalis*
- Swamp Forest - Cca Ecotone - *Carapa guianensis - Lonchocarpus sereeus - Pterocarpus officinalis*
- Marsh Forest - *Manicaria saccifera - Jessenia oligocarpa - Euterpe langloisii*
- Marsh Forest - Cco Ecotone
- Other Woody Wetland

Young Secondary Forest
- Brazilian Rubber - Former Plantation
- Young Secondary Forest
- Young Secondary Forest and Abandoned or Semi-Active Woody Agriculture
- Secondary Forest - Former Coconut Plantation
- *Bambusa vulgaris*