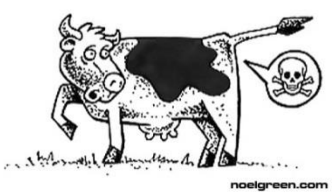
About me:

- Bachelor degree in Applied and Computational Mathematics (2010), University of Campinas, Brazil;
- Master's degree in Applied Mathematics (2013), University of Campinas, Brazil;
- PhD candidate in Optimization and Operational Research (Start in 2014) at The University of Edinburgh and Scotland's Rural College (SRUC), UK.
- I have strong collaboration with the Brazilian Agricultural Research Corporation (Embrapa);
- I have particular interest in modelling livestock and GHG related problems;



Background

- Demand for meat and milk is going to double by 2050 (FAO, 2006).

- Furthermore, international projections indicate expressive increase in the demand for other agricultural products such as grain, wood, fibre and biofuels (Smith et al., 2010)

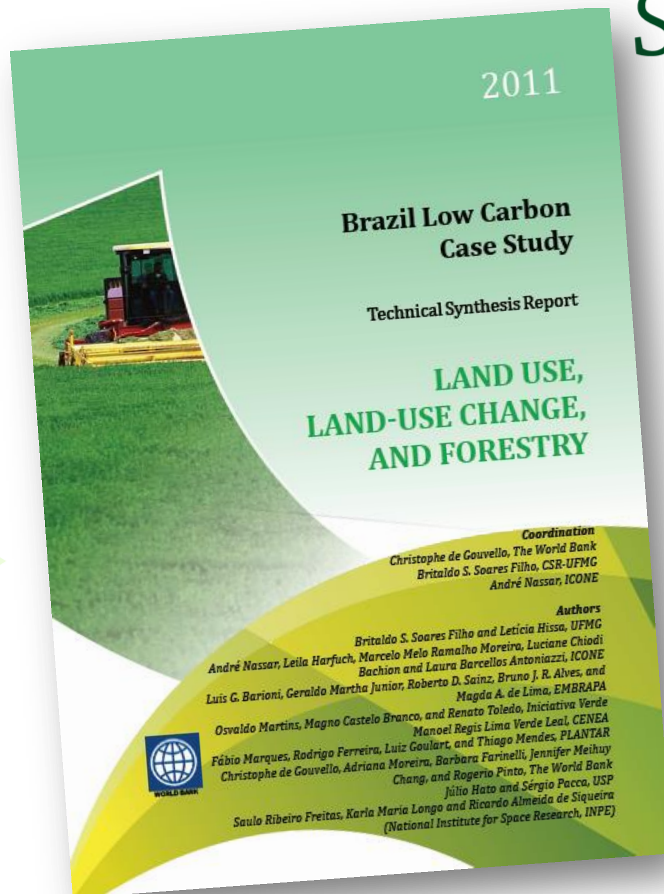
- It is expected, therefore, increase in competition for land and consequently, increased rates of deforestation (TGOS, 2011)

- However, the expansion of cropping on grasslands areas may buffer this effect: Grasslands cover about 70 % of agricultural land worldwide (FAO, 2009), making it a promising source of land for other agricultural uses.

Background

- This buffering effect of grasslands would require, however, increasing the productivity of grazing production systems.

- A recent study (Gouvello et al. 2010) has estimated that increasing beef productivity would be capable of providing the land area needed for the expansion of crops for food and biofuel production in a near-zero deforestation scenario in Brazil until 2030.



Is Brazilian livestock production intensified?

Biggest problem: pasture degradation, it is estimated that between 50 to 80% of grasslands in Brazil present some level of degradation.

degradation

Further, such actions are likely to reduce greenhouse gases emissions through lowering methane emissions per unit of product (Gouvello et al. 2010) and increasing soil carbon stocks (FAO, 2009).

ABC Plan

Brazil's Policy to Develop a Low-Carbon Agriculture

Technology	Commitment (area increase/use)	Mitigation Potential (million Mg CO_2 e)
Recovering Pastures	15.0 million ha	83 a 104
Crop-Livestock-Forest Integration	4.0 million ha	18 a 22
No-Tillage System	8.0 million ha	16 a 20
Biological Nitrogen Fixation	5.5 million ha	10
Planted Forests	3.0 million ha	-
Treatment of Animal Residues	4.4 million m^3	6.9
Total		133.9 – 162.9

The objective of this paper is:

(1) To present a new method for pasture management optimization - Partition Based Pasture Productivity Dynamics (PBPPD) and compared it with competing management strategies: cyclical (model 1) and semi-cyclical (model 2) under different scenarios, and

(2) To use PBPPD to investigate the effects of cattle prices variations over pasture intensification.

The objective is the profit maximization under bioeconomic constraints.

$$\begin{aligned} &\text{Max } z(x) = c^T x \\ &\text{s.a} \quad Ax \leq b \\ &\qquad\quad x \geq 0 \end{aligned}$$

Where:

x = vector of activities (decison variables);

c^T = vector of net income per unit of activity;

A = matrix of general coefficients;

b = vector of min/max values for the activities.

Herd dynamics

Age-structured model

Age cohert	Age, months	LW[1], kg	DMI[2], kg/day	Mortality[3], %/year	Price R$/animal[4]	Costs, R$/animal/month[5]
1	[6,9)	180	4.83	4.9	585	1.731
2	[9,12)	214	5.54	4.9	626	1.971
3	[12,15)	249	6.24	2.4	727	2.181
4	[15,18)	283	6.96	2.4	828	2.391
5	[18,21)	318	7.66	2.4	946	2.631
6	[21,24)	352	8.37	2.4	1.049	2.841
7	[24,27)	387	9.08	0.4	1.152	3.051
8	[27,30)	421	9.8	0.4	1.278	3.261
9	[30,33)	456	10.53	0.4	1.383	3.471
10	33	490	11.33	0.4	1.481	3.711

Slaughter weight

K=1

K=10

$y_{m,k}$ be the number of stocked animals and

$x_{m,k}$ be the number of purchased animals in cohort $k \in \{1,2,\ldots,10\}$ at the month $m \in \{1,2,3,\ldots,T_m\}$, μ_k the mortality rate of age cohort k. Then the dynamics of age cohorts can be modelled as follows:

$$y_{m.,k} = x_{m,k} + (1-\mu_{k-1})y_{m-1,k-1} + \sum_{j}\prod_{i=1}^{j}(1-\mu_{k-i})^3 x_{m-3j,k-j} -$$

$$-\sum_{j}\prod_{i=1}^{j}(1-\mu_{k+1-i})^3 x_{m-3j,k-j+1} \quad ,1 \le k < 10\,, \quad j \in \{1,2,..\}$$

Modelling pasture degradation

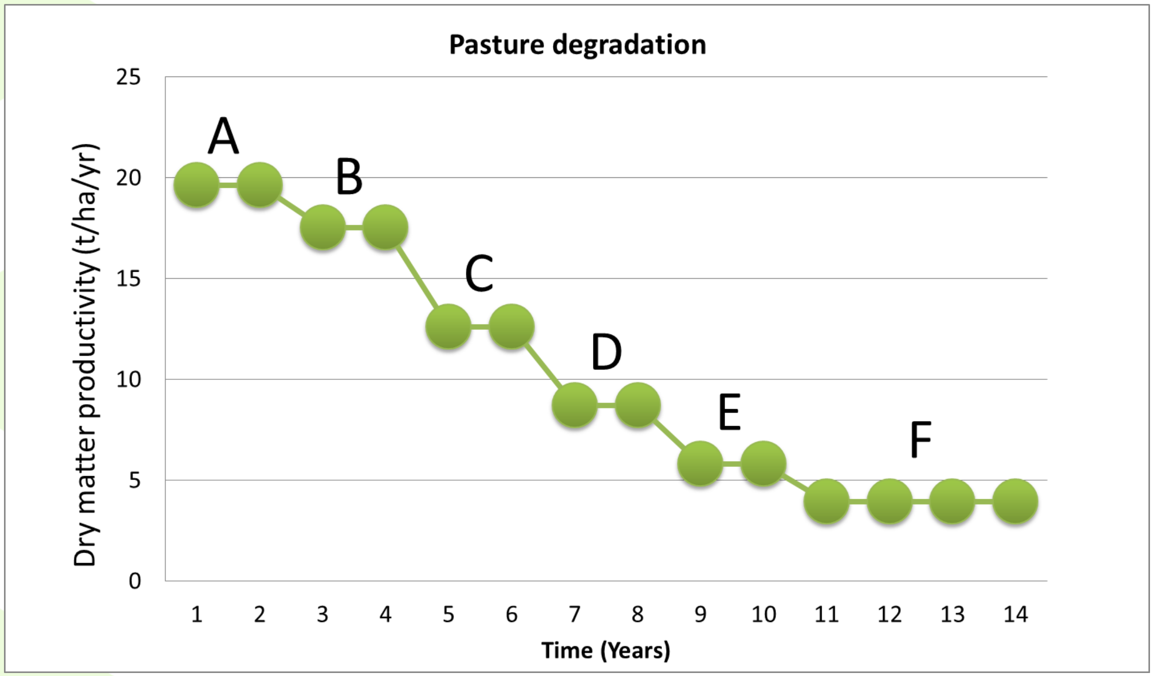


Fig. 1: Discrete representation of pasture (brachiaria) degradation.

Modelling pasture restoration

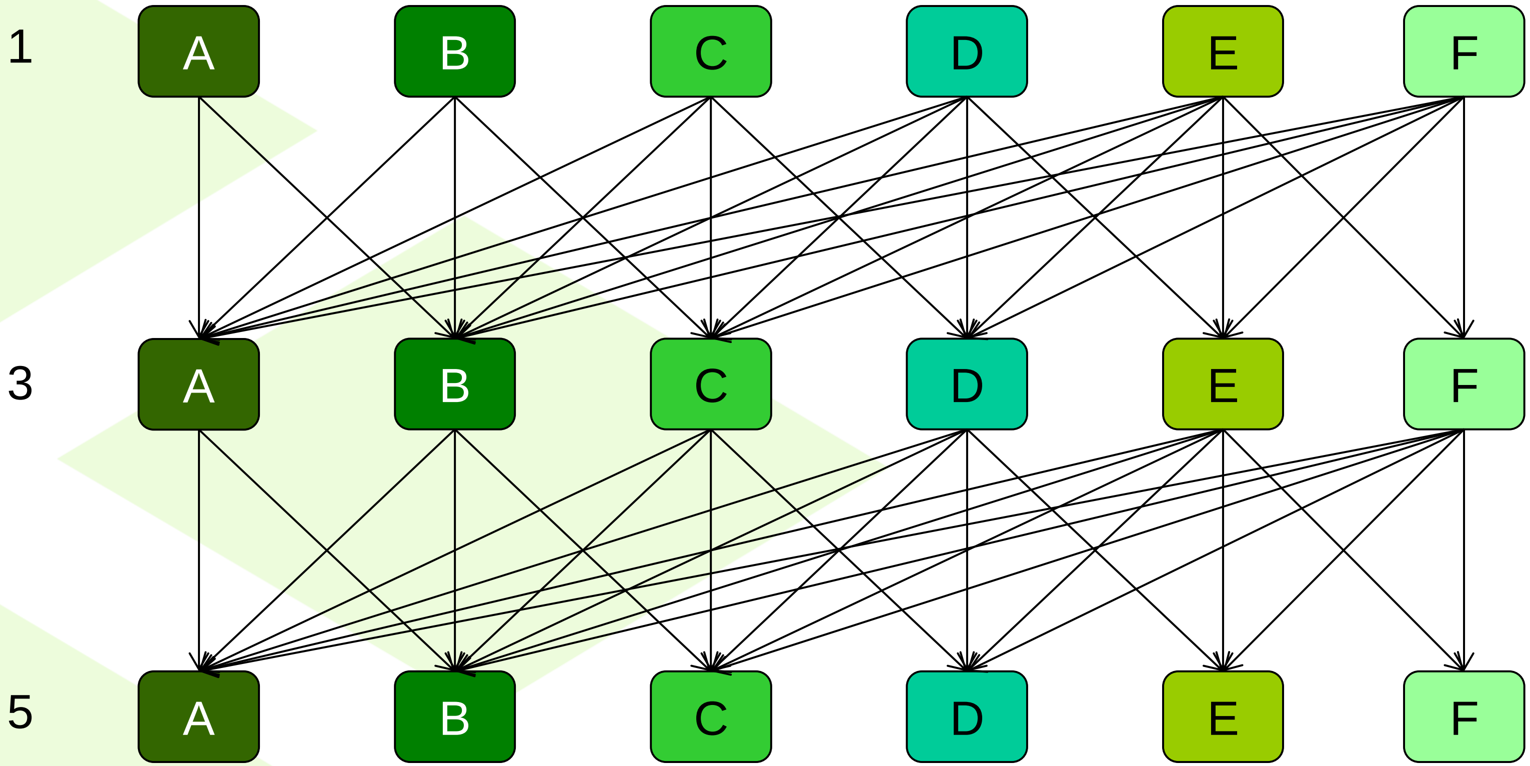


Figure 2: Diagram of pasture reclaiming strategy.

Restoration costs

From partition		To partition					
		A	B	C	D	E	F
	A	219.6					
	B	292.8	142.0				
	C	779.9	487.1	29.2			
	D	1230.4	937.6	450.5	18.3		
	E	1415.2	1122.3	635.3	184.8	10.9	
	F	1498.1	1205.3	718.2	267.7	82.9	10.9

Costs calculated according to amount of inputs and services. Ex.: calcium, limestone, fertilizers, micronutrients, seeds, urea distribution, mowing.

Pasture management through partition

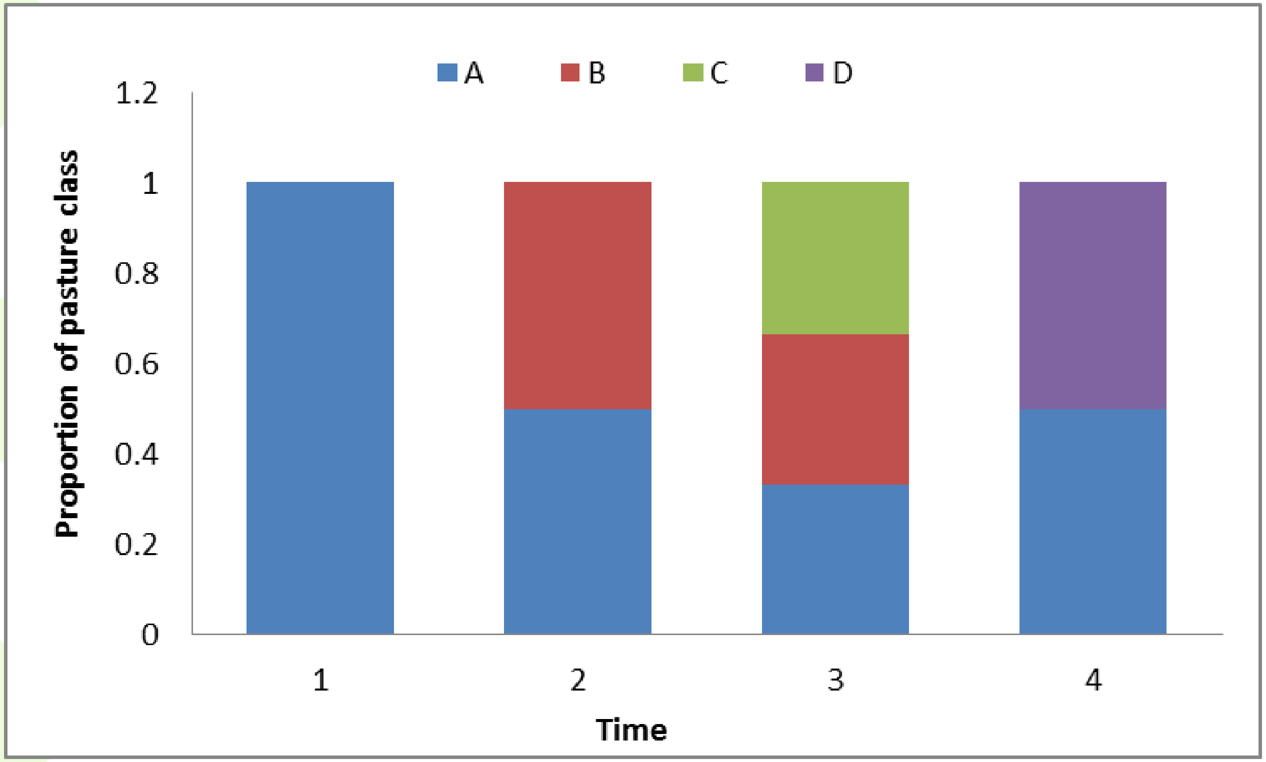


Figure 3: Pasture decomposition method.

Degradation/restoration equations

$$z_{t,p} = z_{t-1,p} \, , \quad if \;\; t \; is \; even$$

$$z_{t,p} = z_{t-1,p-1} + \sum_{q} (rz_{t,q,p} - rz_{t-1,p,q})$$

$$t \; is \; odd \; and \; t > 1$$

Competing methods

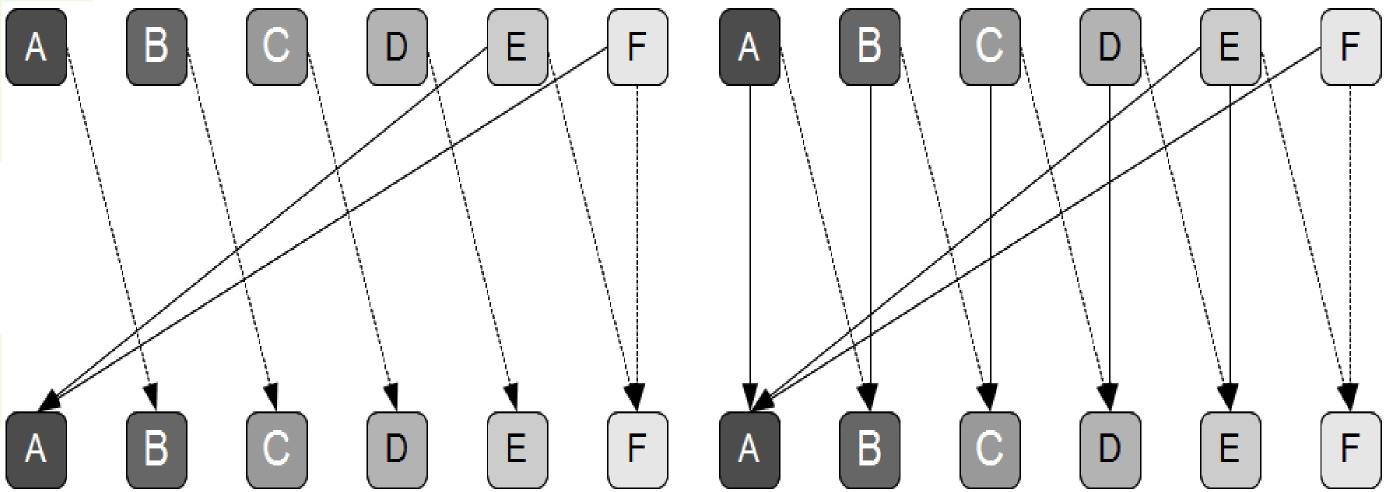


FIG. 4.a: Cyclical (model 1) pasture interventions

FIG. 4.b: Semi-cyclical (model 2) pasture interventions

Farm Initial conditions

Table 9 : Initial pasture productivity scenarios.

		Pasture initial composition[1], ha					
		Classes					
		A	B	C	D	E	F
Scenario	HPP	600					
	IPP	200	200	200			
	LPP			150	150	150	150

Results

Profit comparison (NPV) and stocking rate for different models and scenarios

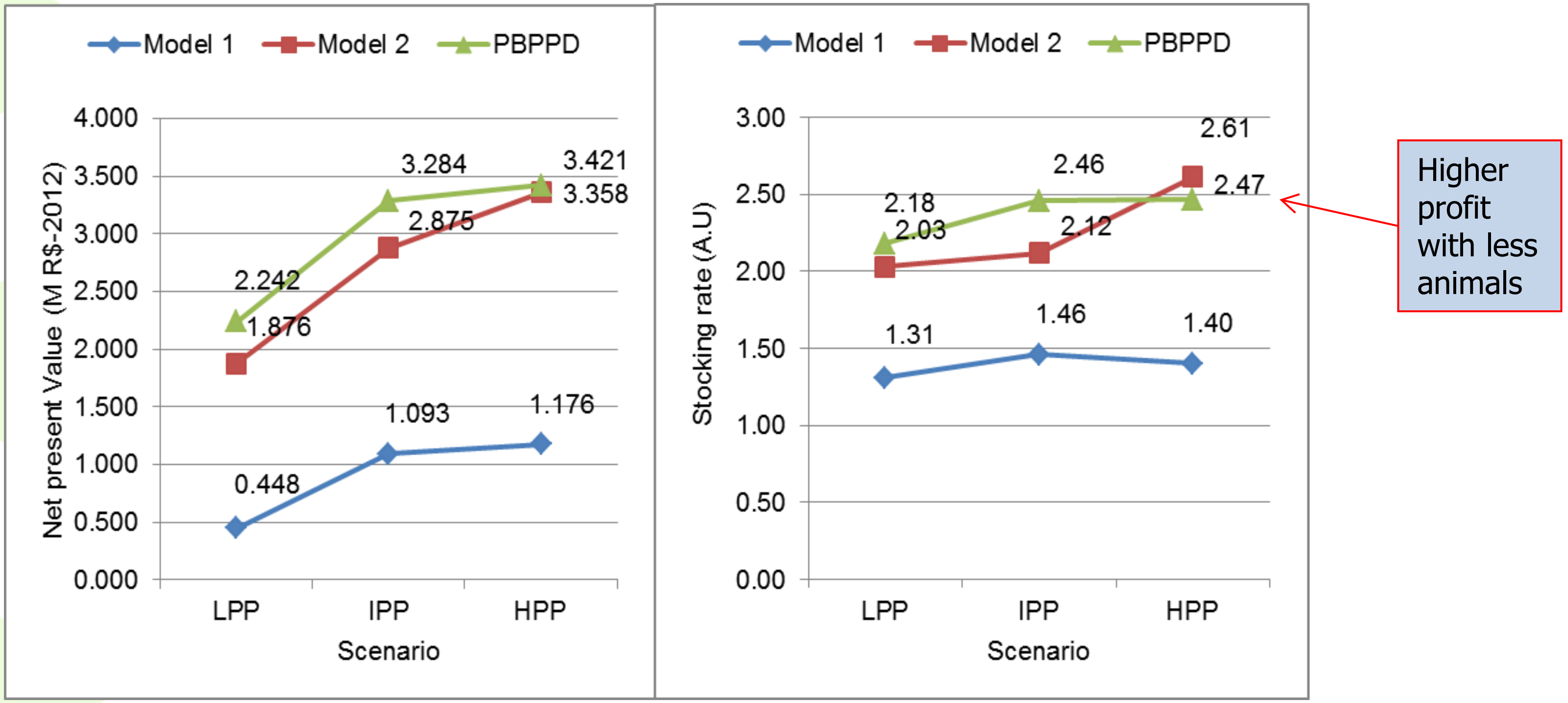


FIGURE 5: Comparison of the results of PBPPD and alternative models for: (a) Net present value of total accumulated value at the end of the project (converted to January 2012 net present value), and; (b) average stocking rate (A.U. ha^{-1}) under the three different scenarios.

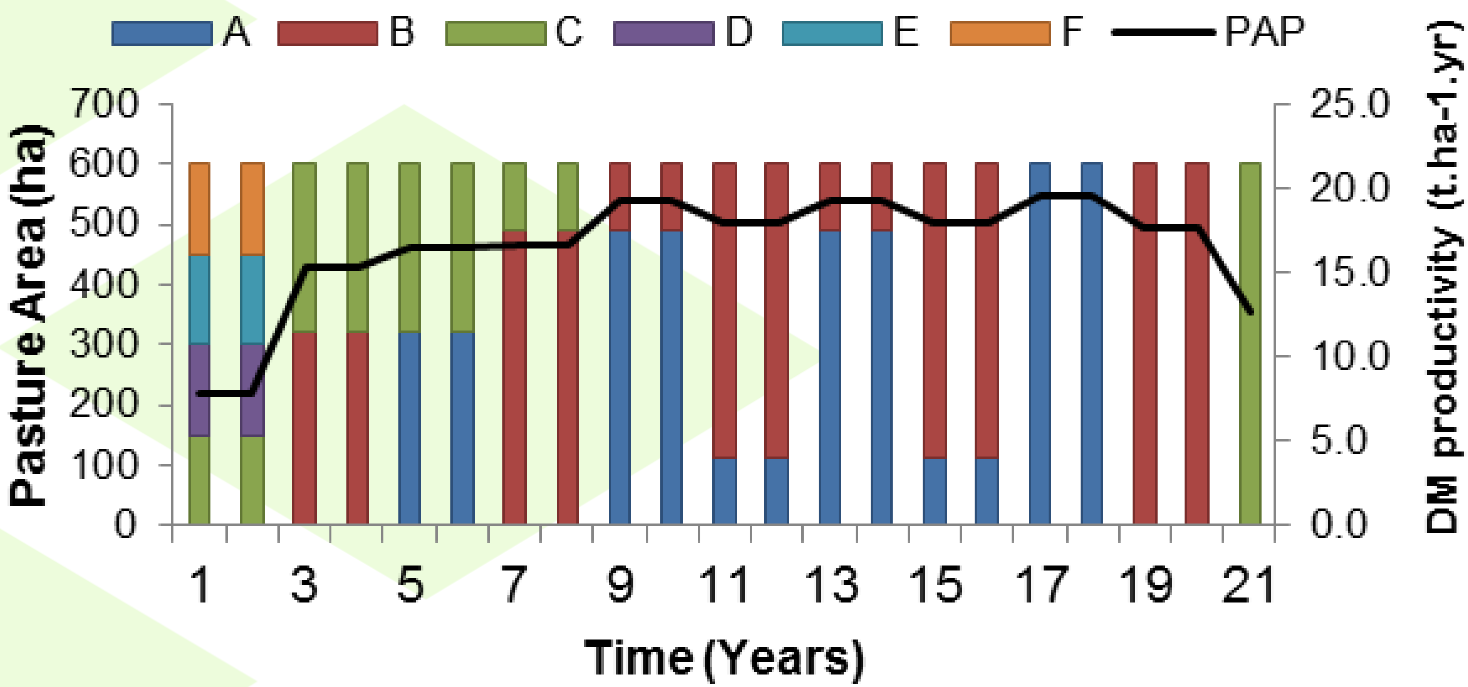


FIGURE 6: Pasture composition and pasture average productivity (PAP) under PBPPD strategy and LPP.

Pasture composition according to cattle price.

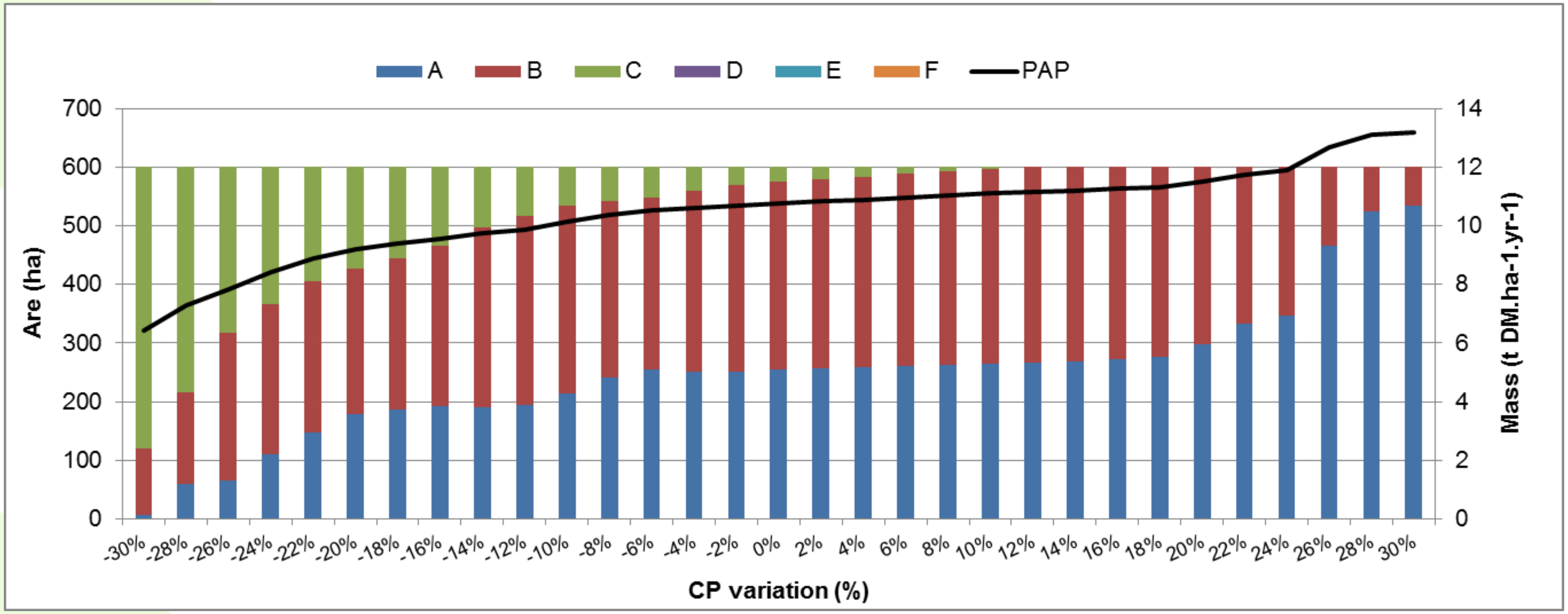


Figure 7: Average pasture composition from the 7th to the 15th year of production for the -30% to 30% variation over the cattle prices.

Conclusion

The model showed that pasture reclaiming decisions can make the difference between financial loss and high profitability, with the same fixes budgets, invested capital and credit options;

The proposed PBPPD model proved its effectiveness by increasing profitability in all evaluated scenarios with small variation on stocking rate

Decisions regarding the proportion of pasture area to let to degrade or restored are not trivial and require detailed mathematical modelling approach

Next steps

- Include females;
- Model breeding;
- Model feedlot (land allocation to produce crops used to ration formulation);

- Account herd GHG emissions (Tier 2);
- Model soil carbon stock change in function of time and pasture management;
- Model further mitigation measures, e.g., supplements;

Thanks!

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