BBEST
Sustainability

Measuring Land Use Changes due to Biofuels Expansion: Methodological Advances

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Campos do Jordão
17 August 2011

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Sustainability Initiaves

- Bomsucro
- Roundtable on Sustainable Biofuels (RSB)
- International Standard Organization

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Why the Debate on Land Use Change is Relevant for Agricultural Based Biofuels?

		Today	Future		
			Business as Usual	Additional Demand	Difference
Production	bi. Liters	30.0	60.0	80.0	20.0
	GJ	655,350,000	1,310,700,000	1,747,600,000	436,900,000
Area	mi. Ha	3.8	6.5	8.7	2.2

	LUC 1 (mi. Ha)	Emissions 1 (mi. T CO2e)		LUC 2 (mi. Ha)	Emissions 2 (mi. T CO2e)	
		Annual	Perennial		Anual	Perennial
Pastures	1.7 (80%)	201.0	-7.0	1.3 (60%)	150.8	-5.3
Cerrado	0.4 (20%)	443.3	130.5	0.5 (25%)	443.3	163.1
Amazon	0.0 (0%)	0.0	0.0	0.3 (15%)	255.8	200.8
Total	**2.2**	**644.3**	**123.5**	**2.2**	**849.9**	**358.7**
iLUC Factor (g CO2e/MJ)		49.2	9.4		64.8	27.4
Direct emissions (g CO2e/MJ)		12 a 24			12 a 24	
Kha/Mtoe (iLUC)	39.5			78.9		

Assumptions:
Emission period: 30 years
Yield gain: 15% between today and future (8000 to 9200 thousand liters per hectare)
Uptake: 18 T CO2e /ha on annual crops and 44 T CO2e/ha perennial crops.

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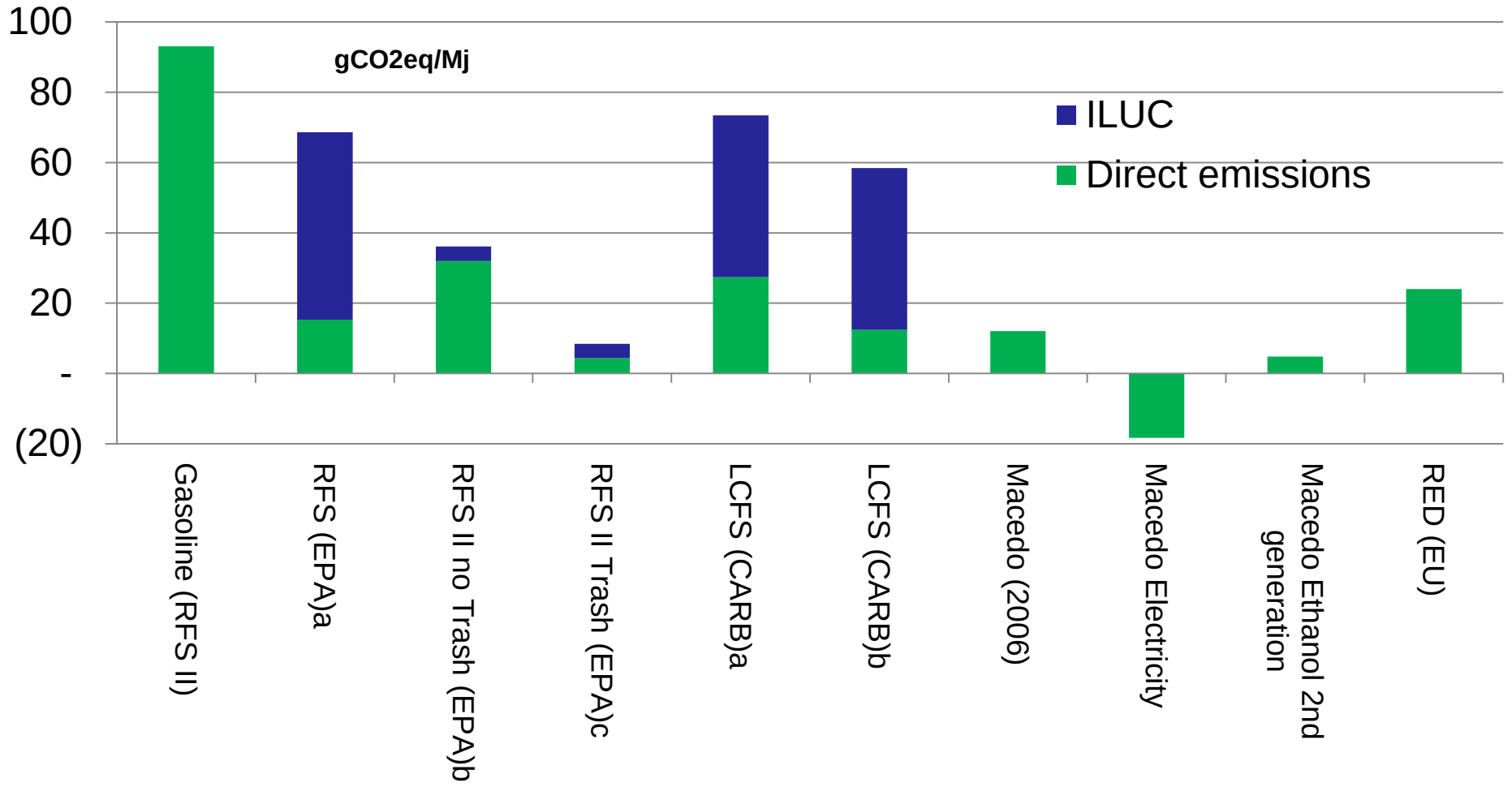
Sugarcane Ethanol: GHG Emissions According to Different Calculations



NOTES:
a: Preliminary rule; b: final rule, no trash for energy and marginal electricity credit; c: final rule, trash for energy and marginal electricity credit; d: no electricity credit; e: average electricity credit and mechanically harvested. Source: EPA; CARB; European Commission; Macedo(2009).

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Key Issues on Measuring Land Use Changes

- How much land is available for production?
- How agricultural activities compete by land?
- What are the drives of the frontier expansion (deforestation)?
- How competition and expansion are related (cause-effect relations)?
- What is the capacity of pastures to intensify without reducing beef and milk production?
- How local and global models can be integrated (or take advantage of each other)?
- How to incorporate conservation policies into models?
- How to combine economic models with geospatial information?

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European Union: Public Consultation on iLUC

Figure 16 Marginal changes in area per Mtoe for all models and scenarios

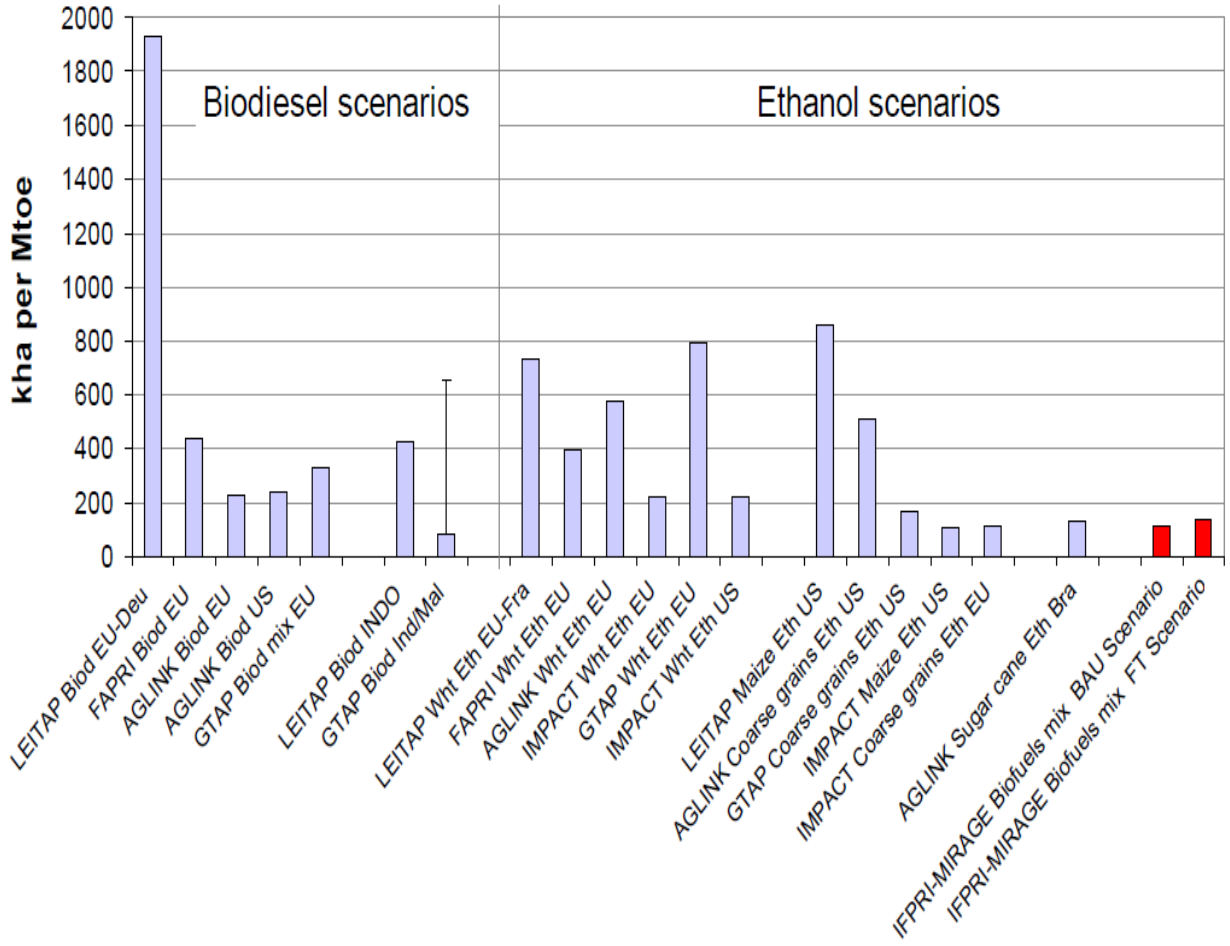

Table 37 Summary of modelled LUC results for biodiesel scenarios

Scenarios	Modelled results kha per Mtoe	Modelled results ha per toe
Biodiesel scenarios		
LEITAP Biod EU-Deu	1928	1.93
FAPRI Biod EU	435	0.44
AGLINK Biod EU	230	0.23
AGLINK Biod US	242	0.24
GTAP Biod mix EU	376	0.38
LEITAP Biod INDO	425	0.43
GTAP Biod Ind/Mal	82	0.08
Ethanol scenarios		
LEITAP Wht Eth EU-Fra	731	0.73
FAPRI Wht Eth EU	394	0.39
AGLINK Wht Eth EU	574	0.57
IMPACT Wht Eth EU	223	0.22
GTAP Wht Eth EU	794	0.79
IMPACT Wht Eth US	223	0.22
LEITAP Maize Eth US	863	0.86
AGLINK Coarse grains Eth US	510	0.51
GTAP Coarse grains Eth US	165	0.17
IMPACT Maize Eth US	107	0.11
IMPACT Coarse grains Eth EU	116	0.12
AGLINK Sugar cane Eth Bra	134	0.13

Including pasture intensification = 33.7 Kha/Mtoe

Source: Joint Research Center

Including Pasture Intensification in IFPRI-MIRAGE and Aglink-IE simulations

	Marginal Cropland Demand (1,000 ha)			
	Brazil		World	
	Original	Net of Pasture Intensification	Original	corrected
IFPRI-MIRAGE (*Al-Riffai et al., 2010)*	481	83	820	422
Aglink-IPTS (*Edwards et al., 2010)*	989	208	5,214	4,433

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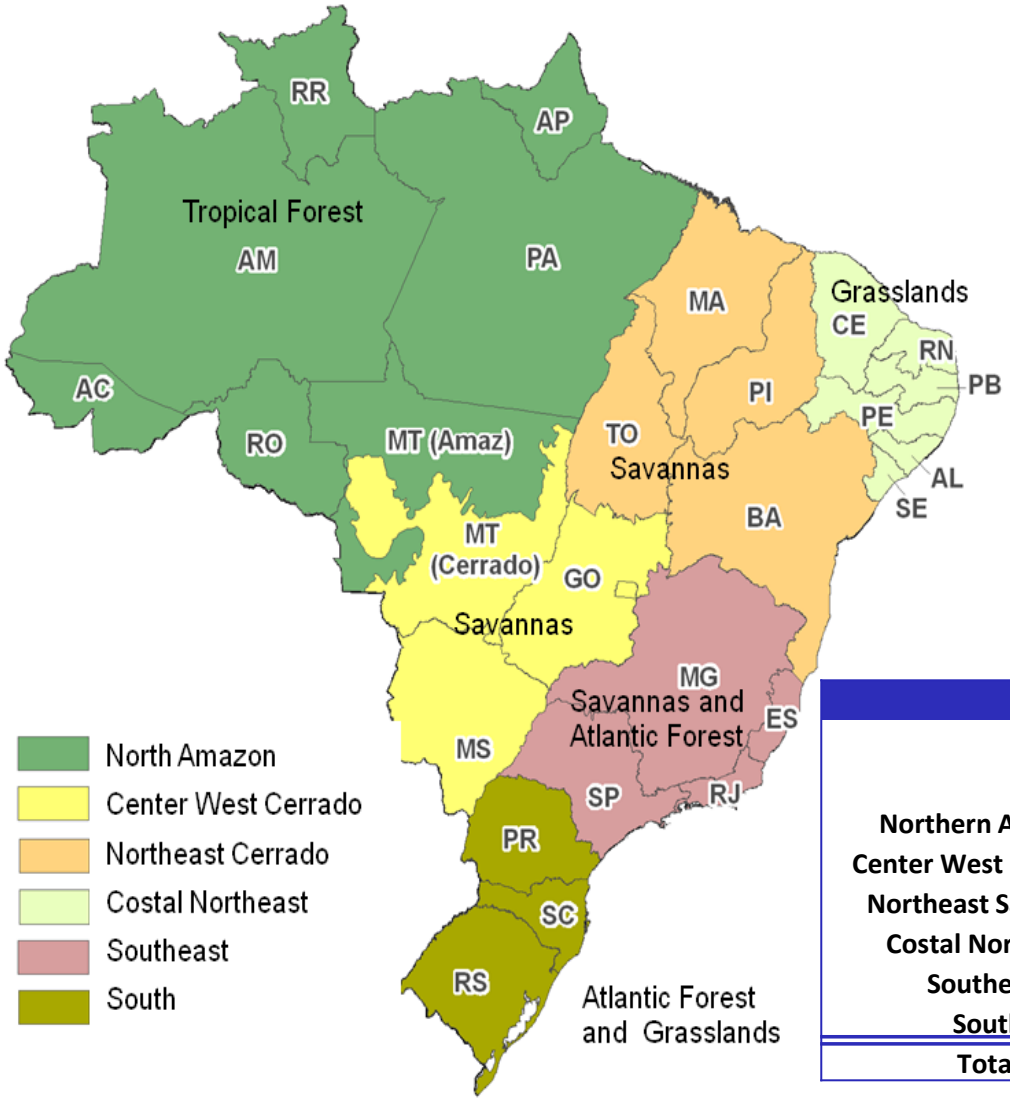
Brazil: Land Use

Land Use	Area (1,000 ha)	Total/Brazil
National parks and indigenous reserves	175,049	21%
Riparian and high slopes areas	100,336	12%
Remaining vegetation	293,953	35%
Land available for agriculture	102,684	12%
Pastures	171,711	20%
Crops	57,379	7%
Commercial forests	5,611	1%
Cities, water and other uses	47,414	6%
Total	851,453	100%

Fonte: Agricultural Land Use and Expansion Model – Brazil - AgLUE-BR (Gerd Sparovek, ESALQ-USP).
Elaboração: ICONE

Brazilian Main Agriculture Producing Regions (current and potential)



	Crops	Pastures		Land Available	
		Total	Suitable for annual crops	Total	Suitable for annual crops
Northern Amazon	6,198	39,851	19,830	16,108	2,256
Center West Savannas	13,969	37,318	22,592	18,057	8,872
Northeast Savannas	3,884	32,804	10,430	39,763	12,066
Costal Northeast	673	11,154	251	9,300	68
Southeast	17,861	31,456	12,220	12,004	4,324
South	14,795	19,128	6,569	7,452	2,081
Total	**57,379**	**171,711**	**71,891**	**102,684**	**29,667**

Source: ICONE.

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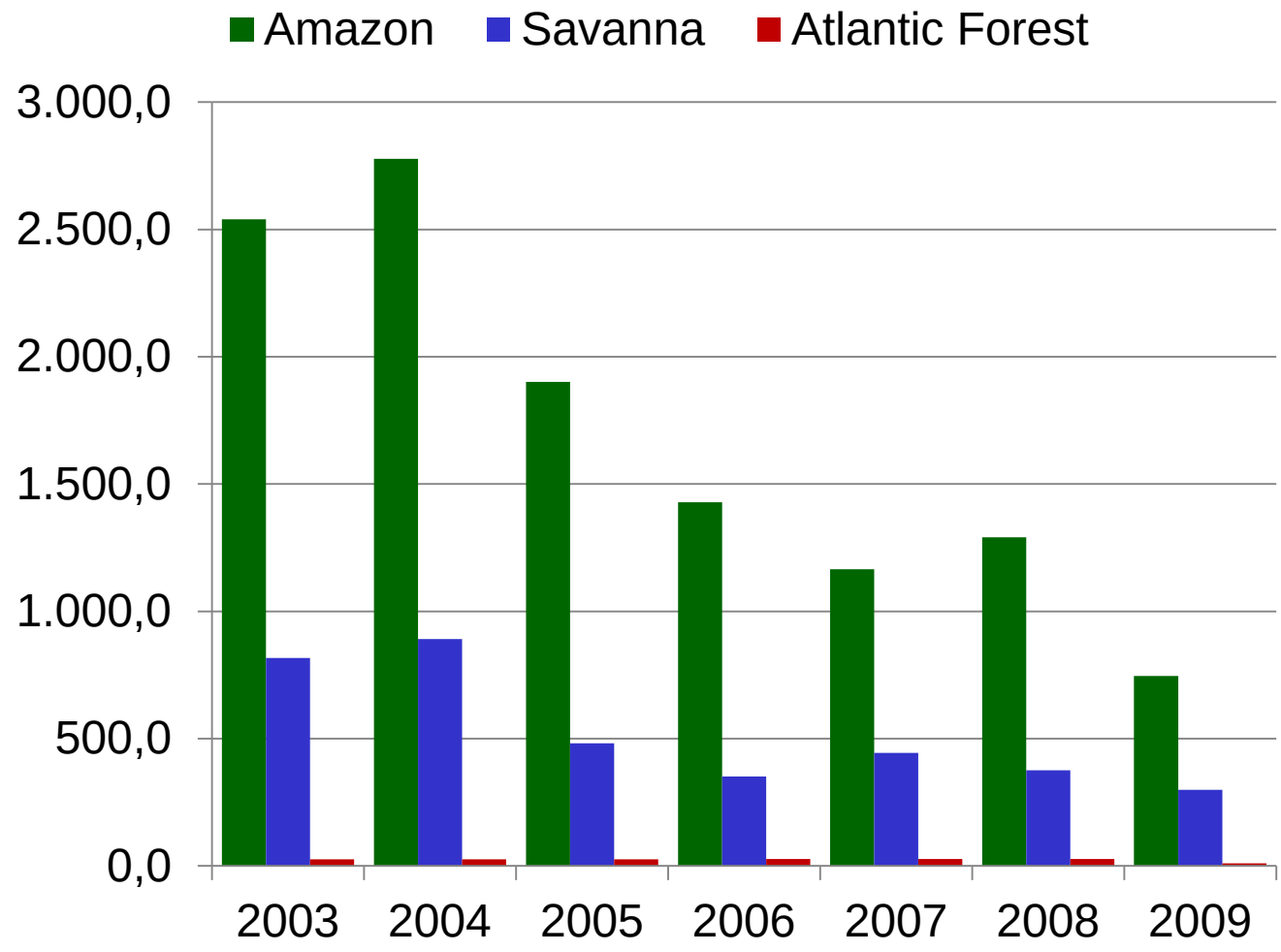
Accumulated Deforestation
(1,000 hectares)



Accumulated Deforestation (2002-2009, 1.000 hectares)	
Amazon (INPE/PRODES)	11,849
Savanna (LAPIG/UFG)	3,660
Savanna (IBAMA/MMA, 2008)	8,507
Atlantic Forest(INPE/SOS MA)	168

Source: LAPIG/UFG, PRODES/INPE, SOS Mata Atlântica, MMA

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Pasture intensification

Variable	Unit	1996	2008	Growth rate	Total Variation in the Period
Beef Production	Million Tons	6,186.9	9,765.4	5.34%	57.8%
Pasture Area	Million Hectares	184,141	180,143	-0.14%	-2.17%
Slaughter Rate	% of Cattle Herd	0.1781	0.2175	2.57%	22.1%
Stock Rate	Heads/Hectare	0.8596	1.1111	2.69%	29.3%
Carcass Weight	Tons/Head	0.2194	0.2243	0.16%	2.24%
Beef per Hectare	Tons/Hectare	0.0336	0.0542	5.49%	61.3%

Source: ICONE, original data from IBGE, UFMG and ICONE

Huge stock of pasture area, and significant rate of pasture intensification. But production has also grown very fast.

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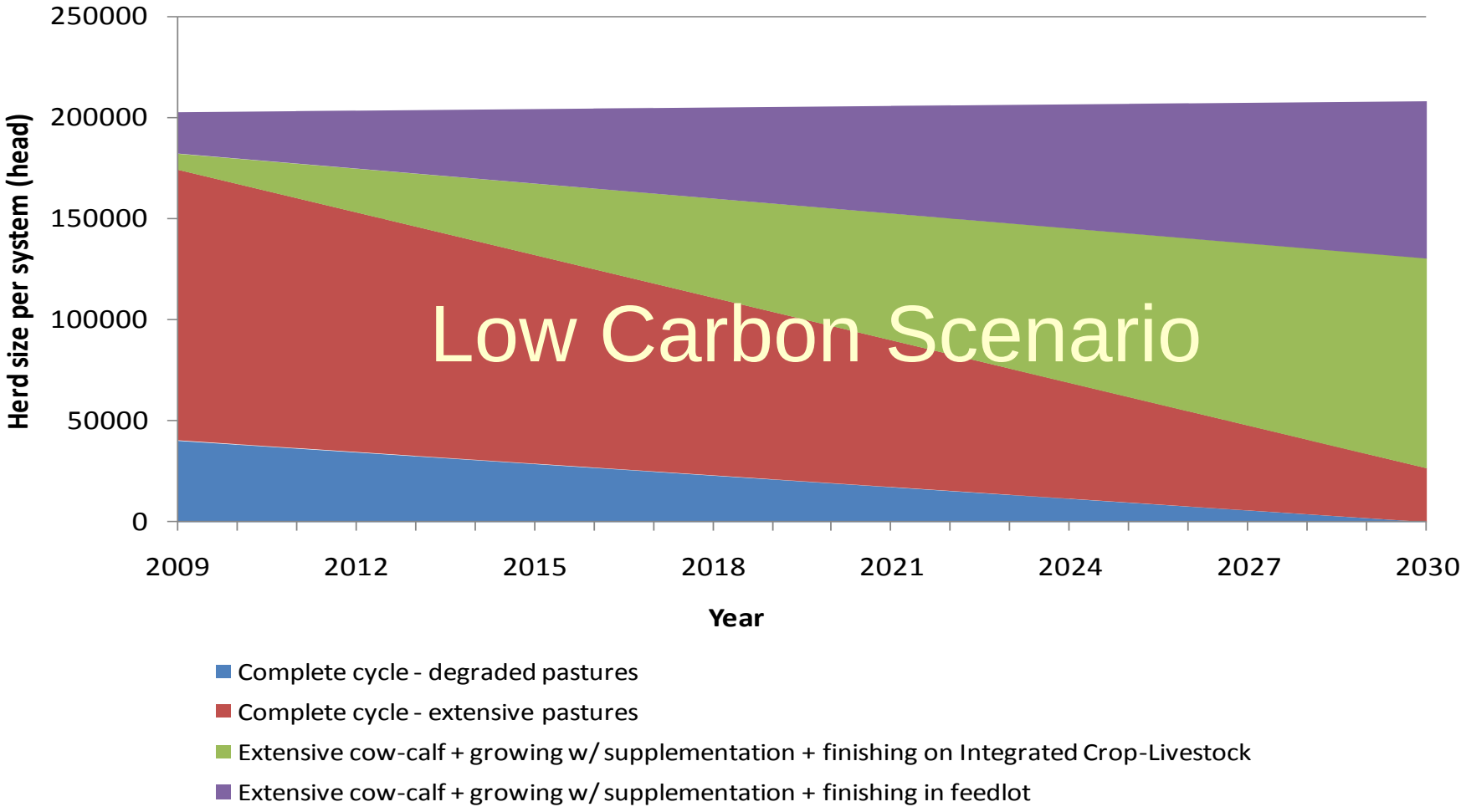
Table 2.3: Area and Number of Cattle in Each Production System for the Reference-scenario Base Year (2008)

Production system	*Area (millions of ha)*	*No. of cattle (millions of head)*	*Emissions (Mt CO_2e/ year)*
Complete cycle on degraded pasture	59.53	22.38	26.94
Complete cycle on extensive pasture	132.18	155.51	171.36
Extensive cow-calf raising on pasture, plus supplemented stocking and finishing in crop-livestock systems	5.50	10.00	12.11
Extensive cow-calf raising on pasture, plus supplemented stocking and finishing in feedlots	8.18	14.88	18.94
Total	**205.39.00**	**202.77.00**	**229.35**

Source: Brazil Low-carbon Country Case Study, The World Bank, 2010 (available at: http://siteresources.worldbank.org/BRAZILEXTN/Resources/Brazil_LowcarbonStudy.pdf)

Making cattle raising systems more productive



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Beef production in Brazil, "potential production" and reallocation effect

	Pasture Area 1000 ha		Beef Production 1000 tons (observed) (i)		Growth Rate (ii)	Production induced by world demand 1000 tons (iii)	Difference (based on 2008) 1000 tons (iv)	Implied area loss (v)	Additional area (vi)
	1996	2008	1996	2008	1996-2008	1.05%	(i)-(iii)	(1000 ha)	(1000 ha)
South	20,697	15,784	1,034	1,147	1.52%	1,172	-25	-549	
Southeast	31,287	28,008	1,763	2,368	4.97%	1,998	370		-3,279
Center-West Cerrado	55,058	47,588	2,061	3,520	4.84%	2,336	1,184		-7,470
North Amazon	33,945	45,518	637	1,520	9.87%	722	798		11,573
Northeast Coast	9,878	10,711	357	375	1.53%	405	-30	-656	
Northeast Cerrado	33,277	32,533	335	835	9.86%	380	455		-744
Brazil (total)	184,141	180,143	6,187	9,765	5.34%	7,013	2,752	-1,205	80
							Reallocation		-6.68%

Source: ICONE.

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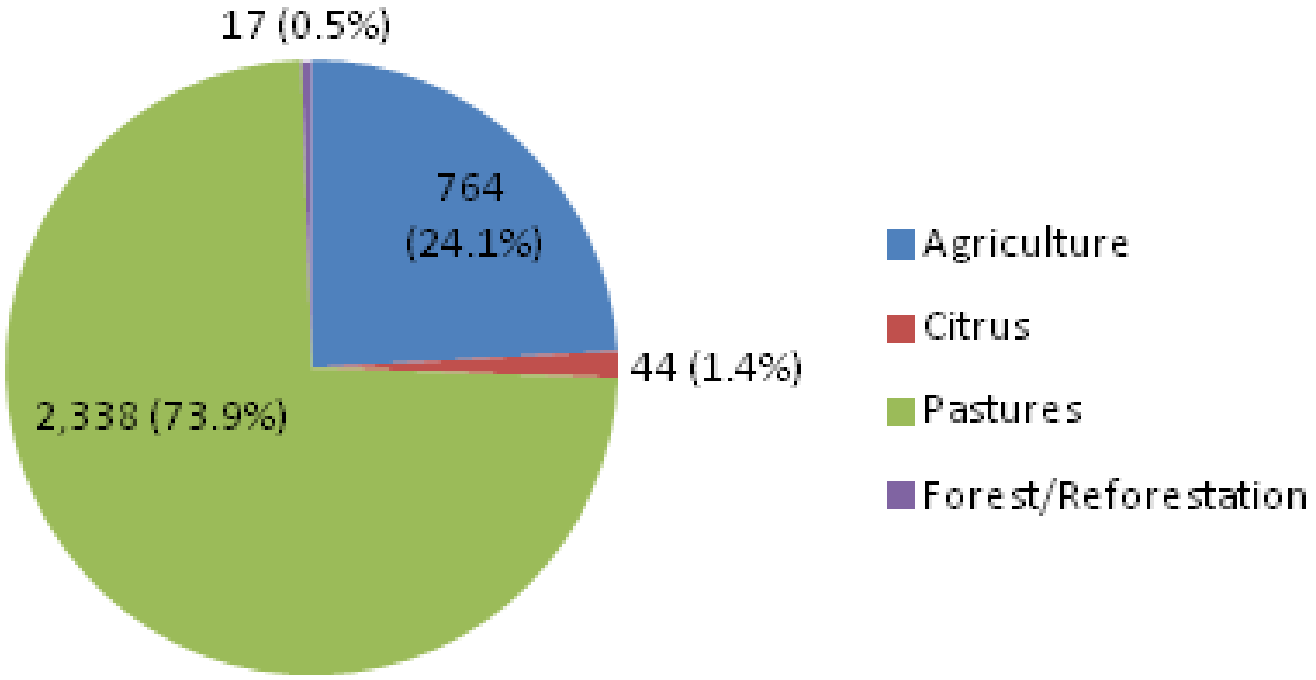
Types of Land Use Converted to Sugarcane from 2000 to 2009 (thousand ha and %)



Source: personal communication with Bernardo Rudorff from CANASAT Project/INPE. This is an on going analysis and it cannot be quoted or cited without the authorization from the author.

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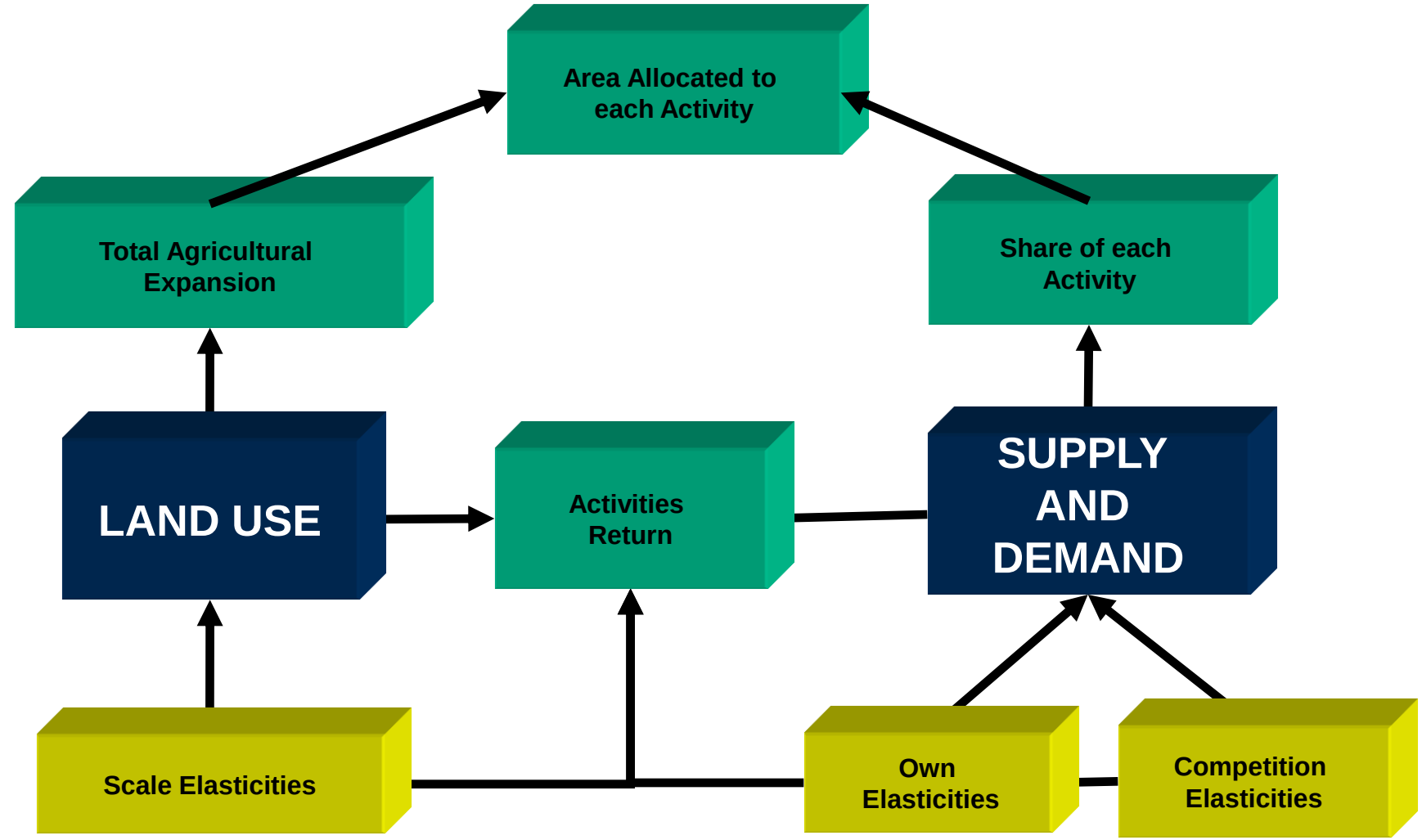
Land Use Dynamic



Source: ICONE.

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Land allocated to agriculture (1,000 ha) and weighted average returns (R$/ha)

	South		Southeast		Center-West Cerrado		Northern Amazon		Northeast Coast		Northeast Cerrado	
	Area	Return	Area	Return	Area	Return	Area	Return	Area	Return	Area	Return
2002	31,118	261	37,131	202	60,136	213	43,811	69	13,287	129	36,557	342
2003	31,133	309	37,195	281	60,783	269	46,097	88	13,468	148	36,927	416
2004	31,148	313	37,255	246	61,399	246	48,542	73	13,785	146	37,486	466
2005	31,162	294	37,299	191	61,765	168	50,203	52	14,077	159	37,808	323
2006	31,176	165	37,351	143	61,997	98	51,453	28	14,663	151	38,058	174
2007	31,190	120	37,439	172	62,175	104	52,522	26	14,790	124	38,344	132
2008	31,203	218	37,488	215	62,346	167	53,601	64	14,996	106	38,726	152
2009	31,211	253	37,526	173	62,523	162	54,159	57	15,250	135	39,008	193

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Land Supply Elasticities

Regions	Previous Version	Updated Version
South	0.057	0.002
Southeast	0.067	0.007
Center West Cerrado	0.180	0.031
Northern Amazon	0.250	0.103
Northeast Coast	0.010	0.056
Northeast Cerrado	0.100	0.066

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Example: Competition Elasticity Matrix - Southeast

	Corn 1st crop	Soybean	Cotton	Rice	Dry Bean 1st crop	Sugarcane	Pasture
Corn - 1st crop	0.1994	-0.1299	-0.0011	-0.0012	-0.0011	-0.2038	-0.0259
Soybean	-0.0782	0.4299	-0.0031	-0.0024	-0.0034	-0.1249	-0.0273
Cotton	-0.0093	-0.0437	0.2087	-0.0001	-0.0001	-0.0180	-0.0146
Rice	-0.0139	-0.0458	-0.0002	0.1200	-0.0002	-0.0181	-0.0107
Dry Bean - 1st crop	-0.0038	-0.0187	0.0000	0.0000	0.0947	-0.0069	-0.0080
Sugarcane	-0.0134	-0.0136	-0.0001	-0.0001	-0.0001	0.4029	-0.0068
Pasture	-0.0080	-0.0140	-0.0005	-0.0003	-0.0007	-0.0319	0.0047