

Land Use/Cover Change (and Carbon Dynamics) in an Expanding Frontier in Western Amazonia: Acre, Brazil

Foster Brown, Tom Stone and Alberto Setzer
Woods Hole Research Center (WHRC) and National Institute for Space Research (INPE)

Collaborators: Elsa Mendoza, Hiromi Sassagawa, Alejandro Fonseca Duarte, Monica De Los Rios, Kennedy Souza, Benedita Esteves, Andrea Alechandre, Eufraan do Amaral, Diogo Selhorst, Juari Silva, Marcos Silveira, José Augusto Rocha, Sumaia Vasconcelos, Rodrigo Serrano, Rodrigo Guedes, Cleber Salimon, Silvia Freitas, Kelma Araújo, Claudia Saldanha, Simone Vieira, Silvia Brilhante, Peter Schlesinger, Jorcinei Pereira, Ramene dos Santos, Antonio Willian F. de Melo, Judson Valentin, Elaine Prins, Eric Davidson, Dan Nepstad.

Sector of Land Use and Global Change Studies/UFAC

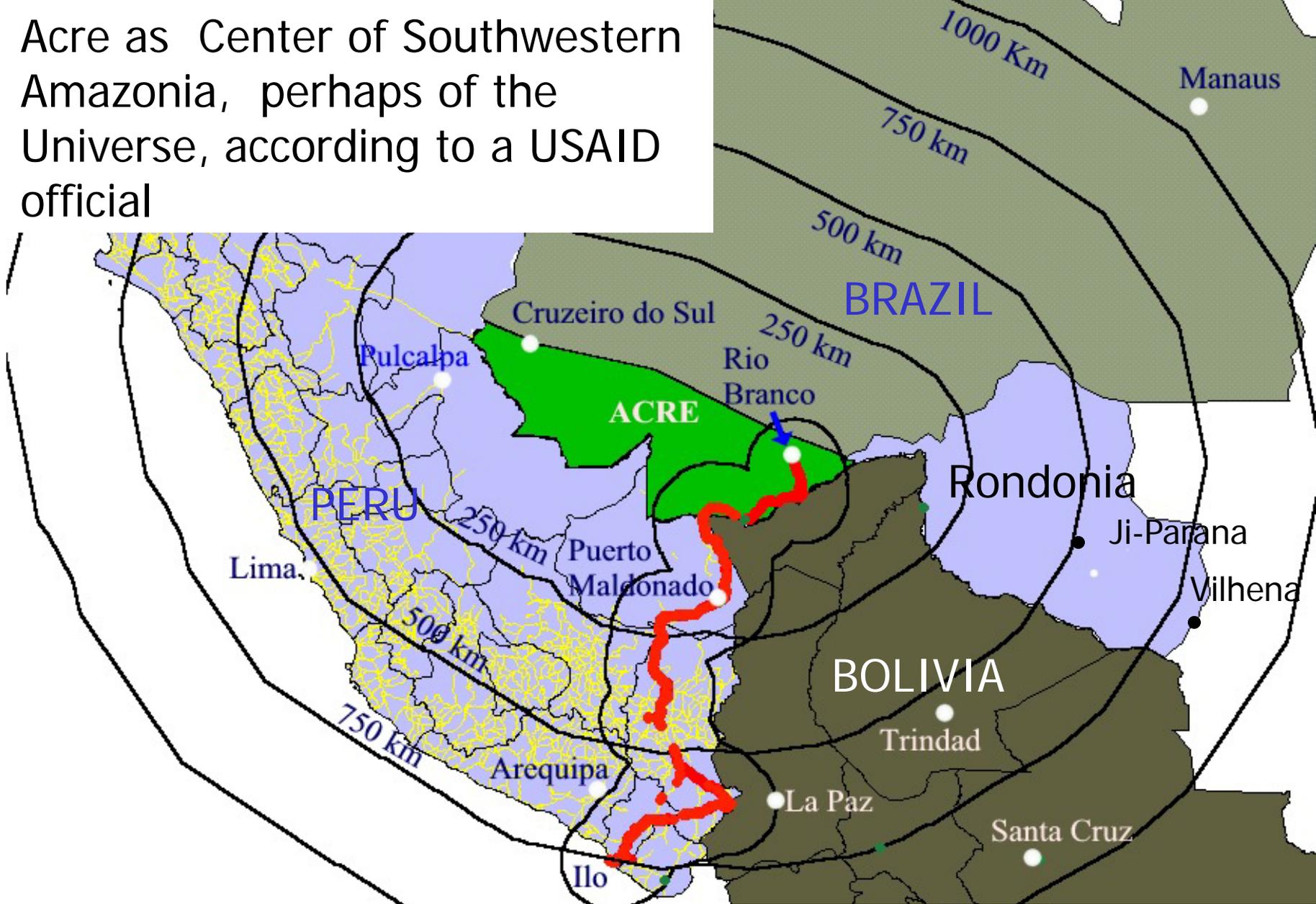




'End of the World'

**'To go to Acre' =
slang meaning 'to die'**

Acre as Center of Southwestern Amazonia, perhaps of the Universe, according to a USAID official



Within 750 km of Acre ~ 30 million persons live + access to Pacific Rim economies via 'Highway to the Pacific'

Structure of Presentation

- Context of LBA – Brazilian perspective
- Policy relevant results and education
 - Rates of forest conversion, logging
 - Burning
 - Scenarios and alternative land uses
 - Interacting with policy makers
 - New factors: migrations, road to the Pacific and building a LCLUC community in SW Amazonia (ASO 2030)

Components of Concise Plan: LCLUC-LBA/NASA

1. Rates and patterns of land conversion and abandonment
2. Selective logging
3. Plausible scenarios of future land cover change in Amazonia
4. Additional analysis to define the socioeconomic factors and conditions that are creating these changes.

Over-all goal: **Translate the results into a form useful for sustainable development policies in Amazonia.**

LBA Experiment in International Cooperation

- **Perception is reality.** Necessity to know each other's views of the world.
- Common perceptions in Brazil:
 - U.S., often called "The Empire," has world hegemony and seeks to consolidate it further.
 - NASA is a high tech spy for U.S. interests.
 - Collaborators may be acting against national interests (all my advisees have received such insinuations).

Steps to alter the perception

- 1996 - Brazilian Scientific Community requests changes in NASA research announcement for LBA: Education and capacity building must be integral part of NASA proposals.
- 1997 - Carlos Nobre expects that in 10 years 70% of the doctorates generated by LBA will be Amazonians, not just Brazilians.

Notable occurrences - I

- 1995 -- In welcoming remarks to LBA meeting in Manaus, the Director of INPA (National Institute for Amazonian Research) spoke harshly of INPA's experience with French and German collaborators (percent of Brazilian co-authors less than 10%) and listed 7 demands for collaboration with LBA, including training and transparency with funding.

Notable occurrences -II

1997 – **Biopiracy in Amazonia:** “...One of the principal forms of biopiracy is via international cooperation agreements... an example of this is the agreement between INPE, INPA and NASA... Via this agreement, baptized LBA, 300 foreign researchers will be coming to Brazil...On the Brazilian side there are no plans to have an equal number of counterparts. In other words, the foreigners will be free to to research whatever they want.” (Gazeta - Rio Branco 21/11/97, p. 12)

Postscript 2001 – Members of the national committee visited Santarem and found many U.S. scientists without counterparts present.

New ruling: U.S. scientists can only go to the field with Brazilian counterpart.

Related Problems

- First LBA-NRA was delayed several months.
- Second LBA-NRA also delayed and bridge funding now being used to maintain current projects functioning

MCT Analysis of LBA **participation** – Sept/01

“The participation of [Amazonian] research groups has not been integrated with - and is often marginal to - international and national groups...

...many times the Amazonian groups act as go-fers for those from international and national centers...demonstrating a clear hierarchy of partners.”

MCT Analysis of LBA Research Results – Sept/01

- "...Paradoxical as it may seem, LBA has made only a modest contribution to public policy for the Amazon Region..."
- **...The non-integration of knowledge generated in the region should be a serious concern for all those involved not only in LBA but also in all S&T programs in Amazonia..."**
- *Editorial of Folha Amazonica Sept 2001 –
General Coordinator of Amazonian Programs
– MCT, Isabel Canto*

Amazonian View of International Collaboration in LBA

- International and Intra-country domination
- Need to change
- Emphasis: Education, policy-relevant information, and integration.
- Metrics: number of Amazonians involved, co-authorship, examples of results affecting policy

Amazonian Participation in LCLUC-Acre

- 34 collaborators, 17 graduated or will graduate from Federal University of Acre (UFAC).
- 5 M.S. Students, all graduated from UFAC or student of UFAC.
- 3 Ph.D. Students, 2 from southern Brazil, one professor at UFAC.
- 5 contracted as research assistants via LBA.

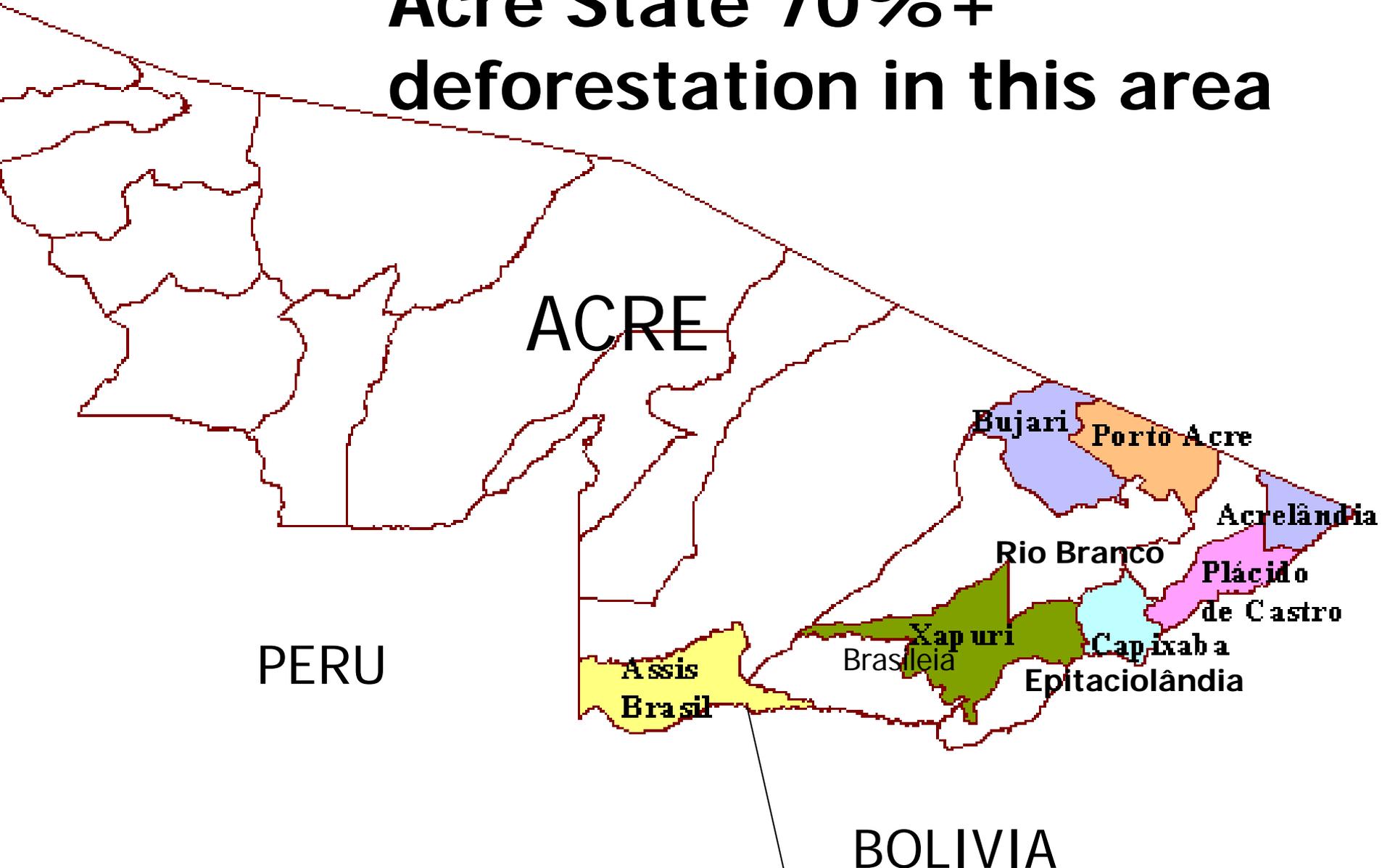
Regional integration of knowledge implies changing what are plausible scenarios

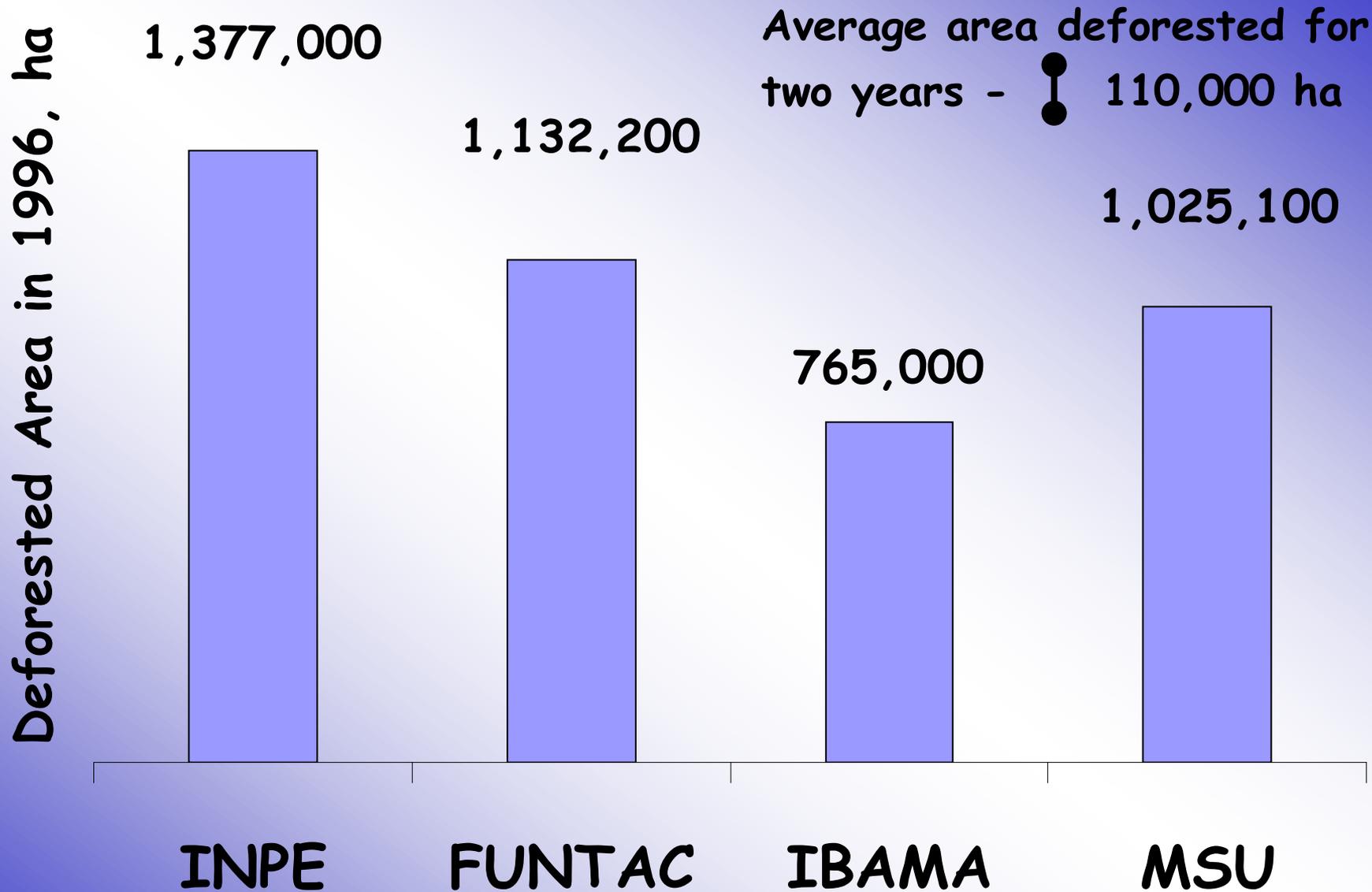
- Modeling must take into account public policy decisions, e.g. Avança Brasil, Pacific Highway
- Information feedback loop for changing public policy -- Paradigm shift from pure description to intervention component.
- In other words, research to make land use trajectories change

Rates of forest conversion

- Wide disparity among official estimates for the State of Acre
- For deforested area in 1996, differences between INPE, Funtac, IBAMA, MSU were equivalent to several years of deforestation.
- Public Policy implications – “Government of the Forest” of Acre requesting 250 million dollar loan from IDB, based on controlling deforestation and sustainable use of forests
- **Depending on what data and methods used, Government will ‘reforest’ state or be the worst deforester in Acre’s history**

Eastern Municipalities of Acre State 70%+ deforestation in this area





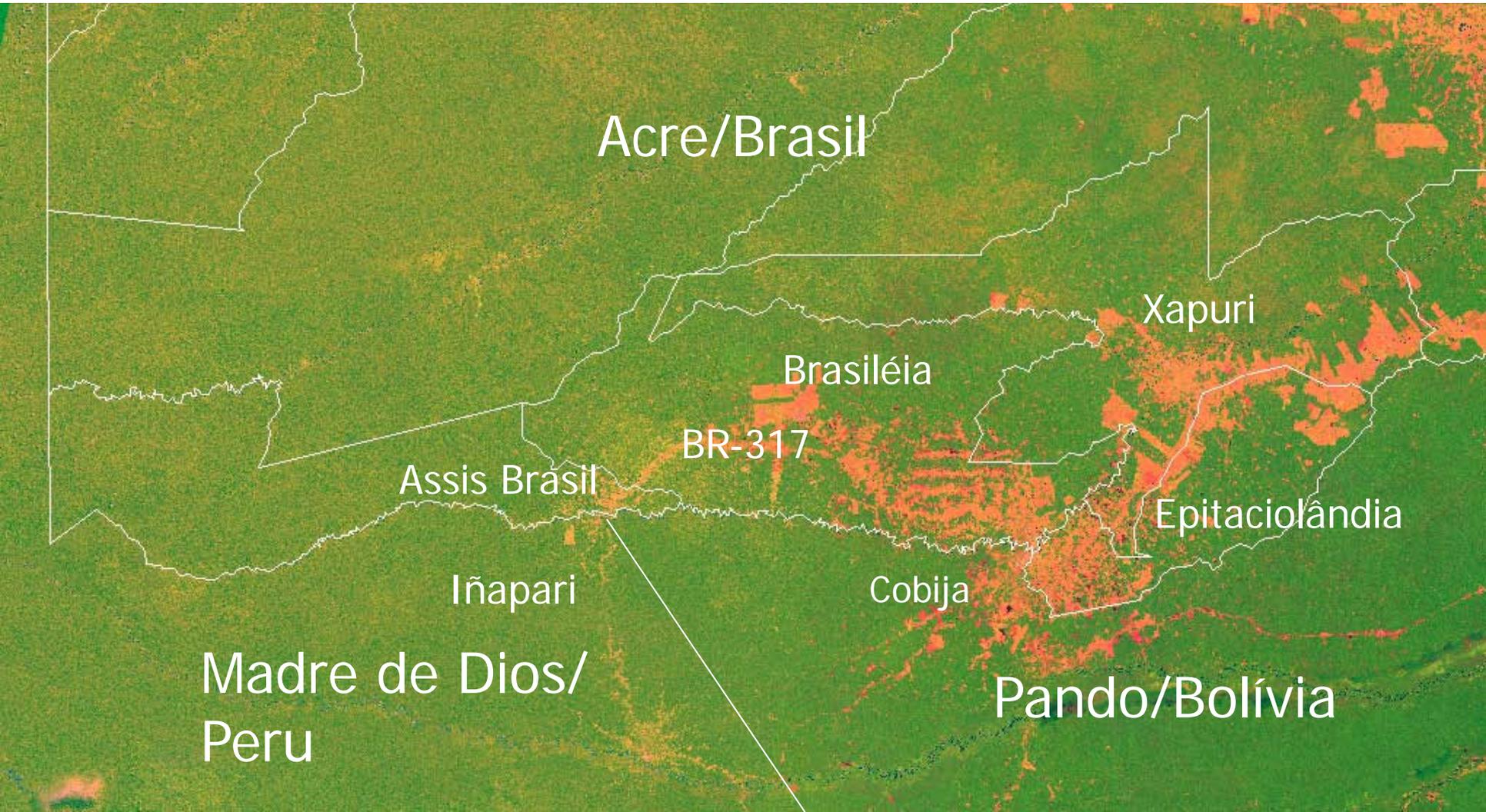
Status of Intercomparison

- Workshop in 2000, INPE, IBAMA, Funtac: A plea for error bars on deforestation estimates.
- Behind schedule in finding the error bars. Our problems and those of State Environmental Institute of Acre (IMAC -budget cut of 60% during summer).
- We are now doing our own municipal level estimates (still needing realistic error bars).

Frontier Region of Bolivia-Brazil-Peru:

Madre de Dios - Acre - Pando = MAP

Route of highway to the Pacific – BR-317



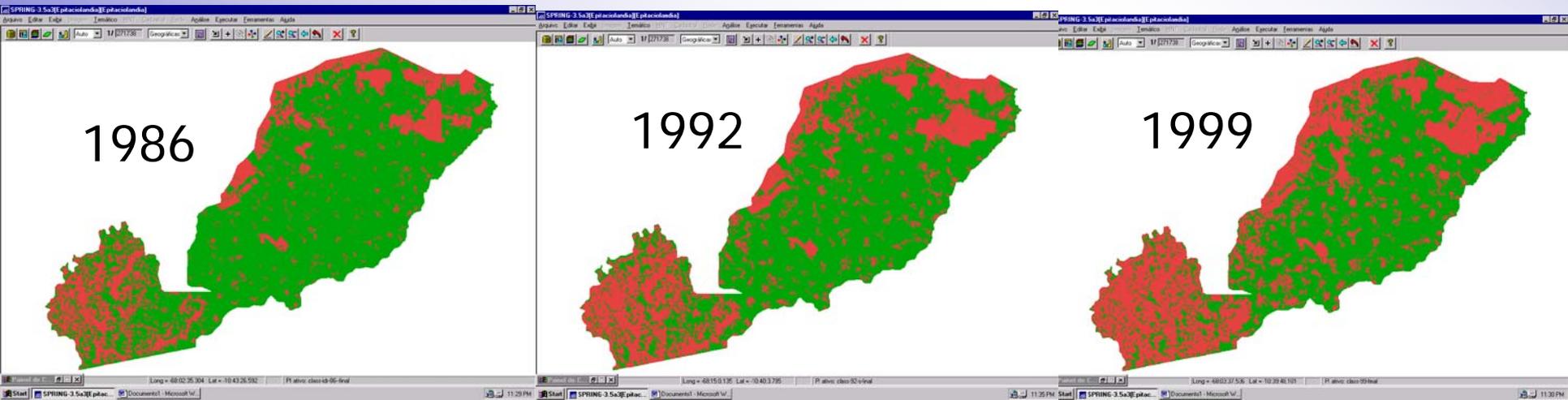
Municipal level analysis

- Acre - 90% forest cover, deforestation apparently not a problem.
- Decentralization of government actions to municipality. PGAI/PPG7 – Integrated Environmental Management Program – 2 million dollar program:
 - focus on Epitaciolandia, Brasileia, and Assis Brasil municipalities.
- Model for environmental management in Amazonia.

	Assis Brasil		Bras iléia		Epitaciolândia	
Área desf	(km ²)	(%)	(km ²)	(%)	(km ²)	(%)
1986	63.4	2.2	640.1	14.9	428.9	25.7
1992	100.2	3.5	853.4	19.8	592.4	35.5
1999	173.8	6.0	1,105.1	25.7	758.9	45.5
Área Total	2,886.6	*	4,307.6	*	1,668.2	*

Note: lack of error estimates

Example of Epitaciolandia municipality



Igarapé Encrenca – Epitaciolândia/AC



In a state of 10% deforestation in the humid tropics, urban centers are now lacking water. Example of the twin cities of Epitaciolândia and Brasileia.

Basin (6,000 ha) for water supply is now 70% deforested. Lack of water during dry season.

Analysis of Frontier Municipalities

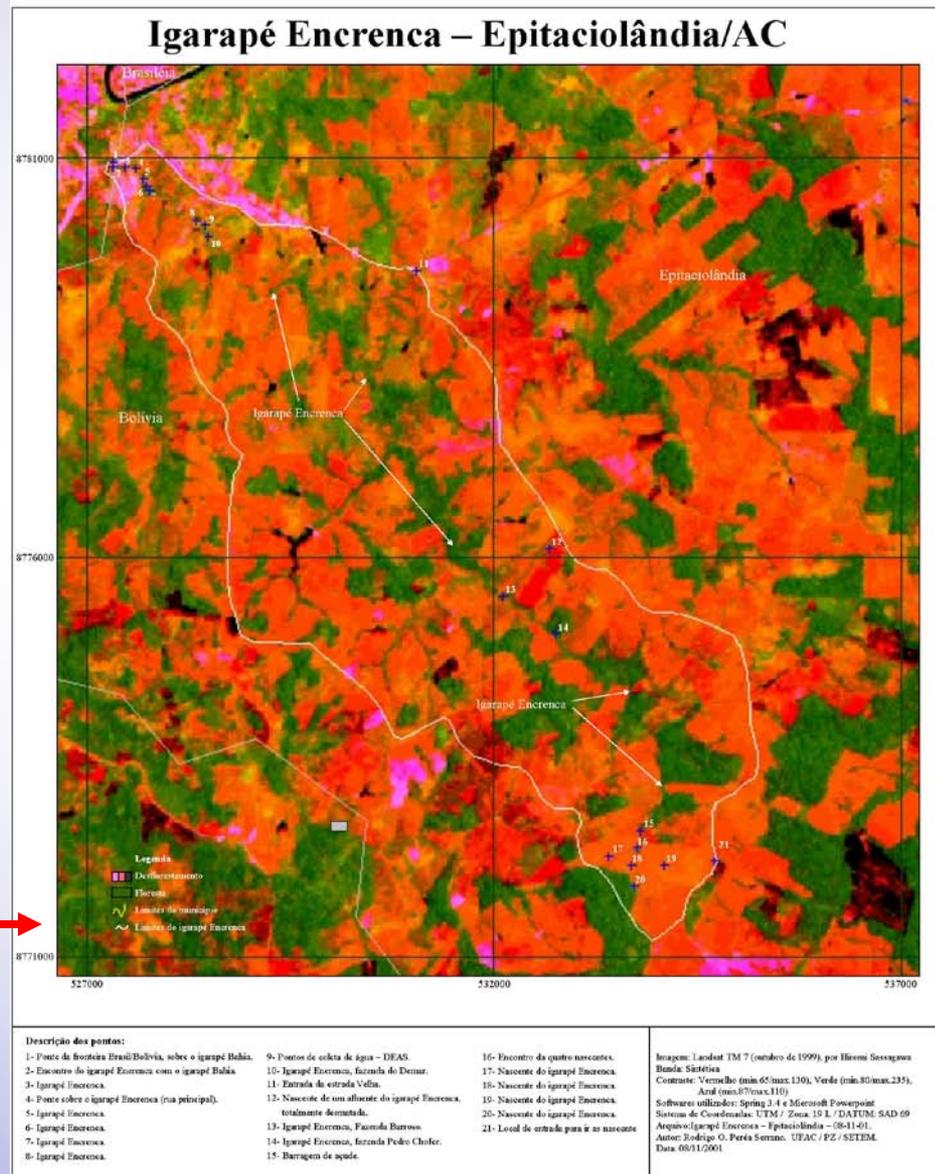
- Rates of cover change 1992-1998, years to 50% forest cover, legal limit
 - Assis Brasil: 0.42%/yr 122 years
 - Brasileia: 0.84%/yr 29 years
 - Epitaciolândia: 1.43%/yr 3 years
- Paradigm Shift: Deforestation is an immediate problem and a public policy issue, i.e. Water supply for urban centers.

Attempts to change the land use trajectories – inclusion of these results in municipal governments and school systems -- Assis Brasil and Epitaciolândia

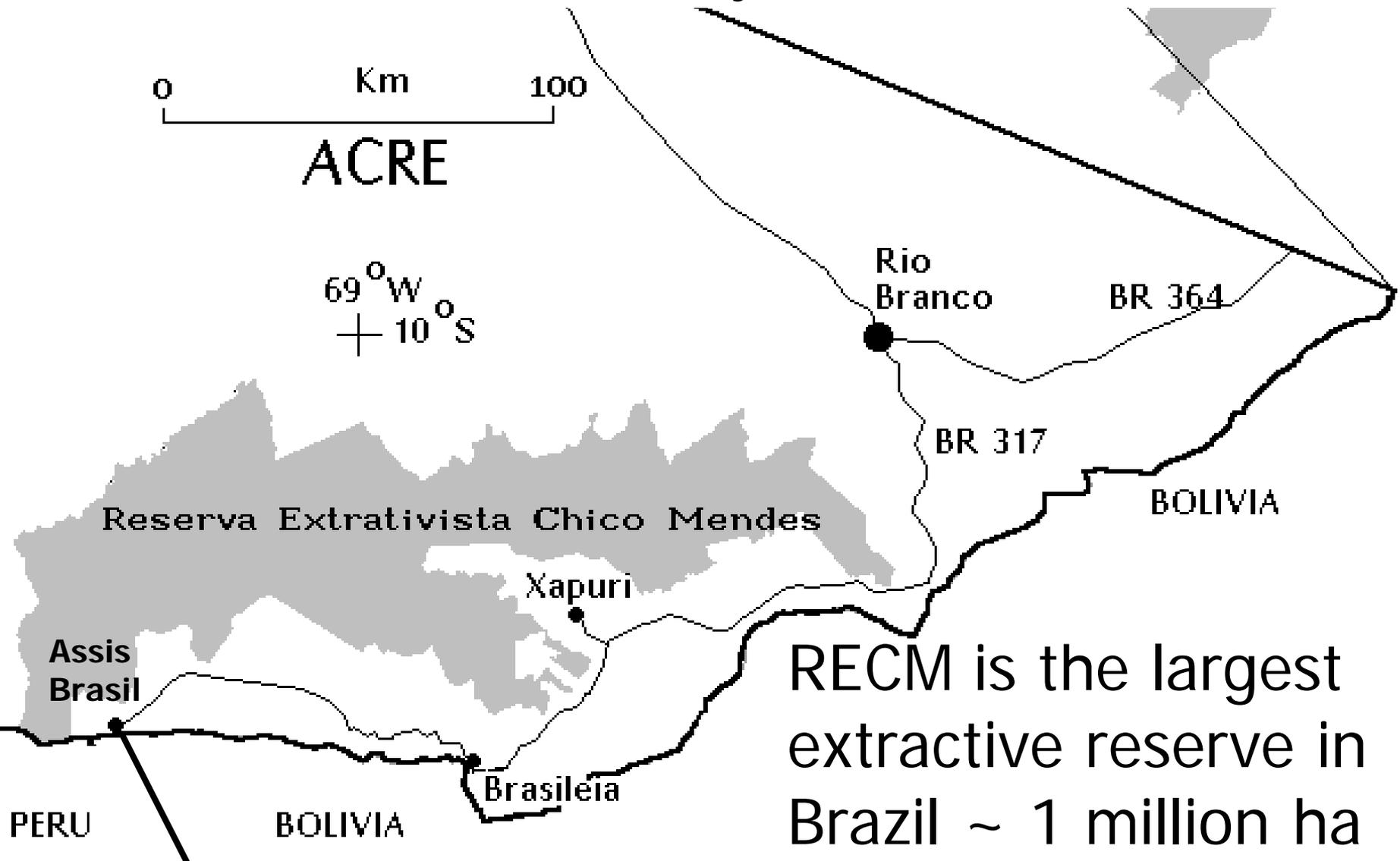


Ivanir Oliveira
Secretary of
Education --
Assis Brasil

Insertion of LCLUC data and concepts into the municipal government and society of Epitaciolândia, Acre

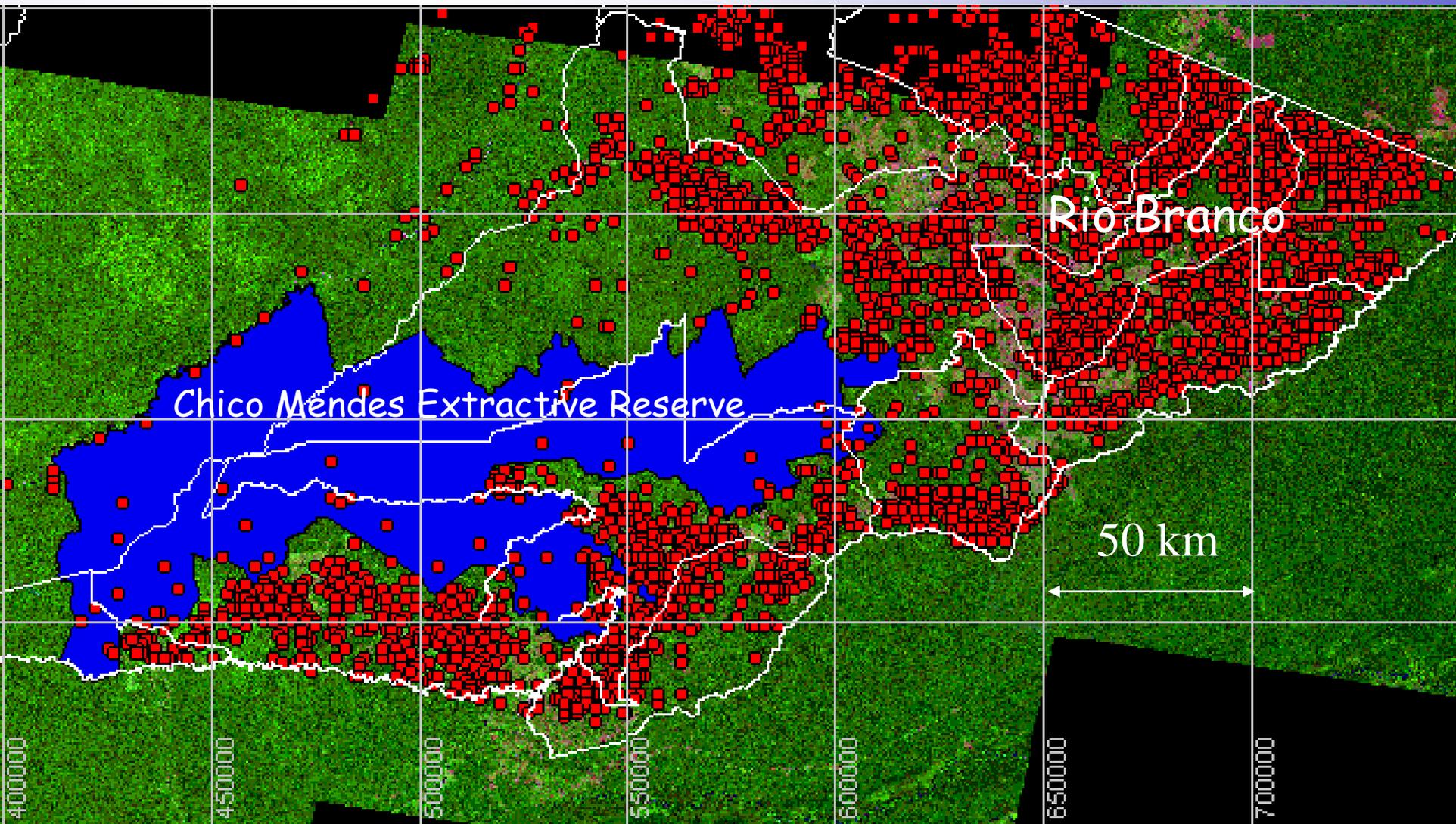


Extractive Reserves: Social land-use experiments for preserving forest cover and providing income for forest dwellers. Potential ~ 25% Brazilian Amazonia; currently 3+ %.



RECM is the largest extractive reserve in Brazil ~ 1 million ha

GOES8 ABBA in 1998: Example of burning around the Chico Mendes Extractive Reserve -- extractive reserve as a barrier for fire.



Deforestation of Chico Mendes Resex

Diverging estimates: 154 ha/yr - IBAMA
2,200 ha/yr Sassagawa (1999)



Hiromi Sassagawa

To re

Extractive Reserves slow deforestation

- Municipalities of Assis Brasil, Brasileia, and Epitaciolândia: 0.42 to 1.43% yr⁻¹
- Extractive Reserve: (0.02) 0.23% yr⁻¹
- Extractive Reserve: 2 to 6 times lower rates than those in municipalities.
- Several extractive reserves have been proposed recently.

Land Use Decisions in Extractive Reserves

- Causes and consequences of land use change
- Extractivists decide between extractive versus agriculture/pasture activities, i.e. Low versus high impact on land cover and carbon fluxes.
- Choice a function of several factors, one of which is economic
- ~ 100 of 250 million dollar loan from IDB to improve extractive activities
 - If successful, changes plausible scenarios change, and so do predictive models of land use.

Deforestation in the Chico
Mendes Extractive Reserve
seems to be accelerating.

WHY?

Julho							Agosto						
D	S	T	Q	Q	S	S	D	S	T	Q	Q	S	S
1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28
30	31												

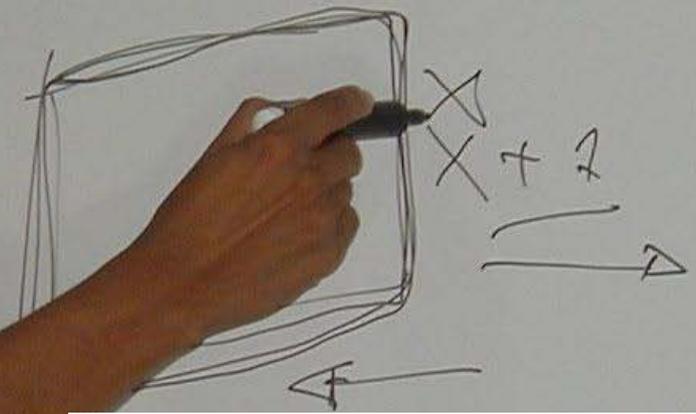
Setembro							Outubro						
D	S	T	Q	Q	S	S	D	S	T	Q	Q	S	S
1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28
30	31												

Novembro							Dezembro						
D	S	T	Q	Q	S	S	D	S	T	Q	Q	S	S
1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28
30	31												

JUAN PABLO - GUERSCHMAN@IFEVA.

Kennedy Souza

Panta



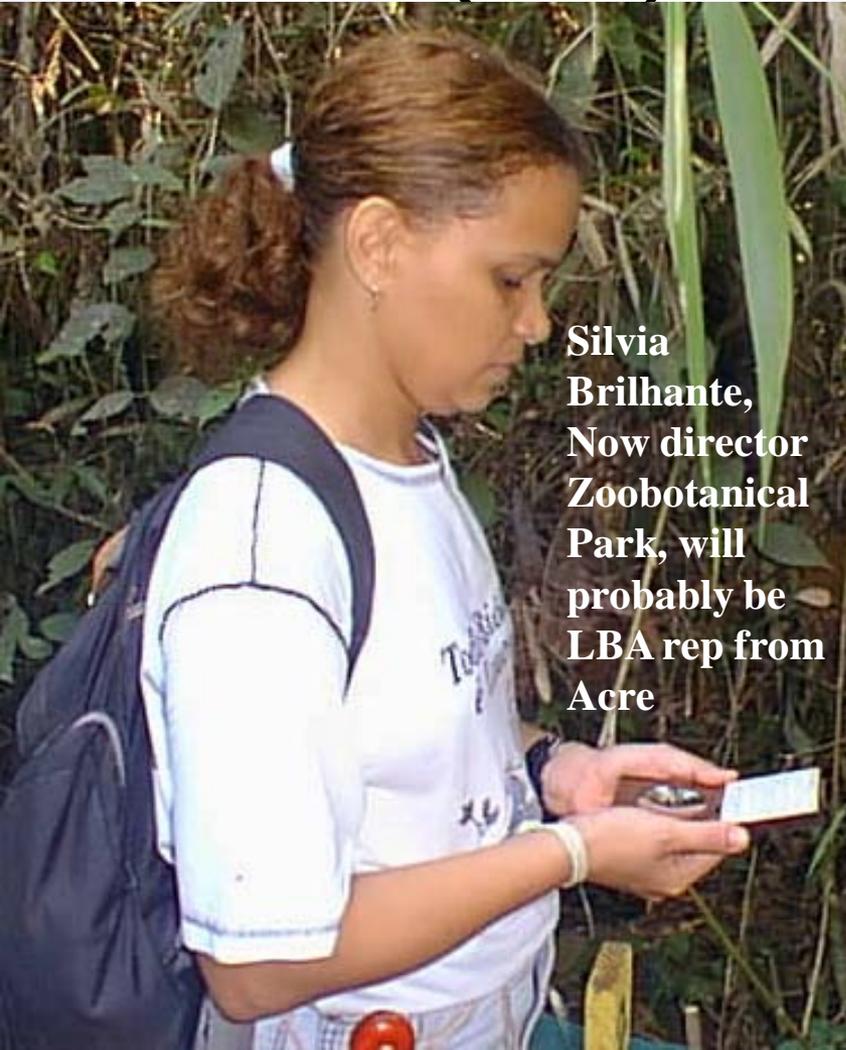
Cows and Agriculture

gilsonm@ufac.br

Estimates of area affected by
logging in Acre and MAP

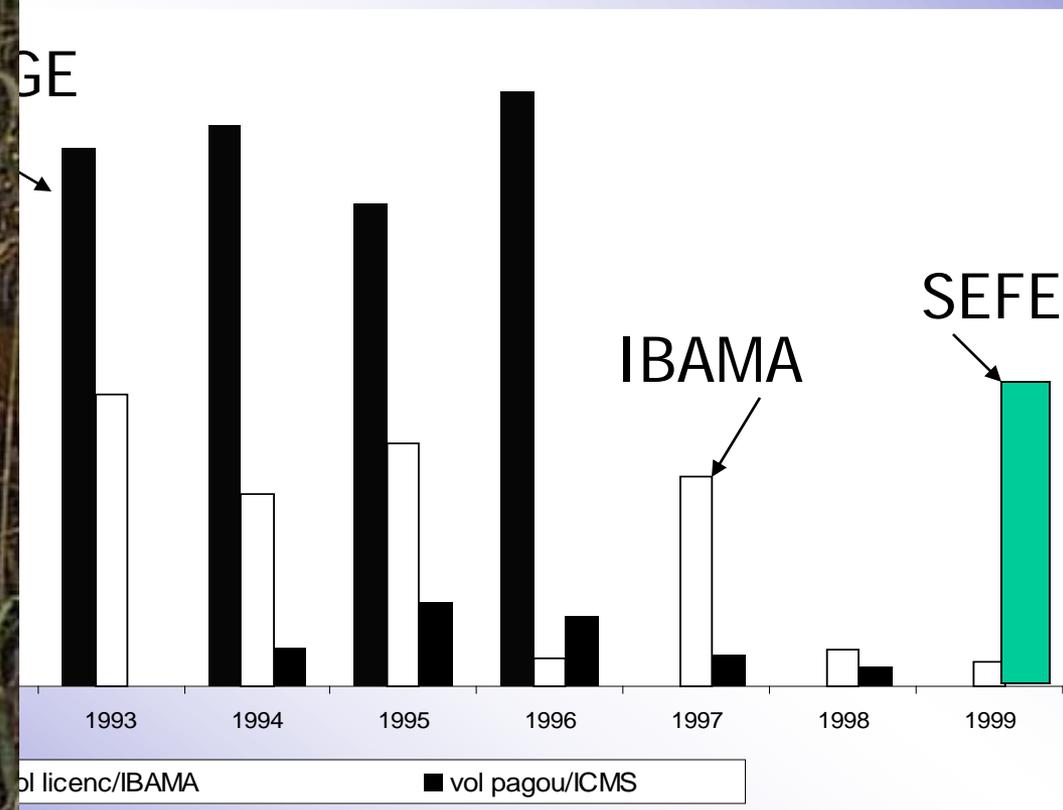
Logging Activity in Acre:

IBGE and IBAMA differ by a factor of 20+x for Acre,
IBGE ~ 2x over estimate, IBAMA ~ 10x underestimate.
Brilhante (2000) and Brilhante and Brown (in prep.)



Silvia Brilhante, Now director Zoobotanical Park, will probably be LBA rep from Acre

of the same logging activity





Note
LBA
← sponsorship

Workshop “Diagnostic of Logging Activity on the Trinational Frontier - Bolívia, Brasil e Peru: Perspectives for o Futuro”
Assis Brasil, Acre 29 to 31/08/01

Current logging activity in region

- Acre (eastern part): ~200,000 m³/yr
- Pando 60,000 m³/yr
- Madre de Dios 130,000 m³/yr
- Total of MAP region: ~400,000 m³/yr

**Five-year plan of Acre government:
increase to 700,000 m³/yr, certified wood,
for Acre alone.**

Logging – Area Affected

- RS approach needs more refinement, patios ~ rubber tapper clearings
- Using 5 to 20 m³ ha⁻¹:
 - Acre - year 1999: 10,000 - 40,000 ha yr⁻¹
 - Acre - year 2006: 35,000 - 140,000 ha yr⁻¹
 - Deforestation in Acre: 38,000 –120,000 ha yr⁻¹
- Double counting – how much?



Rodrigo
Serrano,
GPS training

Silvia
Freitas, RS

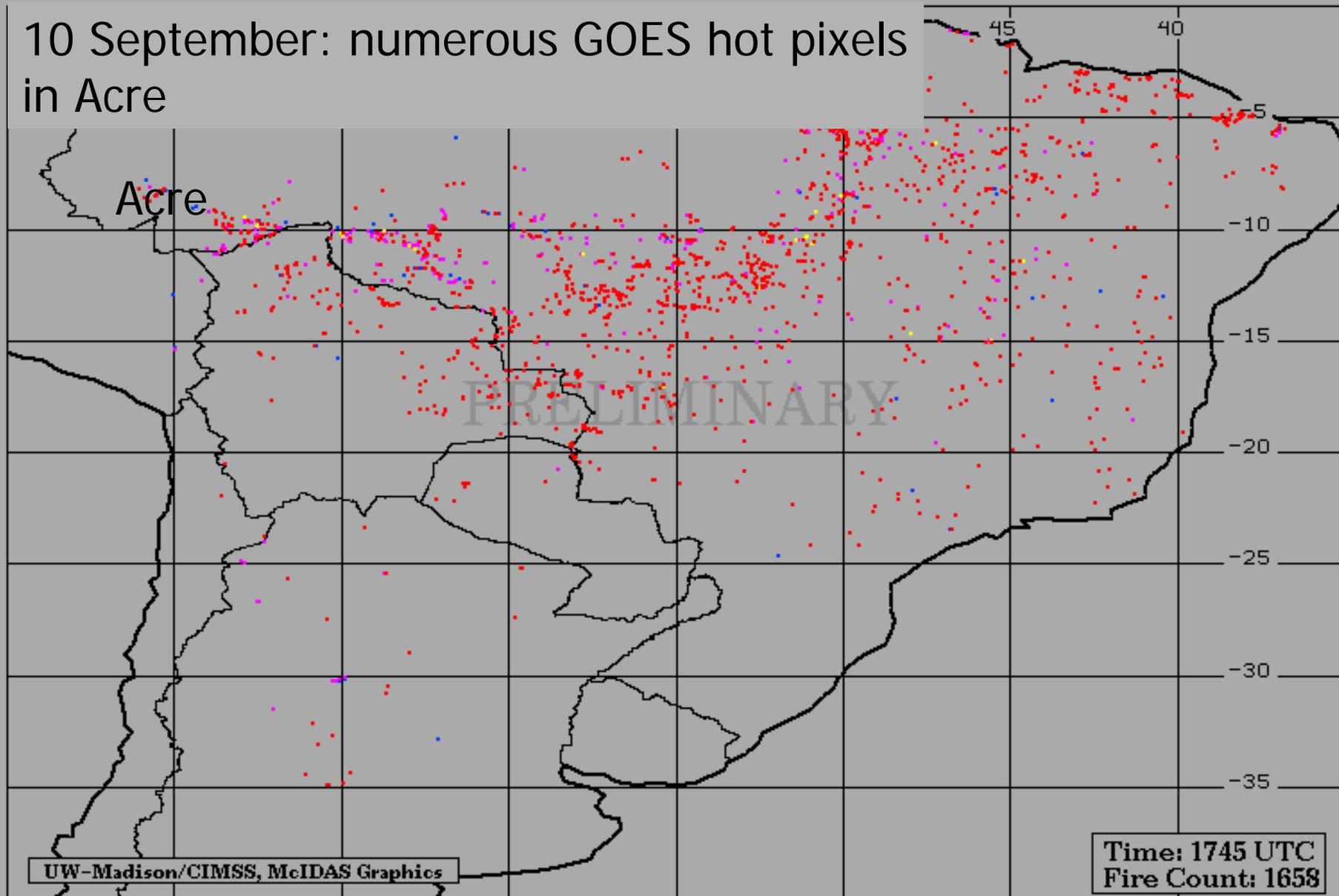
José Augusto
Rocha, RS

Alberto Setzer,
INPE

Alejandro
Fonseca
Duarte,
Climate

Fire in Acre –
the reliability of GOES and
AVHRR hot pixels
and
the economic implications

10 September: numerous GOES hot pixels in Acre



ABBA Processed Fire Pixels



Saturated Fire Pixels



Cloud Covered Fire Pixels



Possible Fire Pixels (High Probability)



UW-MADISON/SSEC/CIMSS NOAA/NESDIS/ORA ASPT

Acre

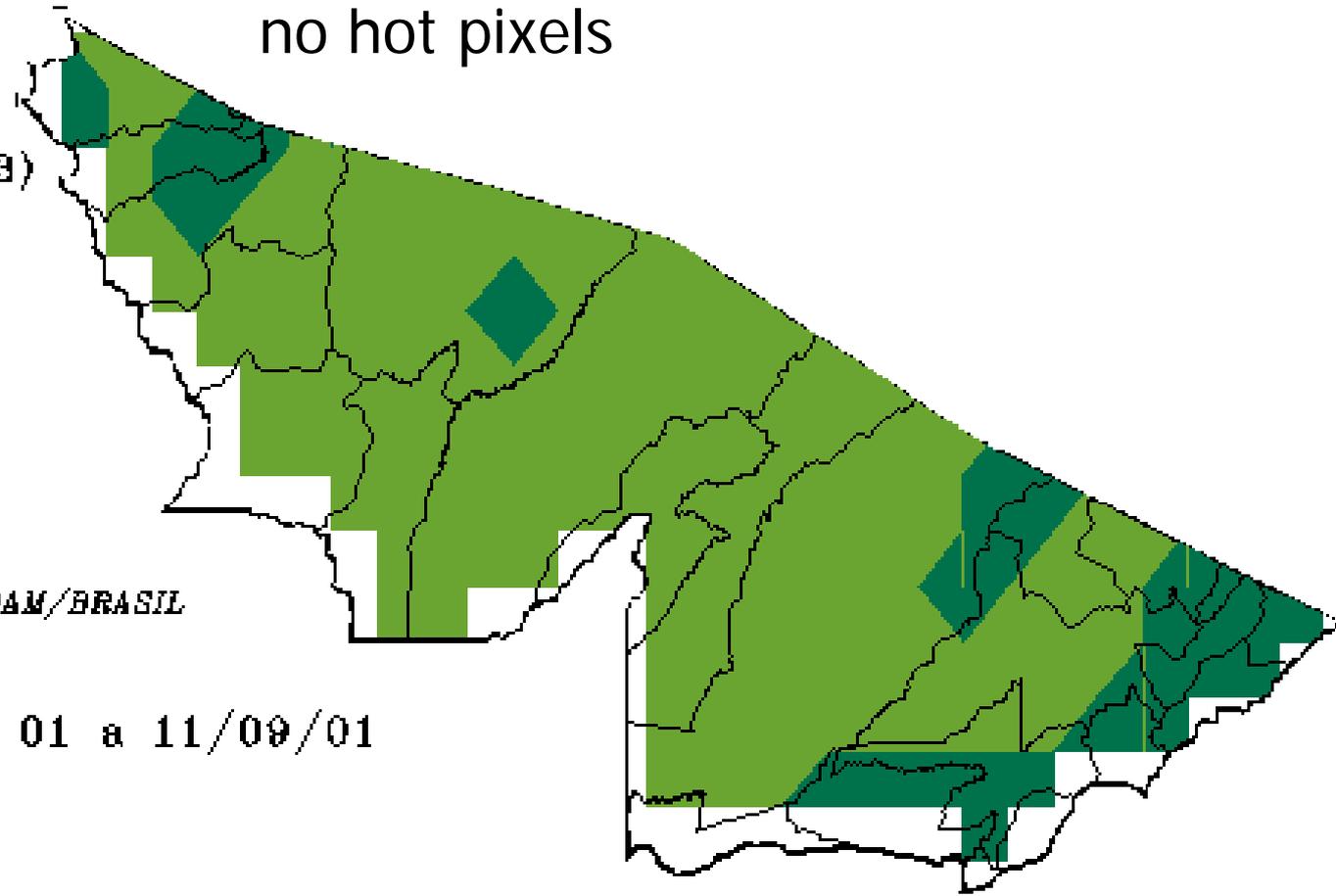
Big problem: Peak burning in Acre is early
September: 11 days of data and AVHRR shows
no hot pixels

Divisao Municipal

Vegetacao (1973 a 1983)



Fonte de Dados: DPI/INPE-RADAM/BRASIL



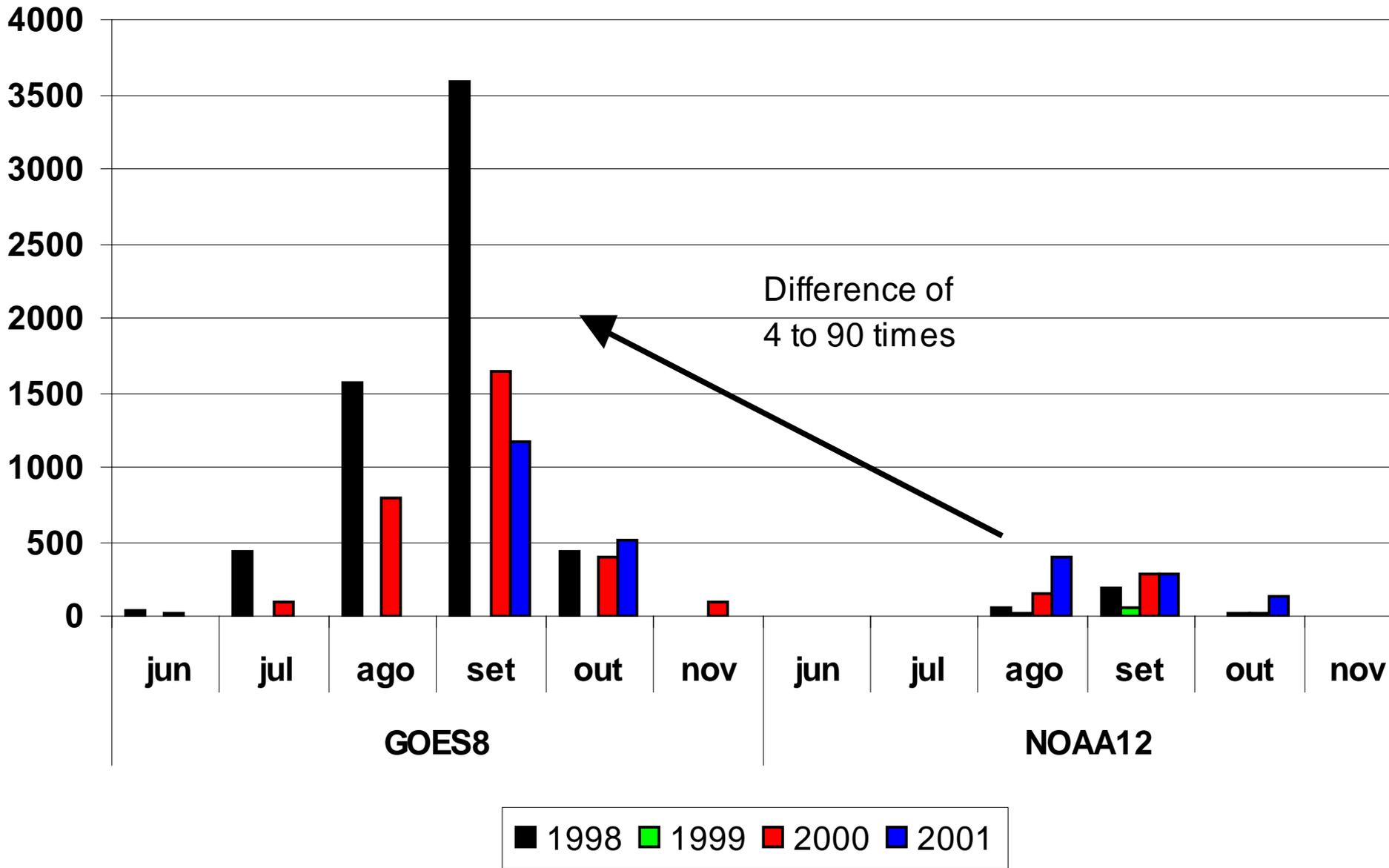
Focos Acumulados de 01 a 11/09/01

Total de Focos NOAA-12N : 0

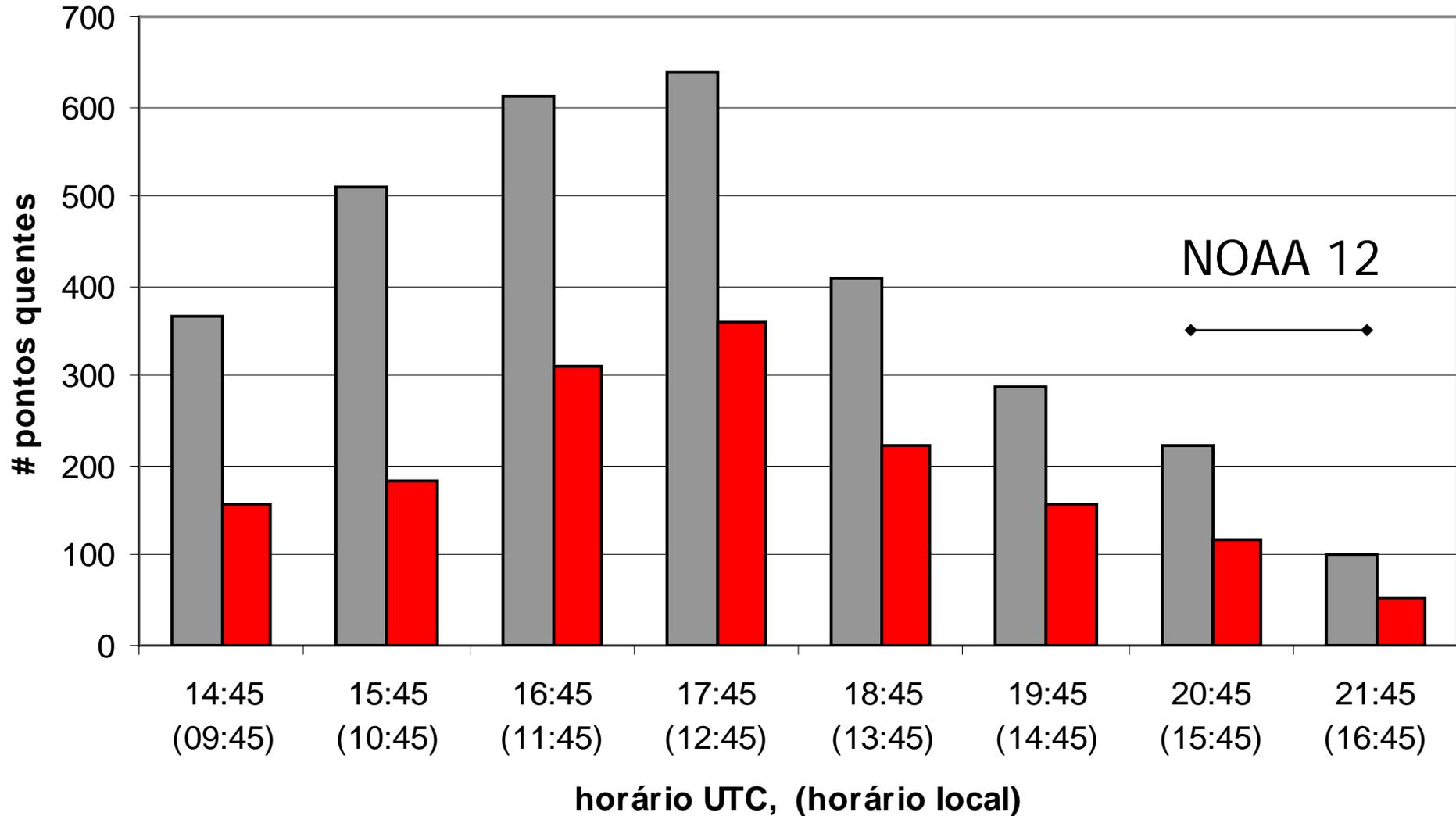


Fonte de Dados: CPTEC/INPE

Comparison of GOES 8 x NOAA 12 for Acre State

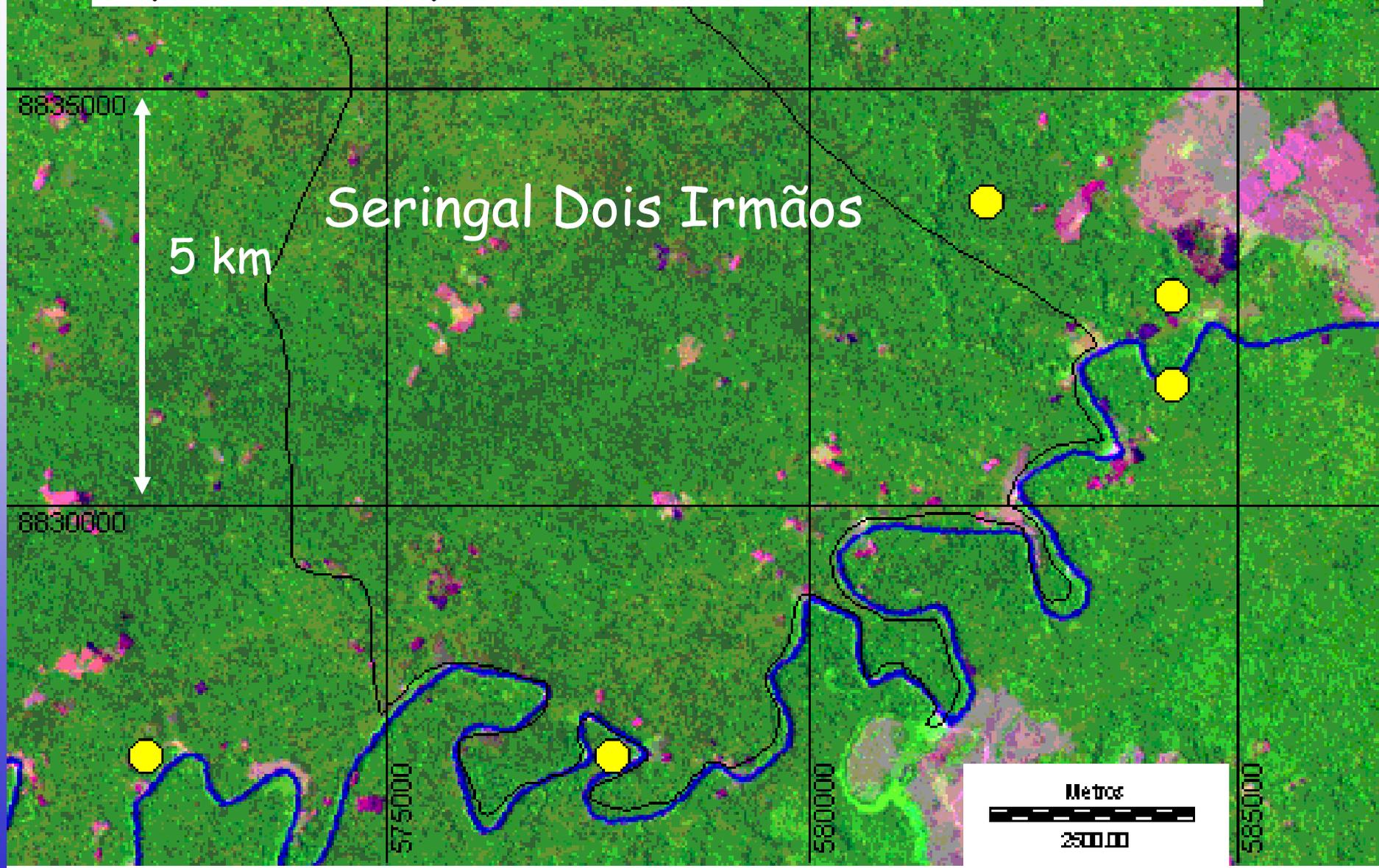


Distribution of GOES8 Hot Pixels by hour of the day, Acre State, Brazil

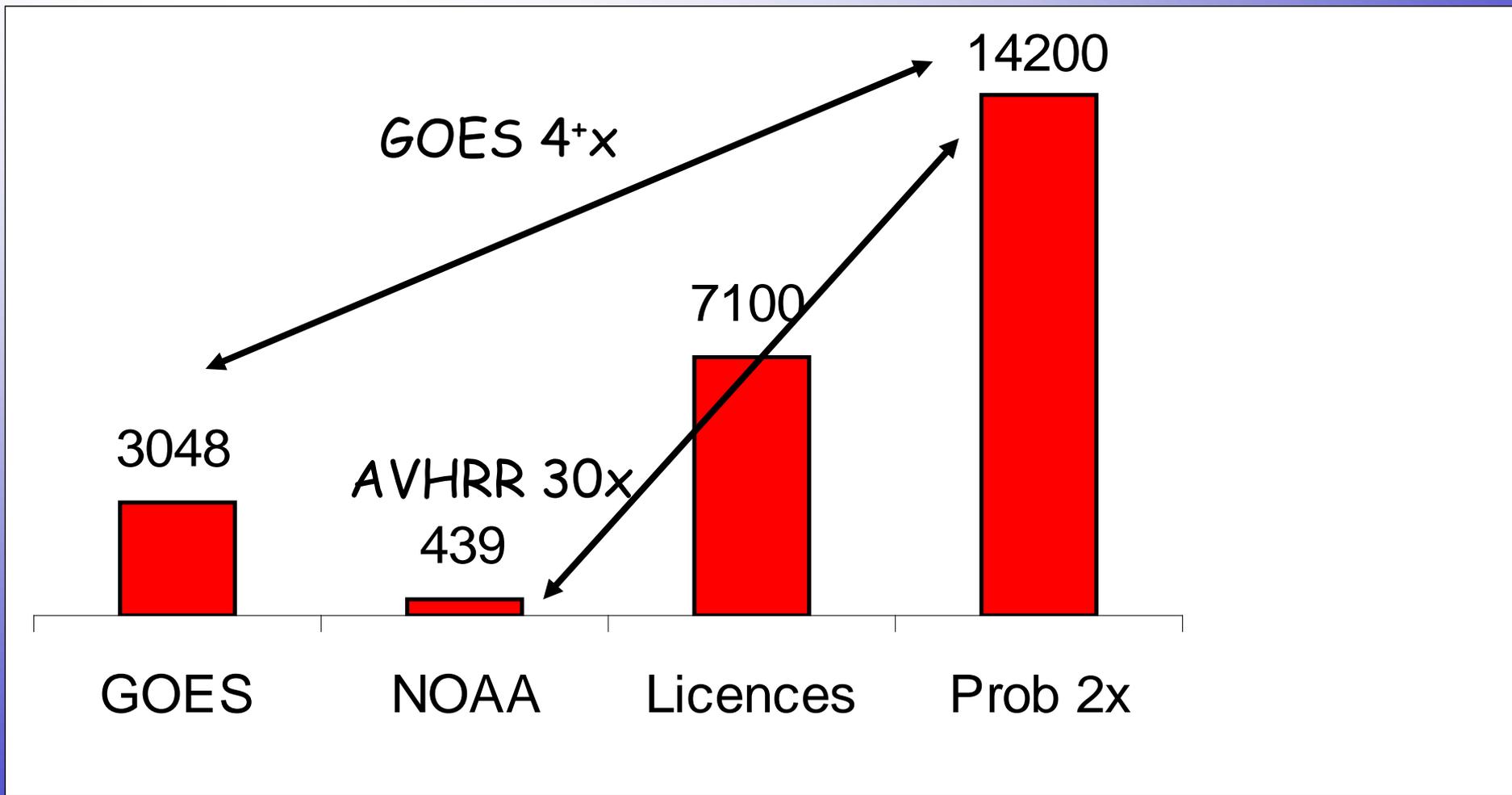


■ média parcial, setembro 2001 ■ média outubro 2001

Seringal Dois Irmãos should have ca. 15 fires within its boundaries. GOES8 for 1998 has a maximum of 4 possible hot pixels.



Hot pixels and probable fires in Acre for 2000





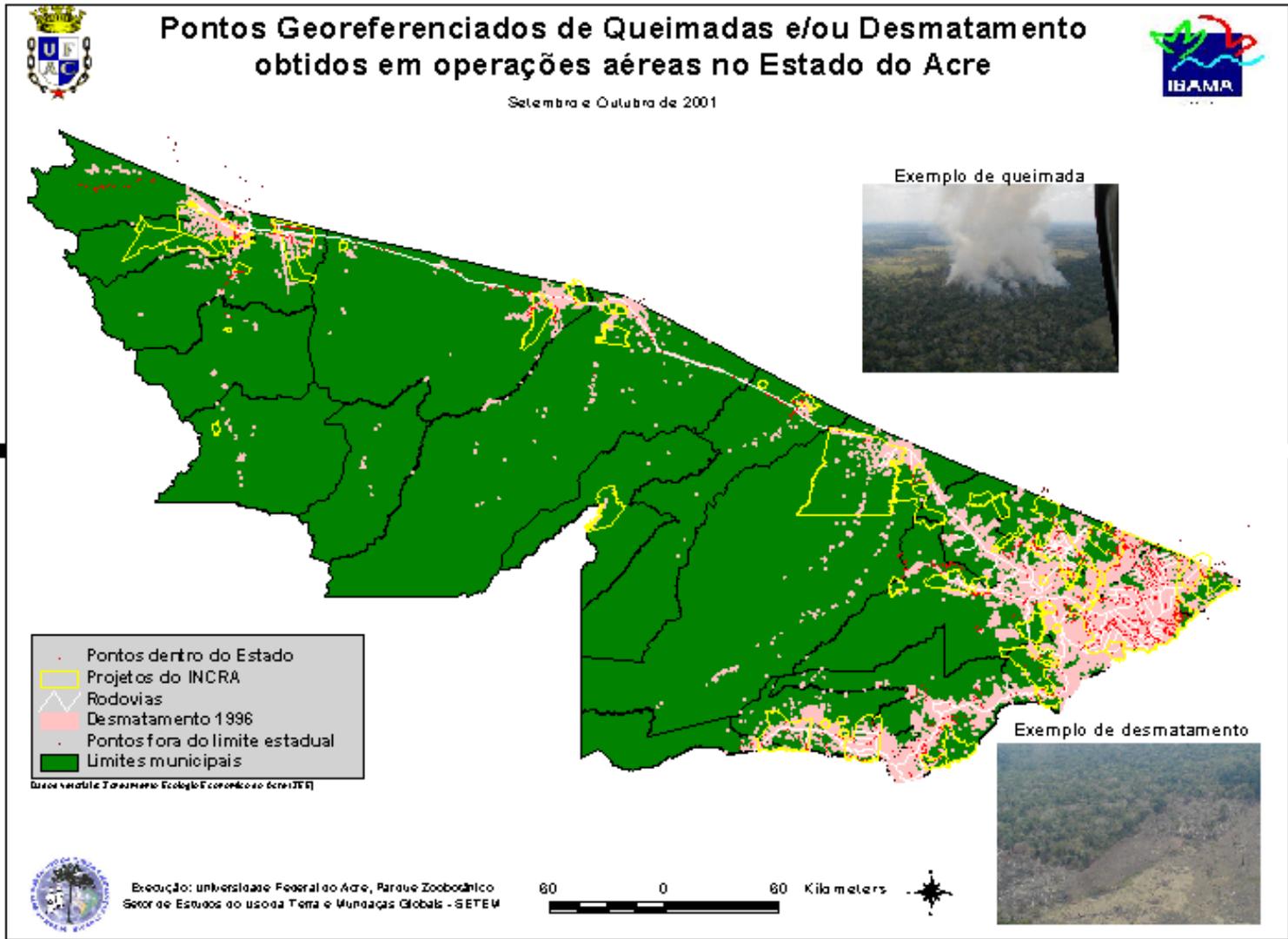
“Hot pixels” mapped on INPE overflight on
19 September 2001

Former student
In GPS course

IBAMA's PROARCO Program

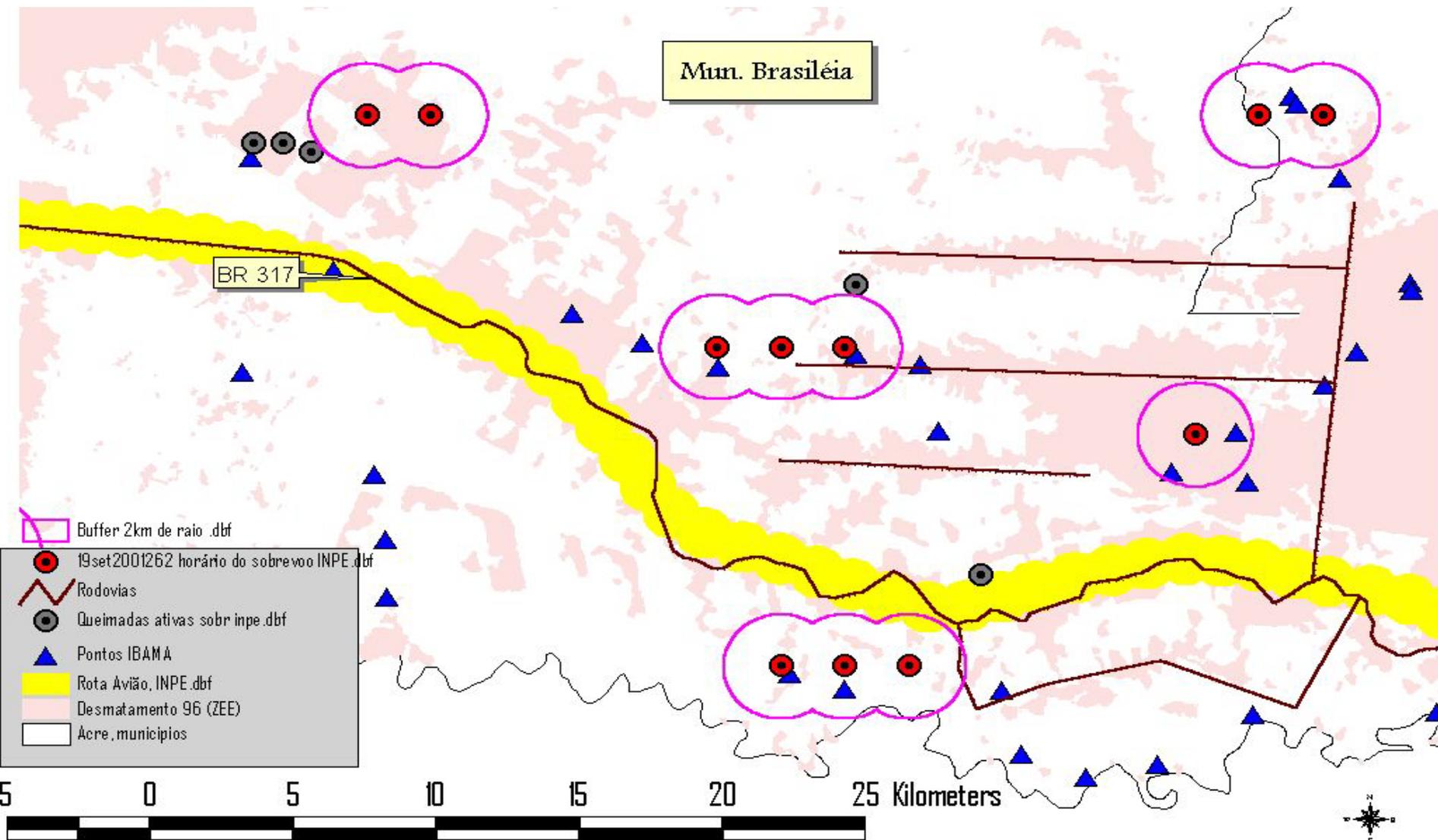


Hot pixel data and collaboration with IBAMA



Collaboration between
And IBAMA

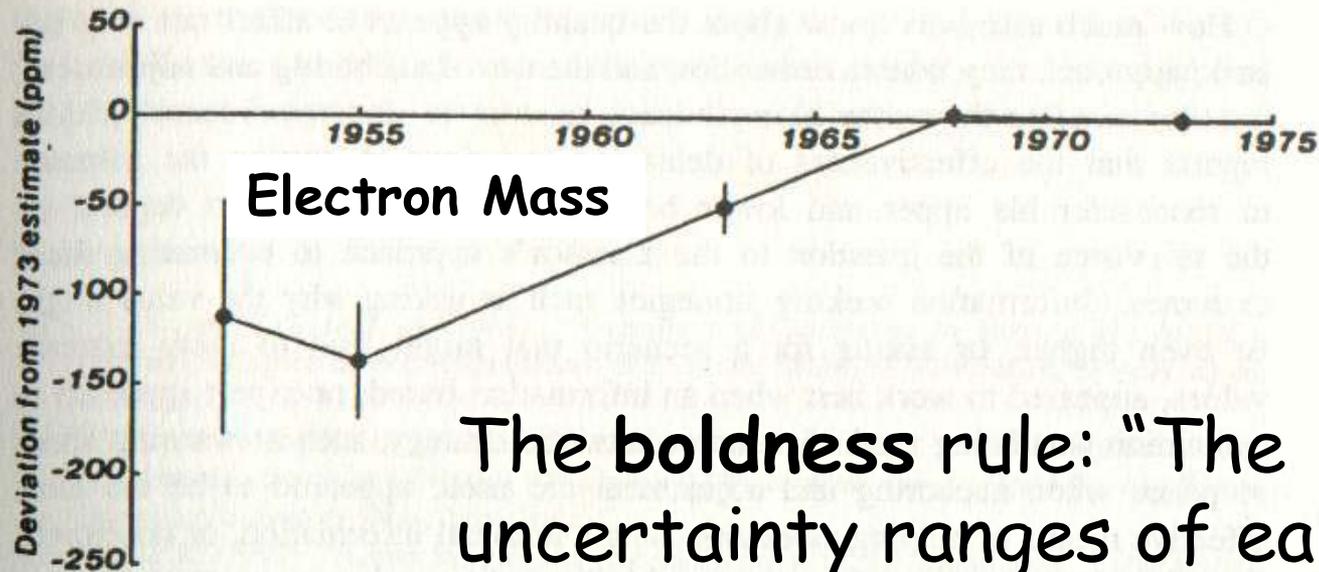
Comparison of Goes hot pixel data and field observations from overflights of helicopter and plane, southern Acre, 19/09/01



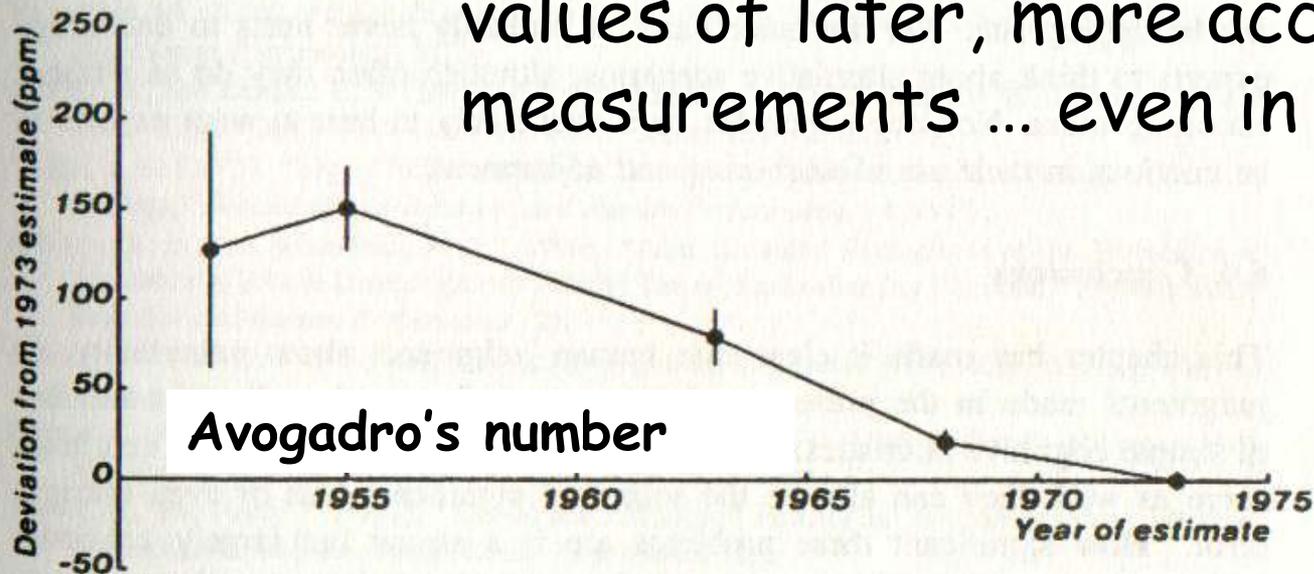
The validation conundrum for
deforestation and hot pixel data,
or
the search for error bars

Those interested in collaborating
on such validation, please contact
me at

fbrown@mdnet.com.br



The boldness rule: "The uncertainty ranges of early measurements rarely include the values of later, more accurate measurements ... even in Physics."



Changing the **Plausible Scenarios**:
providing society with the estimate of
costs of fires

Research in collaboration with
Dan Nepstad

A woman with dark hair, wearing a light grey t-shirt and blue jeans, is seated in a light-colored leather airplane seat. She is leaning forward, focused on writing in a large, open notebook with a wooden cover. The notebook is resting on her lap. She is holding a pen in her right hand. The airplane cabin interior is visible, including the window and the padded wall behind her. The name "Elsa Mendoza" is printed in black text over the image.

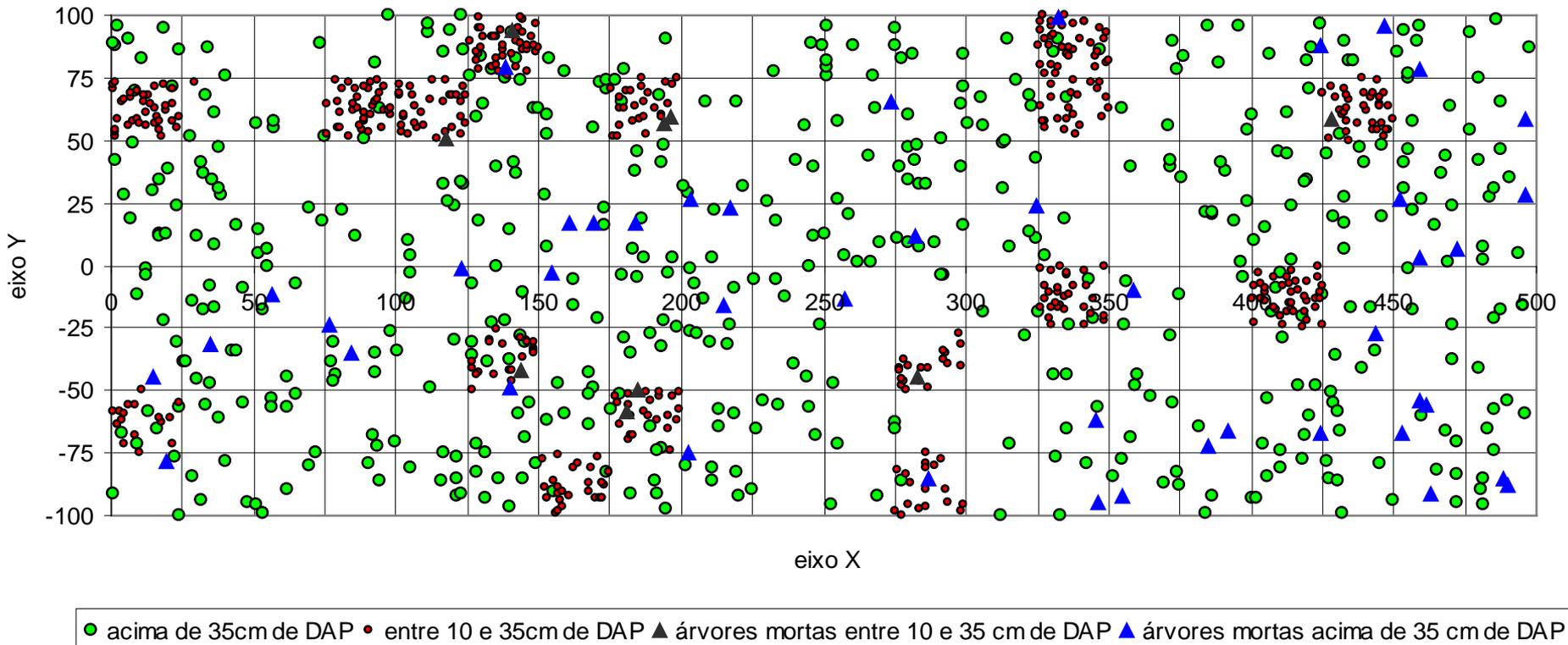
Elsa Mendoza

Forest carbon stocks and fluxes and soil carbon fluxes

Collaboration with Sue Trumbore,
Eric Davidson, and Plinio Camargo

Primary Forest Biomass at Catuaba, 10 ha, 1,000 trees, also C-14 dating, growth rates

Gráfico 1 - Dispersão de indivíduos arbóreos em duas classes de diâmetro (10cm e 35cm de DAP e acima de 35cm de DAP). Fazenda Experimental Catuaba - UFAC, Acre - Brasil.



Selhorst et al. Em prep.

Another 10 ha site should be ready in March

Unanticipated topics - I

Transnational migrations and their
influence on land use and
urbanization

Migrations on the Southwestern Amazonian frontier: a case study of “Brasivianos” and “Biscateiros”

Benedita Maria Gomes Esteves and Paulo Roberto Nunes Ferreira, Department of History and Sector of Land Use and Global Change Studies, UFAC

2001 Open Meeting of the Human Dimensions of Global Environmental Change Research Community
Rio de Janeiro, Brazil



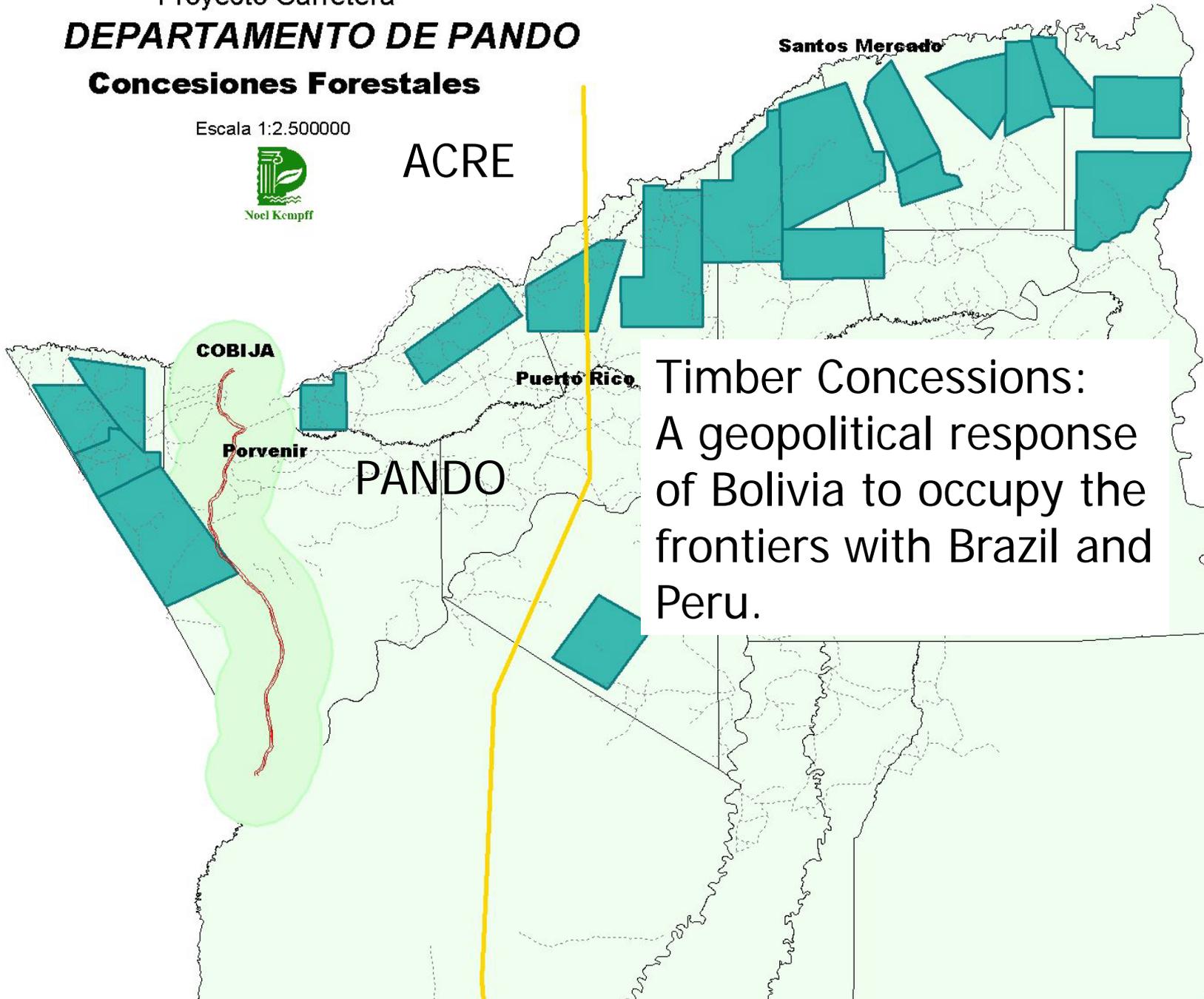
Proyecto Carretera
DEPARTAMENTO DE PANDO
Concesiones Forestales

Escala 1:2.500000



ACRE

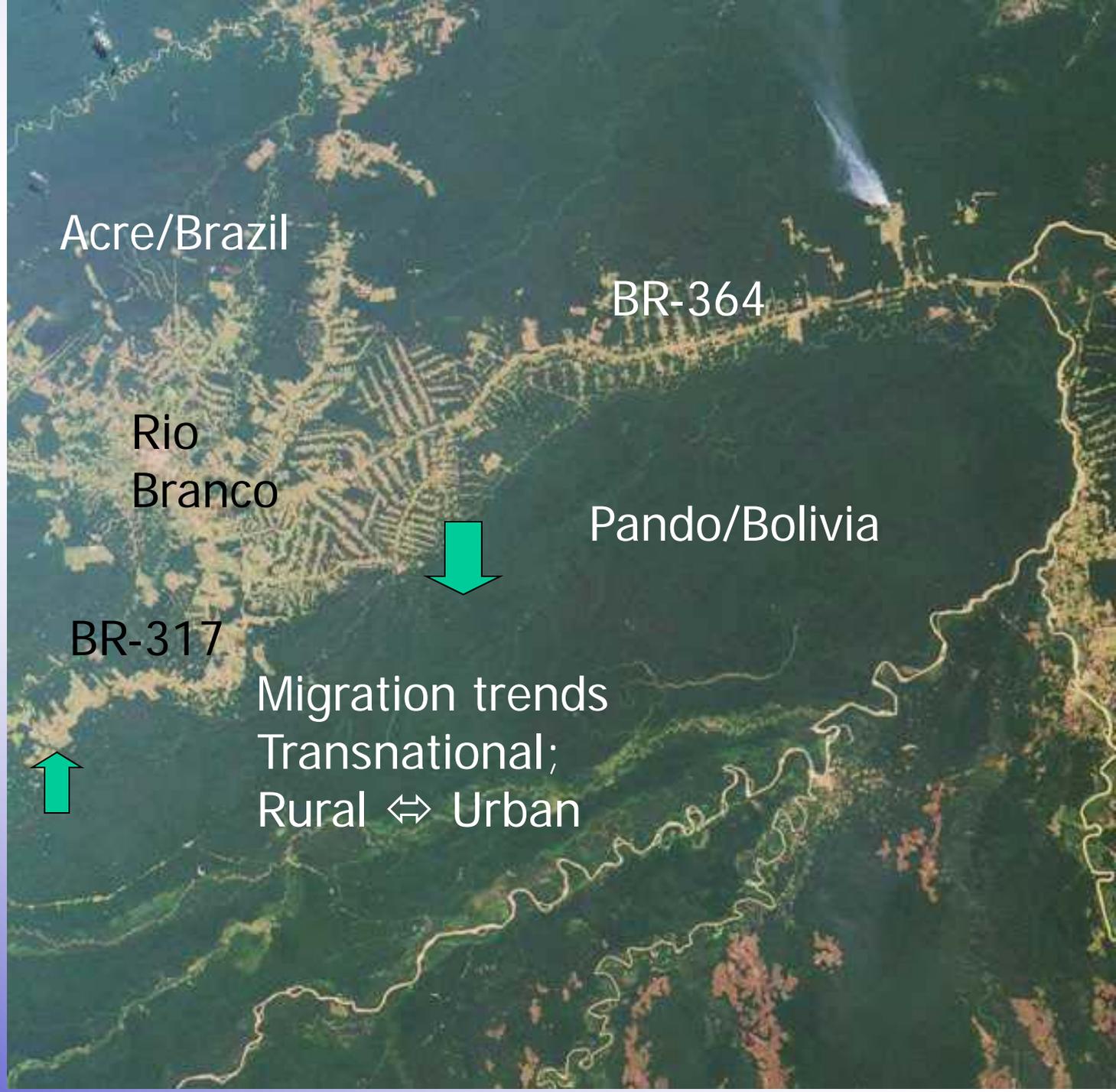
Santos Mercado



Timber Concessions:
A geopolitical response
of Bolivia to occupy the
frontiers with Brazil and
Peru.

MODIS:
The contrast of
regional
development
models – Brasil
and Bolivia,
as indicated by
deforestation
patterns.
09/01

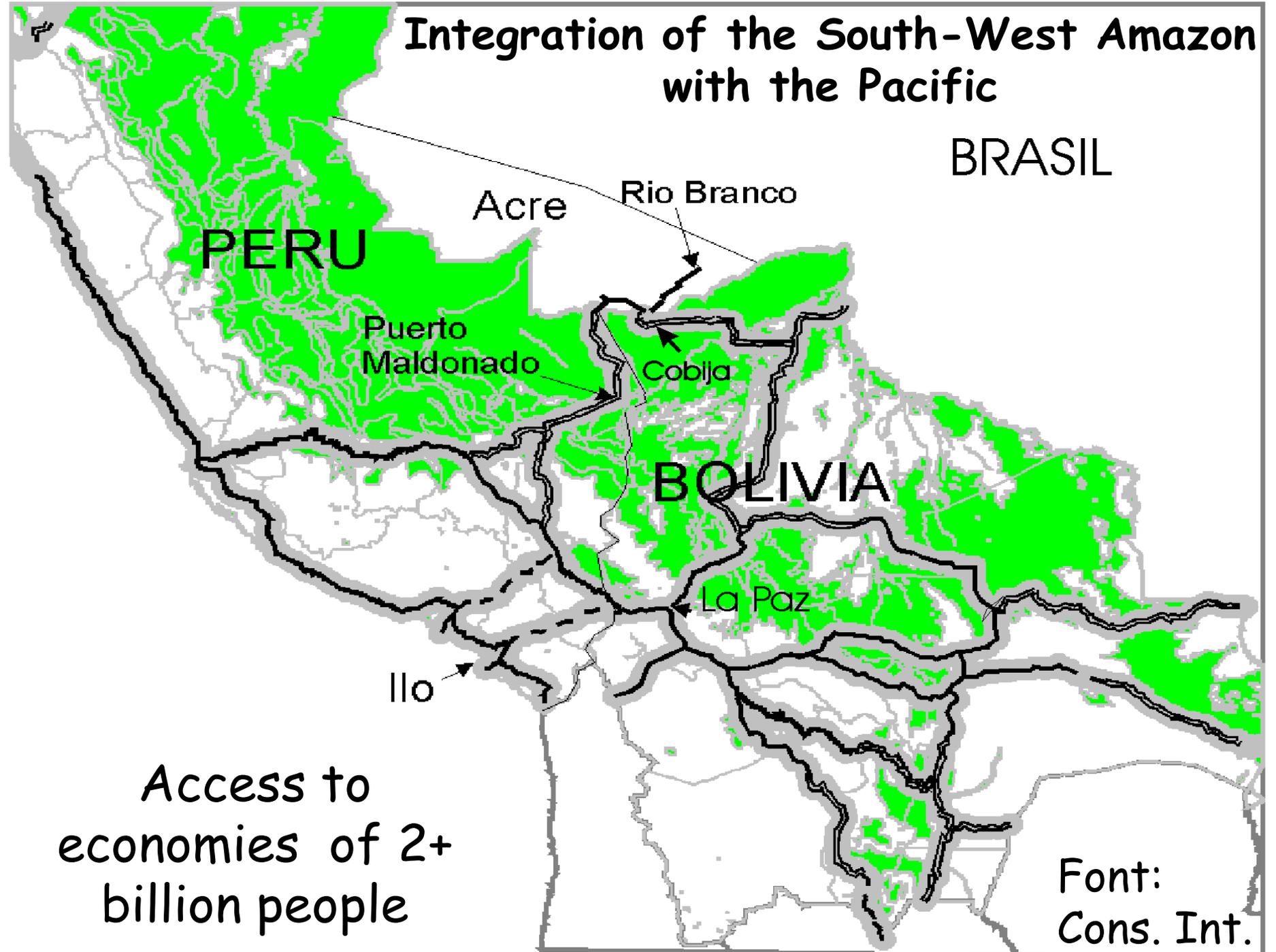
Excellent
product for
school systems
and regional
policy makers.



Unanticipated topics -II

Highway to the Pacific
'Soybeans to Asia'

Integration of the South-West Amazon with the Pacific



BRASIL

PERU

Acre

Rio Branco

Puerto Maldonado

Cobija

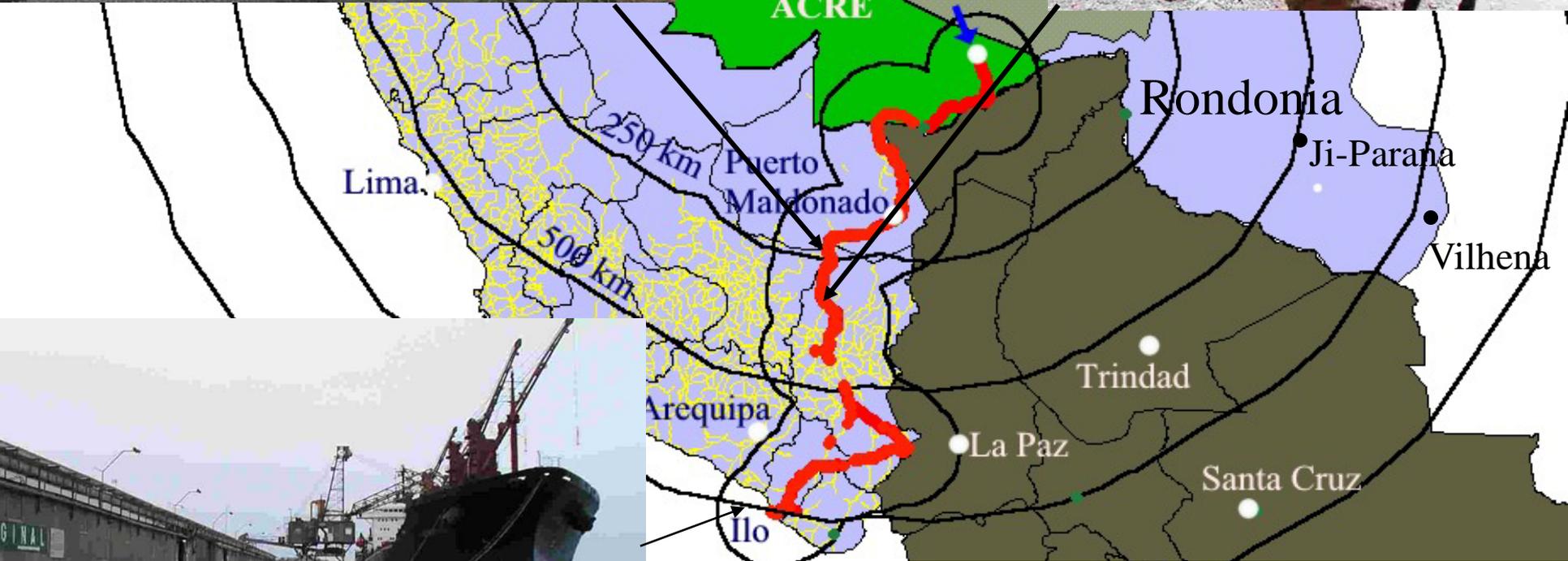
BOLIVIA

La Paz

Ilo

Access to economies of 2+ billion people

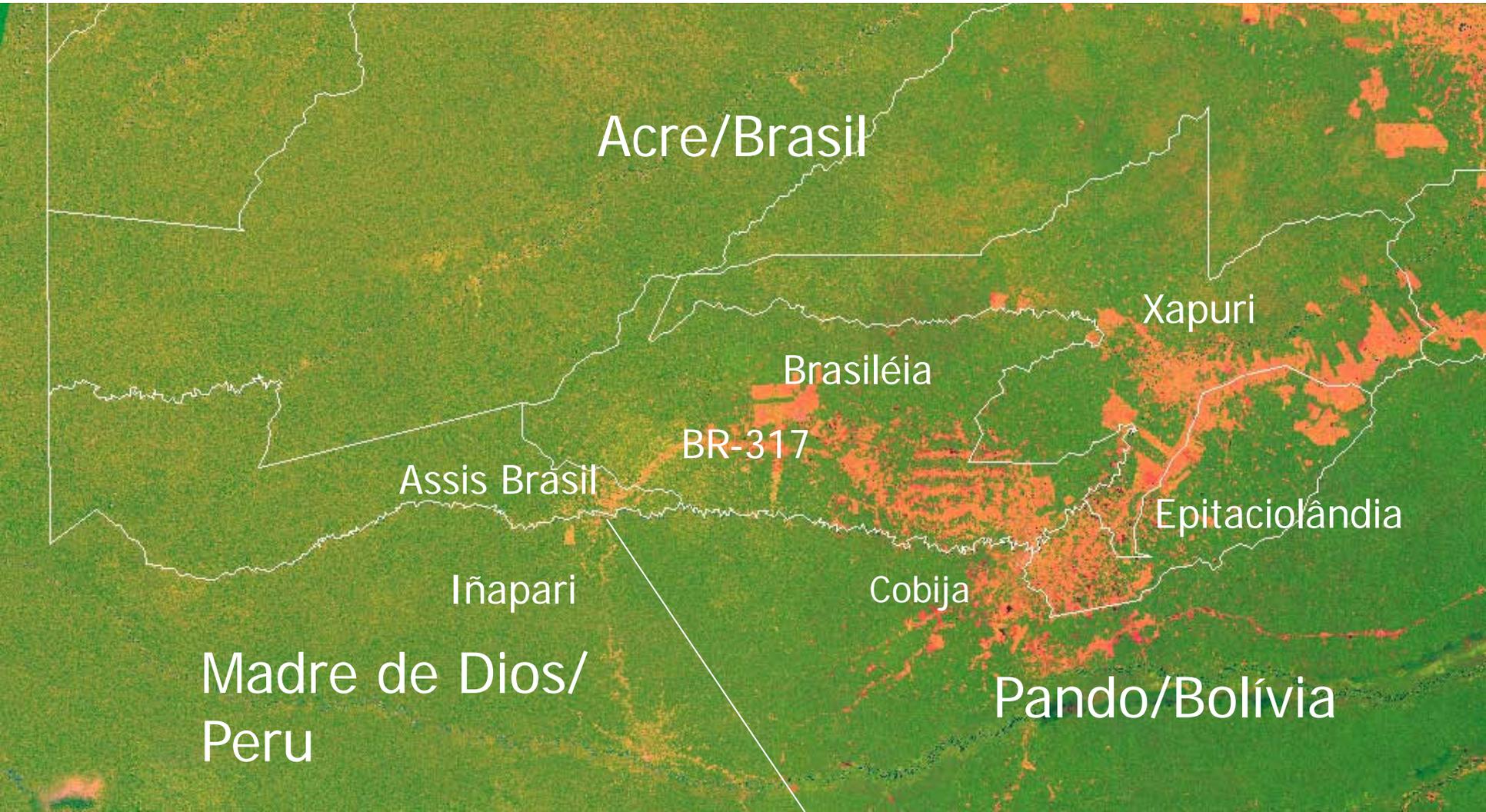
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Frontier Region of Bolivia-Brazil-Peru:

Madre de Dios - Acre - Pando = MAP

Route of highway to the Pacific – BR-317



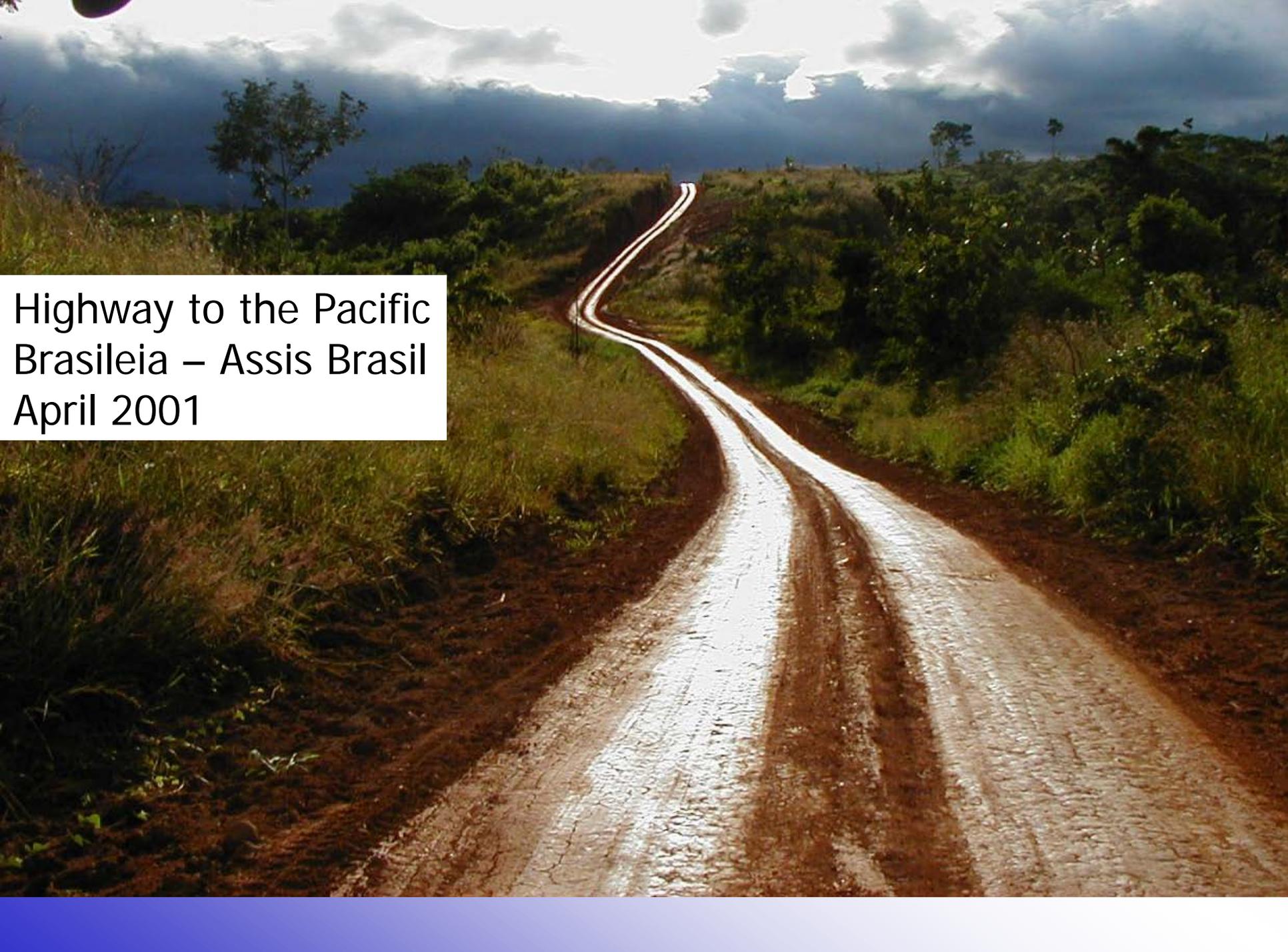


Brasil

Bolivia

Peru

International Bridge at Assis Brasil, Acre

A dirt road with white-painted edges winds through a lush, green landscape. The road is wet and reflects the sky. The surrounding vegetation is dense and green. The sky is filled with large, dark, dramatic clouds, with some light breaking through near the horizon. The overall scene is a rural, natural setting.

Highway to the Pacific
Brasileia – Assis Brasil
April 2001

Highway to the Pacific, Brasileia – Assis Brasil, Acre, August 2001





New regional

Perspective:

Acre - isolated

no longer



Highway Iñapari - Puerto Maldonado
Peru 01-09-2001

Other model of development



Invitation by the Brazilian Embassy in Peru to discuss the environmental implications of the highway to the Pacific.

“The International Meeting On Regional Integration Bolivia – Brazil – Peru”
Arequipa, Peru
2-4 September 2001



Delegations from several Brazilian states, including Acre.

Highway to the Pacific is
in the fast lane

José Viegas. Brazilian
Embassador in Peru:

“If they don’t permit Peru
to take out a loan to finish
the highway to Iñapari, we
are ready to finance it.”

Cost: ~450 million dollars

**EMBAJADOR
DE BRASIL:**

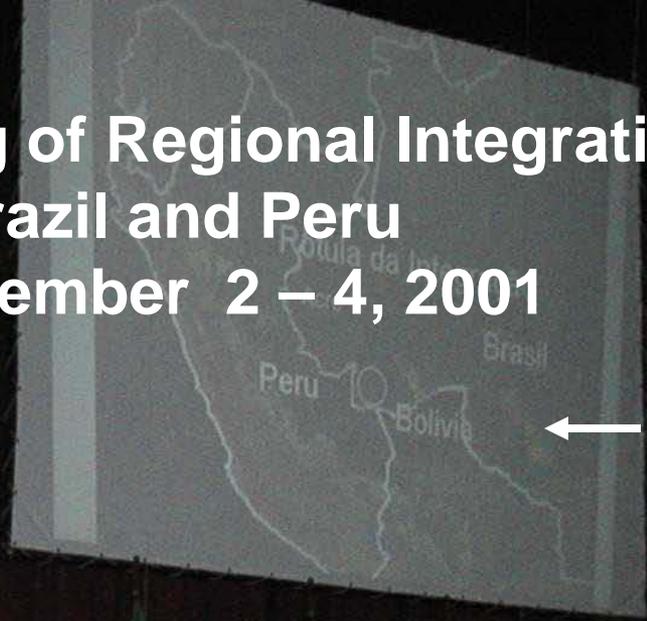
“Si al PERÚ
le niegan
endeudarse
para terminar el
tramo a Iñapari,
nosotros
estamos
dispuestos a
financiarlo”

**TRANS
OCEANICA**

**ES UN SUEÑO PRÁCTICAMENTE
HECHO REALIDAD**

International Meeting of Regional Integration Bolivia, Brazil and Peru Arequipa, September 2 – 4, 2001

Jorge Viana,
Governor of
Acre



Map based
on AVHRR
NDVI data



Transmitting the message to
society and strengthening the
regional LCLUC community

Development of a regional scientific community

Global Change and Land Use in Southwestern Amazonia



Meeting of Universities in SW Amazonia 06/99 Rio Branco



Workshop on Land use 12/00 Rio Branco



Workshop on Strategic Environmental Planning – 04/01 Puerto Maldonado



Workshop on logging activity on the frontier 08/2001 Assis Brasil, Acre

State and local governments

Mayor of Assis Brasil using LBA material



Secretary of Planning of Acre State, using LBA product



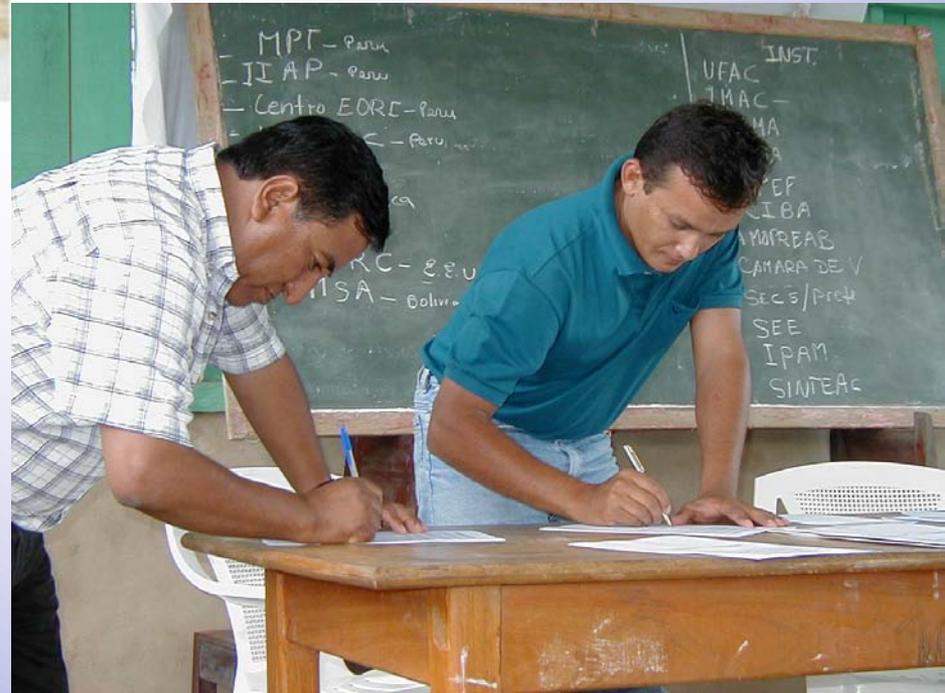
SETEM contributed to six chapters of the Ecological-Economic Zoning of the State of Acre

Letter of Assis Brasil: Constructing Sustainable Development on the Trinational Frontier 19/05/01



Results of LCLUC being incorporated into local, regional, and international planning

Request from local Peruvian and Brazilian government representatives for SETEM/LBA to provide information and aid in regional planning



Monica de los Rios, LBA
RA, explaining global
change to a meeting
of Rotary clubs from
Brazil, Bolivia and
Peru. 15 Sept 01



Desenvolvimento regional é dependente do Meio Ambiente

- Um papel da comunidade científica regional é ajudar as sociedades de Madre de Dios – Acre – Pando na utilização dos seus recursos com mais eficiência e mais sustentabilidade.
- Como fazer?



Elaboration of educational material for local and regional capacity building for LCLUC applications

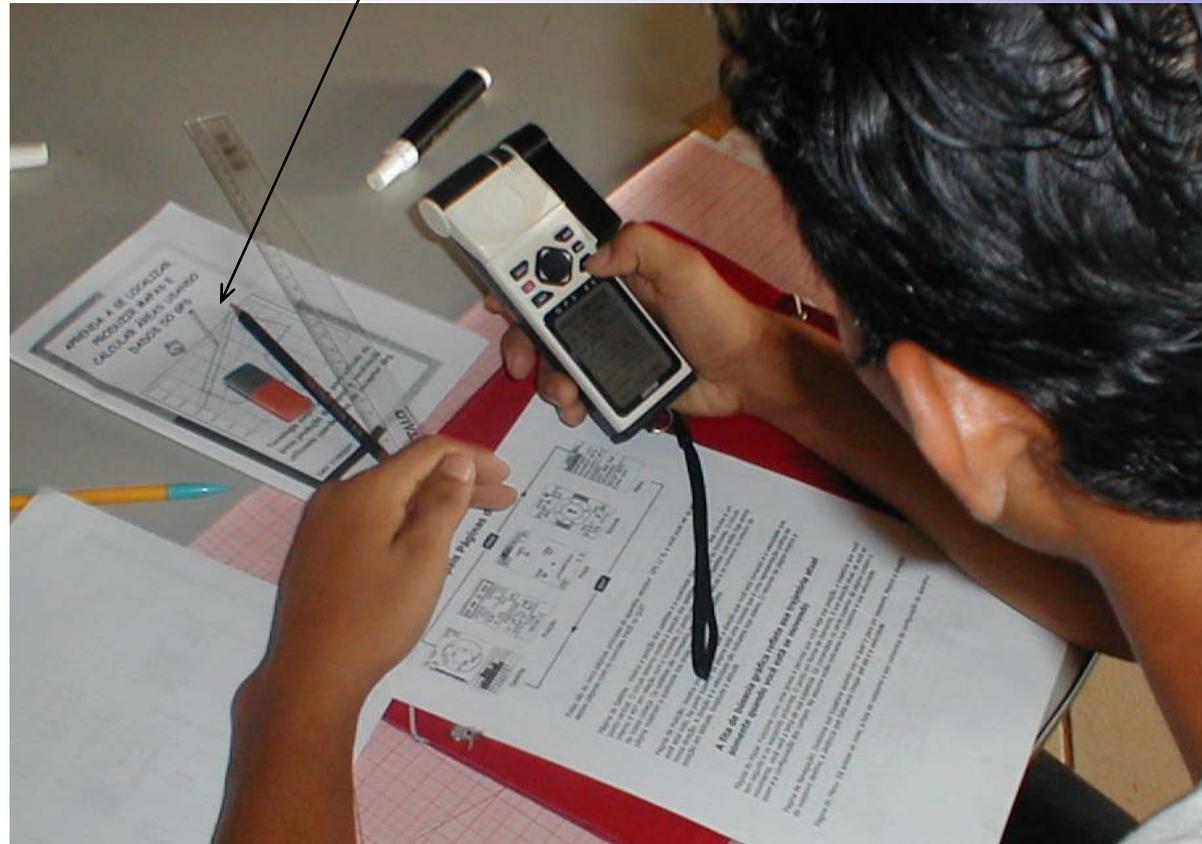
**APRENDA A SE LOCALIZAR E
CALCULAR ÁREAS USANDO
DADOS DO GPS**

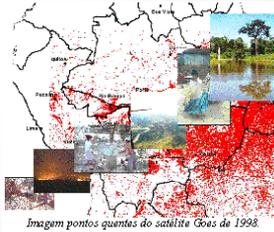


Tecnologia
simplificada
para cálculo
de áreas,
utilizando
coordenadas
do receptor
GPS

Versão Preliminar

Data: 24/07/2001





Universidade Federal do Acre
Pro-Reitoria de Assuntos Comunitários e Extensão
Parque Zoológico

Curso: Dimensões Humanas e Biofísicas em Mudanças na Cobertura e uso da Terra na Amazônia

[Objetivos](#) | [Justificativa](#) | [Metas](#) | [Vagas](#) | [Prazos](#) | [Inscrições](#) | [Clientela](#) | [Produtos Esperados](#)

Universidade Federal do Acre
Campus universitário, BR 364, Km 04 Distrito Industrial
Rio Branco-Acre-Brasil CEP 69. 915-900
Tel: 55 68 2292244 Ramal 291 Fax: 55 68 2291642
Contato: Kennedy/Franks
E-mail: cursomap@zipmail.com.br ou setem@ufac.br

www.ufac.br/cursopz



Course on "Human and Biophysical Dimensions of LCLUC in Amazonia"

Rio Branco, Acre

Dr. Eduardo Brondizio, Indiana University

9 to 15 December 2001

Participants: 6 Bolivians, 6 Peruvians,
And 8 Brazilians

Over 50 applications received.

Southwestern Amazonia 2030 (ASO 2030)

What LCLUC research and dissemination of results should we be doing now, so that in 2030, sustainable land use will be a reality in SW Amazonia and MAP?



REGION MAP

Summary Programmatic Slide I

*Most Significant Results

•Problemology:

- Uncertainties in Amazonian databases for deforestation, fires, and logging are more than recognized and have implications for constructing plausible scenarios and making public policy decisions. The 250 million dollar question in 2002: Did Governor Jorge Viana's policies reduce significantly the rate of deforestation/fire/illegal logging in Acre?

• Solutionology:

- Policy and geopolitical drivers are important for SW Amazonia. Migration and ranching tendencies will influence role of small holders in LCLUC in Acre. All amenable to being addressed via government. State and local governments and school systems both have the interest and the capability of understanding many LCLUC products and can use them to frame land-use issues. Request by the State Education Secretariat to propose a program for introducing concepts of LCLUC, Global Change and Regional Cultures into Acre state school system. Opportunity to serve as model for Amazonia.

Summary Programmatic Slide II

- * The proportion of Social Science in the study: about a quarter and growing
- *The proportion of the LCLUC themes that are covered in project: Carbon GOFC, human dimensions
- *New Findings
 - National level plans for access to Pacific/Atlantic, creating a major road system within the next 3? Years – a new and powerful driver for regional LCLUC.
- *New Products
 - Material to help rural communities and local government plan land use.