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Solutions for environment and development
Soluciones para el ambiente y desarrollo

CGIAR
RESEARCH PROGRAM ON
Forests, Trees and Agroforestry

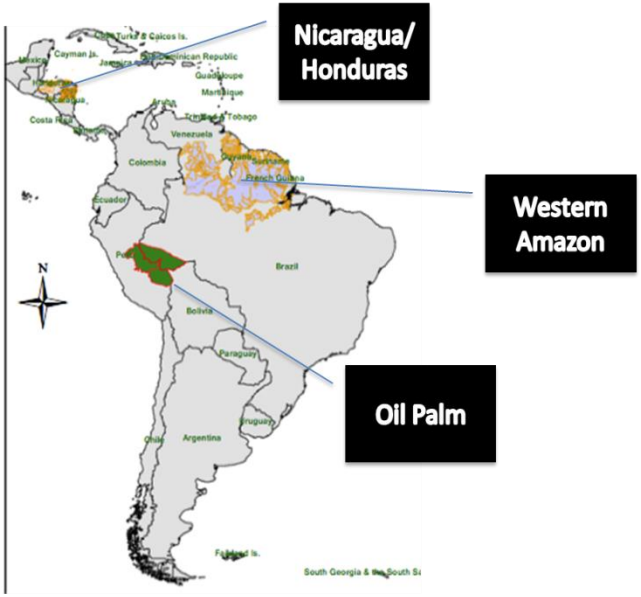
World Agroforestry Centre

Long-term scientific observatories

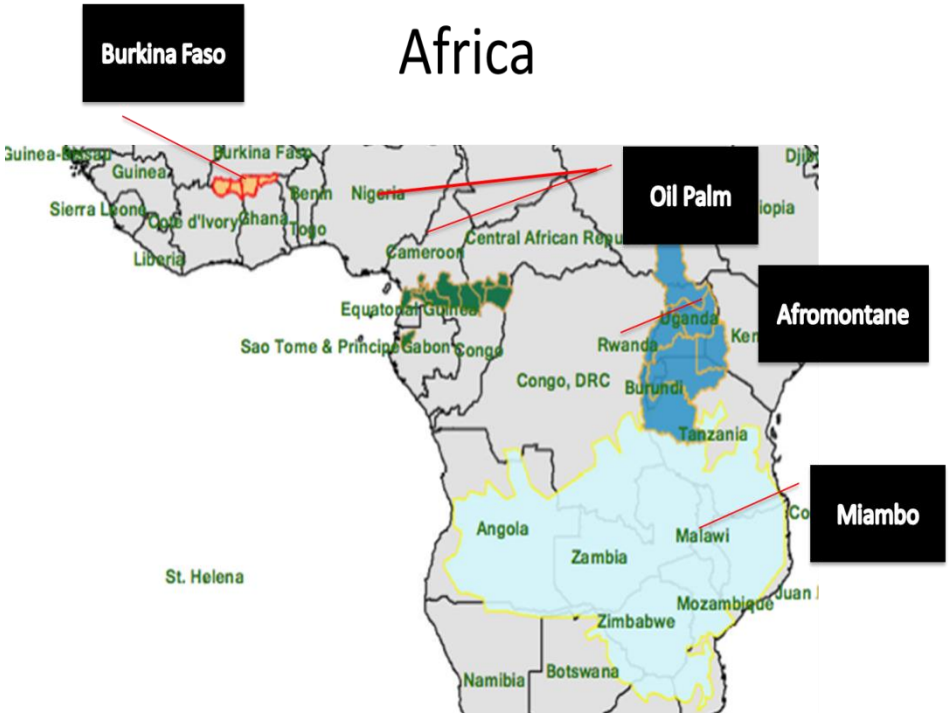
Nicaragua-Honduras Sentinel Landscape (NHSL)

Eduardo Somarriba
Norvin Sepulveda
Geovana Carreño
Jenny Ordonez

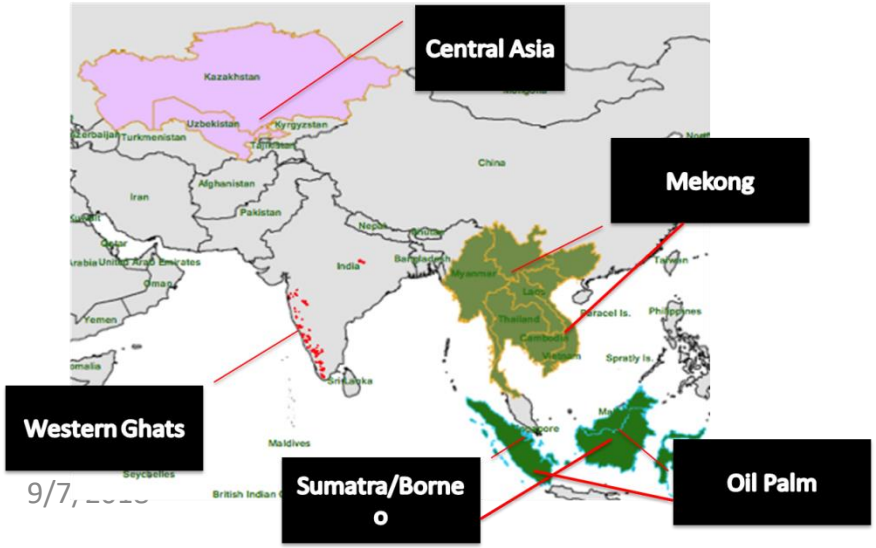
Latin America



Africa



Asia



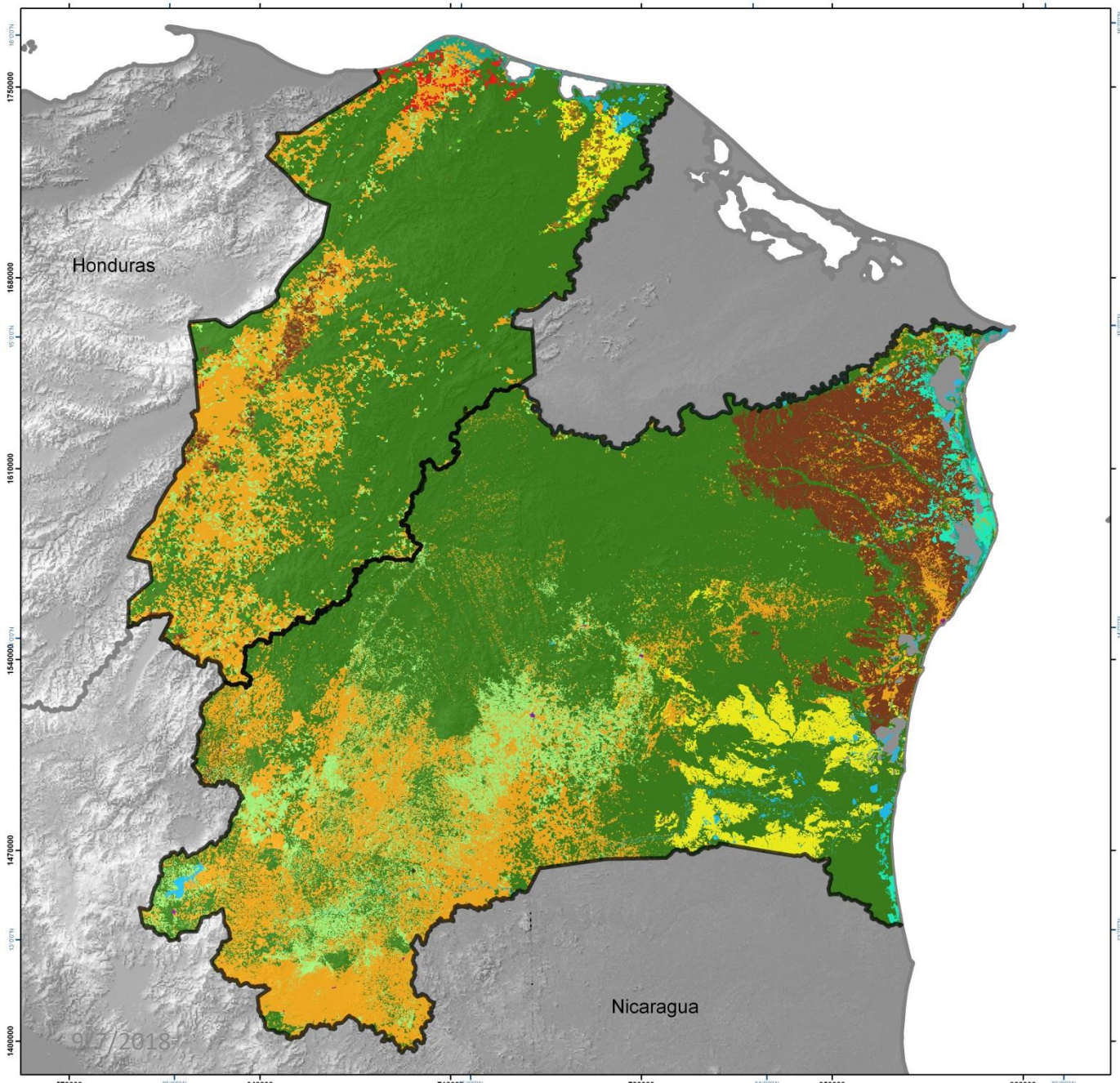
The FTA-SL network

The Nicaragua-Honduras Sentinel Landscape (NHSL)

68 000 km^2 which includes 2 biosphere reserves and 13 protected areas in Nicaragua and Honduras

Map by Norvin Sepulveda and Noel Ulloa

Landuse and vegetation types in Nicaragua - Honduras Sentinel Landscape



Simbology

Sentinel Landscape

Landuse

- Agriculture
- Agro-export agriculture
- Broadleaf forest
- Broadleaf mix forest
- Dense pine forest
- Land flooding
- Land without vegetation
- Mangrove forest
- Savannah with trees
- Shrubs
- Sparse pine forest
- Urban areas
- Water

Projection: UTM Zone 16 N

Datum: WGS-84

Scale 1 : 1.000.000

N W E S

0 10 20 40

Kilometers

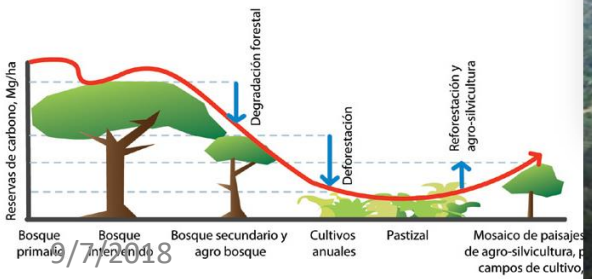
Sources:
ICF 2009 (Honduras) and MARENA 2006 (Nicaragua)

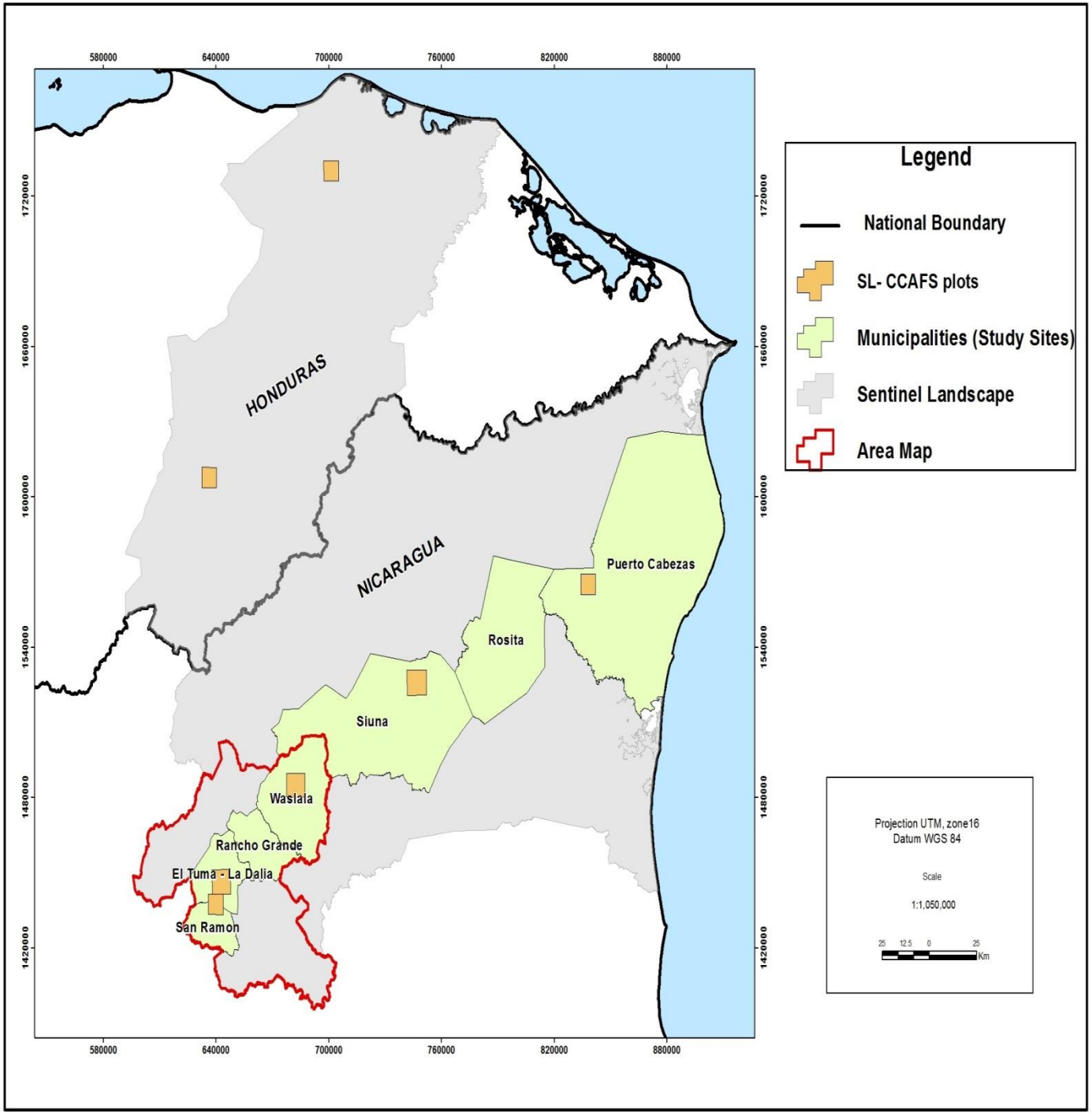
Elaborated by:
Juan Carlos Zamora P. (CATIE)

December 2013

The Nicaragua Honduras SL

The largest remaining forest area in Central America, surrounded by a mosaic of agricultural land, cattle ranching and agroforestry systems.




580000
640000
700000
760000
820000
880000
1720000
1660000
1600000
1540000
1480000
1420000
HONDURAS
NICARAGUA
Puerto Cabezas
Rosita
Siuna
Waslala
Rancho Grande
El Tuma - La Dalia
San Ramon
Legend
National Boundary
SL- CCAFS plots
Municipalities (Study Sites)
Sentinel Landscape
Area Map
Projection UTM, zone16
Datum WGS 84
Scale
1:1,050,000
25 12.5 0 25
Km

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Baseline studies (each with several contents, each content with several files, each file with several variables) x 9 Sites

This is structural….different organizations, projects, etc. in the landscape have their own criteria, preferences, and goals when selecting their action sites and variables of interest…so, there will be more sites and more studies

Biophysical baseline						
Countrie	**Sites**	**Infiltration**	**soils (top and sub)**	**Soils Cum mas**	**Vegetation (plots)**	**Trees (subplots)**
Nicaragua	Tuma-La Dalia	48	320	480	160	640
	Columbus	48	320	480	160	640
Honduras	Rio Platano	48	320	480	160	640
	Rio Blanco	48	320	480	160	640
Total	**4**	**192**	**1280**	**1920**	**640**	**2560**

Socioeconomics baseline							
Countrie	**Sites**	**Settlement**	**Association**	**Forest**	**Product**	**Household**	**Poverty Stages**
Nicaragua	Tuma-La Dalia	8	10	28	104	297	8
	Columbus	8	7	9	76	302	8
Honduras	Rio Platano	9	11	14	27	146	9
	Rio Blanco	8	0	18	54	104	8
Total	**4**	**33**	**28**	**69**	**261**	**849**	**33**

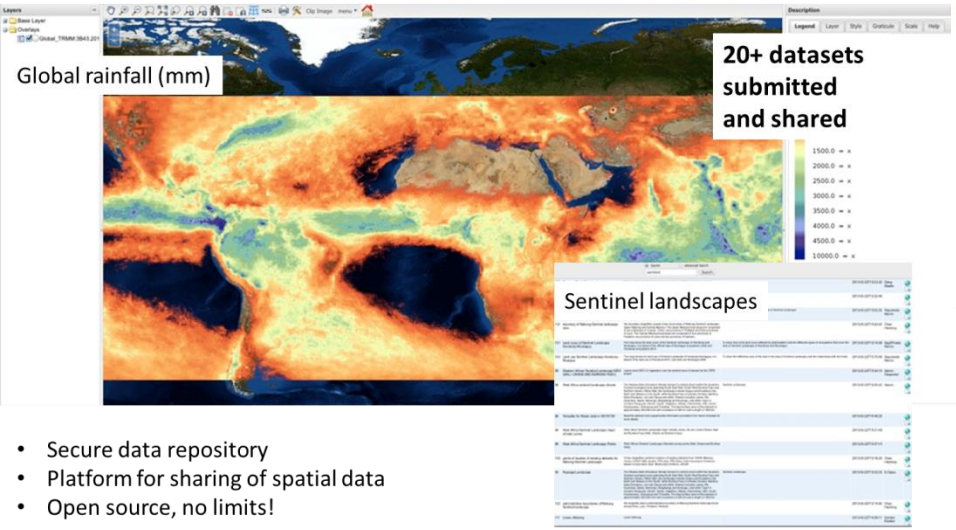
Open access data

- 18 legacy data sets compiled and archived http://thedata.harvard.edu/dvn/dv/N-H-SL
- 126 spatial datasets compiled and archived http://thedata.harvard.edu/dvn/dv/SL
- CATIE agroforestry data bases in (http://thedata.harvard.edu/dvn/dv/CATIE)
- Also www.paisajecentinela.org

ICRAF GeoPortal

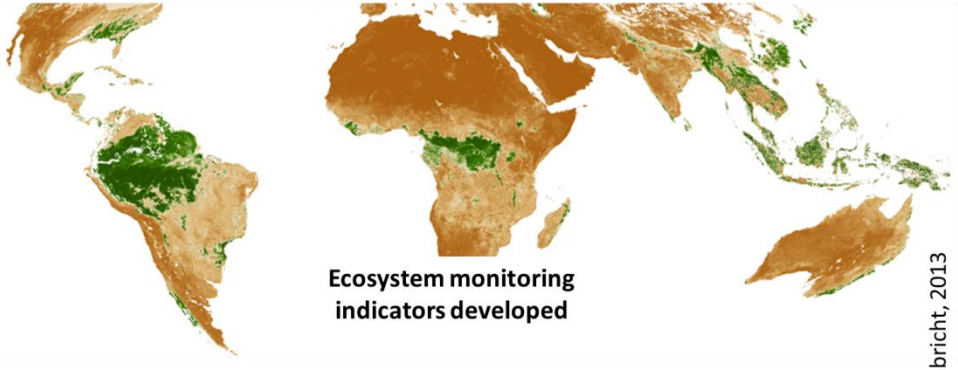
Global spatial data harvesting

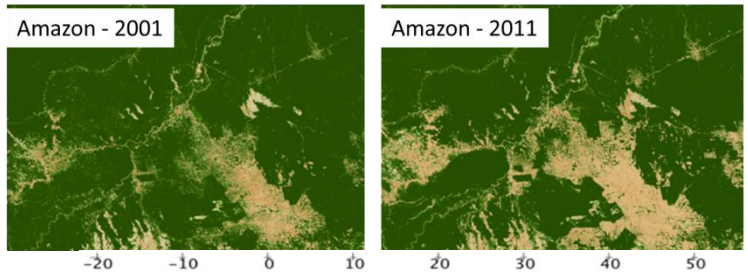
http://geoportal.worldagroforestry.org/



- Secure data repository
- Platform for sharing of spatial data
- Open source, no limits!

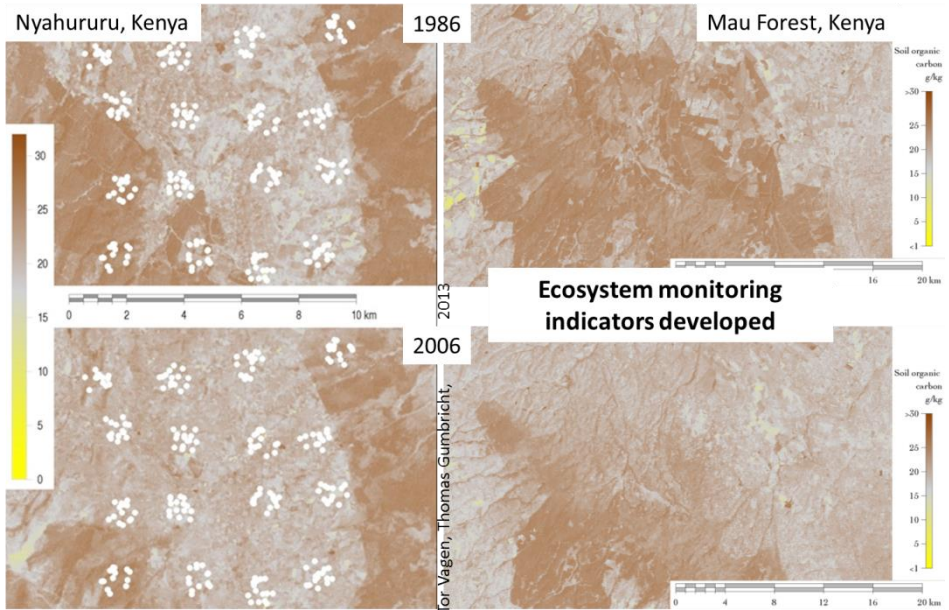
Global Forest Cover Index

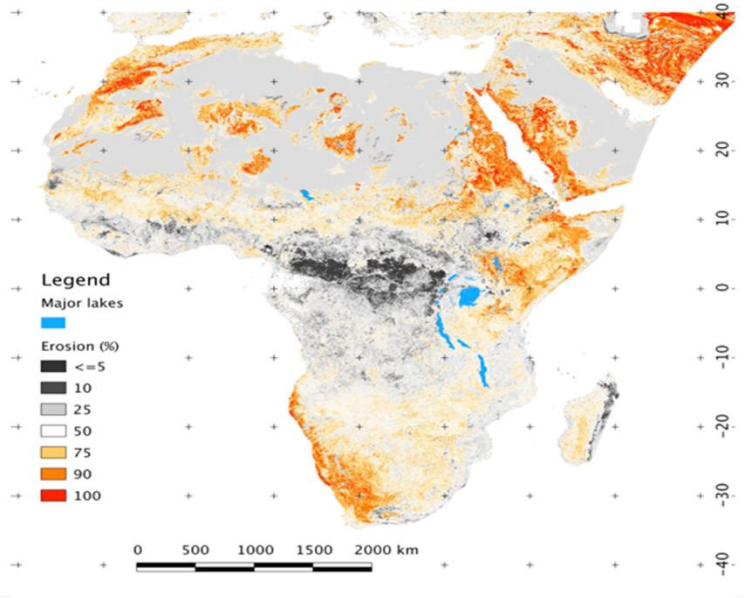




Tor Vagen, Thomas Gumbricht, 2013

Systematic methods for mapping of soil and ecosystem health at multiple scales





Tor Vagen, Thomas Gumbricht,

Landscape governance workshop, CIFOR

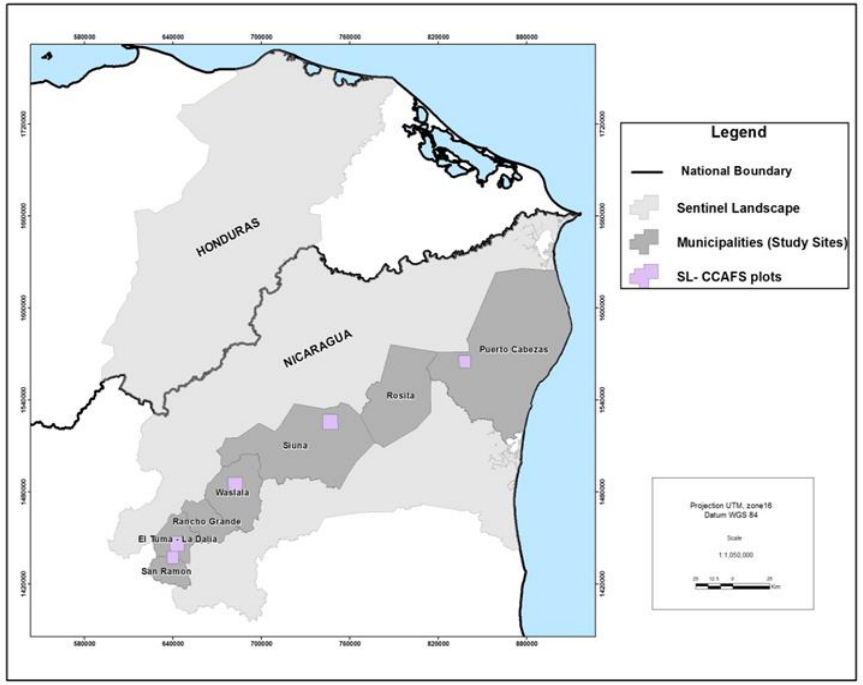
Sentinel Landscape Data Analysis workshop, CATIE, March 2014

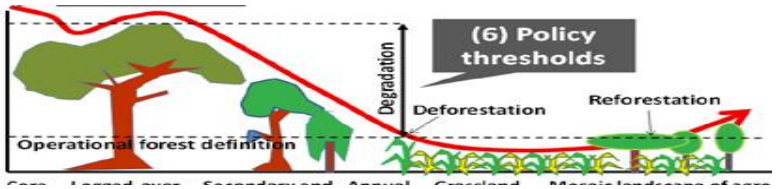
Biophysical Baseline coordination within the Western Amazonia Sentinel Landscape

"Science and Development Platform" to help set up relevant research agenda and secure an impact pathways of science-based innovations to development processes in Climate Smart Territories in Nicaragua (Nicacentral)

Articulating Science, Rural Development and Education in Nicaragua

More than 120 representatives , from 12 NGOs, 8 Governmental organizations, 8 Universities, 6 international centers, and 4 International Cooperation. organizations

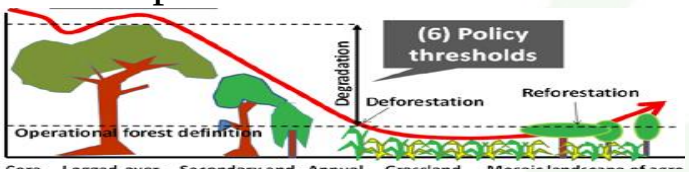




Tree cover transition

Agroecologycal intensification

People -livelihoods



Tree cover transition

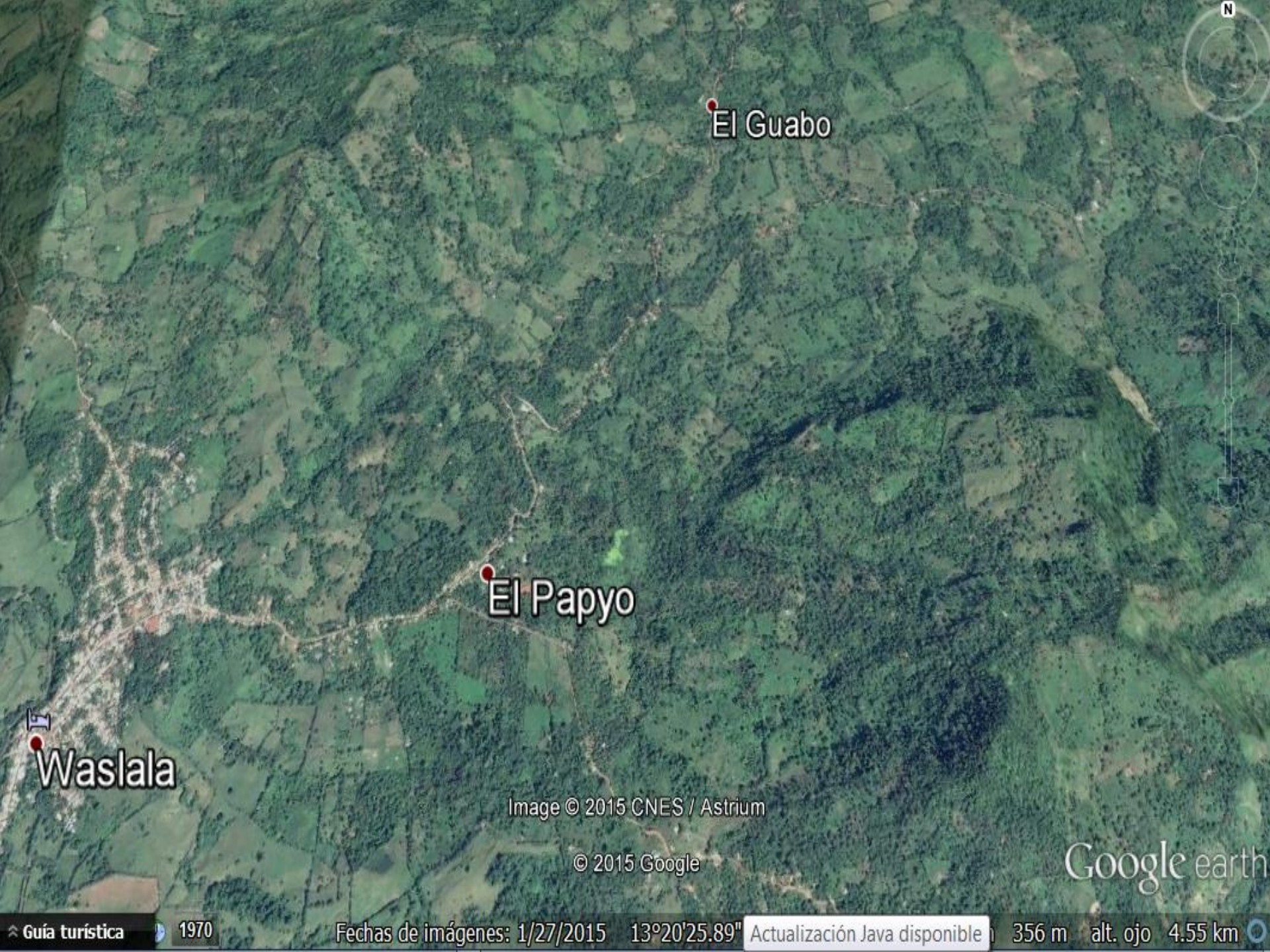
Agroecologycal intensification

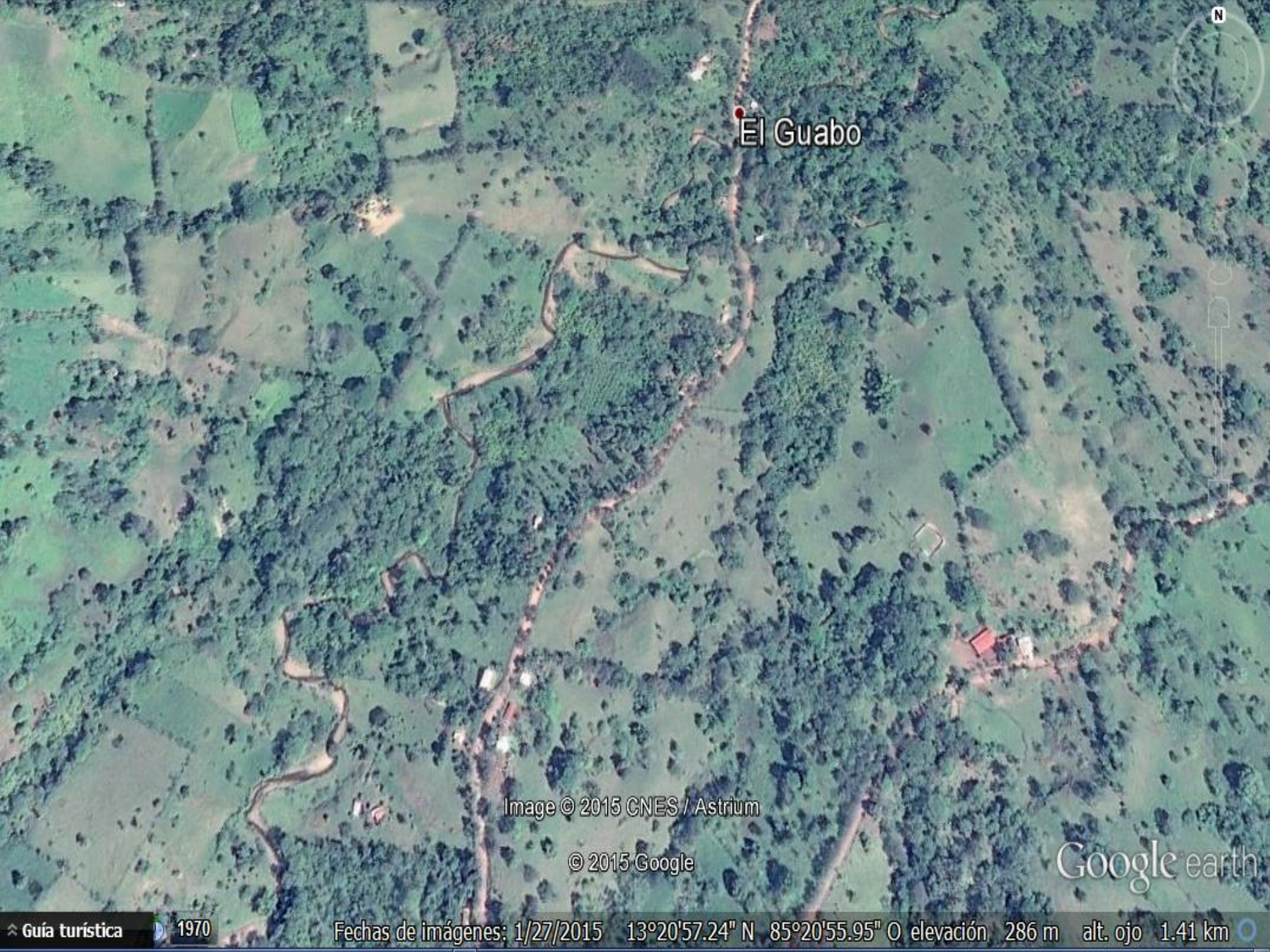
- **Espinoza, V. 2015**. Cambio de uso de suelo y su incidencia sobre el almacenamiento de carbono. análisis multitemporal mediante imágenes de satélite para cuatro zonas del paisaje centinela. Tesis de Maestria
- **Oblitas, S. 2015**. Tipología de fincas agropecuarias por intensidad de manejo en el paisaje centinela. Tesis de Maestria.
- **Caicedo. W. 2015**. Diversidad y almacenamiento de carbono, en dos sitios con diferente grado de intensificación de uso de suelo en el paisaje centinela. Tesis de Maestría.
- **Amores, F. 2015**. Contribución de los árboles en finca a los medios de vida de familias rurales del paisaje centinela. Tesis de Maestria.

Students research in the NHSL

- Espinoza, VE. 2016. Impulsores de cambio en el uso del suelo y almacenamiento de carbono sobre un gradiente de modificación humana de paisajes en Nicaragua. Tesis MSc. Turrialba, CR. CATIE.
- Moreira, N. 2016. Análisis de los factores socioeconómicos que influyen sobre la presencia de árboles en fincas del Paisaje Centinela de Nicaragua-Honduras, en Nicaragua. CATIE, MSc. Tesis, Turrialba, Costa Rica.
- Leiva, I.; Henry Bloomfield, H. 2016, Propuesta metodológica bajo el enfoque de bienestar humano y adaptación al cambio climático para la elaboración de Planes de Manejo de las Áreas Protegidas de Nicaragua. Estudio de caso: Plan de Manejo de la Reserva Natural Macizo de Peñas Blancas, Nicaragua. MSc Tesis, CATIE, Turrialba, Costa Rica.
- Pallqui, N.; Hinojosa, S. 2016. Adaptación local al cambio climático a través de la planificación estratégica territorial participativa en la comunidad de Wasaka abajo (Municipio de el Tuma-La Dalia) Nicaragua.
  Guia metodológica para la elaboración de planes de manejo de las áreas protegidas de Nicaragua. MSc Tesis, CATIE, Turrialba, Costa Rica.


Haz clic y arrastra para girar, o haz clic en "N" para restablecer el Norte.
N
El Tuma
El Tuma
Image © 2015 CNES / Astrium
Santa Rosa del Tuma
© 2015 Google
Google earth
Guía turística
1970
Fechas de imágenes: 3/2/2014 13°04'16.82" N 85°44'35.92" O elevación 421 m alt. ojo 2.69 km


El Guabo
El Papyo
15
Waslala
Image © 2015 CNES / Astrium
© 2015 Google
Google earth
Guía turística
1970
Fechas de imágenes: 1/27/2015
13°20'25.89"
Actualización Java disponible
356 m
alt. ojo
4.55 km


El Guabo
Image © 2015 CNES / Astrium
© 2015 Google
Google earth
Guía turística
1970
Fechas de imágenes: 1/27/2015 13°20'57.24" N 85°20'55.95" O elevación 286 m alt. ojo 1.41 km

Forthcoming publication….

Somarriba E, Carreño-Rocabado G, Amores F, Caicedo W, Oblitas S, Cerda R, Ordónez J. 2018. Trees on Farms for Livelihoods, Conservation of Biodiversity and Carbon Storage: Evidence from Nicaragua on This “Invisible” Resource. Advances in Agroforestry, Vol. 12, Florencia Montagnini (Eds): Integrating Landscapes: Agroforestry for Biodiversity Conservation and Food Sovereignty, 978-3-319-69370-5, 427558_1_En, (15)

Activities and on-going bilateral projects in the NHSL

- **Theme: Restoration of agricultural landscapes: trees on farms and on-farm forests**
- **Projects:**
  - LUXDEV (Facilitating the development of small and medium forest enterprises for the management of secondary forests in Guatemala, Nicaragua and Costa Rica);
  - IKI-BMUB (Supporting Initiative 20 by 20: A country-led effort to bring 20 million hectares of degraded land in Latin America and the Caribbean into restoration by 2020);
  - IKI-BMUB (Harnessing the potential of trees- on-farms for meeting national and global biodiversity targets; Sustainable Forest Management, Program on Forests, Biodiversity and Climate Change;
  - BMUB-IKI (Development of sustainable forestry models & links to private finance for secondary forests
  - 2017-2019 euros 1.9 million Guatemala, El Salvador, Honduras, Costa Rica
- **Partners:** CATIE, ICRAF
- FP4-CoA3, FP3-CoAs1-3
- Links to FP5
-
- **Theme. Title: Diversification of shaded cocoa and coffee smallholder systems**
- **Projects:**
  - PROCAGICA (Programa Centroamericano de Gestión Integral de la Roya del Café (Central American Coffee Leaf-Rust Project);
  - STRADIV (Multi stakeholder design of coffee agro-ecological systems in Nicaragua);
  - FORECAST (Towards multi-functional, sustainable and connected rural territories, relying upon the multi-functionality of agriculture);
- **Partners:** IICA (Instituto Interamericano de Cooperación para la Agricultura), ICRAF, CIRAD
- FP4-CoA3
- **Links** to FP2-CoA3
-
- **Theme: Governance and Capacity building in the NHSL**
  - Dialog platform between science-development-policy-development stakeholders in Nicaragua
- **Partners:** ICRAF, CIAT, CIRAD, CONICYT-Vice Presidency Government of Nicaragua, CEN (Centro de Entendimimento con la Naturaleza, MARENA (Ministerio de Ambiente y Recursos Naturales), INTA (Instituto Nacional de Tecnología Agropecuaria), Red GESCOM (Gestión del Conocimiento), NITLAPAN, UNA (Universidad Nacional Agraria, Nicaragua), UCA (Universidad CentroAmericana, Nicaragua)
- FP4-CoA1
- **Links** to FP5, FP2

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Initiative 20x20

Bringing **20 million** hectares of degraded land in Latin America & the Caribbean into restoration by **2020**

http://www.wri.org/news/2014/12/release-latin-american-and-caribbean-countries-and-regional-programs-launch-initiative

CIAT

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WORLD RESOURCES INSTITUTE

IUCN

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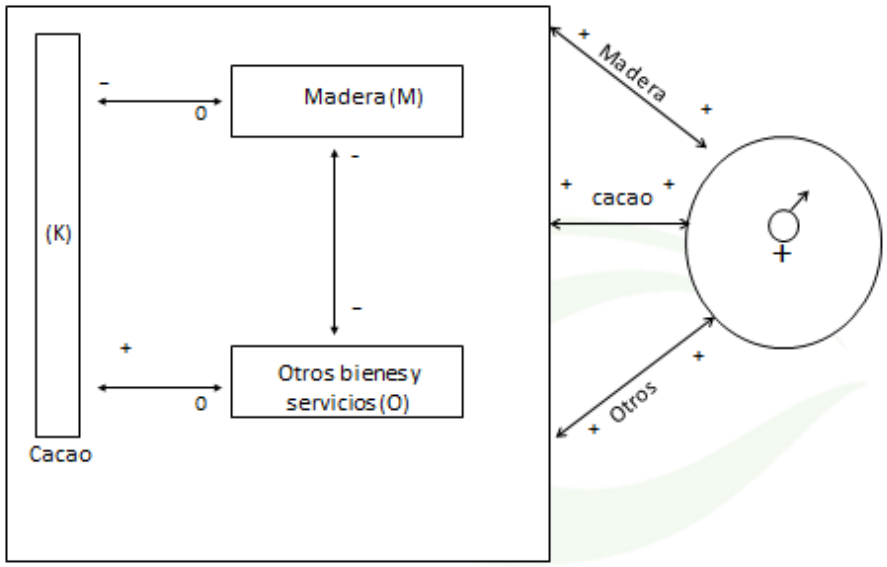
On-going research…on shaded cocoa and coffee agroforestry systems

Optimizing cocoa shade canopies for multiple objectives

Can we design and manage cocoa shade canopies to simultaneously conserve biodiversity, attain high cocoa yields and mitigate/adapt to climate change?

Plantación



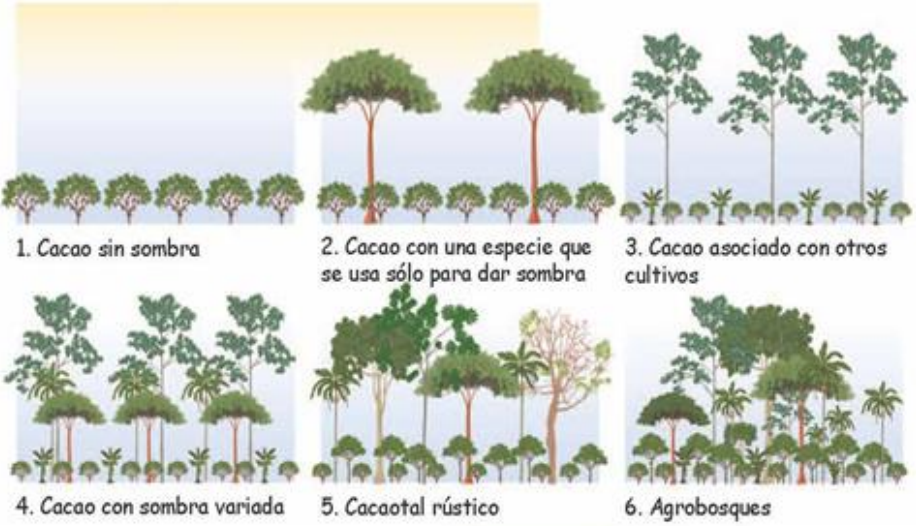
Methodology: how to analyze and design improved shade canopies for cocoa?

1. Determine **farmers' objectives**
2. Evaluate **plantation status**
   1. Self-shading: age, spacing, variety, pruning
   2. Crop phenology
   3. Canopy cover spatial homogeneity
3. Evaluate **site conditions**
   1. Soil fertility and water availability
   2. Latitude, exposure, slopes
   3. Nearby vegetation – lateral shade
   4. Wind, clouds
4. Evaluate **tree species**
   1. Use
   2. Crown characteristics: diameter, density, phenology
   3. Tree height

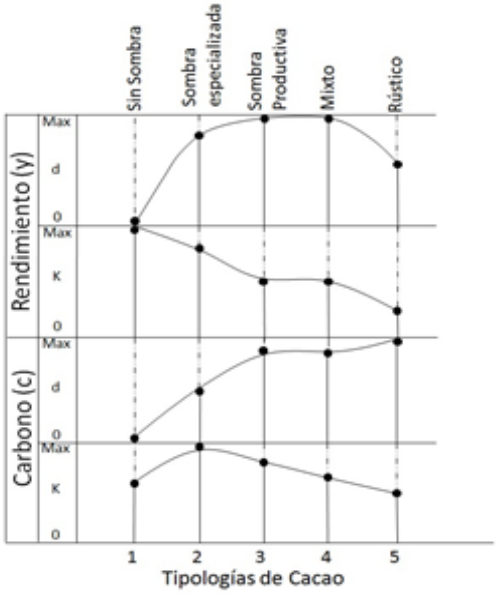
Elementos básicos del modelo de asignación competitiva del área basal de la plantación (ABCOMP)

- Zonificación ecológica del sitio de plantación determina el nivel máximo de biomasa, carbono o área basal alcanzable por la vegetación clímax local
- El cacaotal (o cualquier otro sistema agroforestal) alcanza un nivel de biomasa, carbono o área basal inferior al de la vegetación clímax. Apenas un 25% de la biomasa clímax.
- Diferentes tipologías retienen diferentes niveles máximos de biomasa, carbono o área basal compatibles con los objetivos de producción de la tipología
- El modelo ABCOMP permite analizar la forma de asignar el área basal de la plantación
  - Entre el cacao y el dosel de sombra
  - Entre diferentes grupos útiles de especies dentro del dosel.

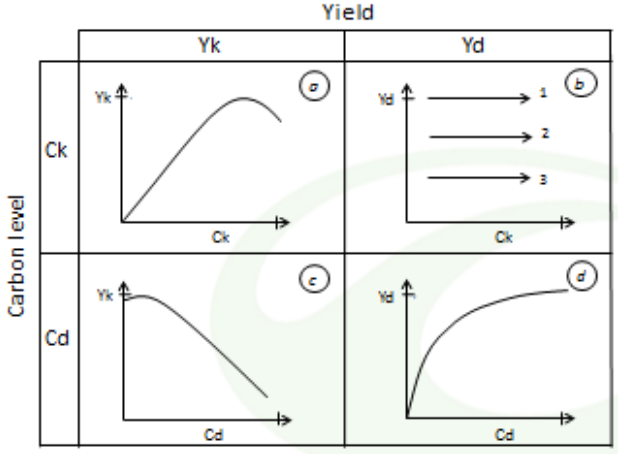
Tipologías cacaoteras



La distribución hipotética del carbono de la plantación entre el cacao y el dosel de sombra y sus efectos sobre los rendimientos del cacao y del dosel.



Need to look at the qualitative relationships between levels of stored C in vegetation (shade canopy –Ck- and cocoa trees Cd) and yields of cocoa (Yk) and shade canopy (Yd)

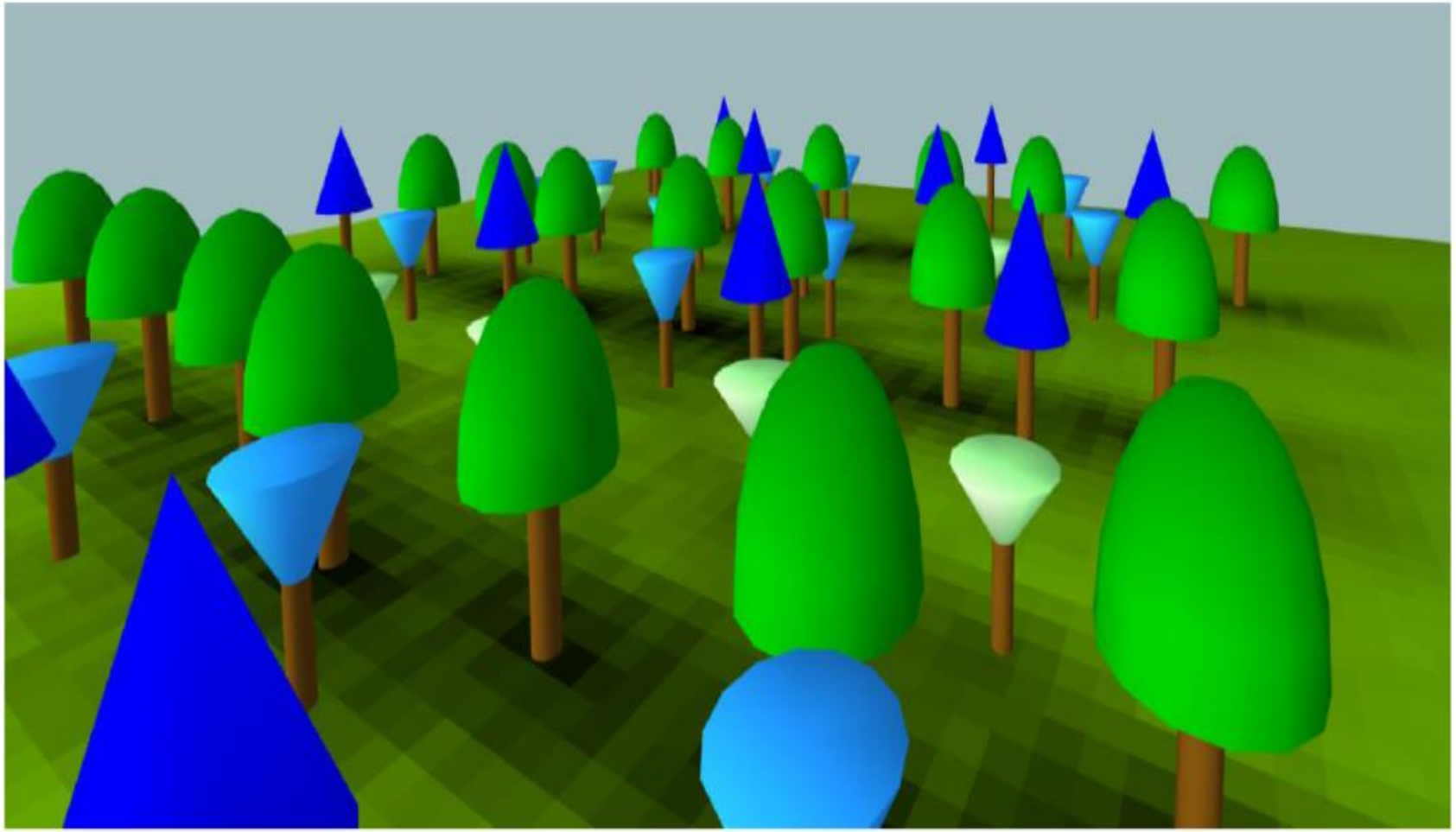


Rasgos funcionales de los árboles del dosel y optimización del diseño y manejo

- Árboles altos "tipo sequoia" almacenan mas carbono que árboles pequeños
- Árboles altos producen "una sombra rala" buena para lograr altos rendimientos de cacao
- Especies con hojas pequeñas y caducifolia permiten la entrada de radiación solar al cultivo y mejora los rendimientos
- Especies con sistemas radiculares profundos y masivos que acumulen mucho carbono muy estable en el tiempo y que no aumente competencia radicular con los cultivos asociados
- Especies con fenología revertida.....

TUTORIAL DE SHADEMOTION 4.0

ShadeMotion 4.0 es una aplicación de software que calcula la cantidad de horas de sombra que se acumulan en cada "punto" (celdilla) de una parcela con árboles, durante períodos de tiempo de cualquier duración y en cualquier lugar de la Tierra.



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Rehabilitate, renovate the orchard at the same site, or plant a new one at another site ?

Eduardo Somarriba, Rolando Cerda, Olivier Deheuvels, Patrick Jagoret

ISCR 2017 Lima Peru

17 November 2017

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Tree crop plantations like milking cows, a planted forest or a industrial machine have a productive life cycle and eventually need to be replaced by a new one.

A central question is then when and how to replace it!...

Four steps

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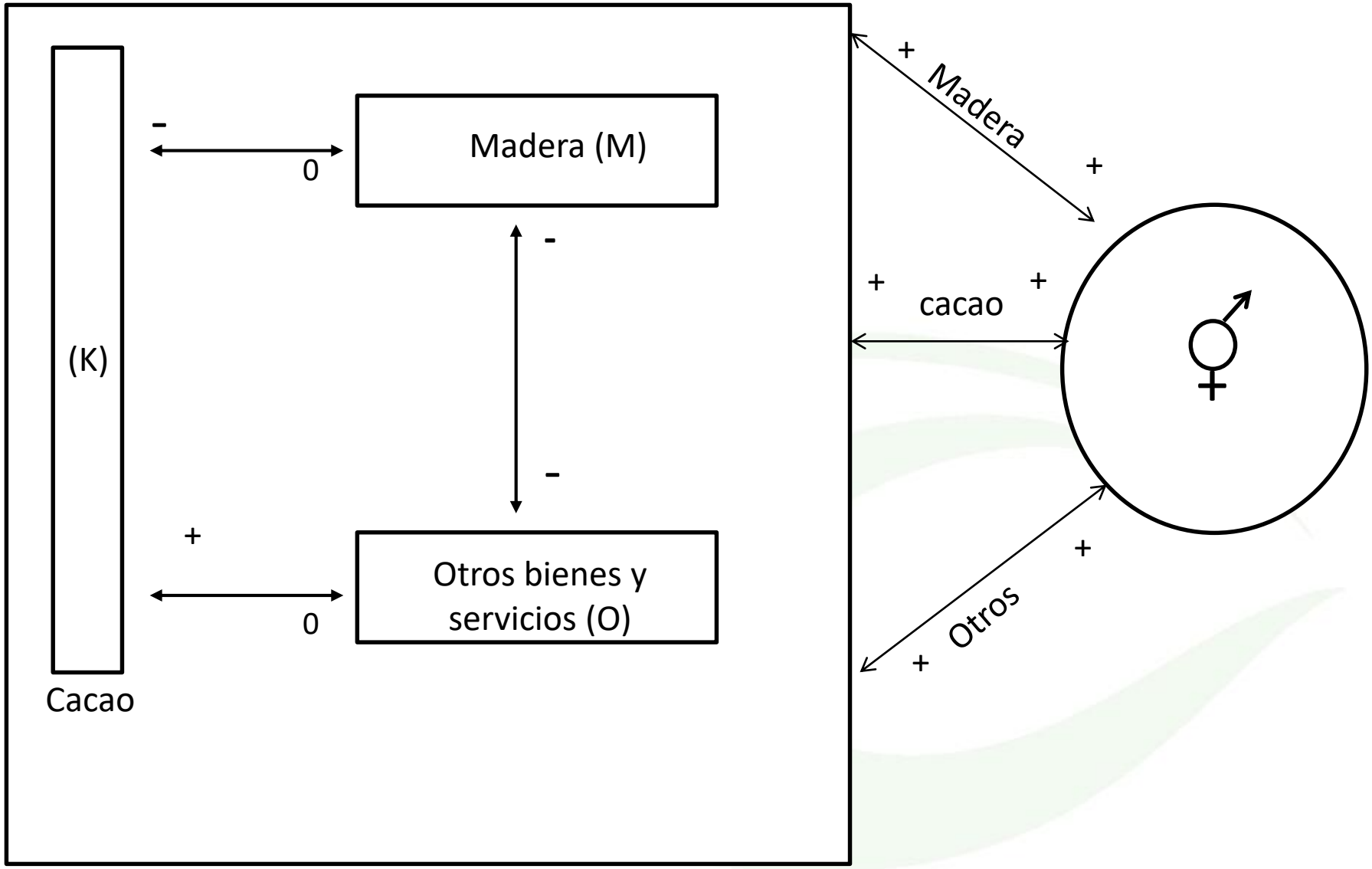
First, optimal design of the cropping system is required

Plantación


(K)
Cacao
-
0
Madera (M)
-
-
+
0
Otros bienes y servicios (O)
+ Madera +
+ cacao +
+
+ Otros

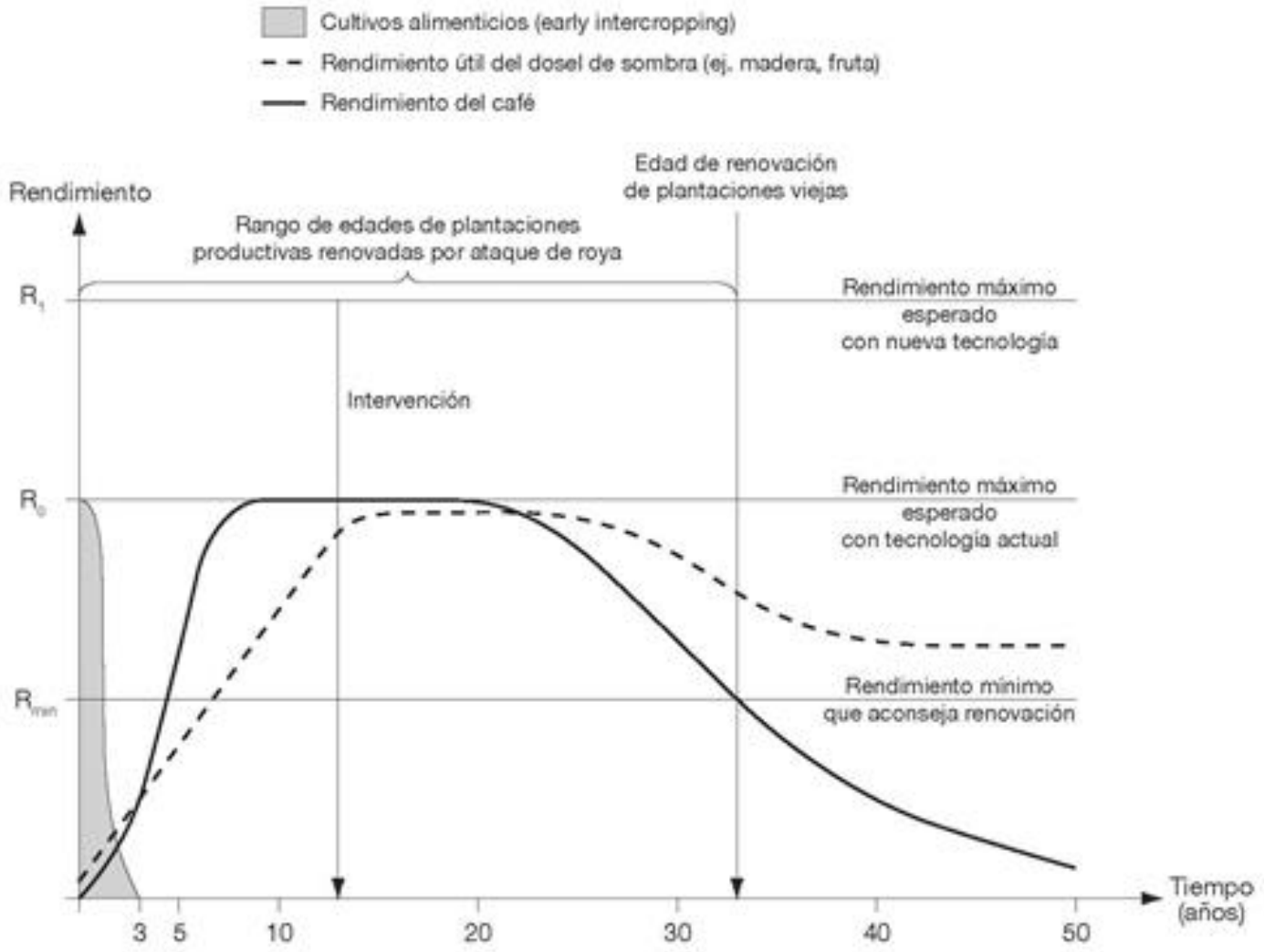

Cocoa monocrop, no
shade, Ecuador


Cocoa-timber, Terminalia ivorensis
plantada, Jesús Sánchez, FHIA,
Honduras


Cocoa-coconuts Jamaica

Mixed shade Systems, Costa Rica, Deheuvels et al 2011

Second, we quantify the yields of the various component of the cropping system over its life cycle


Cultivos alimenticios (early intercropping)
Rendimiento útil del dosel de sombra (ej. madera, fruta)
Rendimiento del café
Rendimiento
Edad de renovación
de plantaciones viejas
Rango de edades de plantaciones
productivas renovadas por ataque de roya
R1
Rendimiento máximo
esperado
con nueva tecnología
Intervención
R0
Rendimiento máximo
esperado
con tecnología actual
Rmin
Rendimiento mínimo
que aconseja renovación
Tiempo
(años)
3
5
10
20
30
40
50

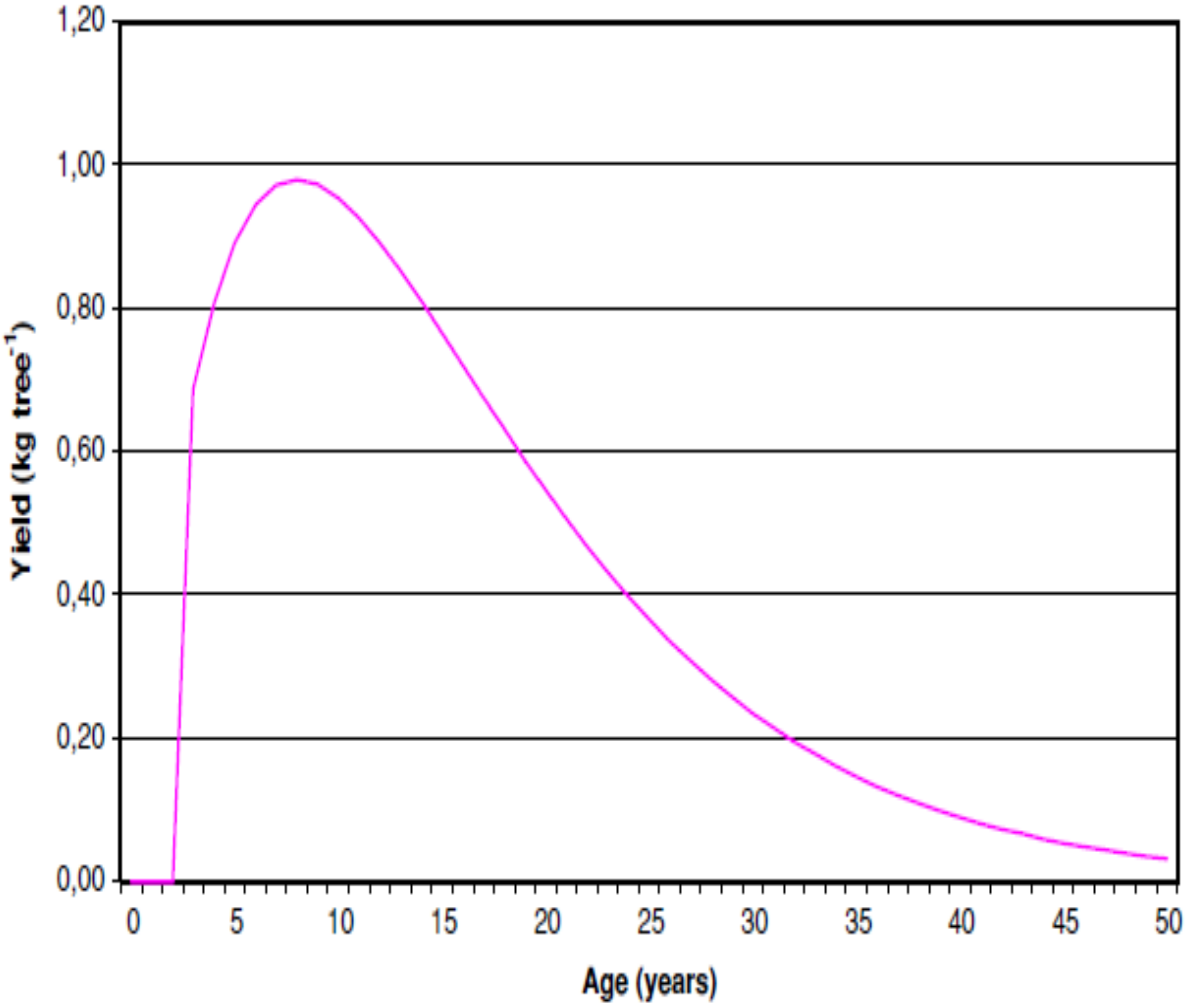
Yield (kg/ha) = (kg/tree) * (trees/ha)

Both the yield per tree (y) and the number of trees per hectare (n) vary with plantation age (t)

$$R(t) = y(t)*n(t)$$

The actual shape and maximum height of the yield curve depends on site quality (soil fertility, water supply, crop management, etc.)

Fig. 1 Cocoa yield curve over a 50-year period based on Eq. 2: $C = e^{(-1.1+\ln(A)-0.125A)}$ where C = cocoa yield and A = age



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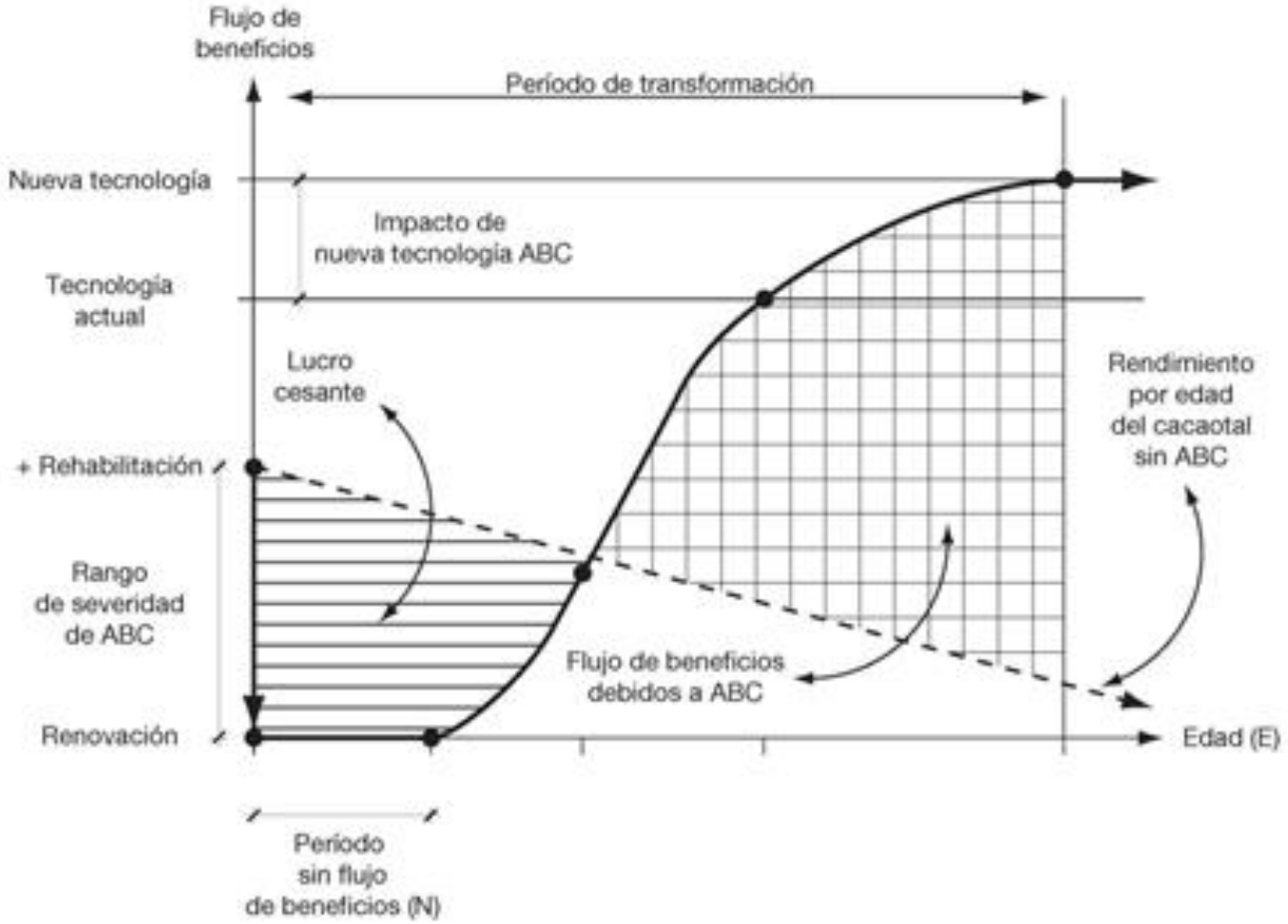
The evolution of population density over time….n(t)

Age-dependent annual mortality rate for cocoa

- Typically between 0.5 2.0% (discount compound rate)
- $n(t) = n(0)*(1+r)^{-t}$
  - n(0) is the initial planting density of cocoa plantación
- N(0) differs depending on the cocoa plantation System
  - State plantation system (America) typically <1000 trees/ha
  - Peasant system (Africa) typically >2000 trees/ha

Third, we assess the consequences of renovating the agroecosystem at different points in its life cycle



ABC = rehabilitación = acondicionamiento de un cafetal existente, renovación = nuevo cafetal en el mismo sitio, fomento = nuevo cafetal en otro sitio

Four, we use an analytical tool to assess when it is best to replace the cocoa/coffee plantation

Asset replacement principles

- The basic marginal principle is to compare gains from keeping the current asset for another time interval with the average OPPORTUNITY gains which could be realized from a replacement asset during the same period
- A common goal: maximize the net present value of the entire flow of future stream of residual earnings from the productive process associated with the asset
- Challengers, Defenders, compounded interest rates (Amer J Agric Econ 54(1):60-67. 1972)

$$(4.2) \qquad R(s) + M'(s) = \frac{\rho}{1 - e^{-\rho s}} V(s)$$

where

$$V(s) = \int_0^s R(t) e^{-\rho t} dt + M(s) - M(o).$$

Renovation strategies and practices

- Two basic models…influence on cash flows
  - Total renovation at optimal renovation age
  - Partial renovation (staggered)…for instance, a fraction of the entire plantation is renovated every year
- Renovation practices
  - Old cocoa stand use as temporary shade for new stand…also generates income while new stand is developing
  - Inter-cropping and productive shade
  - Numerous husbandry practices: stumping, pruning, grafting, etc.

Final considerations

- Continuous replanting and rejuvention practices not usually considered when modelling yield-age curves
- Variations in planting density, mortality rates and age-density-yield interactions not properly considered
- Revenues from early inter-cropping and shade trees (fruit, timber, etc.) usually not considered in optimization exercises….an AGROFORESTRY approach to renovation is absent in current practice


Thank you