PRESENTATION GIVEN AT LTC SPRING FORUM ENTITLED:

“"INTEGRATING GEOSPATIAL AND FIELD-BASED SCIENCE TO ASSESS BIODIVERSITY CONSERVATION: A SPECIAL FORUM OF WOMEN RESEARCH LEADERS"

APRIL 2-3 & 15, 2009

UNIVERSITY OF WISCONSIN, MADISON, WI, USA

HOSTED BY

LAND TENURE SOCIETY

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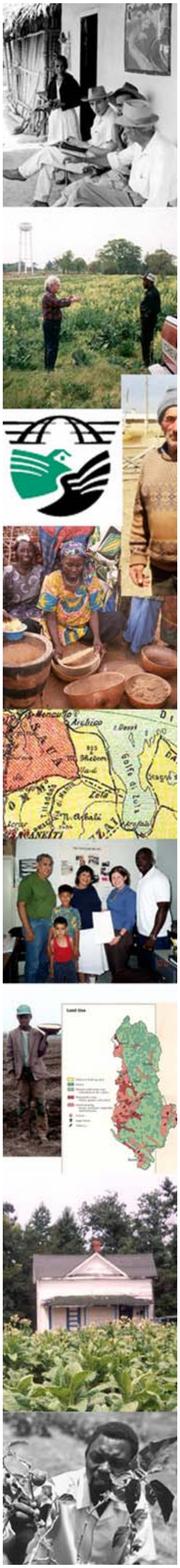

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Land Tenure Center

TROPICAL LAND-USE CHANGE

CONSEQUENCES FOR BIODIVERSITY AND CARBON

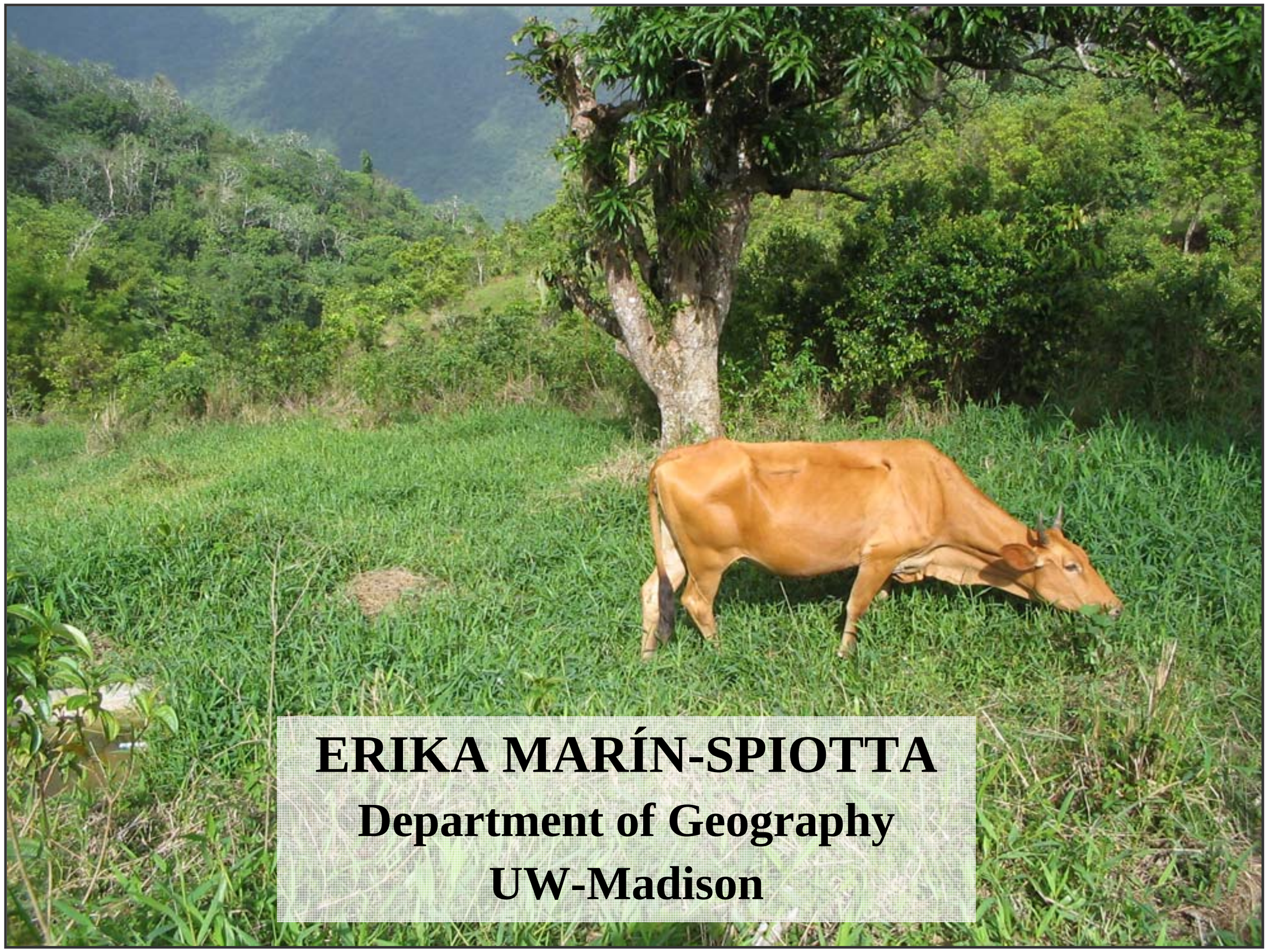
Erika Marin-Spiotta

LTC Spring Forum, Integrating geospatial and field-based science to assess biodiversity conservation.

♦♦♦♦♦♦♦♦

Provided by the **Land Tenure Center.** Comments encouraged:
Land Tenure Center, Nelson Institute of Environmental Studies,
University of Wisconsin, Madison, WI 53706 USA
kdbrown@wisc.edu; tel: +608-262-8029; fax: +608-262-0014
http://www.ies.wisc.edu/ltc

TROPICAL LAND-USE CHANGE: CONSEQUENCES FOR BIODIVERSITY AND CARBON



ERIKA MARÍN-SPIOTTA
Department of Geography
UW-Madison

Land-Use and Land-Cover Change

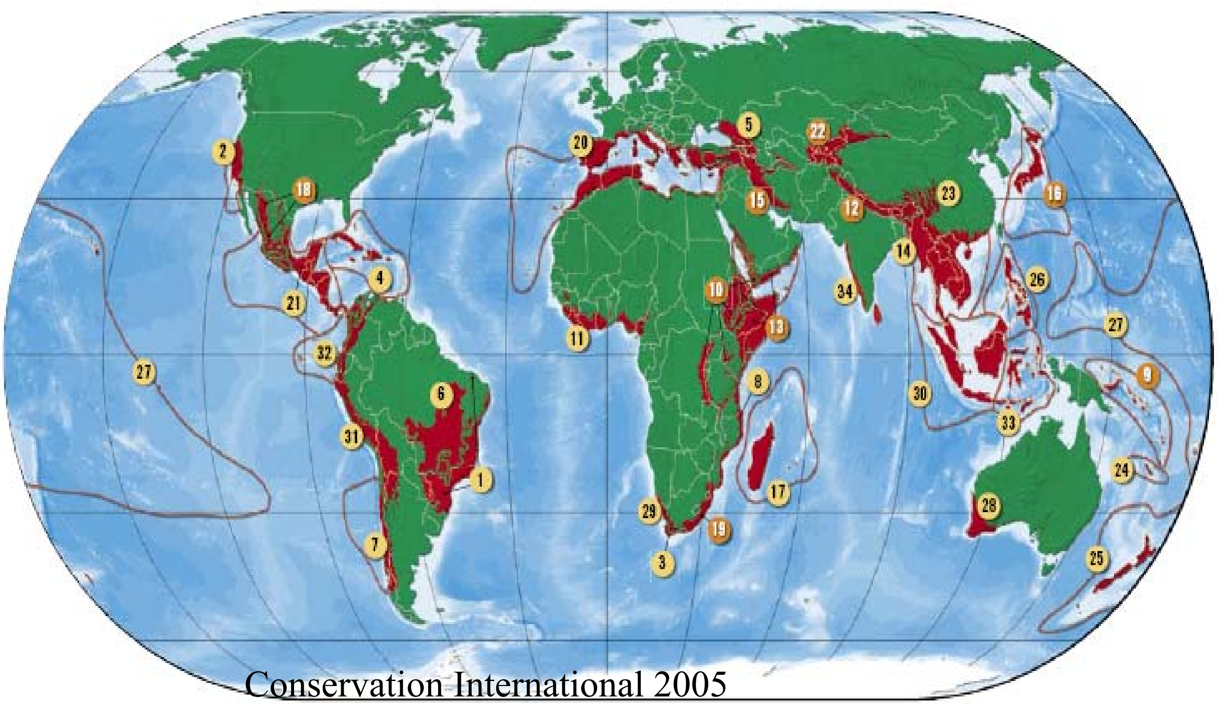
- >75 % ice-free land modified by humans (Ellis and Ramankutty 2008)

- Impacts on:
  - Biodiversity
  - Food and water supplies
  - Biogeochemical cycling
  - Climate

- Spatial scales:
  - Global
  - Regional
  - Local
  - Micro
  - Nano

Loss of Biodiversity

- Already lost 70-90% original vegetation (Conservation International 2005)
- LUC most important driver global biodiversity loss (Sala et al. 2000)

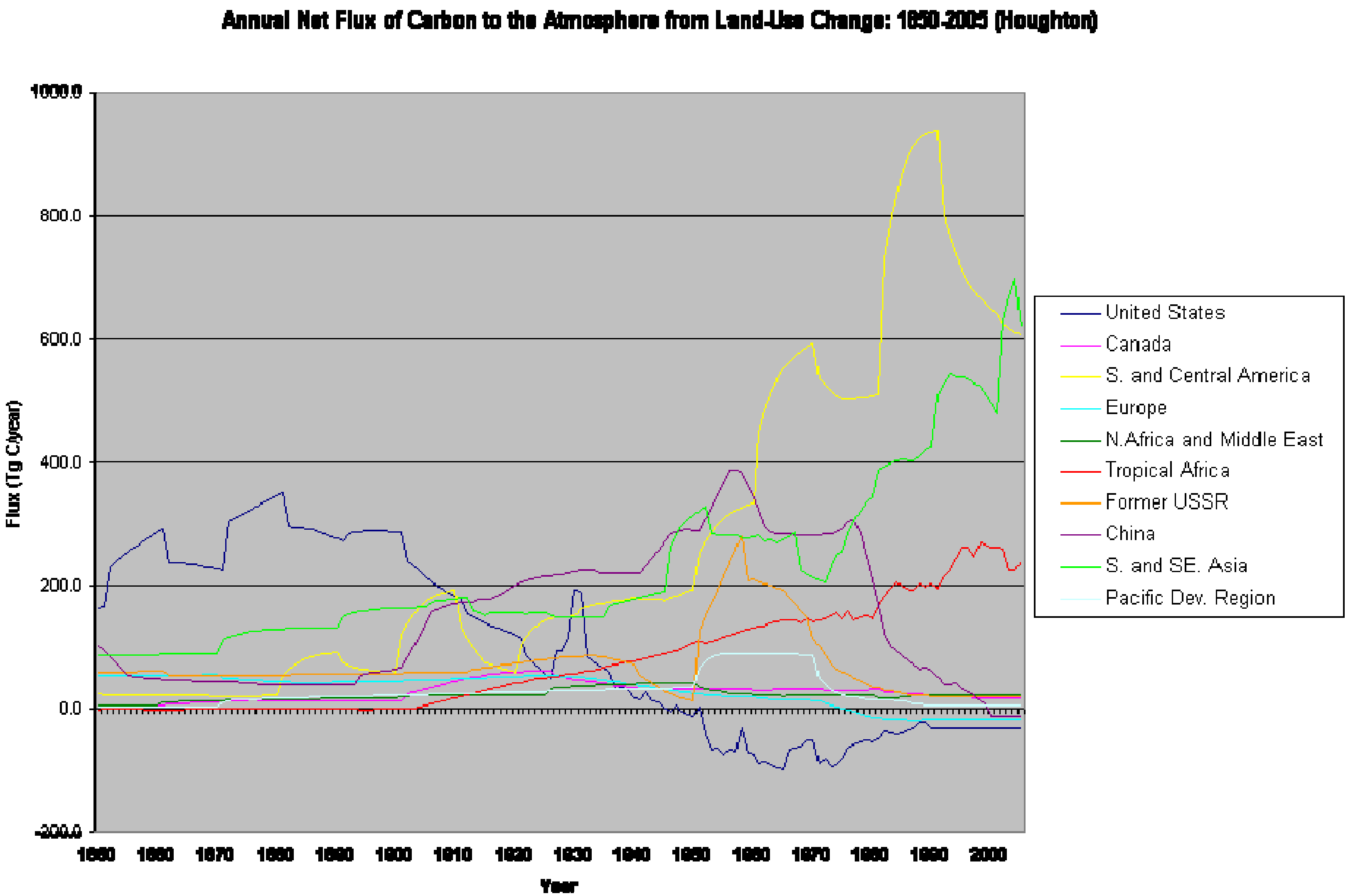


Conservation International 2005

Biodiversity Hotspots

Carbon Feedbacks to Climate

- LUC affects C storage and emissions



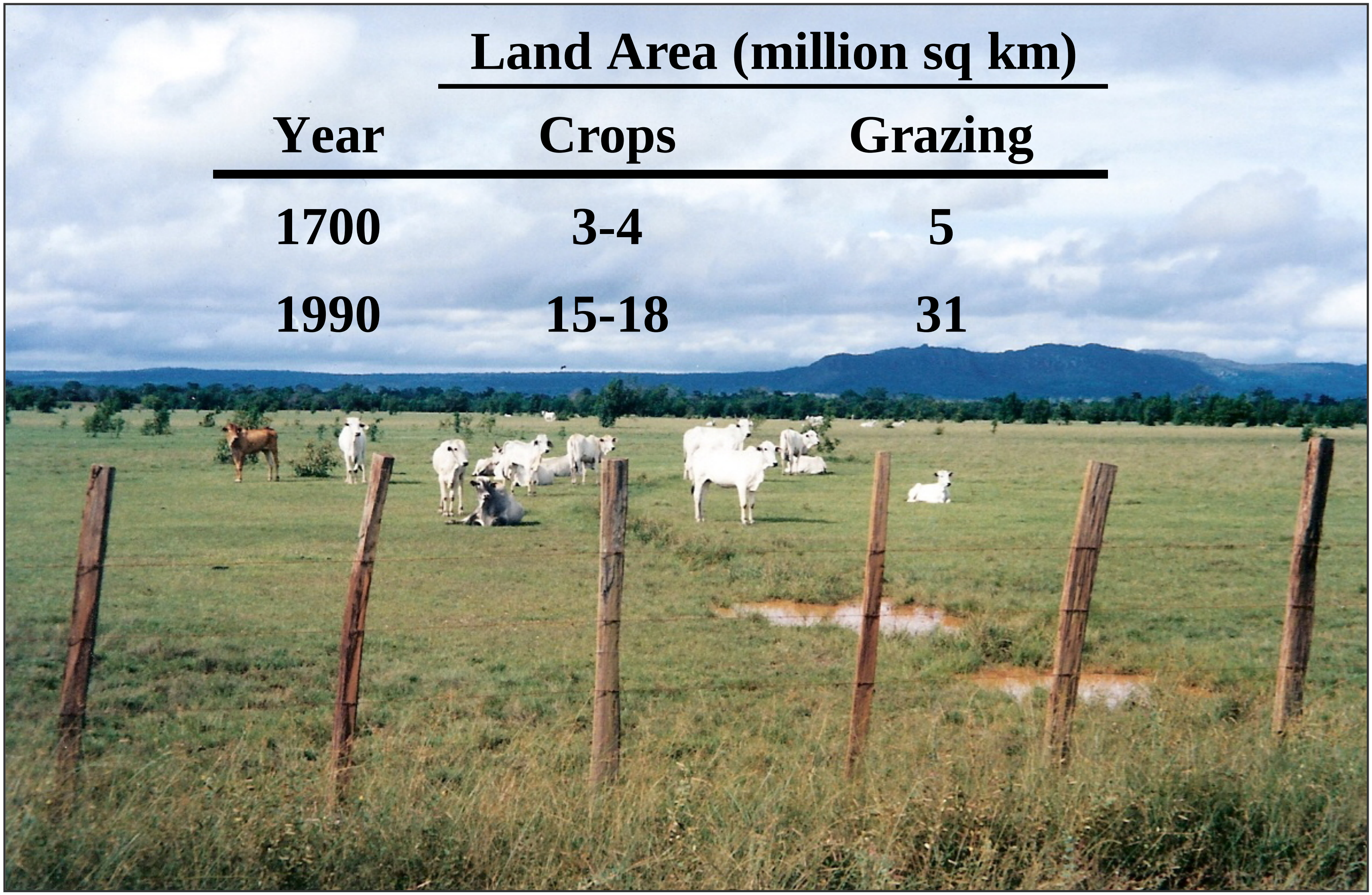
Carbon – Biodiversity Links

- Climate change effects:
  - Habitat loss/suitability
  - Fires
  - Invasions

- Biodiversity affects primary productivity (Hooper et al. 2005, Tilman et al. 2006)

- C sequestration can provide incentives for conservation and restoration

Land Conversion Trends

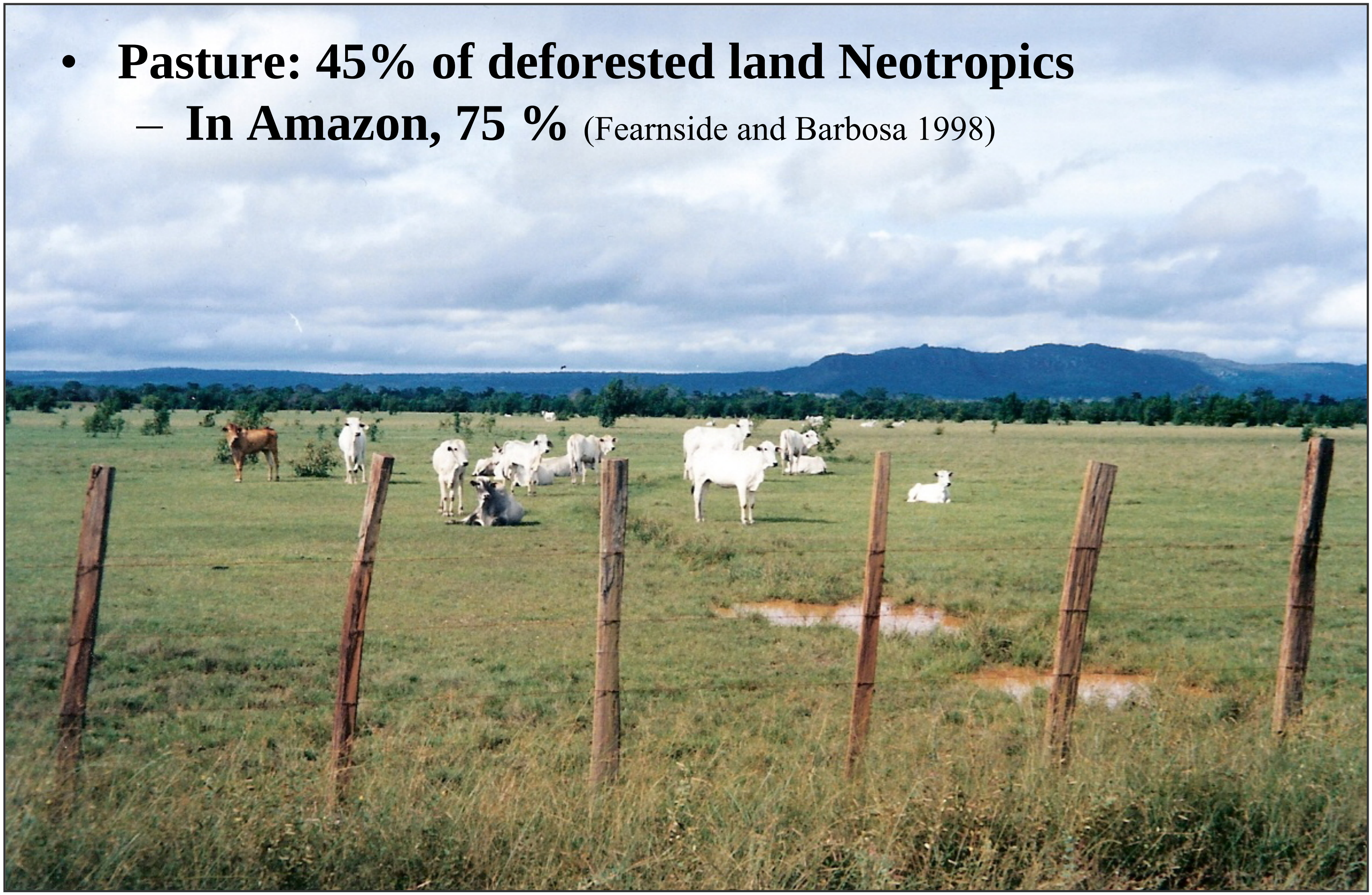


Year	Land Area (million sq km) Crops	Grazing
1700	3-4	5
1990	15-18	31

Data from Goldewijk and Ramankutty 2004

Land Conversion Trends

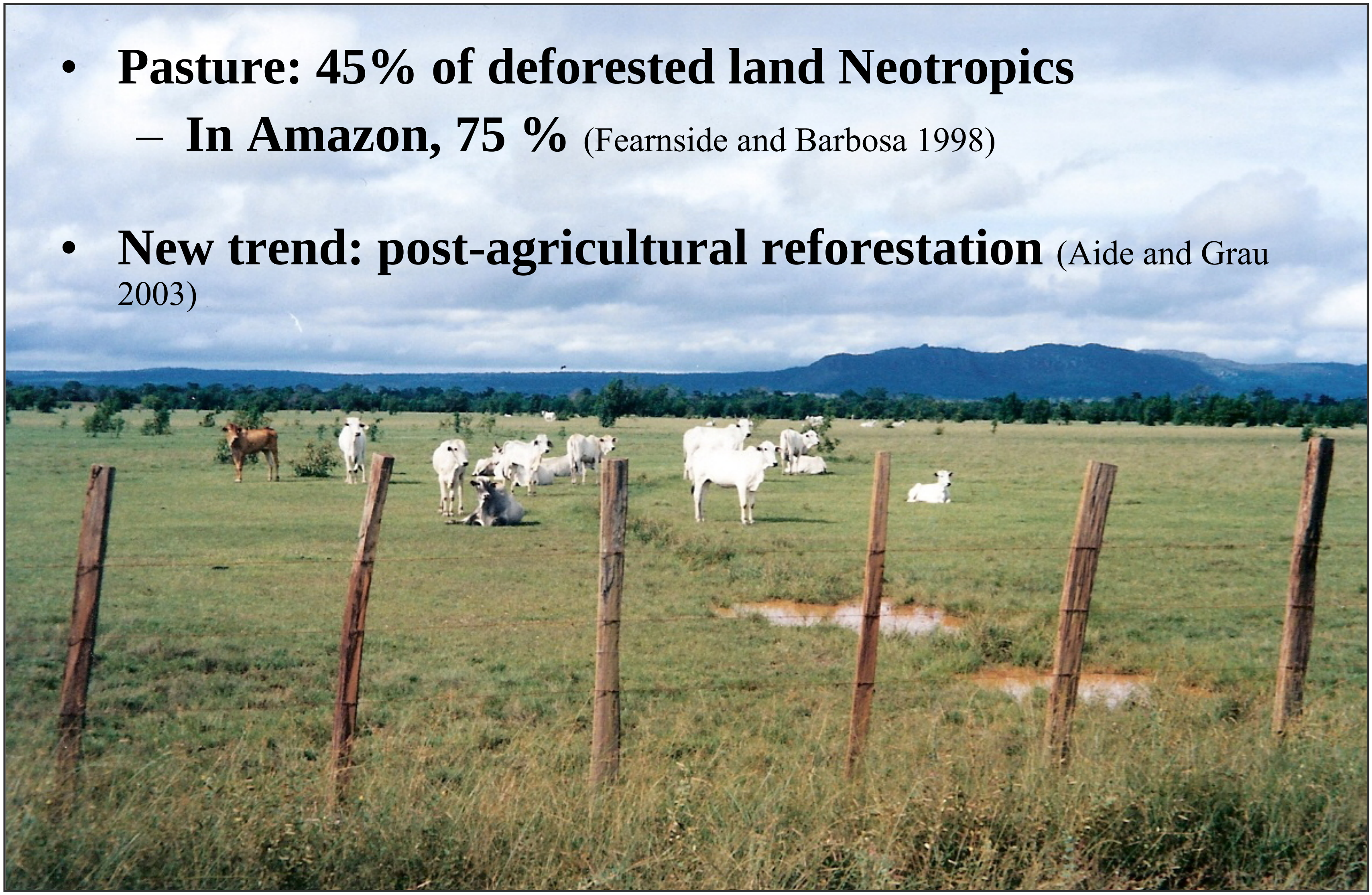
- **Pasture: 45% of deforested land Neotropics**
  - **In Amazon, 75 %** (Fearnside and Barbosa 1998)



Land Conversion Trends

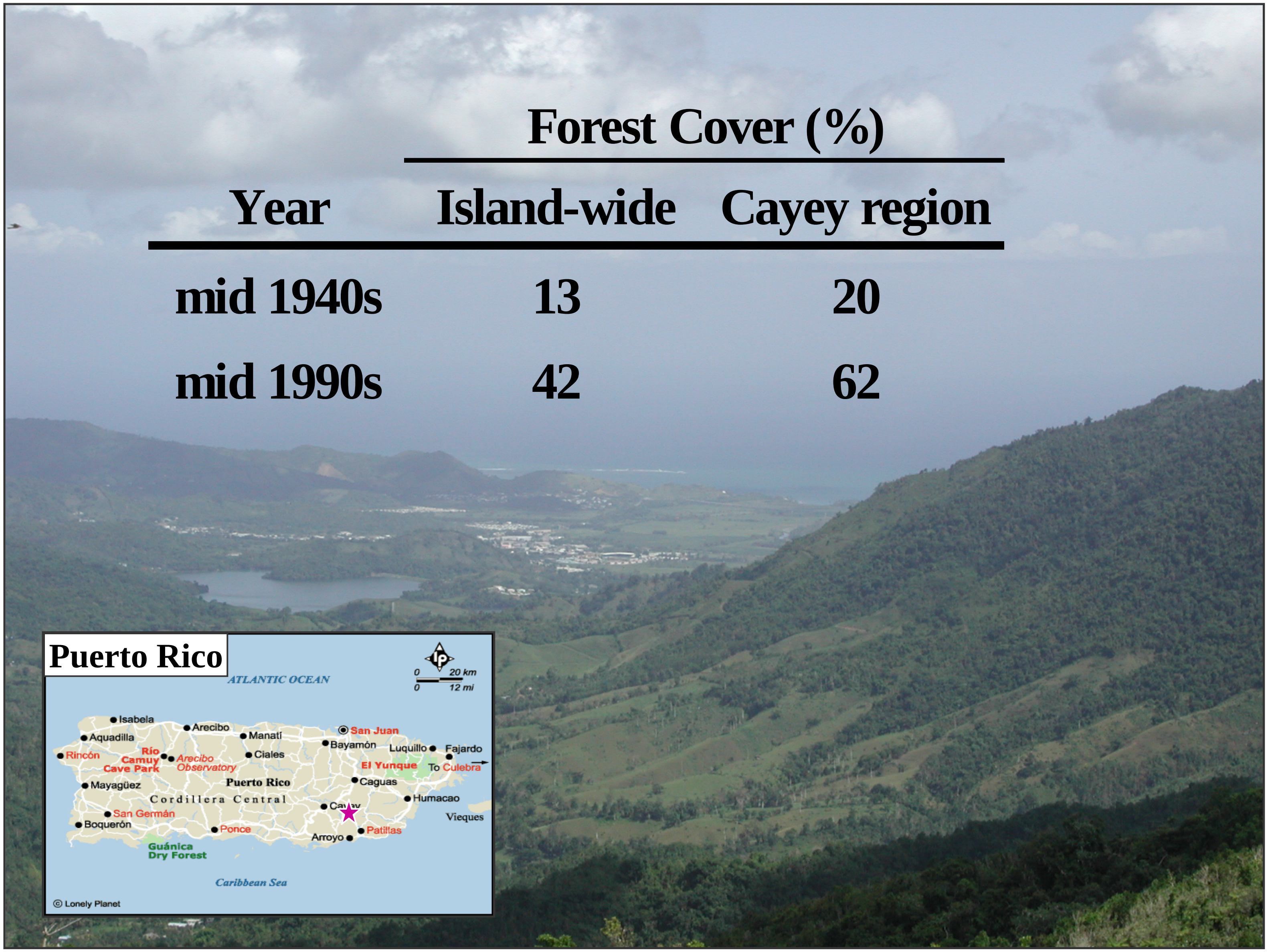
- **Pasture: 45% of deforested land Neotropics**
  - **In Amazon, 75 %** (Fearnside and Barbosa 1998)

- **New trend: post-agricultural reforestation** (Aide and Grau 2003)



Puerto Rico: Post-Agricultural Reforestation

	Forest Cover (%)	
Year	Island-wide	Cayey region
mid 1940s	13	20
mid 1990s	42	62

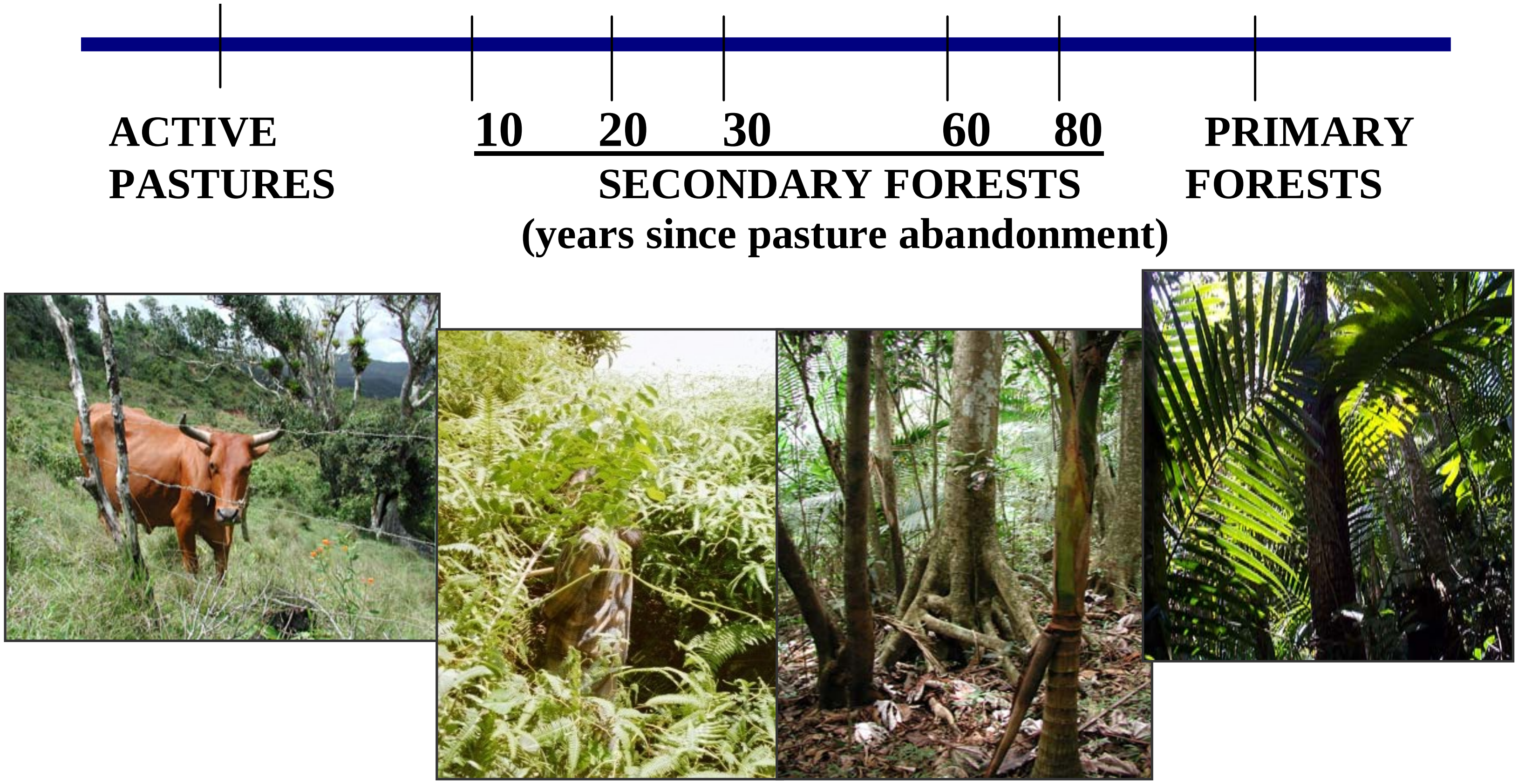


Secondary Forests: Opportunities for C & Biodiversity

- Does reforestation lead to C sequestration in aboveground biomass and in soils?

- Can reforestation of abandoned agricultural lands recover forest structure and composition?

Long-Term Land-Use Chronosequence



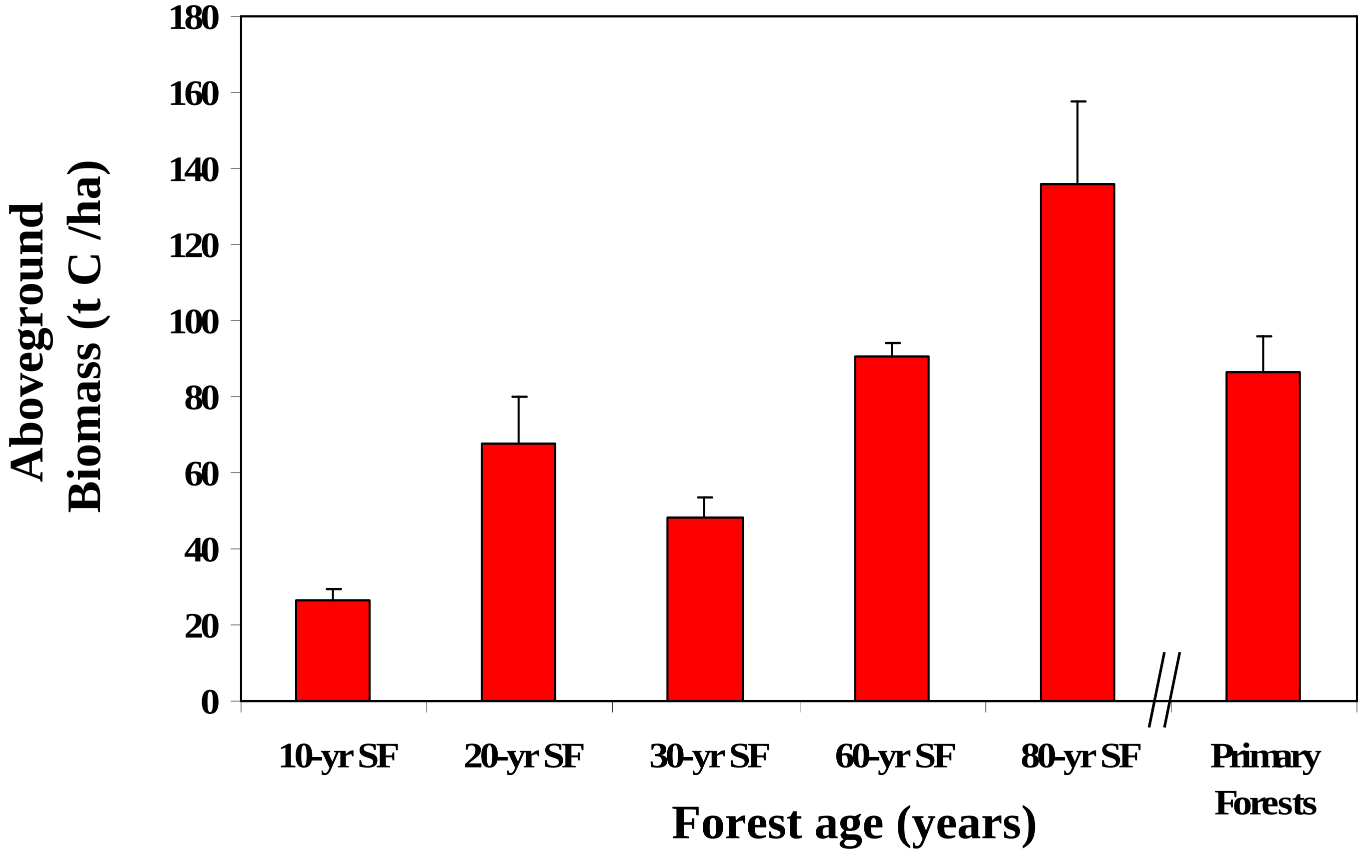
Wet subtropical forest (580 -700 masl), soil type: Oxisols
7 age classes, 3 site replicates, total 21 sites

Reforestation of Abandoned Pastures: Aboveground

Can secondary forests recover characteristics of undisturbed forests?

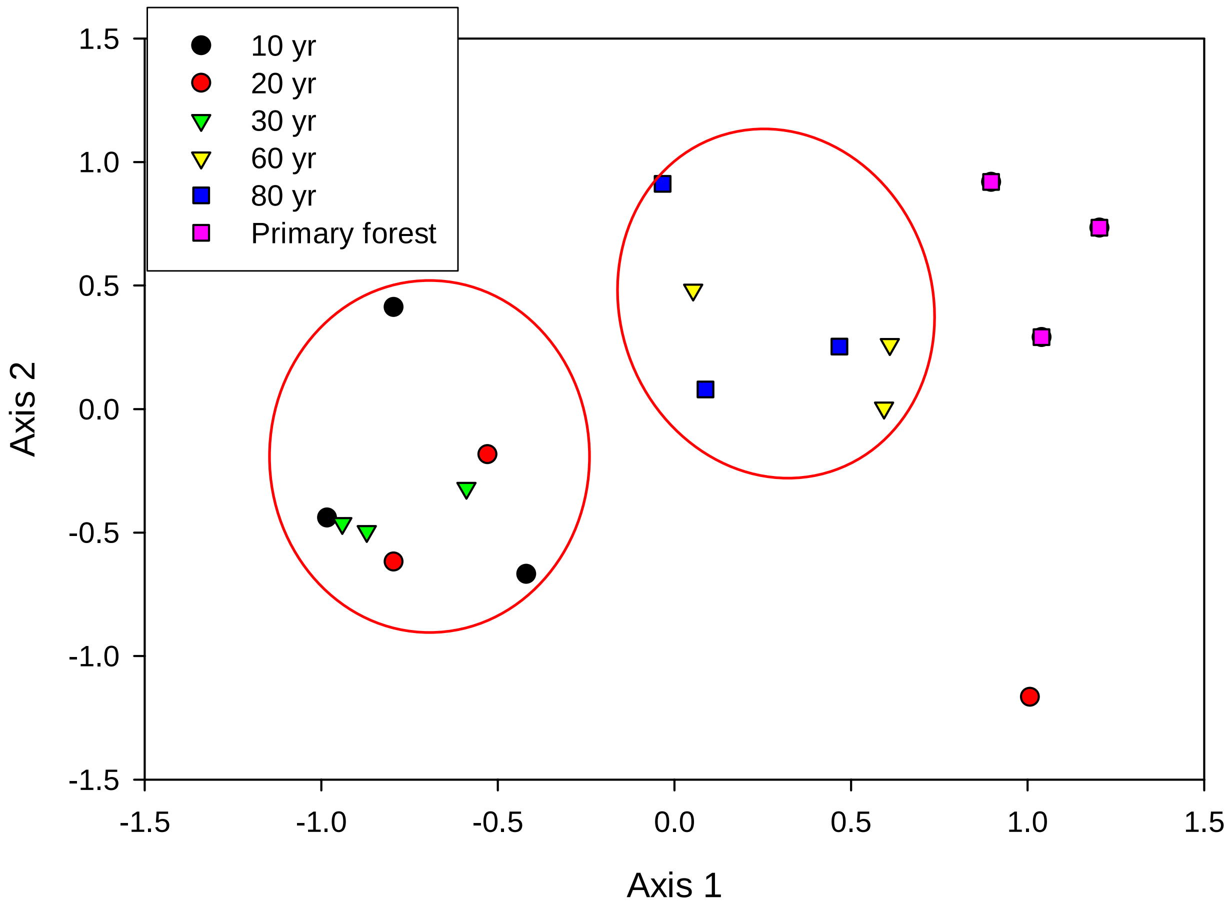
Secondary forests accumulate more biomass C.

- Due to species replacements



Marín-Spiotta et al. 2007. *Ecological Applications*

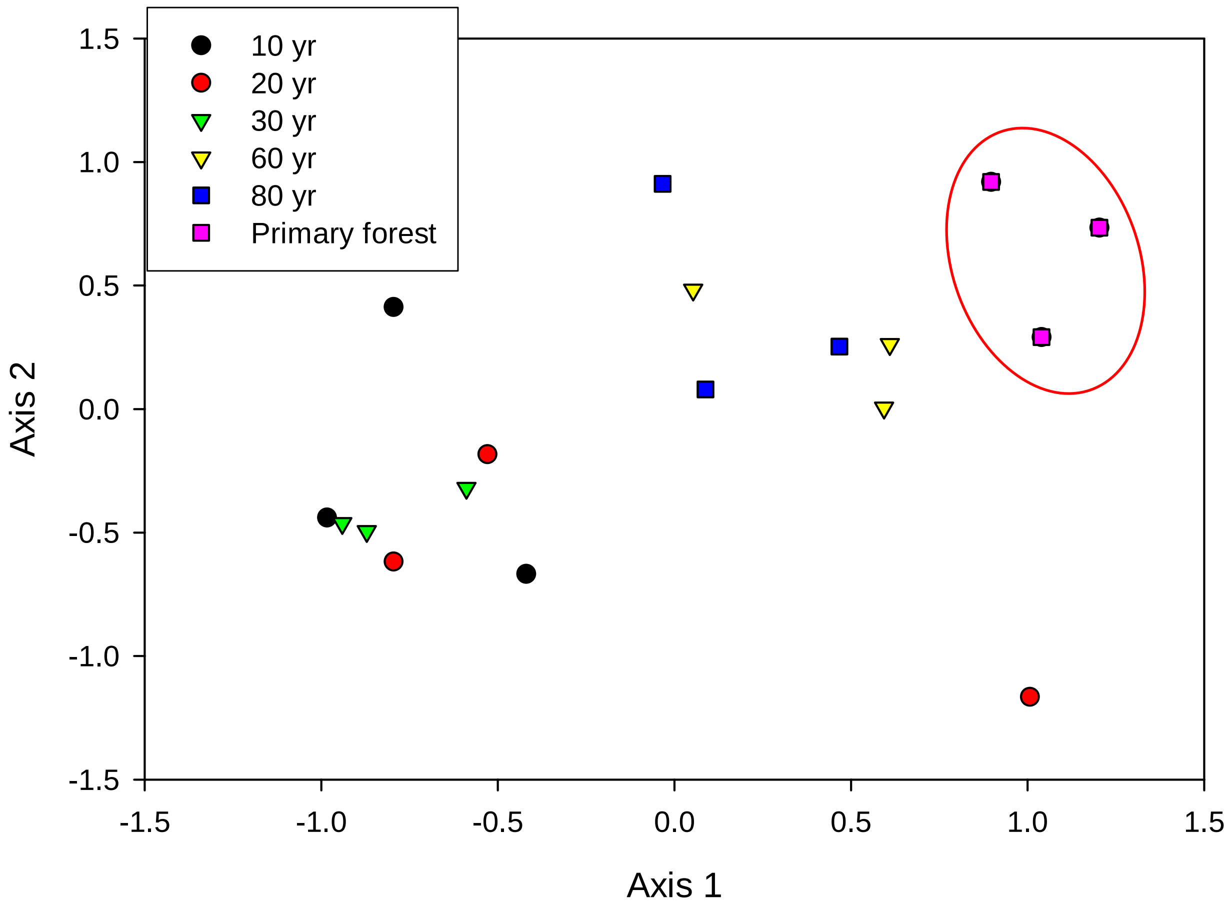
Secondary forests tree species composition differs.



Non-metric Multidimensional Scaling Analysis on Importance Values of Tree Species

Marín-Spiotta et al. 2007. *Ecological Applications*

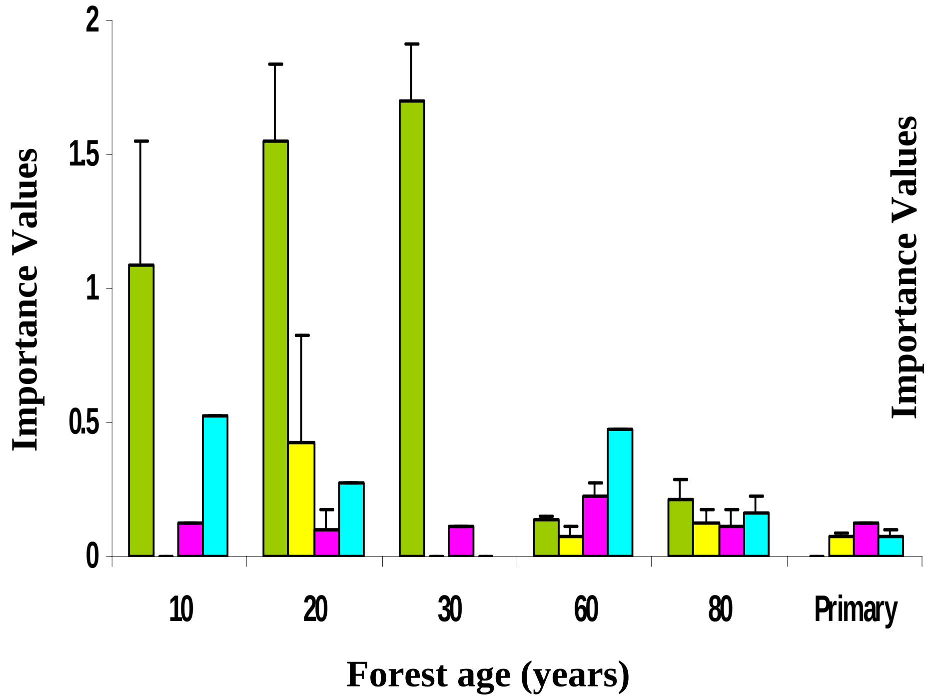
Primary forest composition remains distinct.

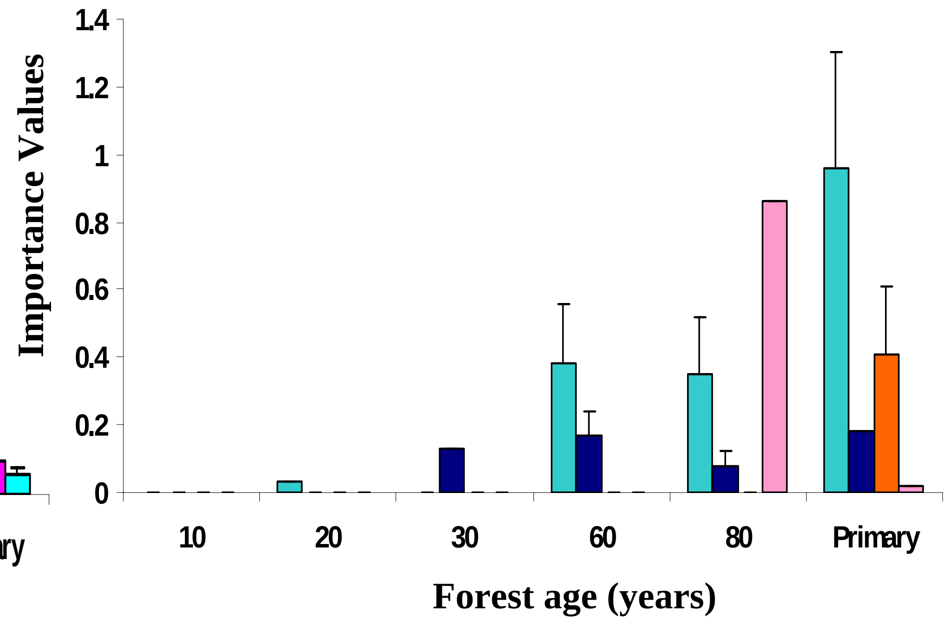


Non-metric Multidimensional Scaling Analysis on Importance Values of Tree Species

Marín-Spiotta et al. 2007. *Ecological Applications*

Tree species composition differed with succession.





4 Most Important
Pioneer Species

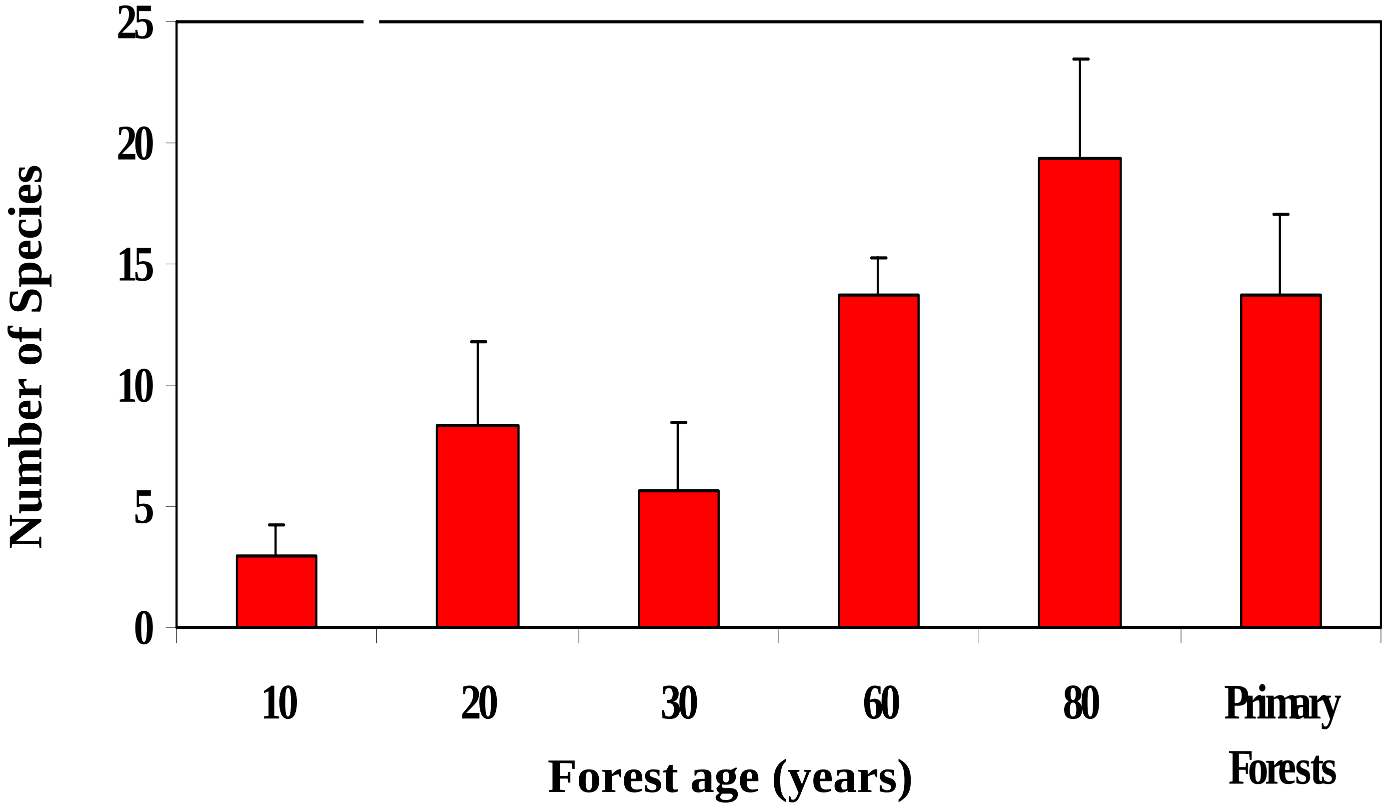
4 Most Important
Primary Forest Species

Marín-Spiotta et al. 2007. *Ecological Applications*

Older secondary forests are as diverse as primary forests.

- Presence endemic species

Trees with dbh $\geq$ 10 cm

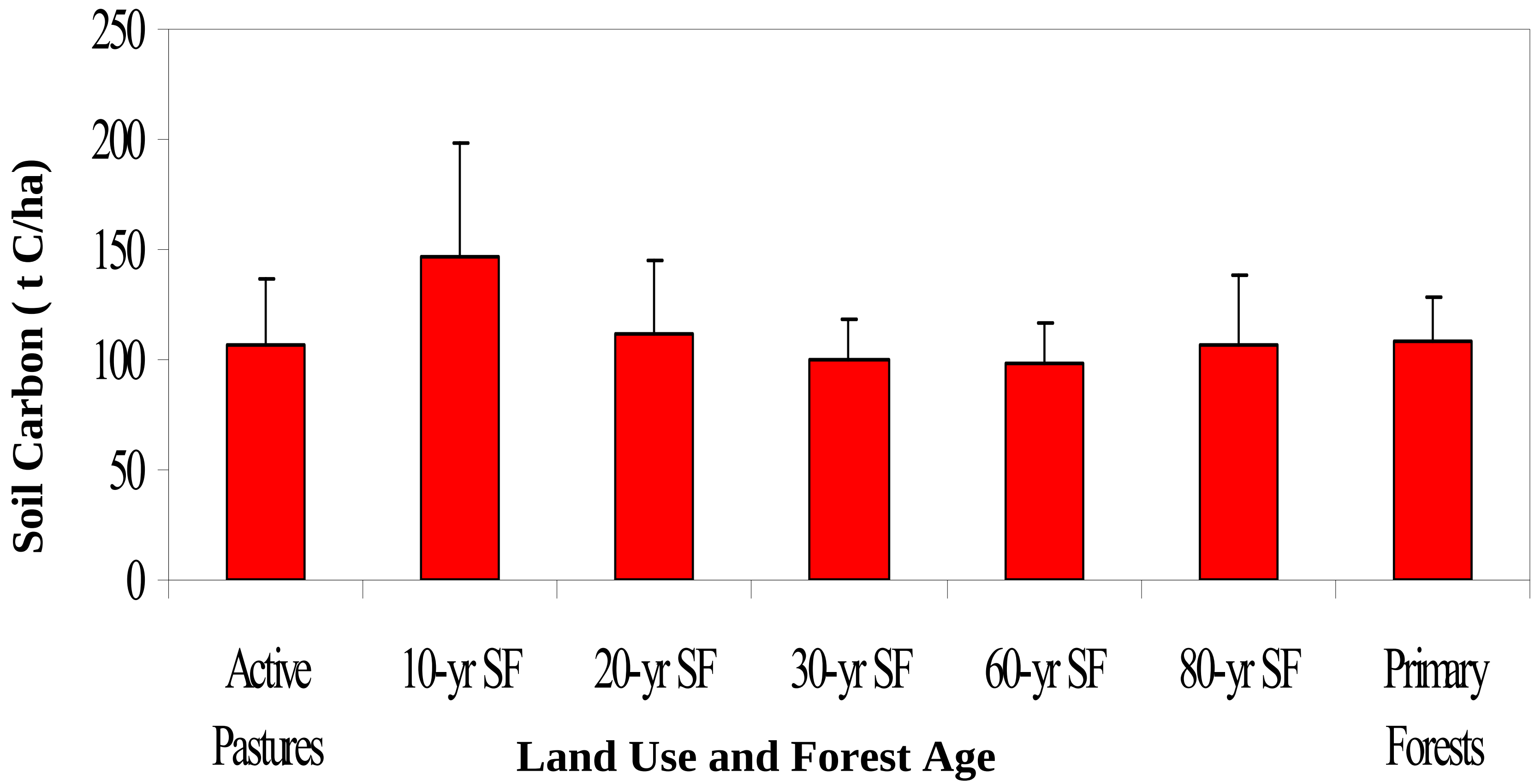


Marín-Spiotta et al. 2007. *Ecological Applications*

Reforestation of Abandoned Pastures: Belowground

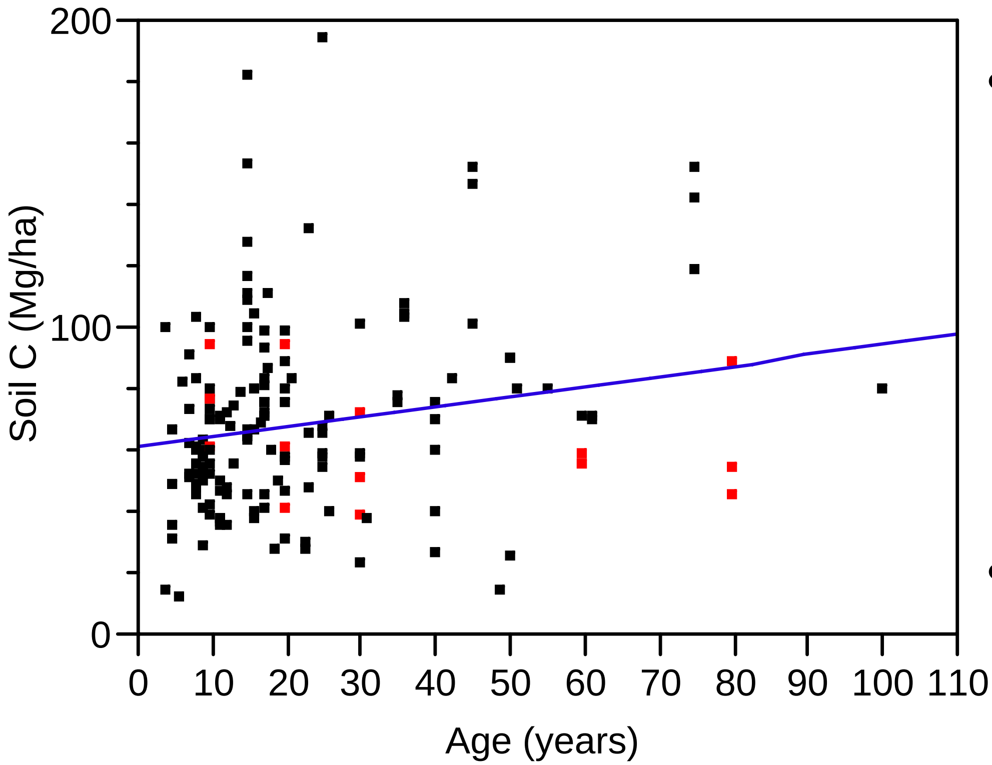
Do secondary forests sequester C in soils?

Soil carbon stocks do not change.



Marín-Spiotta et al. 2009. *Global Change Biology*.

Soil C pattern holds at continental scale.



- All ages Neotropical secondary forests (n = 161):

  R-sq = 0.04

  p-value = 0.01

- Age 4-30 years (n = 128):

  R-sq = 0.01

  p-value = 0.28

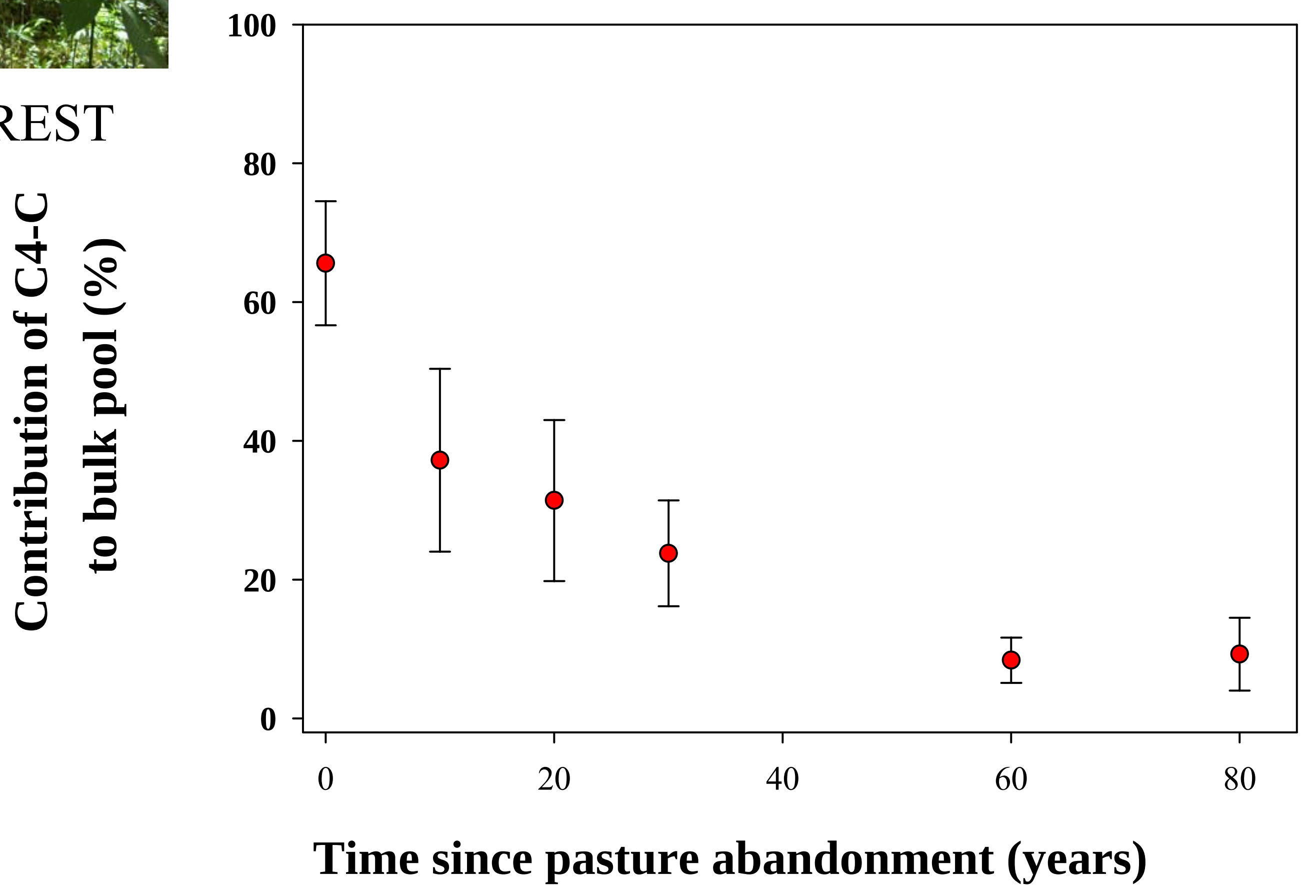
Marín-Spiotta et al. 2008.

Soil Carbon Dynamics: Micro and Nanometer Scales

- What component of the bulk soil C pool is most sensitive to LUC?
- What controls C cycling, plant decomposition, soil organic matter formation, CO_2 emissions?
- Importance of chemistry and spatial interactions in the soil : microbial scale

Gains new forest-C offset by losses pasture-C.

FOREST



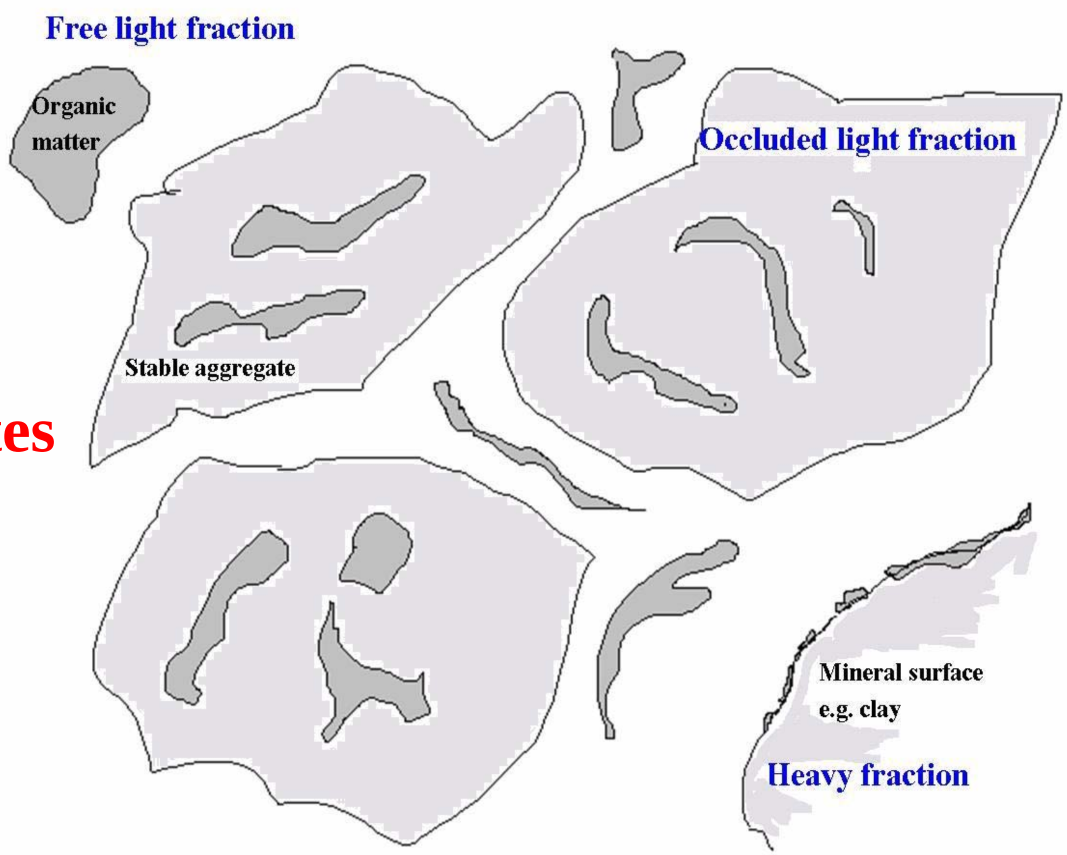
PASTURE

Marín-Spiotta et al. 2009. *Global Change Biology*.

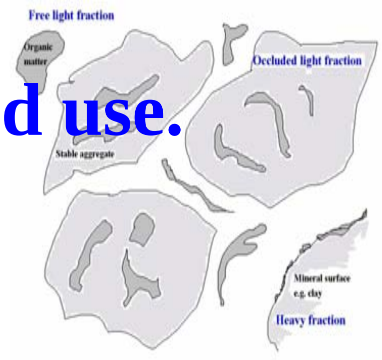
Bulk soil C pool composed of different fractions

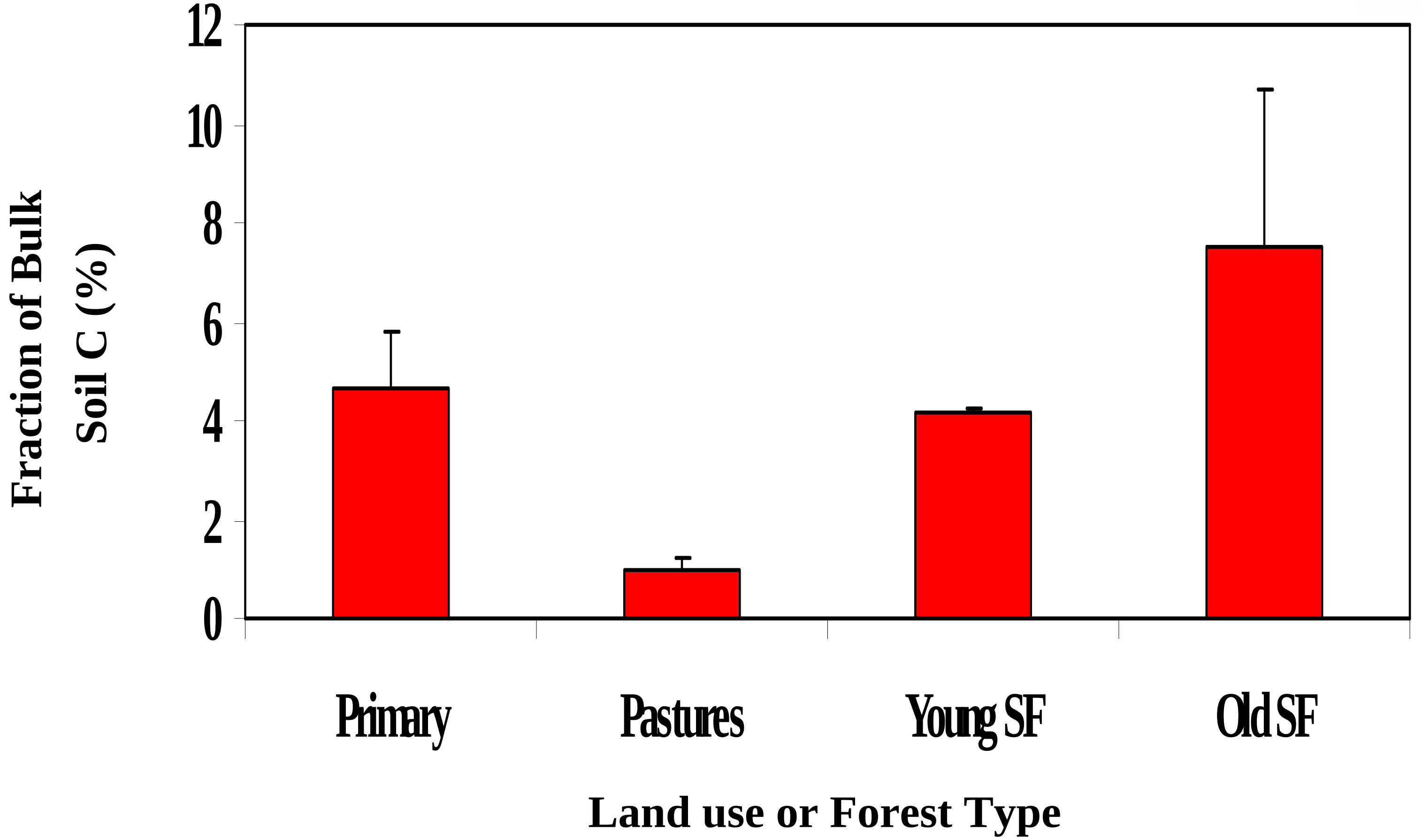
- Based on physical location and mineral-surface association:

- **Physically unprotected C**
- **C inside soil aggregates**
- **Mineral-associated C**



Physically unprotected C most sensitive to land use.





Marín-Spiotta et al. 2009. *Global Change Biology*.

Land use affects soil C turnover.

- Physically protected C:
  - Active pastures ~ 100 yr
  - 10-yr SF ~ 90 yr
  - Other forests ~ 65 yr

- Increased dominance of slowest-cycling pools due to loss of unprotected and labile C.

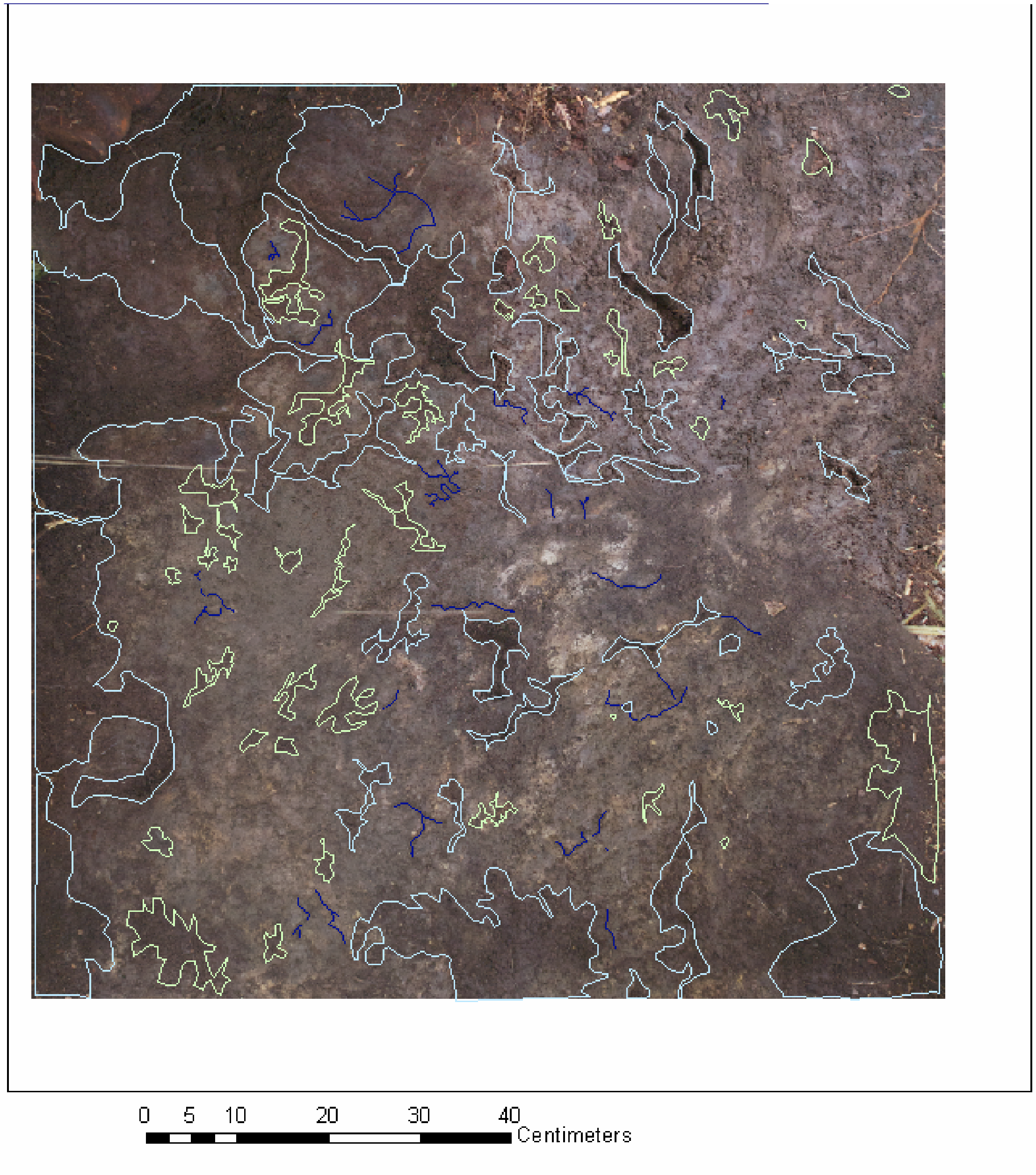
Marín-Spiotta et al. 2008. *Geoderma*

Micromorphology important for C dynamics

A Remote Sensing Approach to Soils: Microtopography

- Calculate spatial variability soil horizon depths
- Map cracks and channels: preferential flow paths
- Digital elevation models
- Water flow

Cracks and channels are pervasive in soil profile.



- **25 %** soil surface area (1 x 1 m)
- Delivery C, metals, and other elements from surface horizons to deeper mineral horizons.

Reforestation of Abandoned Pastures

- Recovery forest structure and soil C turnover
- Differences in biomass C and tree composition
- Maintenance of soil C stocks
- Different responses of soil C pools to disturbance
- Soil C sequestration ?


Land Use: Type and Intensity Matter

- Fate of C depends on management:
  - Cultivation (tillage vs non-tillage)
  - Grazing intensity
  - Duration of land use
  - Mechanized deforestation
  - Disturbance regime (fire)
  - Species allocation patterns
- Not all forests/soils are created equal

Reviewed in Marín-Spiotta et al. 2008.



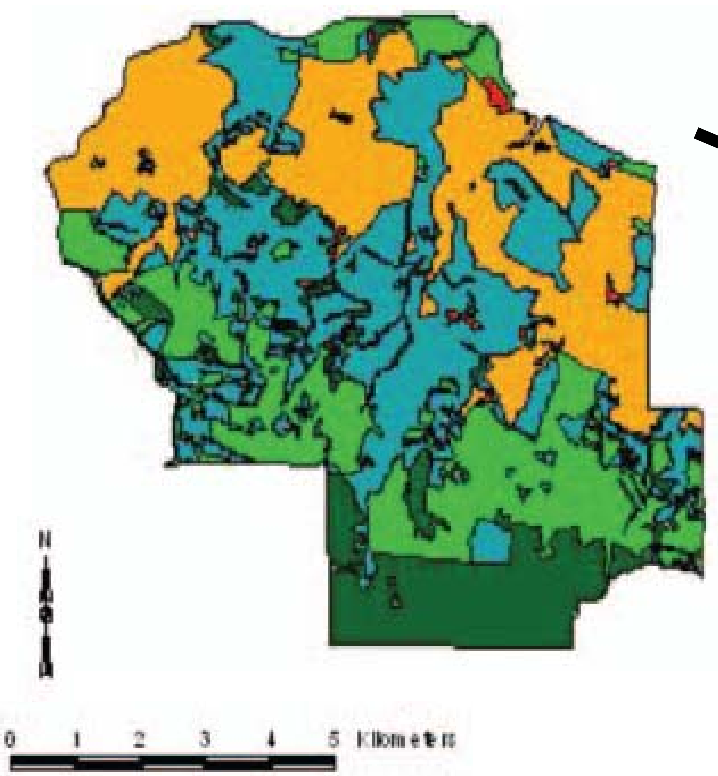
Implications for Forest Recovery

- Potential for biodiversity conservation and C sequestration.
- Post-agricultural successional trajectory, new species assemblages: “novel ecosystems” (Lugo and Helmer 2004).
- Land use history legacies
- How will these new forests respond to future disturbances?

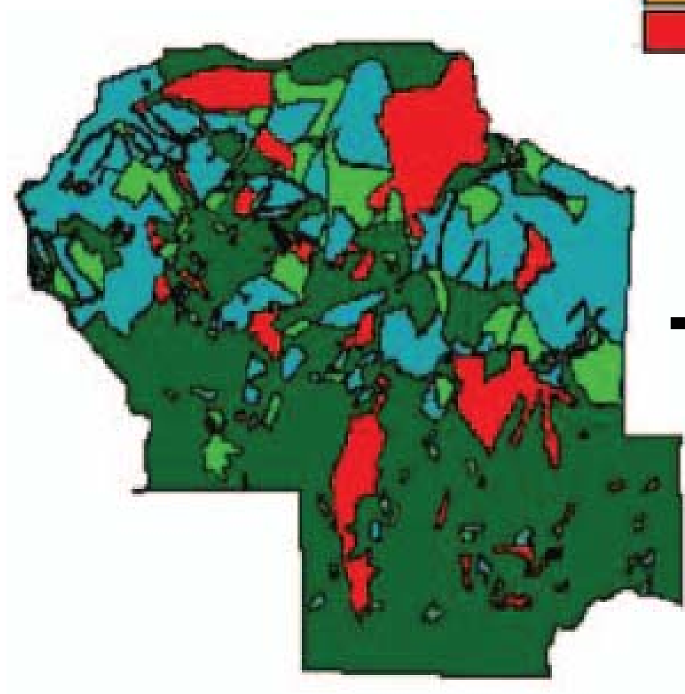


Challenge: Constantly Evolving Landscapes

1936



1988



→ ?

Modified from Grau et al. 2003.

Luquillo, Puerto Rico