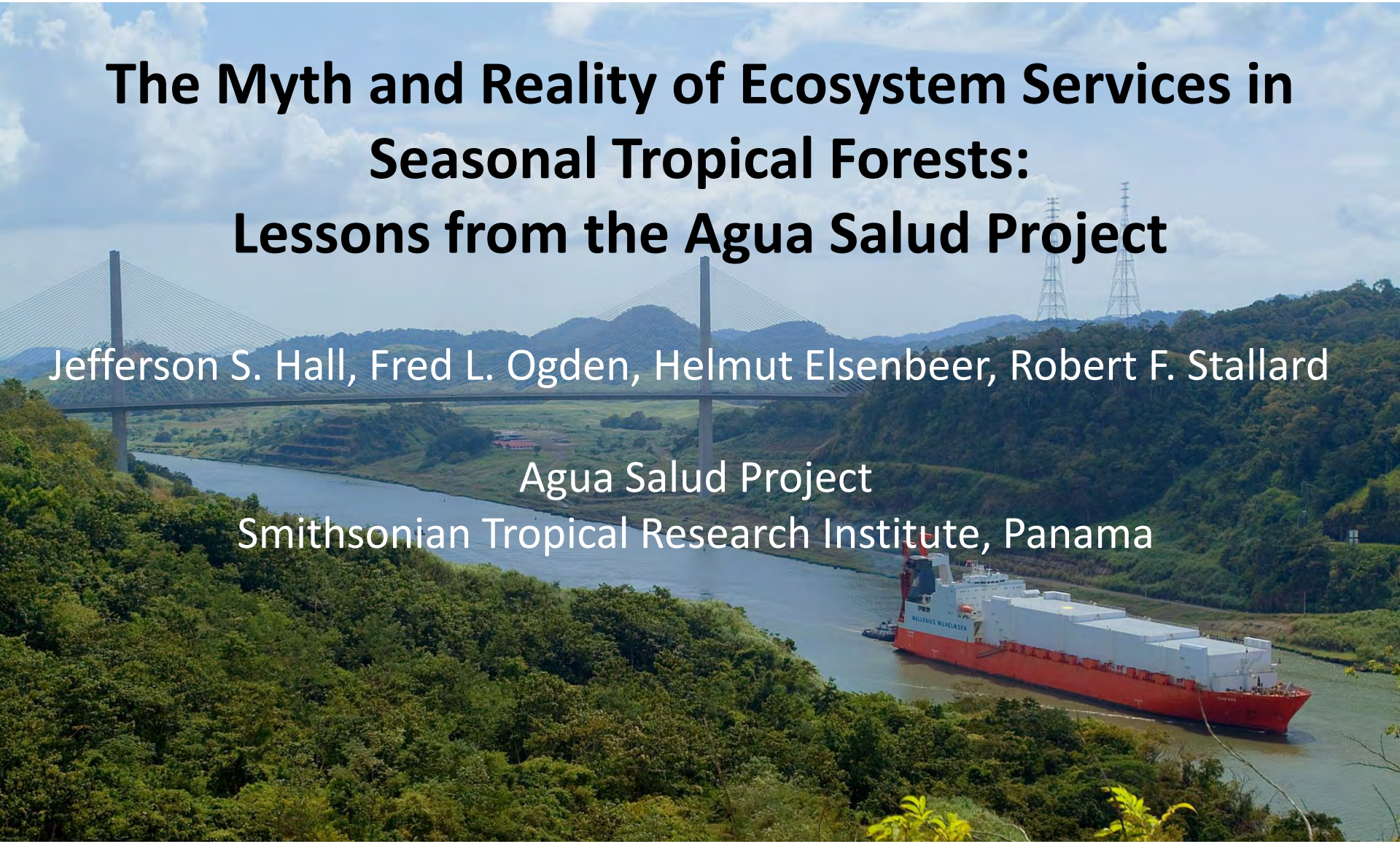
The Myth and Reality of Ecosystem Services in Seasonal Tropical Forests: Lessons from the Agua Salud Project

Jefferson S. Hall, Fred L. Ogden, Helmut Elsenbeer, Robert F. Stallard

Agua Salud Project
Smithsonian Tropical Research Institute, Panama



autoridad nacional del ambiente

Smithsonian Tropical Research Institute

ACP
AUTORIDAD DEL CANAL DE PANAMÁ

Panama Canal: part of a global network

Source: Autoridad del Canal de Panama (ACP)

Ecosystem Services in the Panama Canal Watershed

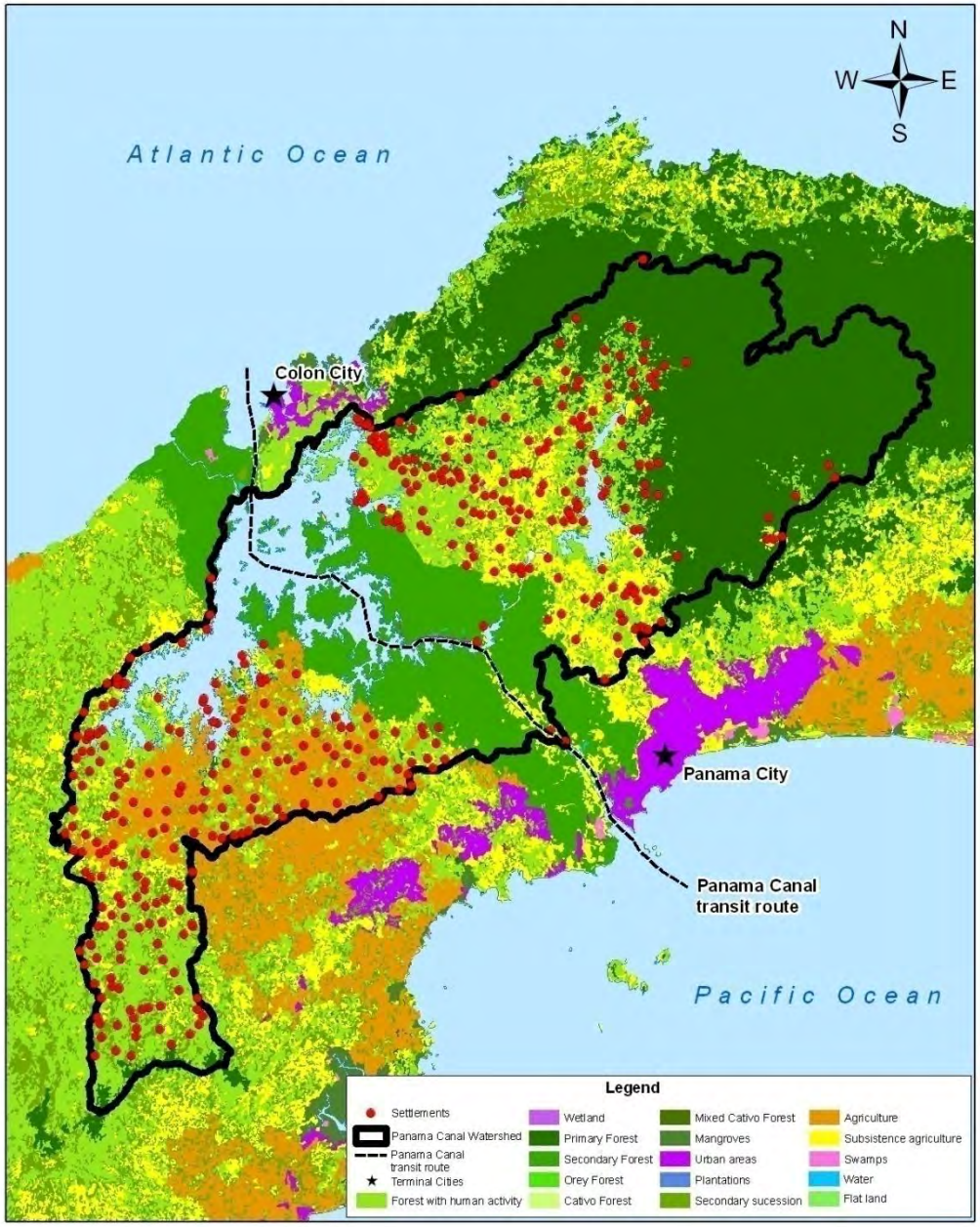
Water: Quality & Quantity

Biodiversity Conservation

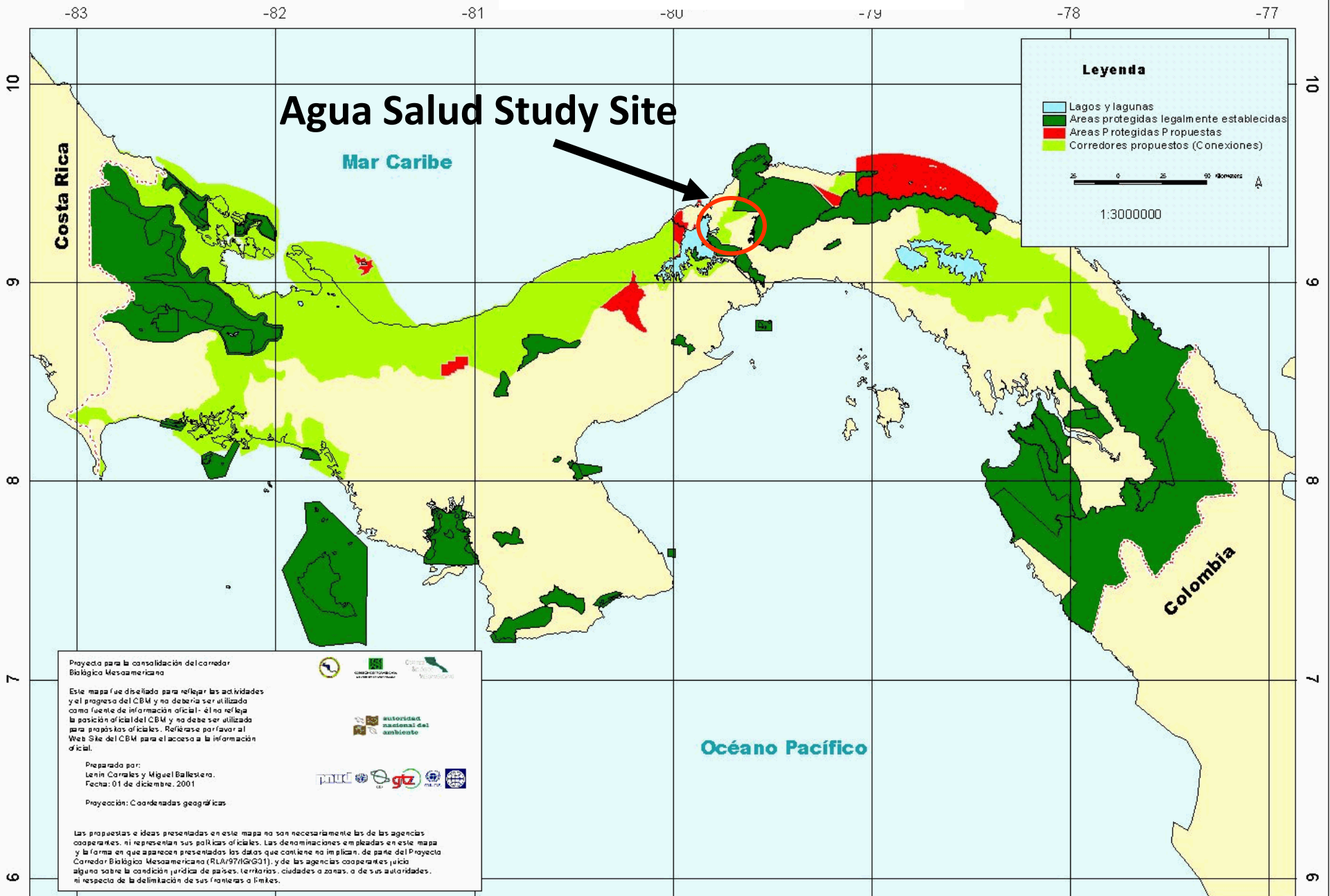
Carbon Sequestration

Rural Populations

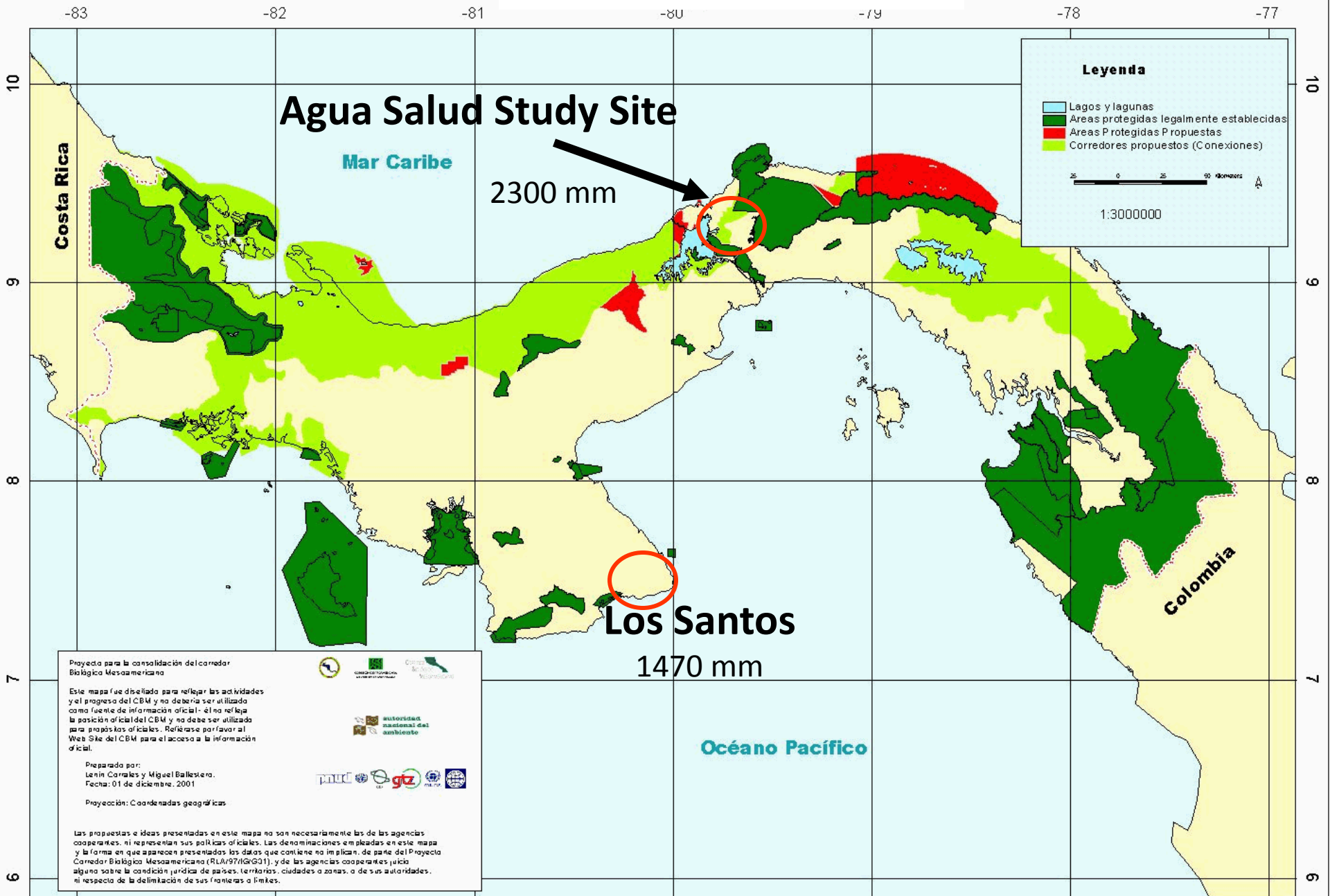
Human Communities of Panama Canal Watershed



Mesoamerican Biological Corridor



Mesoamerican Biological Corridor



Panama's Forests are Rich in Biodiversity

Forests and Trees Provide Services for Local People

Living fences provide shade and fodder for cattle

Medicinal plants

Construction materials

Managing Water is Essential for Canal Operations

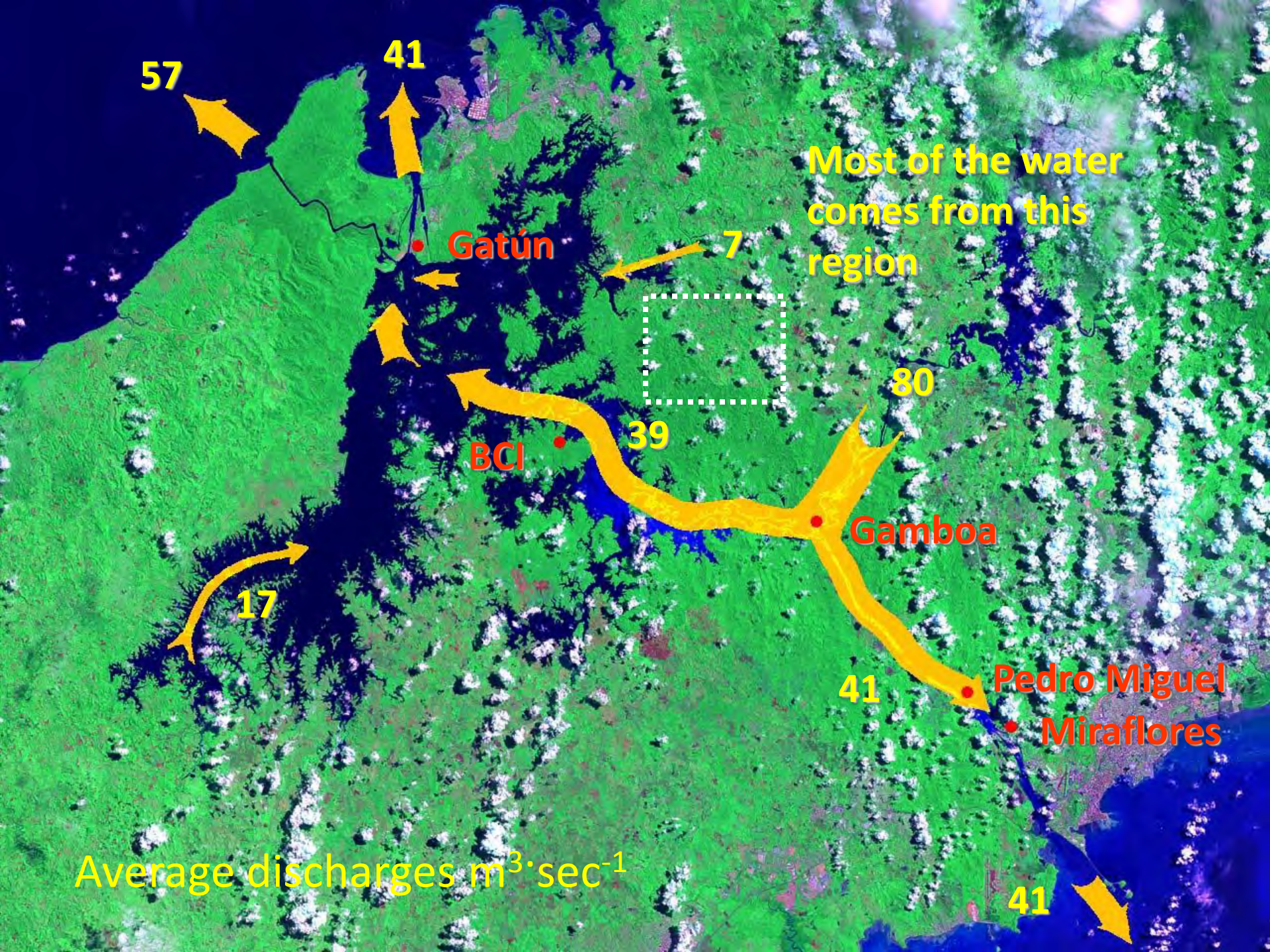
Too little water leads to draft restrictions as in the 1997 El Niño

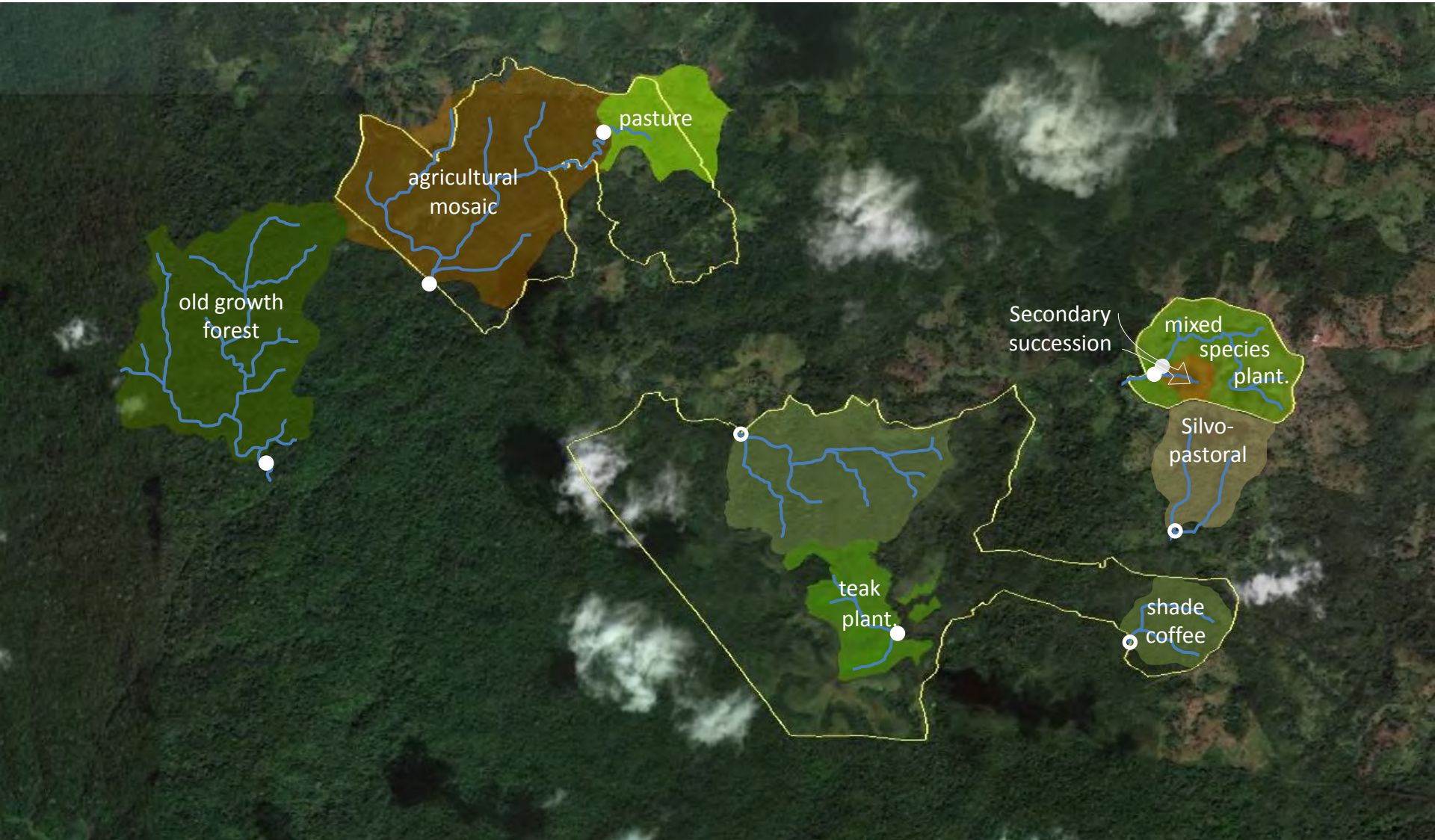
Too much water puts Canal infrastructure at risk as in 2000 (and 2010!)

Panama Canal Water Budget

	cubic km/yr	cubic m/sec
Total Runoff:	4.4	139
Lockages*:	2.6	82
Hydroelectricity:	1.2	39
Drinking:	0.27	9
L+H+D =	4.1	130
Total, 1982:	3.3	105

* 37 per day at 191,000 cubic meters per lockage


57
41
Most of the water comes from this region
Gatún
7
80
39
BCI
Gamboa
17
41
Pedro Miguel
Miraflores
Average discharges $m^3 \cdot sec^{-1}$
41


pasture
agricultural mosaic
old growth forest
Secondary succession
mixed species plant.
Silvo-pastoral
teak plant.
shade coffee

Inputs and Outputs in Two Agua Salud Watersheds

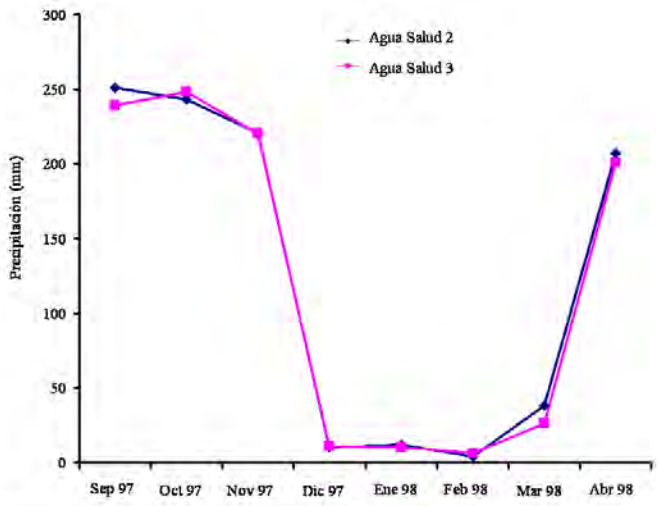


Figura 14 Precipitación mensual en las microcuencas de Agua Salud 2 y Agua Salud 3 (PMCC 1998).

Precipitation in focal watersheds in 1997-98

Stream flow in focal watersheds in 1997-98

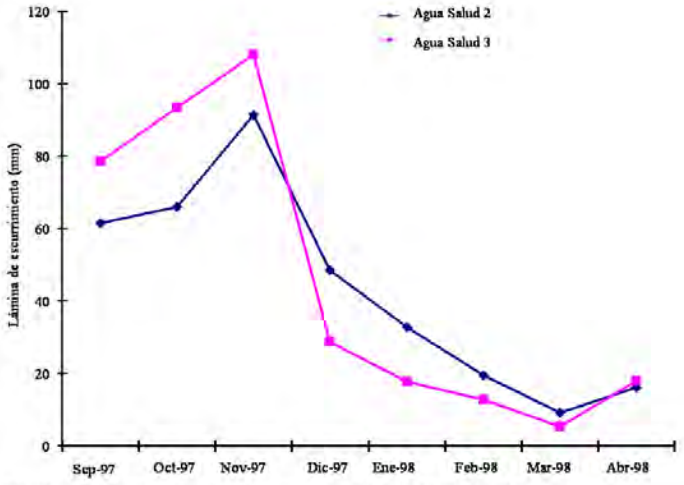
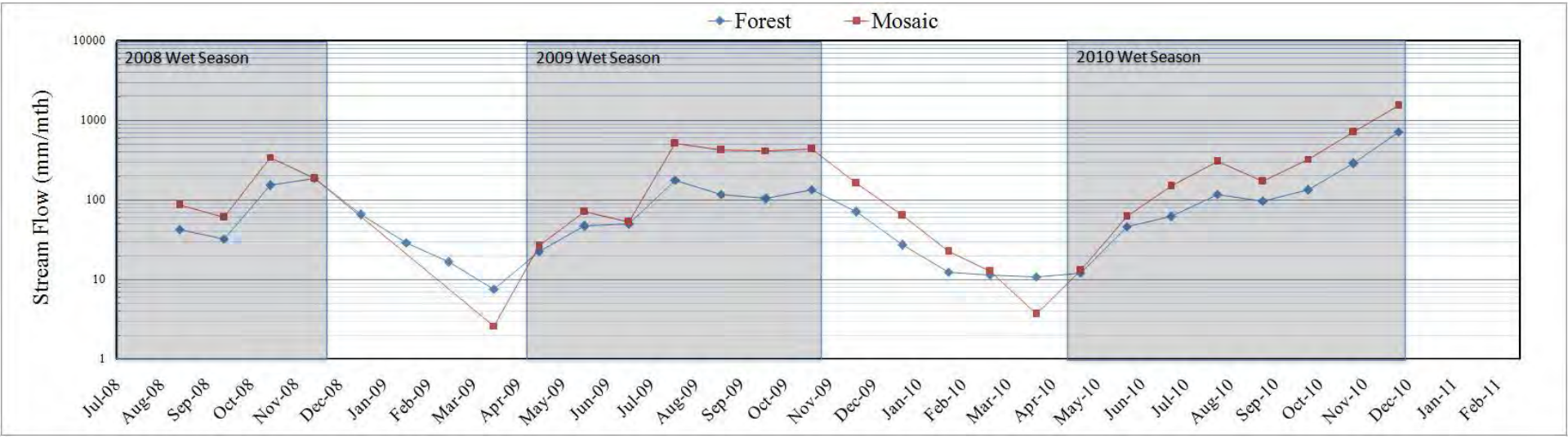
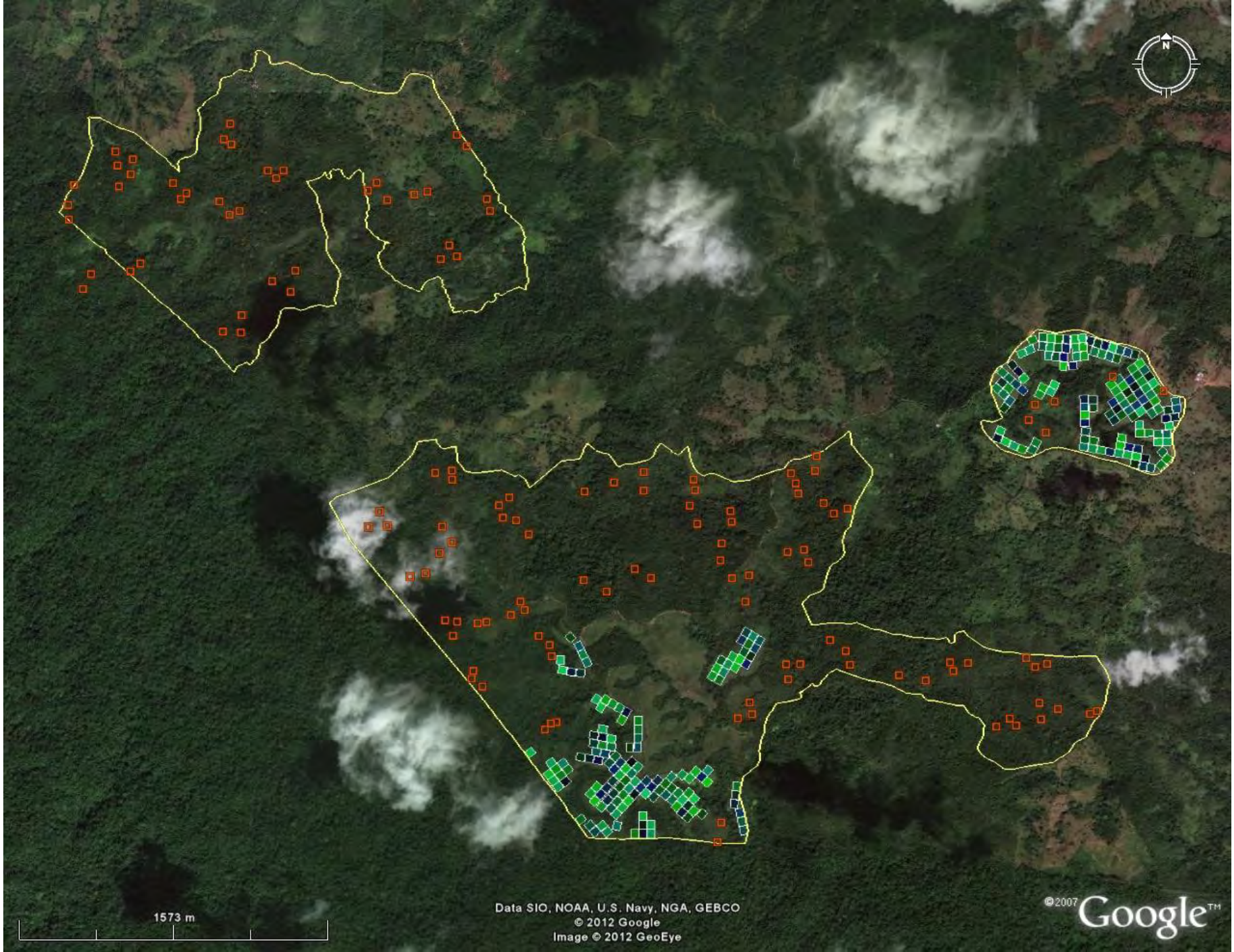


Figura 15 Lámina de escurrimiento mensual en las microcuencas de Agua Salud 2 y Agua Salud 3 (PMCC 1998).

Stream Flow in Mature Forest and Mosaic Watersheds



Ogden et al. unpublished data


N
1573 m
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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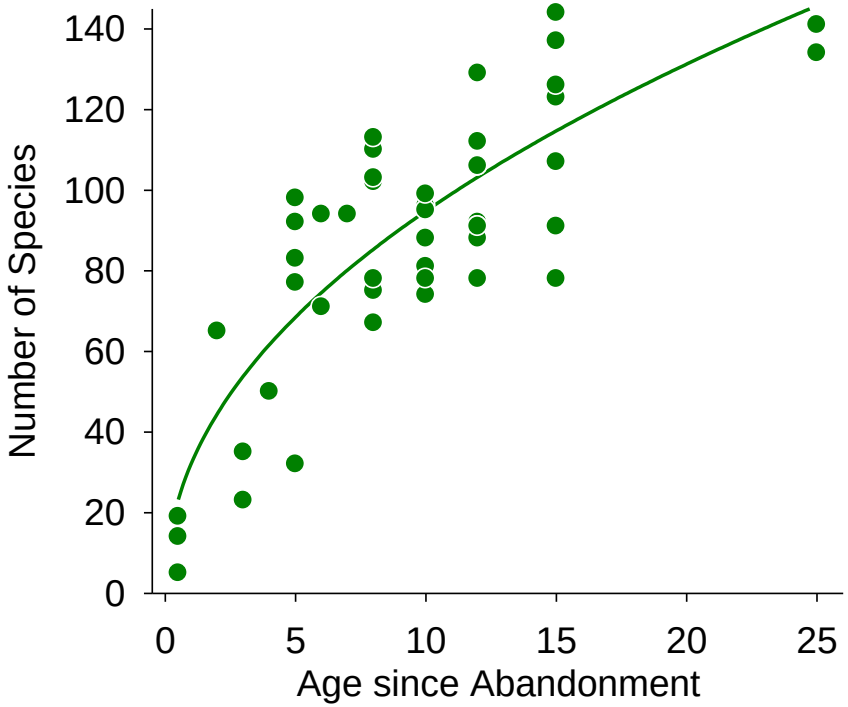
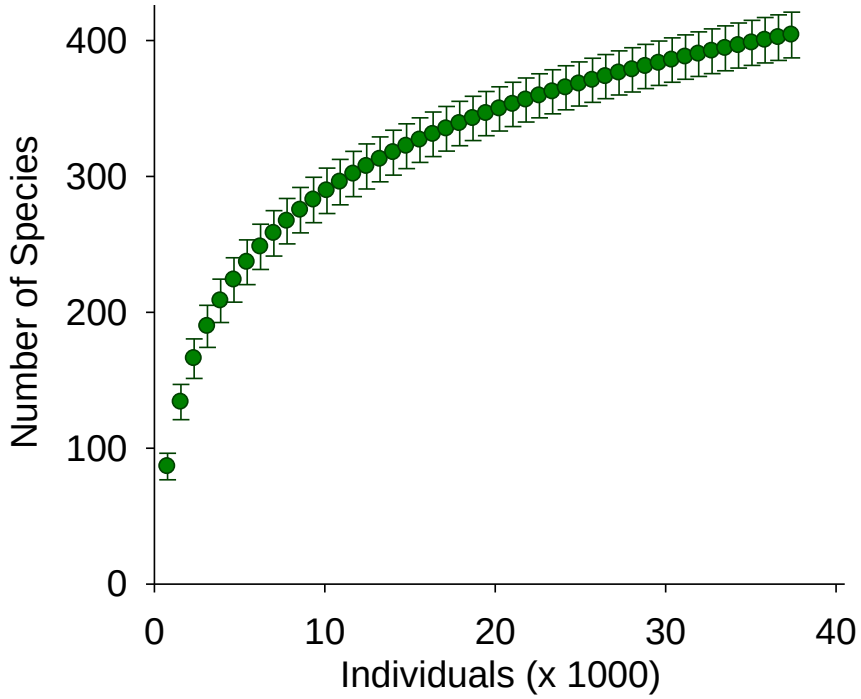




Sites

54

Random Location

Age Range:

1-25 year

≥ 5 cm DBH:

10 ha Total

≥ 1 cm DBH:

5 ha Total

Individuals:

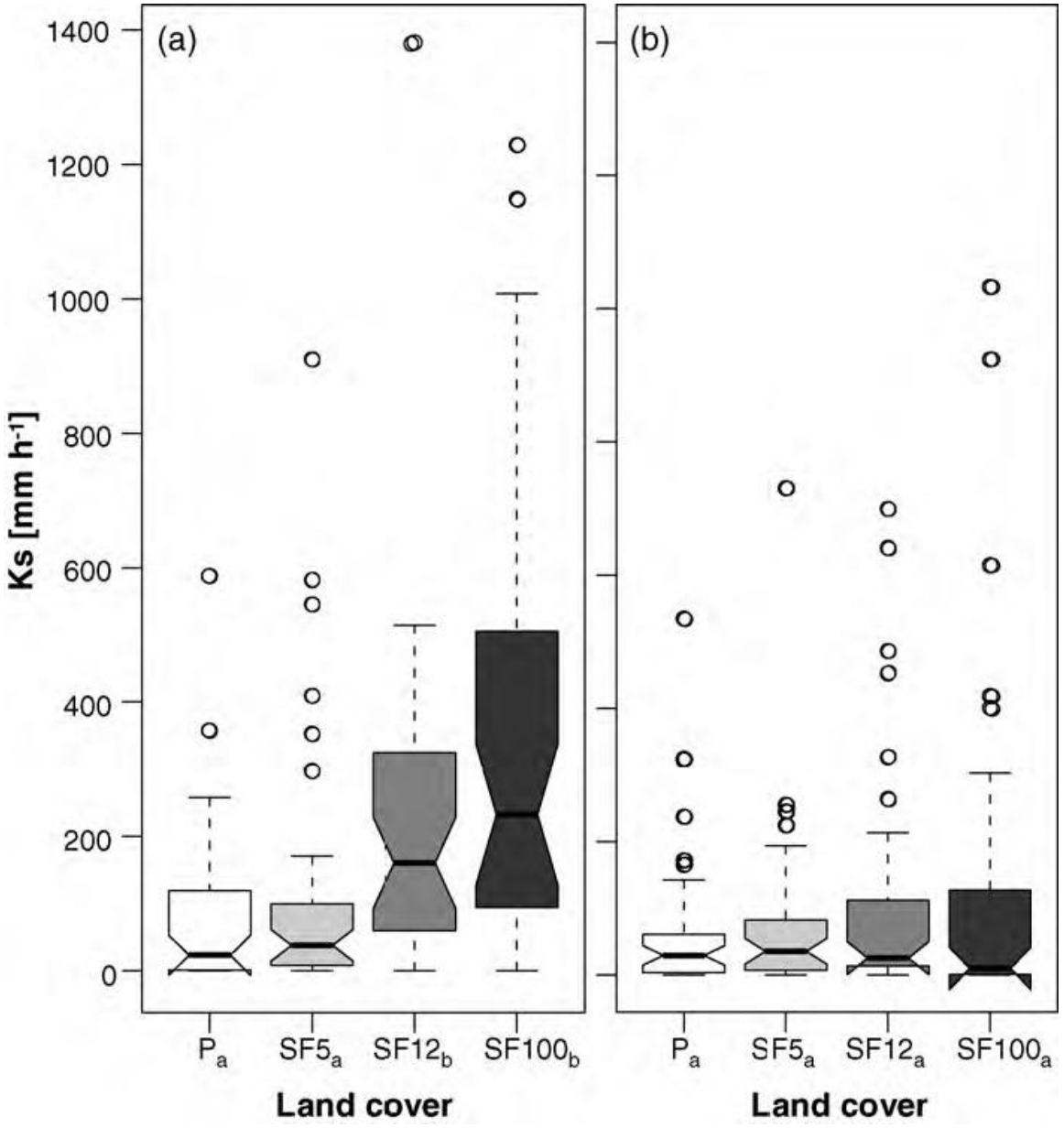
44,865 (9,289 Lianas)

Stems:

67,976 (15,603 Lianas)

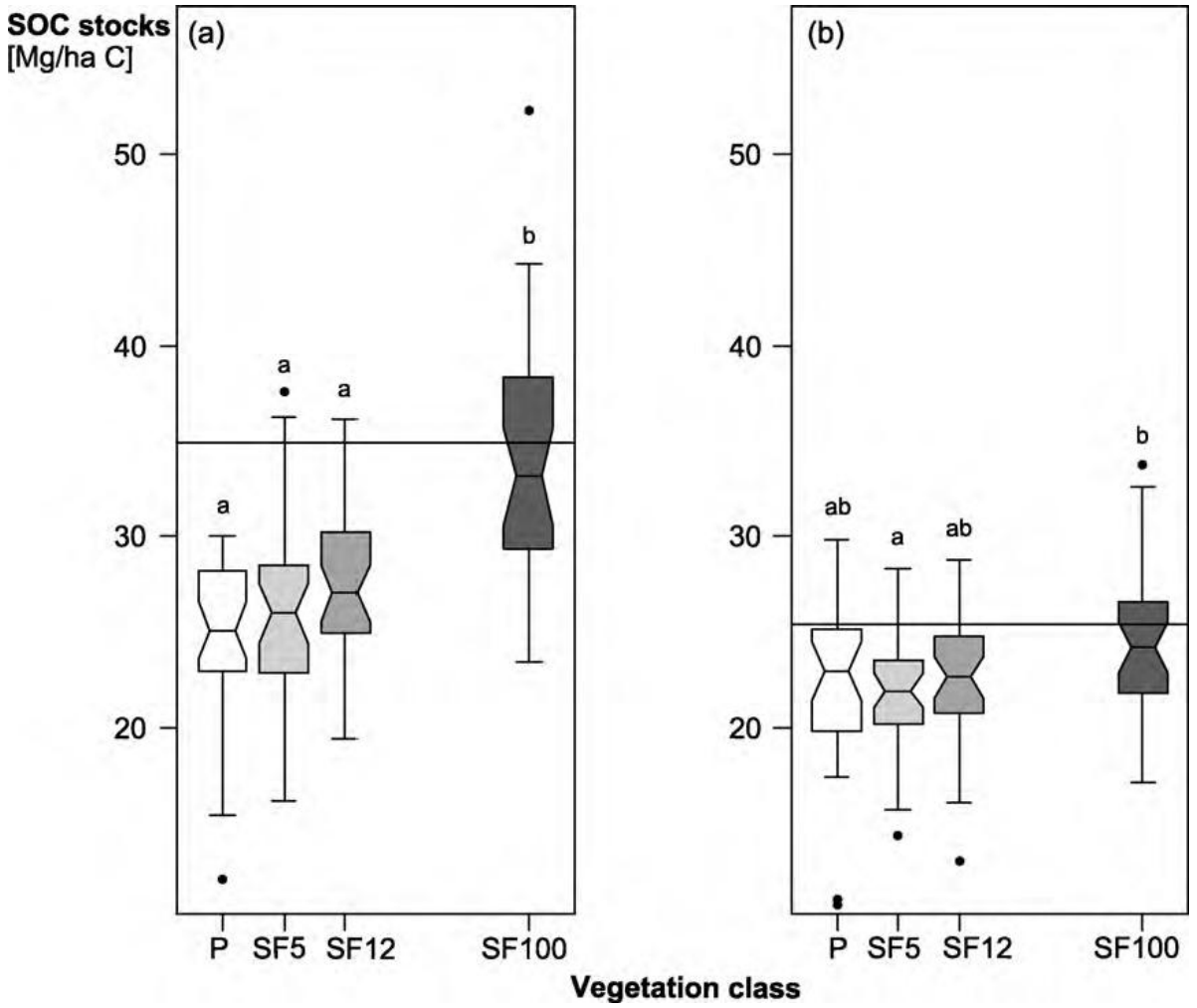
Species:

555 (150 Lianas)

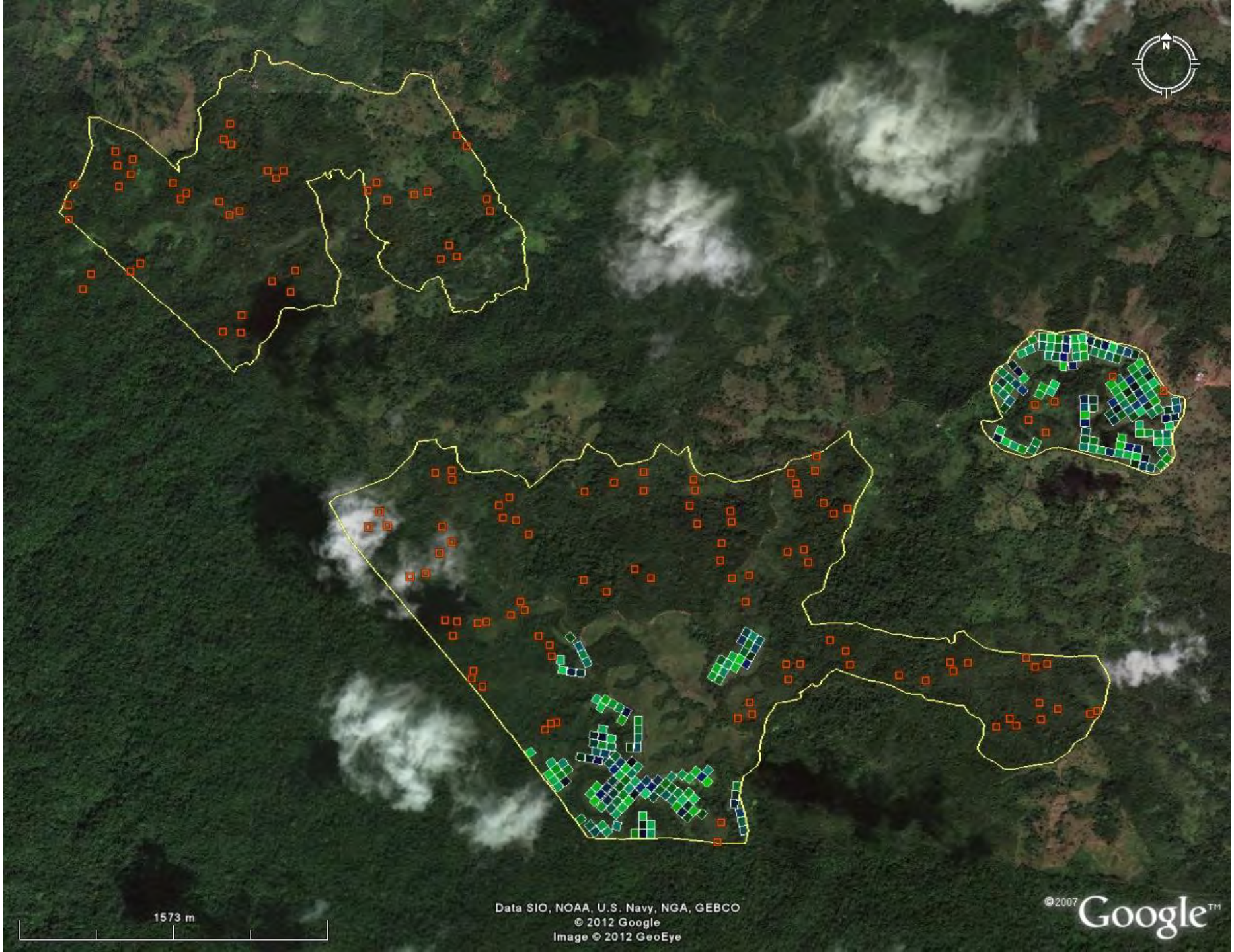


Hassler et al. (en imprenta): *Ks* depende de uso del terreno en los a) 0-6 cm de profundidad y de b) 6-12 cm de profundidad. Clases de cobertura de terreno están abreviados con P para potrero, SF5 para bosque secundario joven, SF12 para bosque secundario de 12 anos y SF100 para bosque de 100 anos. Los parámetros de los diagramas de cajas están explicados en la sección 2.6. Letras del subíndice visualizan el resultado del test de Kruskal-Wallis: Letras diferentes indican diferencias significativas entre los grupos ($p < 0.05$).

Soil Organic Carbon Stocks in Regenerating Forests at the Agua Salud Focal Research Site



Neumann-Cosel et al. (2011) Forest Ecology and Management


N
1573 m
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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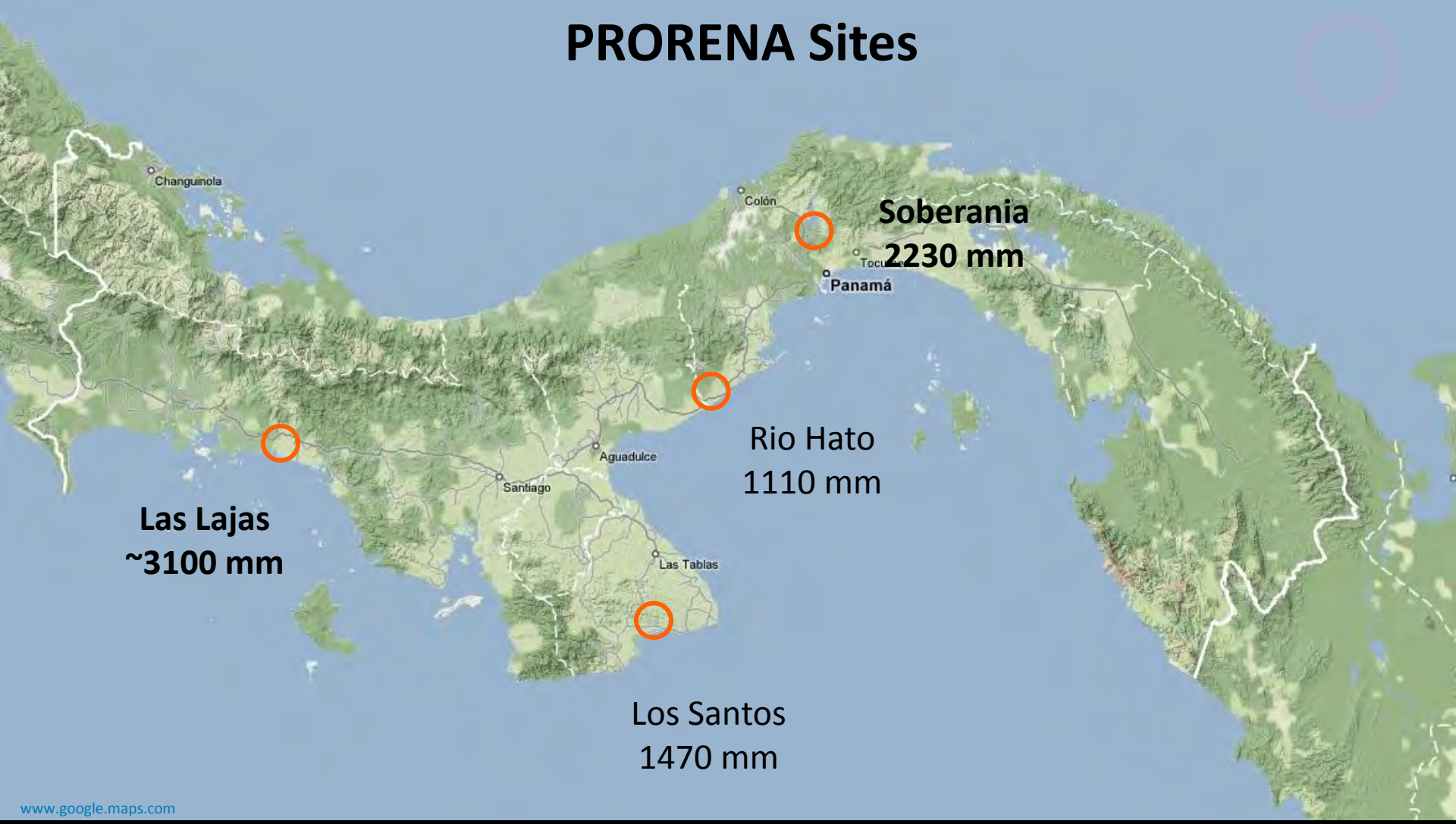
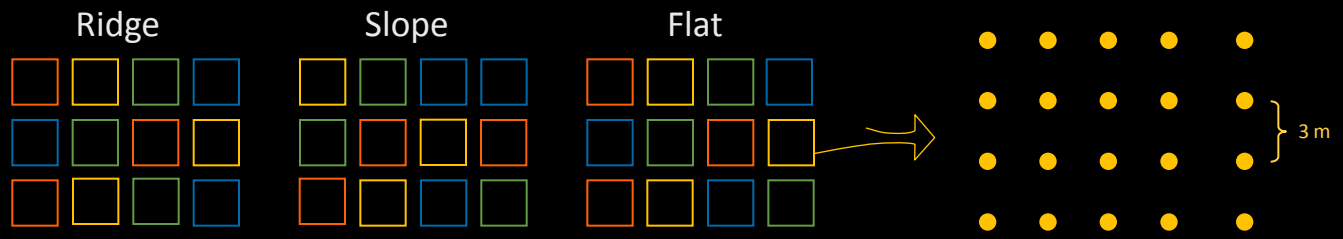
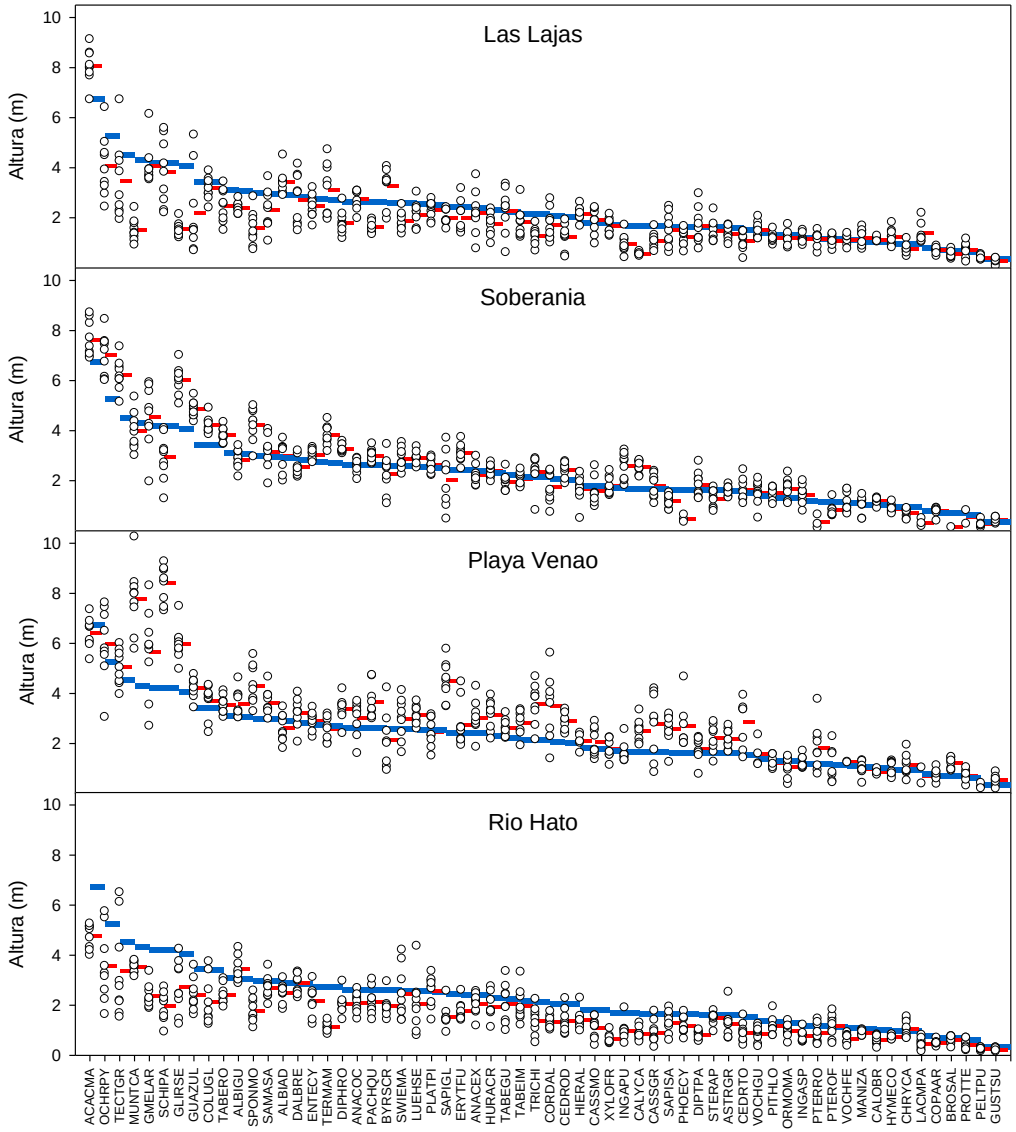
PRORENA Sites



Each Site:

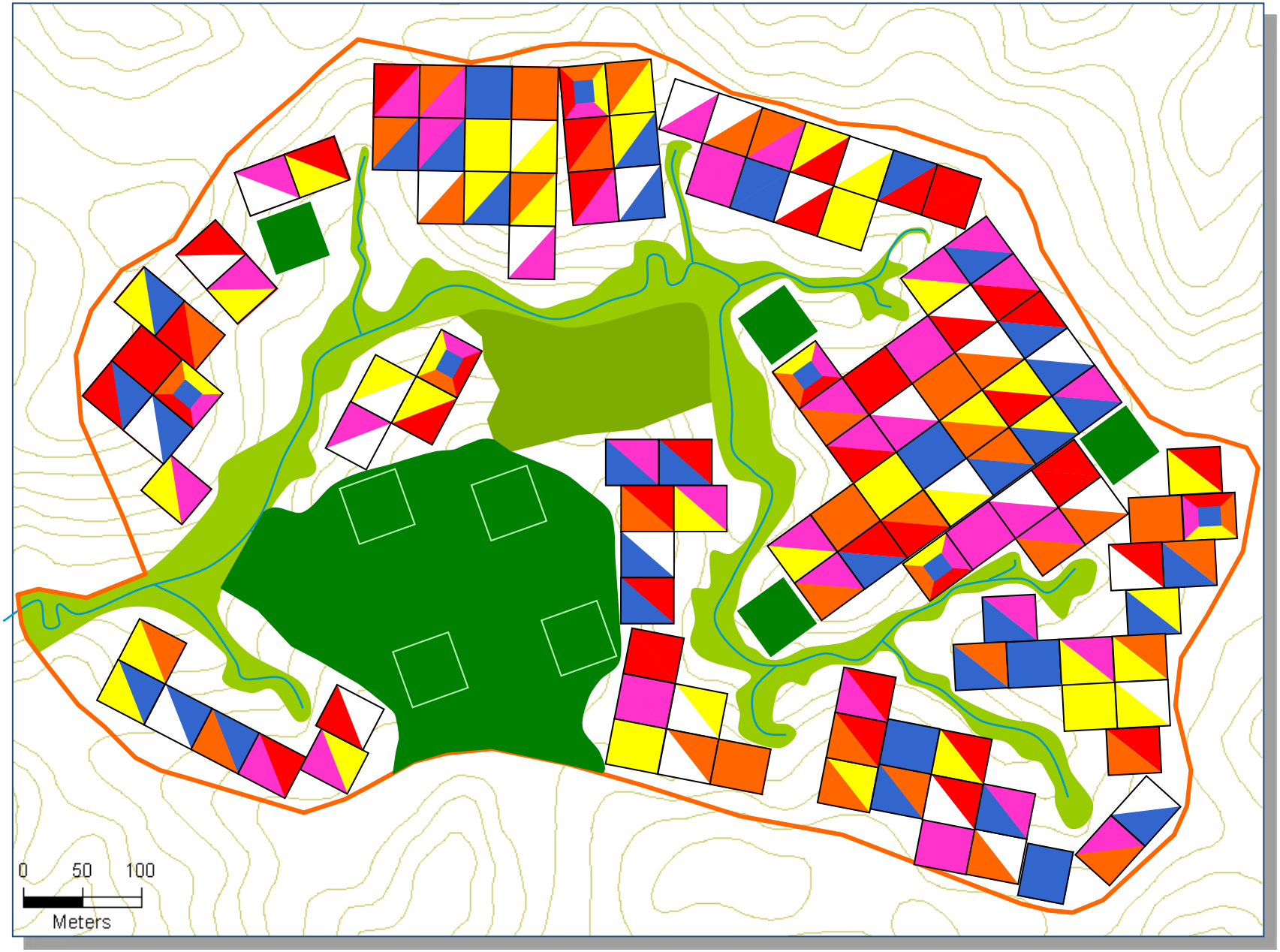


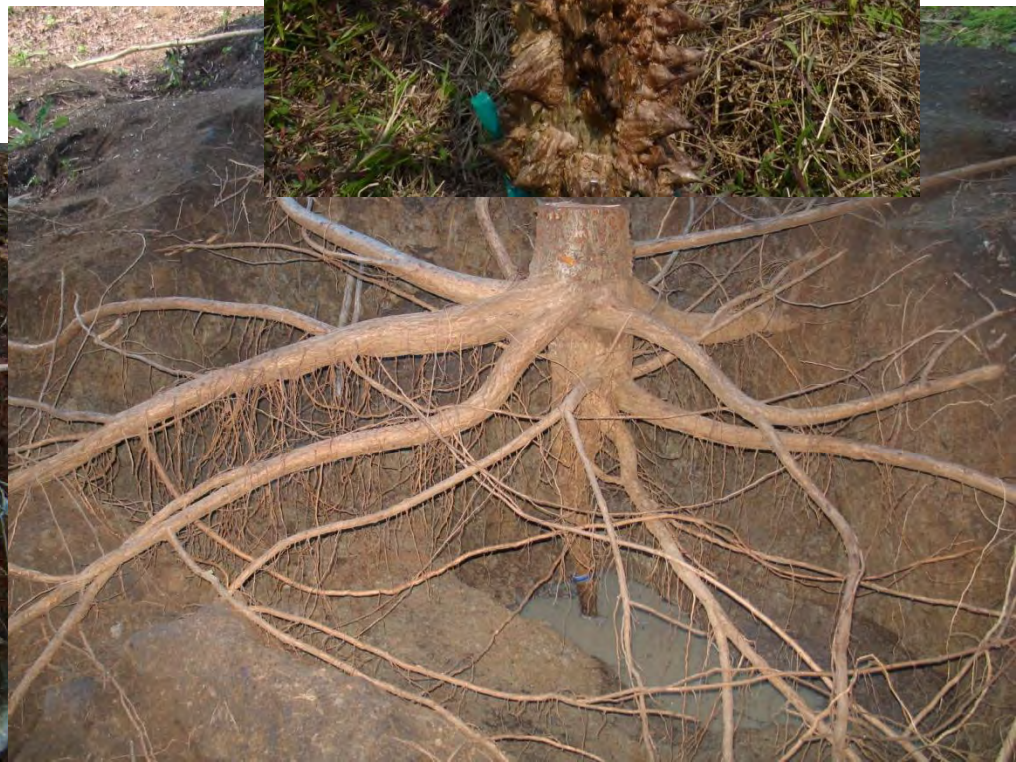
PRORENA is Studying the Growth and Development of 70 Native Species



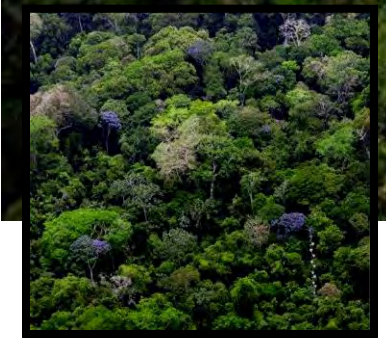
Breugel M.v. et al (2011) Forest Ecology and Management;
Hall et al. (2011) Forest Ecology and Management

Native Species and Secondary Succession Catchments





Carbon Stocks Across Different Land-use Types in a Rural Landscape



Mature Forest

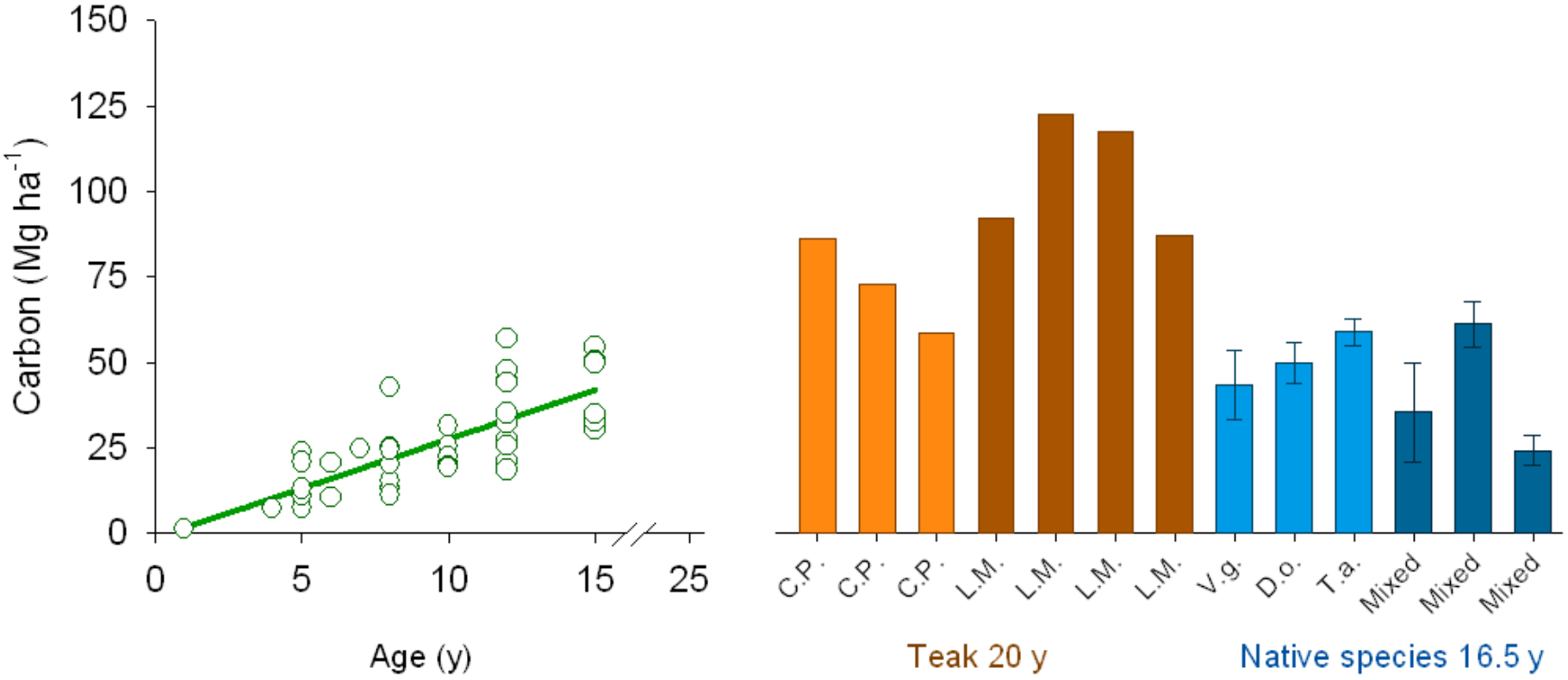
Canal grass

Pasture

Plantation

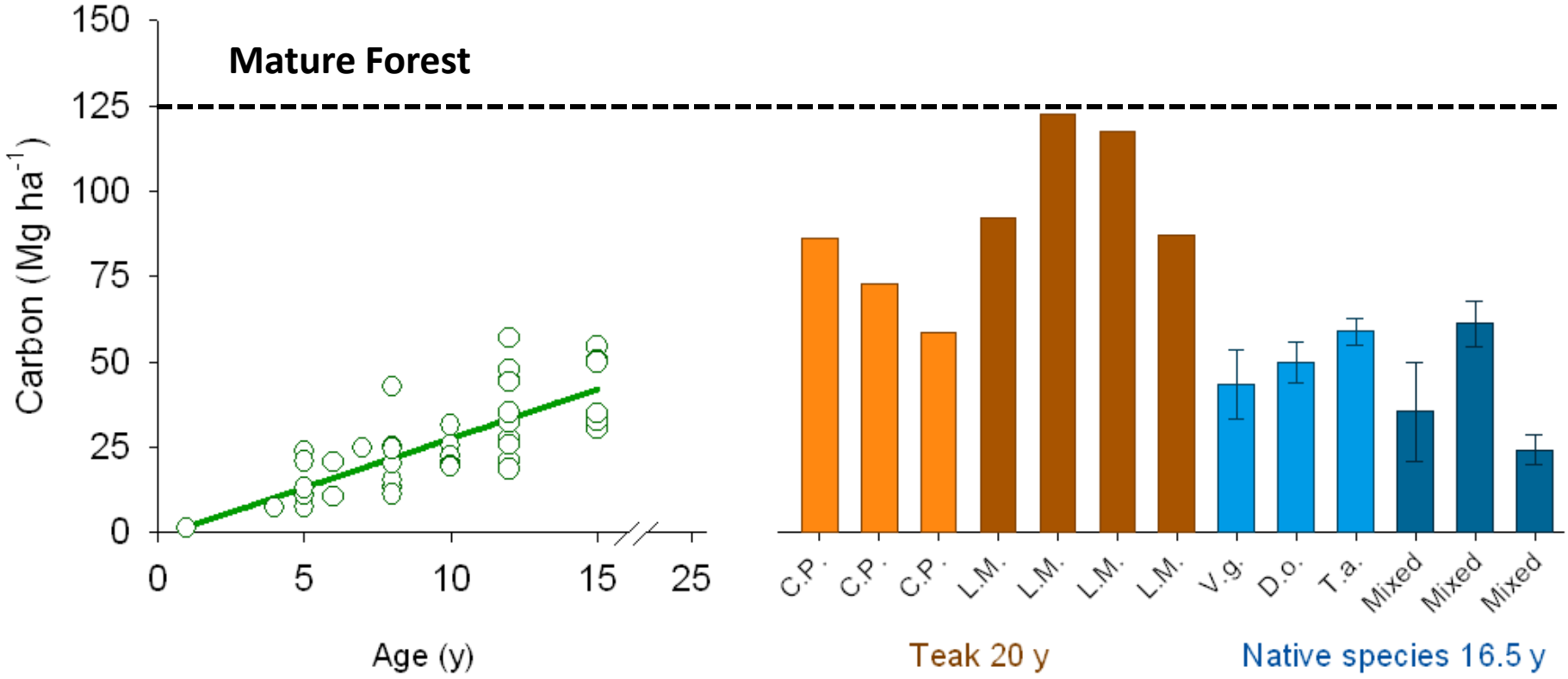
Succession

Carbon Across Land Uses



Secondary succession equation in Breugel et al. 2011; Teak common practice (C.P.): calculated with stand data of Bermejo *et al*. 1998 and allometric equation of Kraenzel *et al*. 2003, Teak low maintenance (L.M.): data from Kraenzel *et al*. 2003, Native species: data from Piotto *et al.* 2009 online

Carbon Across Land Uses



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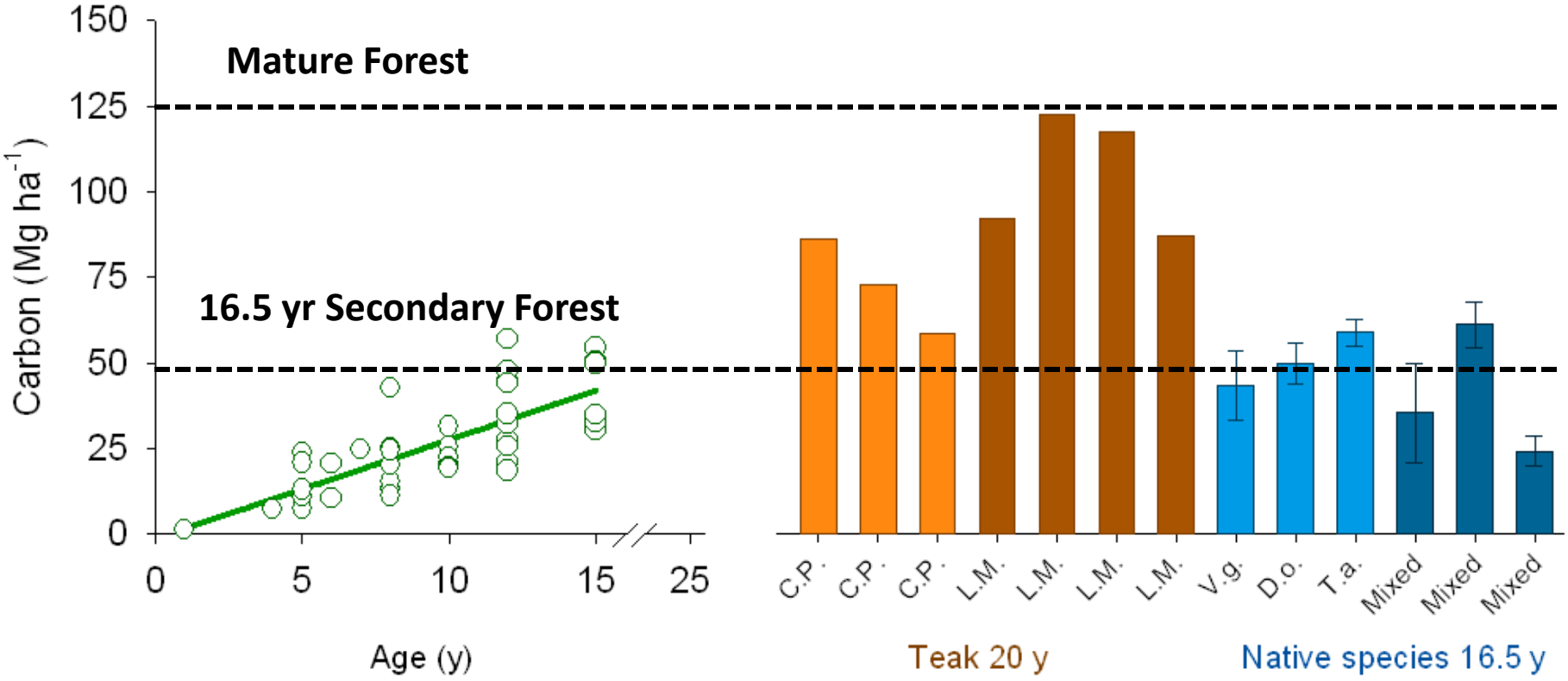
Carbon Across Land Uses



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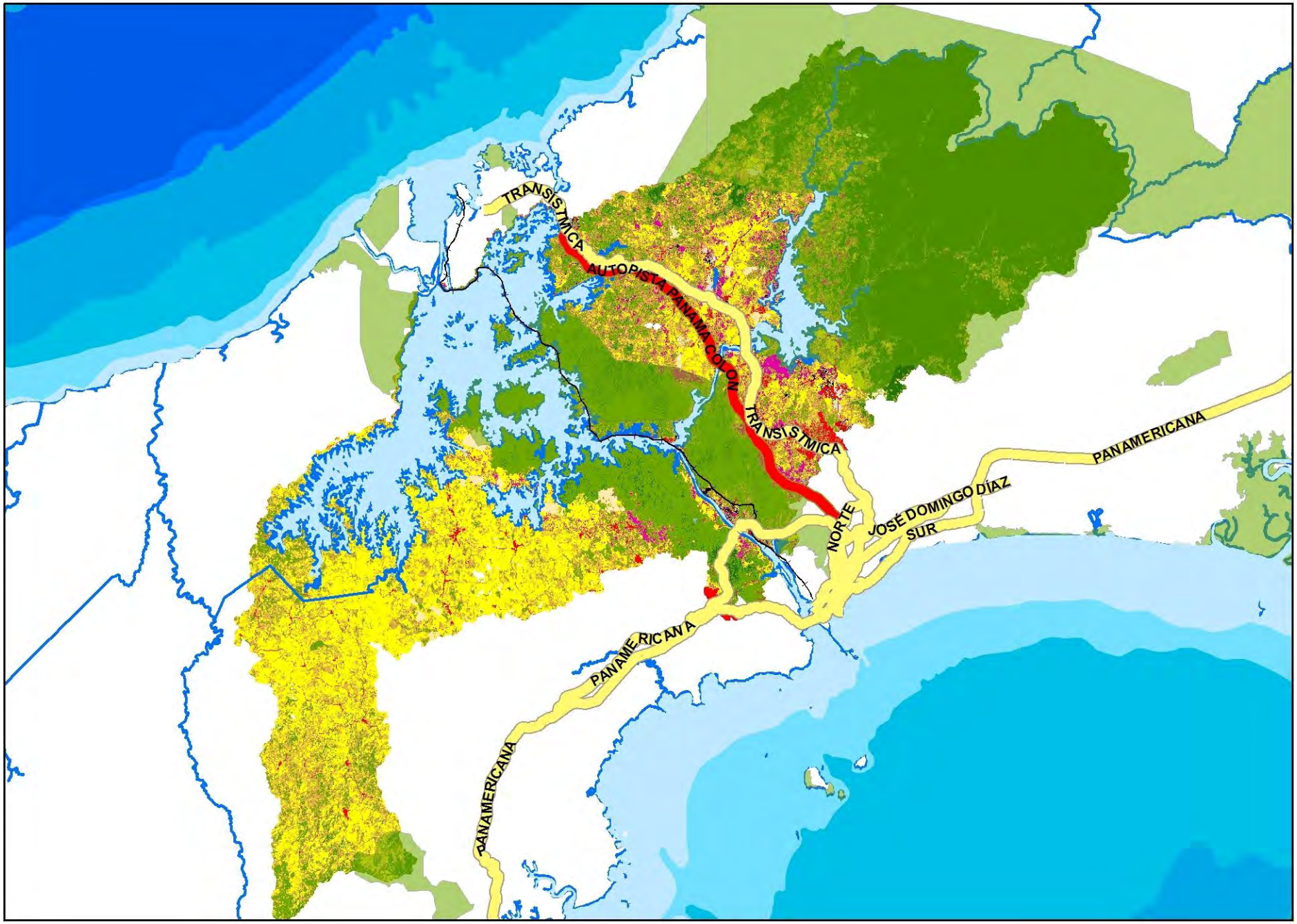
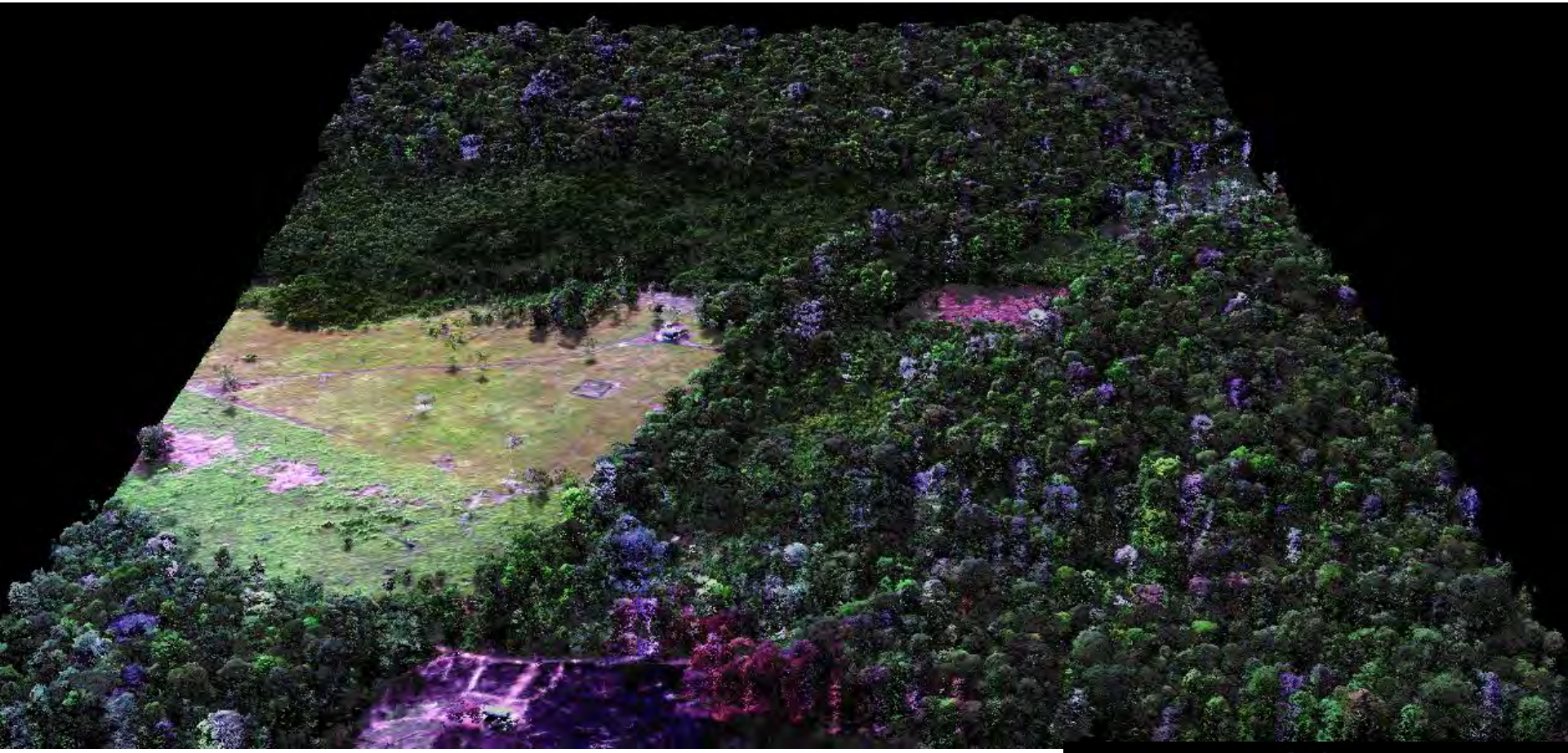

TRANSISTMICA
AUTOPISTA PANAMA COLON
TRANSISTMICA
PANAMERICANA
JOSÉ DOMINGO DÍAZ
NORTE
SUR
PANAMERICANA
PANAMERICANA

Light Detection and Ranging - LiDAR

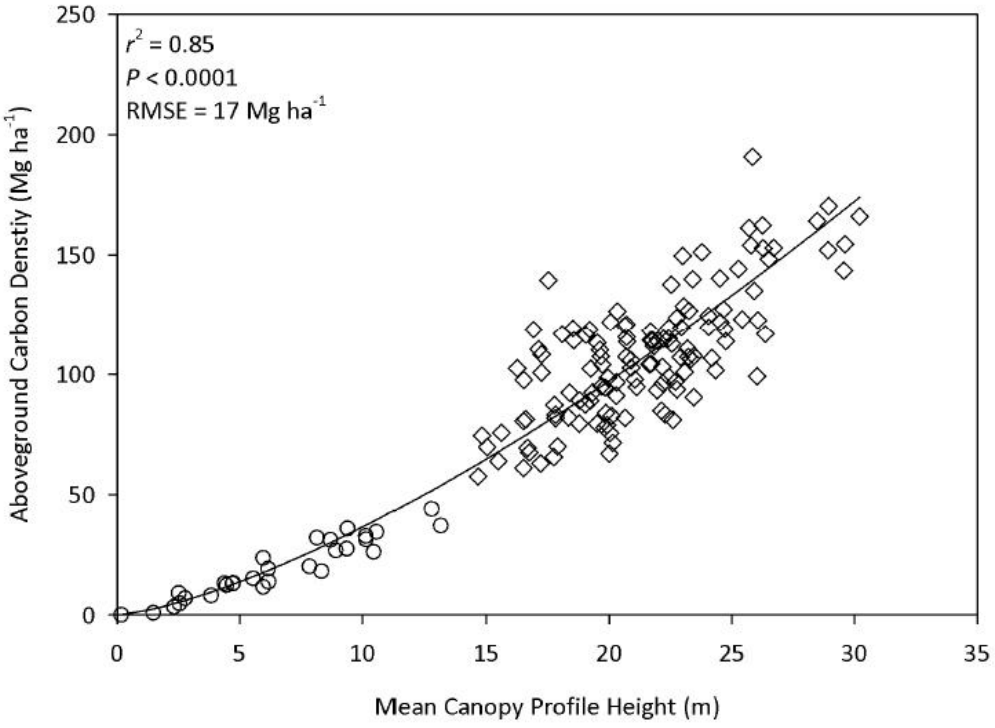
Carnegie Airborne Observatory

Understanding Forest Structure and Aboveground Biomass in a Mixed Land-use Landscape



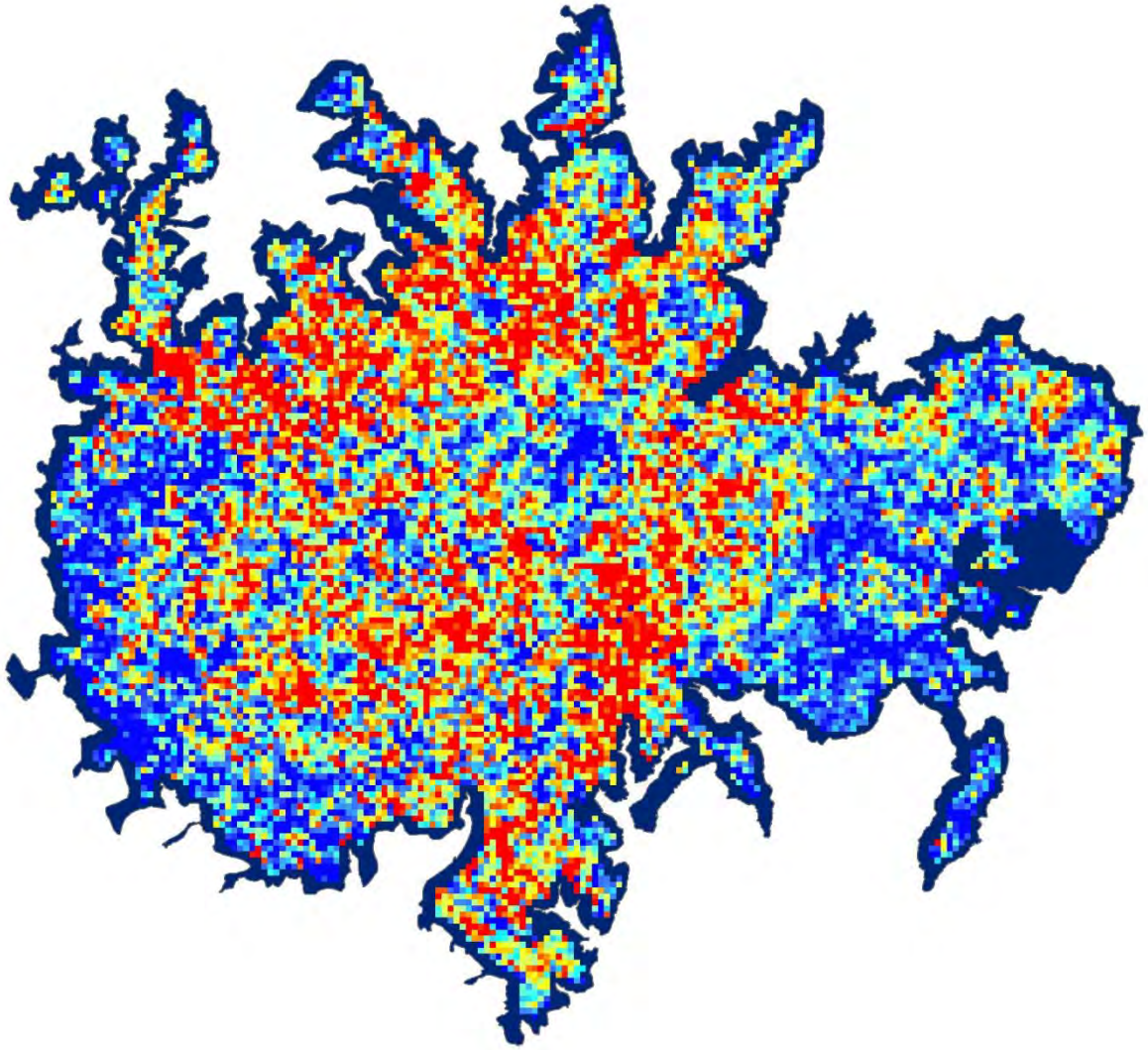
Carnegie **Airborne** Observatory

Field data


r^2 = 0.85
P < 0.0001
RMSE = 17 Mg ha^{-1}
Aboveground Carbon Denstiy (Mg ha^{-1})
Mean Canopy Profile Height (m)
0
50
100
150
200
250
0
5
10
15
20
25
30
35

Panama
Height (m)
0
10
20
30
40
50
0 1 2 3 4 5 6 7

Barro Colorado Island



Aboveground Carbon Density (Mg/ha)

128

65

Mascaro et al. 2011

0 1 2 4 Kilometers

N W E S

CAO

Carnegie Airborne Observatory

Smithsonian Tropical Research Institute

Más Información: http://www.ctfs.si.edu/aguasalud/

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Robert F. Stallard, Hidrología, Geological Survey Estados Unidos

Manejo del Proyecto: Daniela Weber, Gerente de Proyecto, STRI

Post-Doctoral Fellows: Michiel van Breugel, Dinámica de vegetación, STRI
Beate Zimmermann, Hidrología, STRI y Universidad de Potsdam

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