Integrating sustainable cattle ranching, forestry and landscape restoration into intensive silvopastoral systems

Zoraida Calle¹, Enrique Murgueitio¹, Julián Chará¹, Andrés Felipe Zuluaga², Fernando Uribe¹, Adolfo Galindo¹, Luis H. Solarte¹, Alicia Calle³

¹ CIPAV - Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria. Cali, Colombia.
² Fedegán – Federación Colombiana de Ganaderos
³ ELTI, Yale School of Forestry & Environmental Studies and Smithsonian Tropical Research Institute
Cattle ranching often involves a very low density of cattle grazing in degraded pastures that resemble biological deserts.

FAO, 2006, 2009; Steinfeld et al., 2006; Boucher et al., 2012
Cattle ranching is the main current land use

550 million hectares in Latin America

In Latin America, cattle ranching activities have expanded mostly at the expense of forests.

FAO, 2002; IGAC 2002
Cattle ranching, a leading driver of:

**Land degradation:** a loss of potential resources through:
- Soil erosion
- Deterioration of the physical, chemical and biological soil properties
- Deforestation and long term loss of natural vegetation

*(Steinfeld et al., 2006)*

**Land use change is the main cause of biodiversity loss**
*(Millenium Ecosystem Assessment, 2005)*

**Altered water cycles:**
- Reduced infiltration and water storage
- Increased runoff

*(Ward & Robinson, 2000)*

**Greenhouse gas emissions that contribute to climate change**
*(Steinfeld et al., 2006)*

The livestock sector: a leading driver of deforestation, land degradation, pollution, climate change, the sedimentation of coastal areas and invasions by alien species *(FAO and LEAD, 2006)*
Land use efficiency?

- Average annual per hectare stocking rate: 0.59 animals

- Average annual per hectare productivity:
  - 19.9 kg of beef
  - 89.7 L of milk

- Minimum animal loads
- Low per animal and per hectare production indexes
- Meager contributions to rural employment

Los Santos province, Arco Seco region, Panama
Photo: Fernando Uribe

FAO, 2006
Cattle ranching can be:

- Conventionally managed in treeless pastures: a driver of ecosystem degradation
- Sustainably managed with silvopastoral systems: Tool for rehabilitating degraded lands.
- Silvopastoral systems integrated with connectivity corridors and protected areas: Part of a strategy for the ecological restoration of agricultural landscapes.
Cattle ranching is not likely to decline any time soon in Latin America!

1. A large and growing demand exists for all cattle products.
2. This activity is deeply rooted in the Spanish and Portuguese ancestry of the region.
3. It has often been a reaction to agricultural failures that result from biophysical constraints.
4. It has become instrumental as a means to consolidate land control.
Environmental transformation of livestock production: a priority for Latin America

Cattle production needs to shift from its current path of degradation of the natural and social capitals, onto one which generates goods (milk, meat, and timber) while maintaining some ecosystem attributes and services.
This change should consist of 4 basic elements:

1. **Increasing plant biomass and diversity**
2. Curbing soil degradation and promoting its recovery
3. Protecting water sources and using them rationally
4. Increasing animal productivity on a per hectare basis.
Rehabilitation of cattle ranching lands must:

1. Increase productivity and profitability of the production system
2. Enhance the generation of environmental goods and services.
3. Facilitate the release of fragile, marginal and strategic areas for ecological restoration.
Silvopastoral Systems - SPS

- Agroforestry arrangements that combine fodder plants, such as grasses and leguminous herbs, with shrubs and trees for animal nutrition and complementary uses.

Pezo & Ibrahim, 1998; Harvey 2004
Four silvopastoral systems

Scattered trees in pastureland

Living fence

Intensive silvopastoral system

Mixed fodder bank (cut-and-carry system)
Intensive silvopastoral system ISS

A system that can be directly grazed by livestock. It combines:

- *Fodder shrubs* planted at high densities (>10,000 plants ha⁻¹), intercropped with

- 500 timber trees planted in east-west lines to minimize shading.

*Murgueitio et al., 2011*
What is *intensive* about ISS?

Efficiency of biological processes:

- Photosynthesis & biomass production
- Nitrogen fixation
- Solubilization of soil phosphorus and other nutrients
- Organic matter and soil biological activity

The “inputs” of the system are the natural processes themselves.
The key to successful ISS is the adequate selection of the species, particularly the fodder shrub that is the backbone of the system.

Two species have shown the best results:

- Mexican sunflower *Tithonia diversifolia* Helms
- and in particular *leucaena* *Leucaena leucocephala* (Lam.) de Wit
**Leucaena leucocephala** (Lam.) de Wit
Well adapted to periodic cattle browsing

- Efficient nitrogen fixer that makes N readily available to neighboring plants.
- Associates well with grasses.
- **Avidly consumed by cattle** but elastic enough to withstand repeated browsing.
- **Regrows rapidly and vigorously**
- Conserves soil moisture and extracts nutrients from deep layers not available to other legumes.
- Litter decomposes rapidly.
- **Provides much higher levels of energy, protein and minerals than do improved grasses.**

Shelton & Brewbaker, 1994; Hughes, 1998; Calle *et al.*, 2011
<table>
<thead>
<tr>
<th>Lucerna Farm</th>
<th>1990 Star grass monoculture</th>
<th>2011 Intensive SPS (30,000 <em>Leucaena</em> ha$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical fertilizer</td>
<td>450-500 kg urea ha$^{-1}$ yr$^{-1}$</td>
<td>No fertilizer!</td>
</tr>
<tr>
<td>Animal load</td>
<td>3.5 cows ha$^{-1}$</td>
<td>4.5 cows ha$^{-1}$</td>
</tr>
<tr>
<td>Milk production</td>
<td>9000 L ha$^{-1}$ yr$^{-1}$</td>
<td>15,000 L ha$^{-1}$ yr$^{-1}$</td>
</tr>
</tbody>
</table>
Maximum biomass production is not achieved in treeless grass monocultures but in agroforests combining pastures, trees and shrubs.
Regional Integrated Silvopastoral Approaches to Ecosystem Management (RISAEM) Project, 2002-2007

La Vieja river basin, Colombia

- 20-24° C
- 990 - 1800 m.a.s.l.
Ant species richness at La Vieja landscape

68,860 individuals; 232 ant species

Rivera, Armbrecht & Calle (submitted to Agr. Ecosys. & Env.)
Tree cover vs. ant species richness

* Spearman $\rho = 0.75$, N=7, p<0.005
Biodiversity

- Increased plant and animal diversity: 54%
- More sightings of small wild mammals in pastures: 36%
- More sightings of animals in forests and riparian corridors: 32%
- Increased regeneration of rare species: 25%
- Increased use of native species for reforestation: 50%
- Increased tree regeneration in pastures: 50%
- Higher tree diversity: 54%
- Increased sightings of endangered or rare species: 11%
- Enhanced pest control resulting from higher biodiversity: 21%

Vegetation

- Reduced pressure on forests: 14%
- More variety of plant species for animal nutrition: 21%

_**RISAEM Project**_

Farmers’ perceptions on the benefits of the adopted silvopastoral systems
Silvopastoral systems as a landscape matrix at El Chaco Farm, Piedras, Tolima

Riparian buffer and secondary forest

Rice monoculture matrix

Silvopastoral matrix

Silvopastoral matrix

Rice monoculture matrix
Silvopastures enhance landscape connectivity
Mainstreaming Biodiversity into Sustainable Cattle Ranching Project
Connectivity corridors – MBSCR Project

- Core strip (10 m wide)
  - Natural ecosystem fragments
  - Forest restoration

- Buffer strips (25 m wide)
  - Natural ecosystem fragments
  - Scattered trees
  - Intensive silvopastoral systems
  - Live fences
  - Wind breaks

Payment for land uses sufficiently compatible with conservation

Only farmers that commit to strict conservation receive payment
Reference agroecosystem:
Silvopastoral systems at El Hatico reserve
El Cerrito, Valle del Cauca, Colombia

Pioneered the use of silvopastoral systems in Colombia in the 1970s.
1970s:
• Low tree cover: < 10 trees ha\(^{-1}\)
• Herbicides, irrigation and chemical fertilizers

Currently:
• 70 tree species in silvopastures
• Certified organic milk

Transformation of a conventional farm
Silvopastoral systems: a complex and wildlife-friendly matrix

**Palms** Syagrus zancona, Attalea butyracea, and Roystonea regia and **timber trees** Swietenia macrophylla, Cedrela odorata, Zanthoxylum rhoifolium.

**Large trees** Ceiba pentandra, Samanea saman, Enterolobium cyclocarpum at low density

**Medium sized trees** Prosopis juliflora, Senna spectabilis, Guazuma ulmifolia, Guarea guidonia, 30-50 ha⁻¹

**Leucaena** 10,000-15,000 shrubs ha⁻¹

**Creeping grass cover** Cynodon plectostachys, Panicum maximum, Cynodon dactylon and Paspalum notatum
Change in milk production and its relation to the expansion of intensive silvopastoral systems at El Hatico reserve
More milk, higher quality

Milk production

- 1996: 7,436 liters
- 2003: 18,486 liters

Protein

- 1996: 2,5 tons
- 2003: 4,1 tons

Metabolizable energy

- 1996: 56,876 Mcal
- 2003: 70,222 Mcal

Calcium

- 1996: 20 kg
- 2003: 40 kg

More milk, higher quality
Milk production at El Hatico farm (2008-2012)

Rainfall (mm month-1)  
Average daily milk production

0  2  4  6  8  10  12

El Niño  La Niña  El Niño

2008  2009  2010  2011  2012

Monthly rainfall (mm)

0  2  4  6  8  10  12  14

Daily milk production cow-1

Milk production at El Hatico farm (2008-2012)
Soil organic matter (%) in ISPS, conventional pasture and forest at El Hatico

Organic matter (%) in ISPS, conventional pasture and forest at El Hatico

- ISPS (< 5 yrs)
- ISPS (5-10 yrs)
- ISPS (>10 yrs)
- Treeless pasture
- Forest

Baseline (1994): 2.9%

2010-2012:
- 4.9% under tree crown
- 4.6% ISPS (5-10 yrs)
- 4.4% ISPS (>10 yrs)
- 4.3% forest

Vallejo 2012, El Hatico
Lands degraded by cotton monoculture

Rehabilitation with silvopastoral systems

Cesar river valley, Colombia

Caribbean region
Rainfall: 1000-1200 mm
Monomodal regime, few rain events
Biomass production
January, 2006
August, 2006
First grazing

April 2006
January 2007

Animal body condition

Carrying capacity and productivity

1.2 large animals
1.7 L milk cow\(^{-1}\) day\(^{-1}\)

5.1 large animals
4.1 L milk cow\(^{-1}\) day\(^{-1}\)
Land area required to produce 1 ton of beef yr\(^{-1}\) in the dry Caribbean region of Colombia (ha)

“Improved pastures” are conventionally managed with herbicides, irrigation and chemical fertilizers.
Temperature variation in treeless pastures and intensive silvopastoral systems ISPS during the driest months of 2007 in the Colombian dry Caribbean region

Climate change adaptation:
Silvopastoral systems are 12° C cooler!


Lopera, Cuartas & Murgueitio, 2008
A win-win situation
The productive advantages that make SPS attractive for landowners ultimately originate from the environmental benefits they provide.
Silvopastoral system with *Cordia gerascasthus*
Outstanding native tree: *Mimosa trianæae* Benth

- Collected only 8 times since 1856
- Endemic and highly vulnerable
- Excellent performance in silvopastoral systems
Caryodendron orinocense H. Karst. Euphorbiaceae

The Colombian nut: inchi or cacay
Caesalpinia ebano FABACEAE

EN; Endemic from Colombian Caribbean region
In summary, we propose that

- The mainstreaming of silvopastoral systems in degraded tropical landscapes can simultaneously address environmental and productive issues, making cattle ranching part of the solution rather than the problem.
Native trees and shrubs for the productive rehabilitation of tropical cattle ranching lands

Enrique Murgueitio¹, Zoraida Calle¹,*; Fernando Uribe¹; Alicia Calle²; Baldomero Solorio³

Unasylva 239, vol 63, 2012

Integrating forestry, sustainable cattle-ranching and landscape restoration

Z. Calle, E. Murgueitio and J. Chará

Journal of Sustainable Forestry (in press)

A Strategy for Scaling-up Intensive Silvopastoral Systems in Colombia

ZORaida Calle¹, EnriQue Murgueitio¹, JulIán CHARÁ¹, Carlos Hernando Molina¹, 4, Andrés felipe Zuluaga², Alicia Calle³
Colciencias, Ministerio de Agricultura y Desarrollo Rural (Colombia), TWB, GEF, TNC, Fedegán

Researchers: Inge Armbrecht, Leonardo Rivera (Universidad del Valle); Carlos Hernando Molina and Enrique José Molina (El Hatico and CIPAV); Victoria Vallejo; John Jairo Lopera (CIPAV)

Cattle ranchers: Olimpo Montes, Molina Durán family, Roberto Mejía

¡Gracias!

zoraida@cipav.org.co