Reconciling Conservation and Development: A Hotelling Model of Extractive Reserves

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The Amazon Region 1

- The Amazon forests constitute one of the main global strategic ecosystems due to its variety of species and its potential role related to climate change.

- The Amazon basin is the largest piece of contiguous tropical forest left in the world. The so-called “Legal Amazonia” in Brazil comprises about 5 million of square kilometres, more than half of the national territory.

- In the Brazilian Amazon, 70% is continuous forest domain and almost 85% of its original cover is still intact.

The Amazon Region 2

- In the 1960s, the military government decided to implement a wide development programme based on infrastructure building and incentives for settlement initiatives.
- Around 60,000 kilometres of roads, hydroelectric facilities, railways and ports were built.
- Billions of dollars of subsidised credit were conceded along with tax breaks and land concession to whom were willing to establish agricultural enterprises in the region.
- These initiatives have produced huge economic, demographic and ecological impacts.

Growth and Development

- Total population increased from 7.3 million in 1970 to 13.2 million in 1985. Real GDP jumped from US$ 2.2 billion to US$ 13.5 billion

- 33 million hectares of forests were converted into agricultural land. In the 1990s this pace of change seemed to continue.

- Land is extremely concentrated with 50% of the farmland in 1% of the properties. 90% of the agricultural land either has been abandoned for more than 4 years or transformed into pastureland. 40% of the pastureland has less than 0.5 cattle per hectare.

Sources of Deforestation

- Cattle ranching
- Agriculture
- Logging
- Mining
- Hydroelectric dams
- Property rights

Policy Problem

- Maintenance of biologically diverse ecosystems
- Land requirements and the opportunity costs of non-conversion

⇨ critical trade-off for developing countries with large forested areas

Land Use Constraints

- Forest code: Legal forest reserve
- Management plans
- National parks
- Indian reserves
- Biological reserves
- National Forests
- Extractive Reserves

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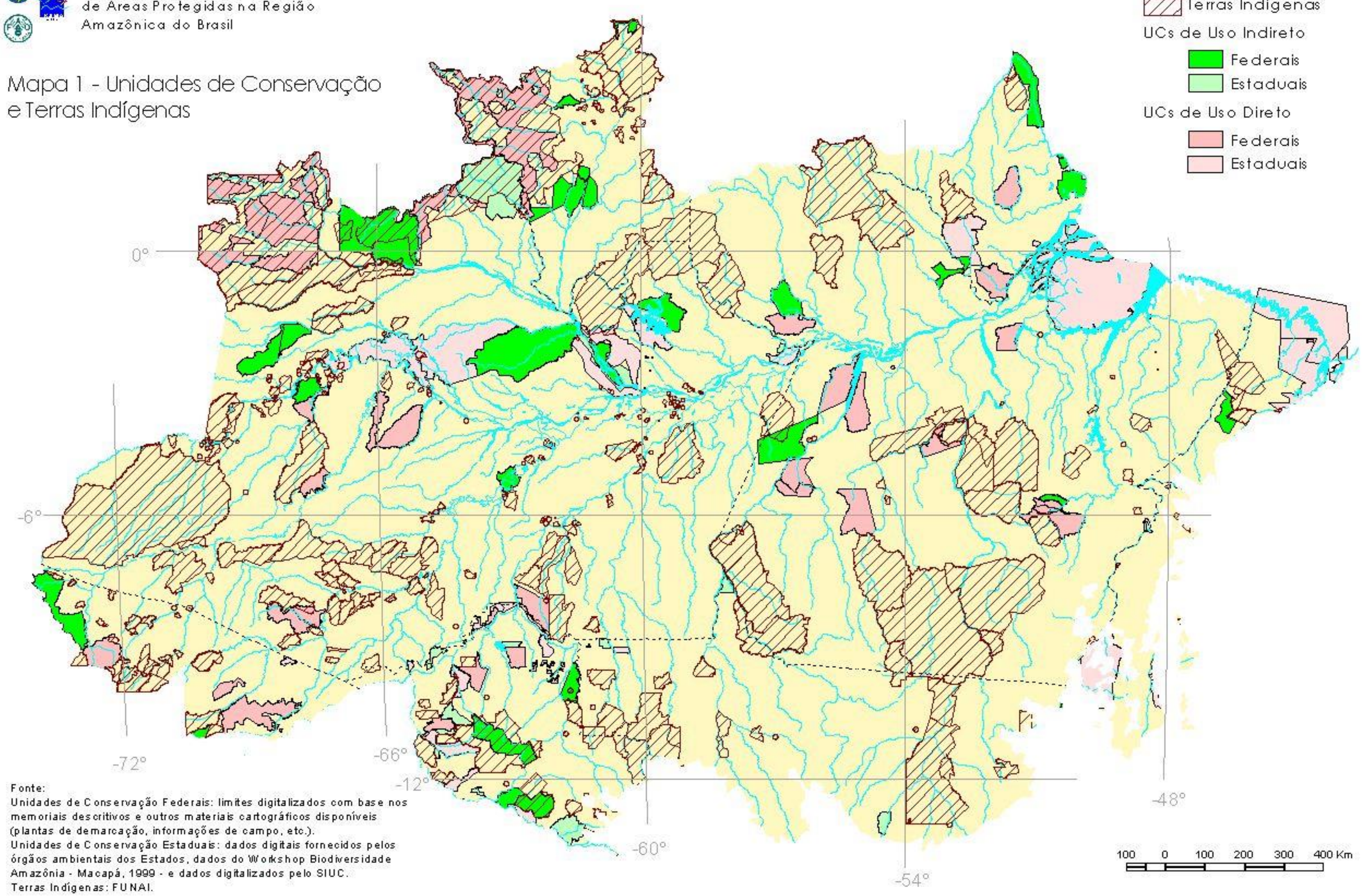
- ZEE x TDRs ?

Projeto Expansão e Consolidação de Áreas Protegidas na Região Amazônica do Brasil

Mapa 1 - Unidades de Conservação e Terras Indígenas



Fonte:
Unidades de Conservação Federais: limites digitalizados com base nos memoriais descritivos e outros materiais cartográficos disponíveis (plantas de demarcação, informações de campo, etc.).
Unidades de Conservação Estaduais: dados digitais fornecidos pelos órgãos ambientais dos Estados, dados do Workshop Biodiversidade Amazônia - Macapá, 1999 - e dados digitalizados pelo SIUC.
Terras Indígenas: FUNAI.

Extractive Reserves

- **Objective:**
  - conservation and development in territorial spaces of ecological and social importance
- **Approach**:
  - Property rights over land and biological capital stock held by the federal government.
  - Property rights over the flow of NWFP contracted out to indigenous community
  - Contract**:** Long-term concession under approved use plan

Origins and Current Status of ER

- Origins in rubber tapper movement
- Status:
  - 12 federal reserves across Amazon states
  - Area in 1995: 21,600 km^2
  - Population: 12,165
  - 30 % of income derived from extractive activities
- Prospects:Expansion under PPG-7, Brazilian Gov and World Bank projects.
- Attract significant interest from NGOs, governments and International Agencies

Extractive Reserves in the Amazon

Name / Federal Unit	Area (ha)	Population	Main Resources
Alto Jurua – AC	506,186	4,170	Rubber
Chico Mendes – AC	970,570	6,028	Nuts/Copaíba / Rubber
Alto Tarauacá – AC	151,199	-	-
Rio Cajari – AP	481,650	3,283	Nuts / Copaíba Oil / Rubber / Açaí Fruit
Rio Ouro Preto – RO	204,583	431	Nuts/ Copaíba Oil / Rubber
Lago do Cunia – RO	52,065	400	Fishery
Extremo Norte do Tocantins – TO	9,280	800	Babaçú Fruit / Fishery
Mata Grande – MA	10,450	500	Babaçú Fruit / Fishery
Quilombo do Frexal – MA	9,542	900	Babaçú Fruit / Fishery
Ciriaco – MA	7,050	1,150	Babaçú Fruit
Tapajos Arapiuns – PA	647,610	4,000	Rubber /Fishery / Oil and Resin
Medio Jurua – AM	253,226	700	Rubber / Fishery
Total	3,303,411	12,164	

Composition of Family Income Sources in Extractive Reserves 1993

Income Source	Extractive Reserves				
	Chico Mendes	Alto Jurua	Rio Ouro Preto	Rio Cajari	Average
Agriculture	47,12	36,08	26,43	43,06	43,06
Cattle /small animals	8,92	10,80	13,69	14,92	12,08
Hunting and fishery	5,78	32,52	8,92	9,66	14,22
Sub total	61,82	79,40	49,04	87,22	69,36
Extractive Products					
Rubber	29,56	20,60	50,96	0,76	25,57
Nuts	8,62	-	-	3,63	3,06
Palm heart - fruits	-	-	-	8,29	2,07
Sub-total	38,18	20,60	50,96	12,68	30,70
Total	100	100	100	100	100

Assessment of ER

- Highly ambiguous
- Key problem: Competition with plantations and quasi-plantations producing NWFP using preferred production conditions
- Common feature: Products produced using a biological capital stock

NWFP Competitors

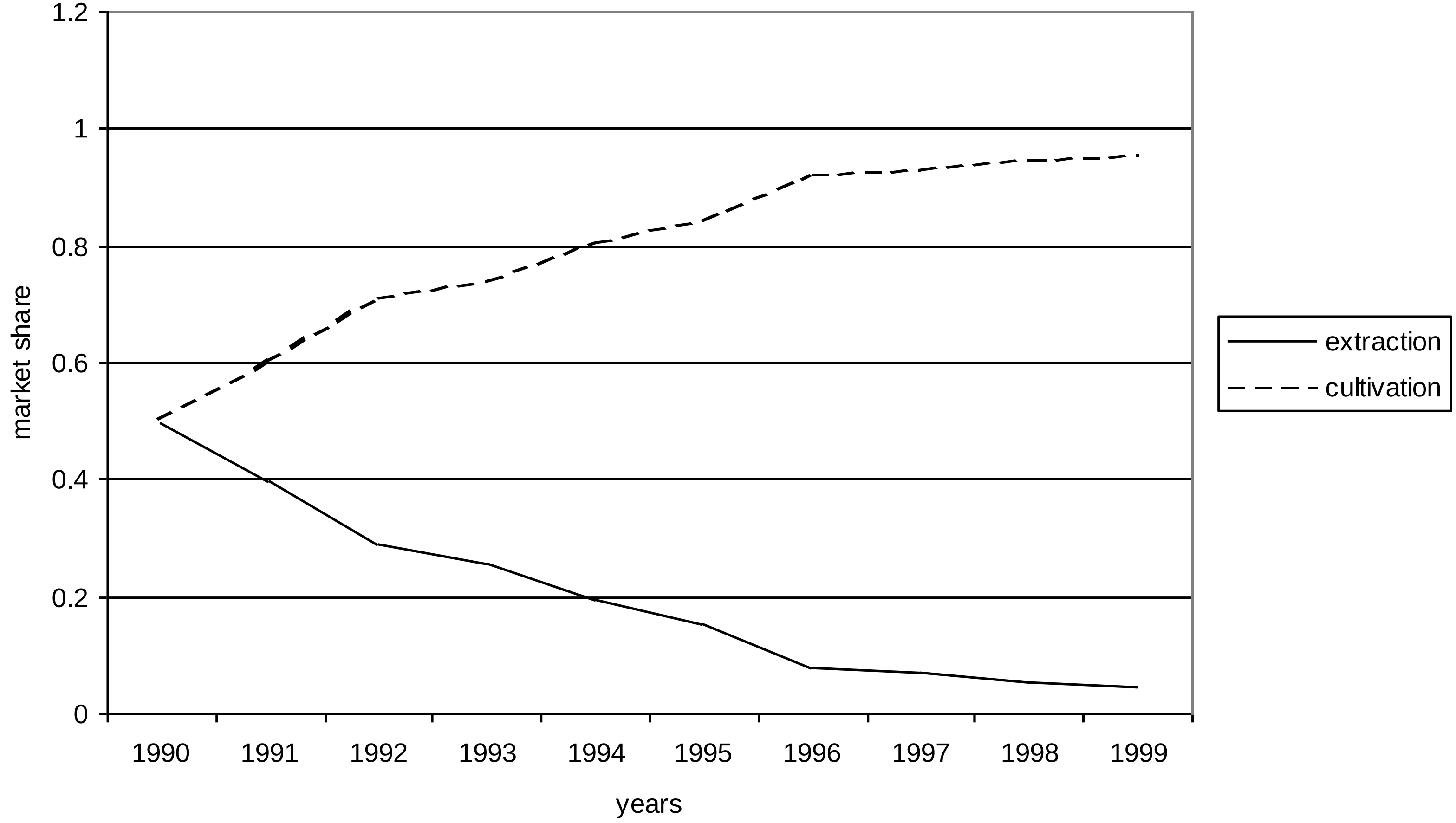
Plantation

- Owns all assets
- Free choice of technology
- Free choice of stock of biological/genetic capital
- Cost dynamics (technology vs. genetic depreciation)

Extractive Reserve

- Owns only outputs and non-biological inputs
- Restricted to technology approved under use plan
- Fixed biological/genetic capital stock
- No cost dynamics

Evidence



1.2
1
0.8
0.6
0.4
0.2
0
market share
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
years
extraction
cultivation

Can ER work in theory?

- Competition between highly heterogeneous producers
- Factors in favour of viable Extractive Reserves
  - Spatial aspects: market power
    Transportation costs, spatial differentiation
  - Intertemporal aspects: cost dynamics
    Yield loss dynamics, pesticides, fertilisers, genetic improvement
  - IO aspects: Vertical interactions with competitors
    Supply of germplasm to intensive production

Are these factors sufficient to generate long-run positive profits?

Model

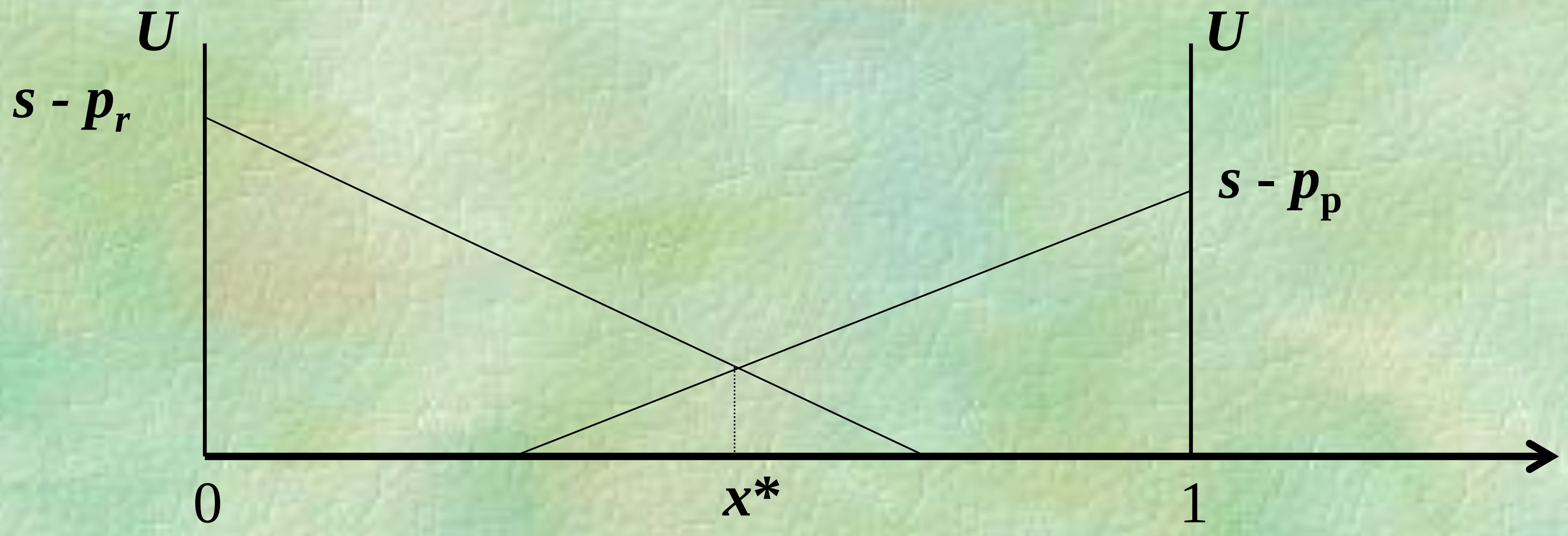
- Positive analysis
- Construct 'most favourable' scenario
  - Stylised model of spatial duopolistic competition between two heterogeneous competitors
  - Heterogenuous dynamics: One competitor features production cost dynamics of investment and depreciation of biological capital

  => Dynamic Hotelling model
- Assess long-term viability of an extractive reserve under this scenario

NWFP market interaction

- Fundamentals
  - Spatial factors
  - Heterogeneity of competitors
- Analytical approach
  - Stylised dynamic model of spatial competition
  - Dynamic Hotelling model with fixed location and cost heterogeneity

The Spatial Set Up



Market demand curves

- Standard Hotelling model with transportation cost τ

- For a competitor *R* charging price p_r and competitor *P* charging price p_p, demand curves (and market shares) are

$$D_r = x = \frac{p_p - p_r + \tau}{2\tau}$$

$$D_p = (1 - x) = \frac{p_r - p_p + \tau}{2\tau}$$

- In benchmark case of homogeneous competitors with cost $c_p = c_r$, we have identical positive profits.

Heterogeneous players I: The Plantation

$$Max \int_0^\infty e^{-\rho t} \pi_p \, dt$$

$$\text{with } \pi_p(t) = \underbrace{[p_p(t) - c_p(t)] D_p(t)}_{\text{Net revenue}} - \underbrace{b(t) I(t)}_{\substack{\text{Investment} \\ \text{expenditure}}}$$

subject to cost dynamics

$$\dot{c}_p(t) = \underbrace{D_p(t)}_{\substack{\text{Biological} \\ \text{Depreciation}}} - \frac{I(t)}{\underbrace{1 + I(t)}_{\substack{\text{Biological} \\ \text{Investment}}}} - \underbrace{K}_{\substack{\text{Exog.} \\ \text{technol.} \\ \text{progress}}}$$

Heterogeneous players II: The Reserve

- No cost dynamics
  - No biological depreciation
  - No technological progress
- Subsistence-style decision-makers
  - Instantaneous pay-off
- Decision criterion therefore

$$\max \pi_r = [p_r(t) - c_r(t)] D_r(t)$$

Long-run market outcomes

- Decision variables
  - Reserve: Gate price p_r
  - Plantation: Gate price p_p and investment I
- Key parameters:
  - Transport costs τ
  - Price of biological inputs b
  - Rate of exogenous technological progress K
  - Discount rate ρ
- Two scenarios regarding supply of biological resources
  - Third party supplies - horizontal interaction only – exogenous b
  - Reserve supplies - vertical interaction – endogenous b

Horizontal interaction only

Proposition I

If biological inputs are priced and relatively scarce ($b > K^2/\rho$), then the extractive reserve can sustain long-run positive profits.

Proposition II

If biological inputs are not priced or not relatively scarce ($b < b^*$) and initial production costs for plantations are high ($c^0_p > c_r + \mu - 3\tau$), then the extractive reserve can earn **interim** positive profits while c_p converges to limit price at which reserve exits.

Vertical and horizontal interaction

Reserve now maximises

$$\pi_r(t) = [p_r(t) - c_r]D_r(t) + \underbrace{b(t)I(t)}_{\text{Receipts from biological inputs}}$$

PROPOSITION III

If the rate of exogenous technological progress is low ($K < 0.25$), the reserve will make positive long-run profits on both the output and input market.

If the rate of technological progress is moderate ($0.25 < K < 0.5$), the reserve will make positive long-run profits on the input market only.

Is vertical interaction beneficial?

PROPOSITION IV:

Vertical interaction is not strictly improving reserve's welfare position.

Example:

If the plantation faced the optimal endogenous price chosen by the reserve as an exogenous price, and K=0.25, the reserve would be better off not interacting on the input market unless $\tau < 2/\rho$.

Reason: Price of output and input are strategic substitutes for reserve.

$$b(t) = \frac{2p_p(t) - p_r(t) - c_p(t) - \tau}{4}$$

Discussion

Under most favourable situation of a spatially differentiated duopoly, reserve generate long-run positive profits only if

- Rate of technological progress low
- Biological inputs are priced and relatively scarce, or if
- Reserve controls access to biological inputs.

Are these conditions approximated in reality?

- ‘Duopoly’
- Spatial differentiation
- Technological progress: Public R&D efforts
- Biological inputs: Absent property rights

Other alternatives?
Markets for new NWFP

- NWFP: Limited long-run revenue potential
- But evidence of short-run potential through temporary monopoly on NWFP market
- Can ER generate sequences of new NWFP?
  - locally abundant biological capital stock
  - Returns to product search?

Other alternatives?
Adding Value and Price Premium

- There have been several initiatives for creating value to products originated in the RESEX
- Examples:

1. *Couro Vegetal*
2. Green Label / Social Label

- Assessment: Early stages…

Development Pathways

Analysis suggests four possible pathways

(1) Continued production of existing NWFP

(3) Supply of biological inputs

(2) Discovery of new NWFP

(4) Value Creation

Questions:

1. Are they robust enough to generate long run profits for the reserve's dwelling?
2. Do they follow the original motivation for creating Resex?

Conclusions

- Four potential development pathways under ER framework
- Existing NWFP is theoretically viable only under highly restrictive conditions
- Conditions generally not fulfilled in reality
- Remaining pathways are highly uncertain
- Development objectives unlikely to be realised under given set of conditions.
- Other non-economic reasons might justify the existence of resex

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