Supporting Material is available for this work. For more information, follow the link from the Table of Contents to "Accessing Supporting Material".

Modelling the grazing system: Grazing system model for the "pampa húmeda argentina"

ABSTRACT

Innovation is regarded as an important factor for increasing profitability on the beef cattle enterprise. However, the profitability of the grazing systems depends not only on the simple applications of a technique such as fertilisers or pasture varieties but on the processes involved as well.
Grazing systems include several components such as climate, soil, plants, animals, parasites and diseases, and complex interactions between components. In complex environments consequences of actions are often no very clear for decision-makers. Due to the complexity and the dynamic behaviour of the system there is a time gap between decision and the evidence of the consequences of the decision itself, that makes the decision process even more difficult. This paper provides a System Dynamics approach reflecting the interactions inside the system and between the system an its environment. The system Dynamics model gives an insight of the dynamics consequences of decisions in innovation management and allows testing different innovation strategies.
A model of the seasonal grass and clover pasture growth and live weight response of grazing heifers was built using first order differential equations to earn insight on the dynamics behaviour on the systems.
Herbage growth is estimated from known relationships with radiation received, leaf area exposed, soil moisture, mineral nutrition and herbage removed by grazing. Changes in soil moisture are estimated from rainfall and calculated evaporation. Live weight change of the grazing animals is calculated as a function of the intake, digestibility, and the partitioning of metabolizable energy between maintenance and weight change.

Key words: modelling, beef cattle, grazing systems, management

INTRODUCTION

The management of innovation in grazing systems is located in a highly complex and dynamic environment.

There are complex interactions inside the system and between the system and the environment. In complex systems consequences of actions are often not very clear for decision-makers. Because of the complexity and the dynamic behaviour of the system there is a time gap between the decision and the evidence of the consequences of the decision itself that makes the decision process even more difficult.

Decision-making at this level of complexity can not be simplified as a cause effect model, but may be supported by formalised and more complex models.
The system Dynamic approach may offer the framework to understand the complexity and inherent dynamic of the innovation process in the grazing system.
A system dynamics model gives an insight of the dynamics consequences of decision in innovation management and allows testing different innovation strategies.

The grazing system includes several components such as climate, soil, plants, animals, parasites, diseases and complex interactions between the components.
In this paper special attention is drawn on modelling grazing systems in a specific site and set of climatic condition in the south east of Buenos Aires of Argentina.

The model was built using data from the literature to synthesise the relationships into a dynamic model to help for a better understanding of the system.

THE MODEL

A simple System Dynamics model as showed in Appendix serves as a first approach integrating the concepts described above linking the basic components together into a feedback structure.

Modelling herbage accumulation was developed using climate and other data as inputs (Arosteguy et. al. 1981. McKenzie et. al. 1999). The model is multiplicative; that is, the factors affecting herbage accumulation are combined by multiplying all together (Forrester 1969). A notional maximum daily herbage accumulation rate under ideal conditions was assumed and each of the factors influencing this rate was converted to a value or index ranging from 0 to1.

A value of 1 indicates that factor is non-limiting and a value of 0 indicates zero growth.

HERBAGE GROWTH RATE

The maximum daily herbage accumulation rate was modified by leaf area index and incoming radiation (Black 1964, Brown and Blaser 1968)

The temperature index was similar to that described by Mc Kenzie et. al. (1999). The soil fertility effect was derived from data published by Arosteguy and Gardner 1976 and Marino et. al. 1995. Reproductive growth is assumed to increase herbage accumulation rate of the vegetative growth and it is introduced on a seasonal basis.

The moisture response was calculated as a soil water balance generated by rainfall and estimated evapotranspiration. Evapotranspiration was calculated from Doorembos and Pruitt (1974)

LIVE WEIGHT OF STEERS

The daily intake rate of pasture by the grazing steers was related to herbage weight (Hodgson, 1990).

The amount of metabolizable energy derived from the digested pasture is calculated as suggested by Blaxter (1964). The rate of live weight change is calculated after allowing for the maintenance requirements, if intake of metabolizable energy exceeds maintenance them live weight gain is calculated after Blaxter (1967).

Compensatory live weight gains after an intake restriction was simulated after Verde (1973).

ECONOMICS ANALYSIS

There is incorporated an economic analysis. It is calculated a gross margin of the beef cattle enterprise, AACREA (1989) .

MODEL PERFORMANCE

Prediction of the weight herbage available agreed with measured values Arosteguy et. al. (1981). The daily growth accumulation rate for two series of climatic data is showed in the Appendix. Prediction of soil moisture content agreed well with pattern of the measured values Arosteguy et. al. (1981). The variation of soil moisture content for the two series of climatic data is showed in Appendix.

The daily animal intake and the daily live weight gain were not validated with real data and are showed in the Appendix. However seasonal animal live weight gain and the annual beef production per unit of area agreed well with experimental unpublished data Fernández Grecco (2002). Conference in26 the Meeting of AAPA. Bs.As. Nov. 2002.

CONCLUSION AND FURTHER RESEARCH

The System Dynamics model presented here links in daily steps the components and interactions of a Grazing System and evaluates the economics results of the beef cattle production.

From the feedback perspective all the relevant interactions which cause the behaviour of a Grazing System were represented.

Further development stages of the model are likely to provide the scope to control and vary individually innovation strategies such as use of fertilisers, fodder conservation from pasture, and evaluate the relative benefits balance against the relative costs.

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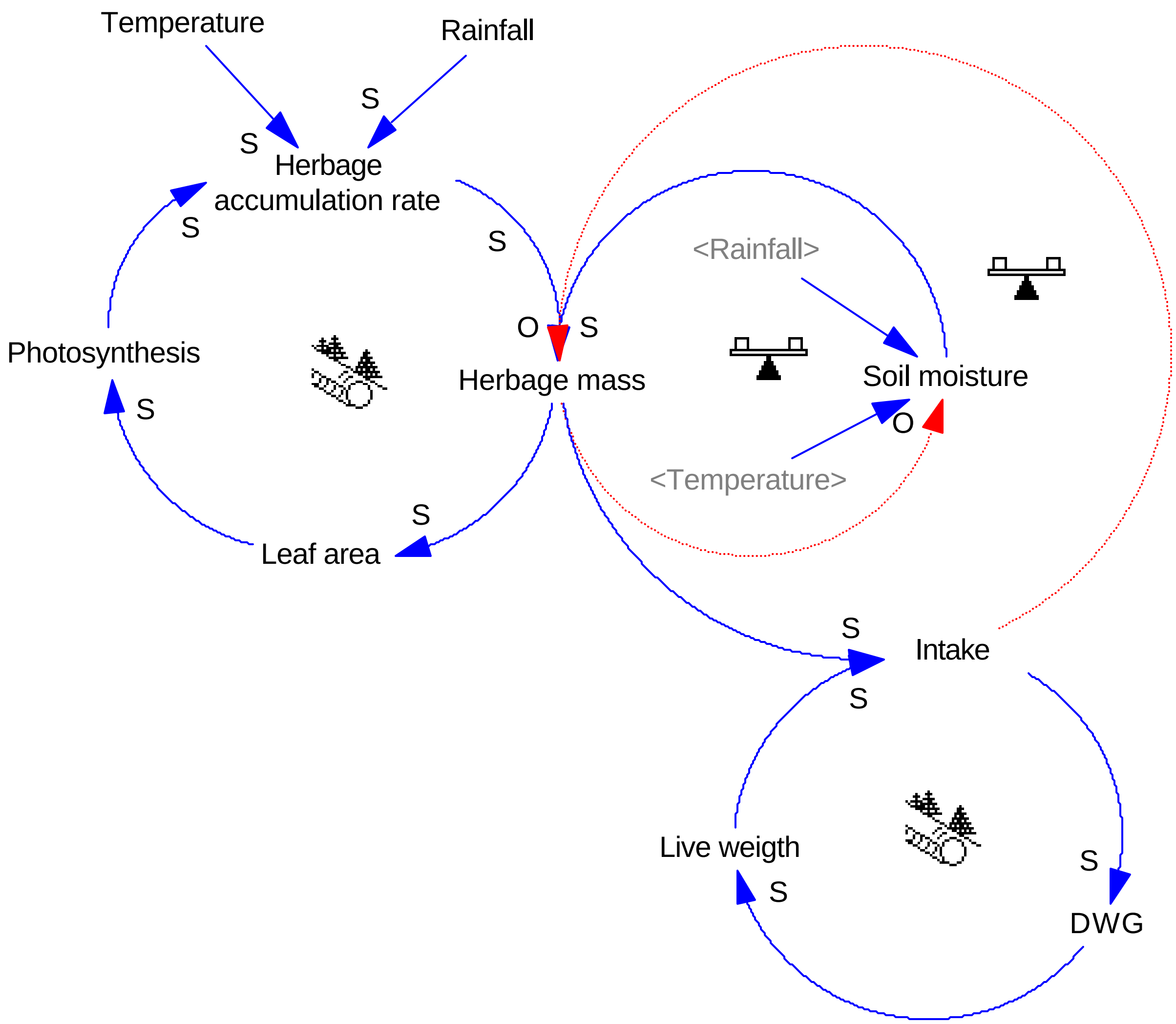
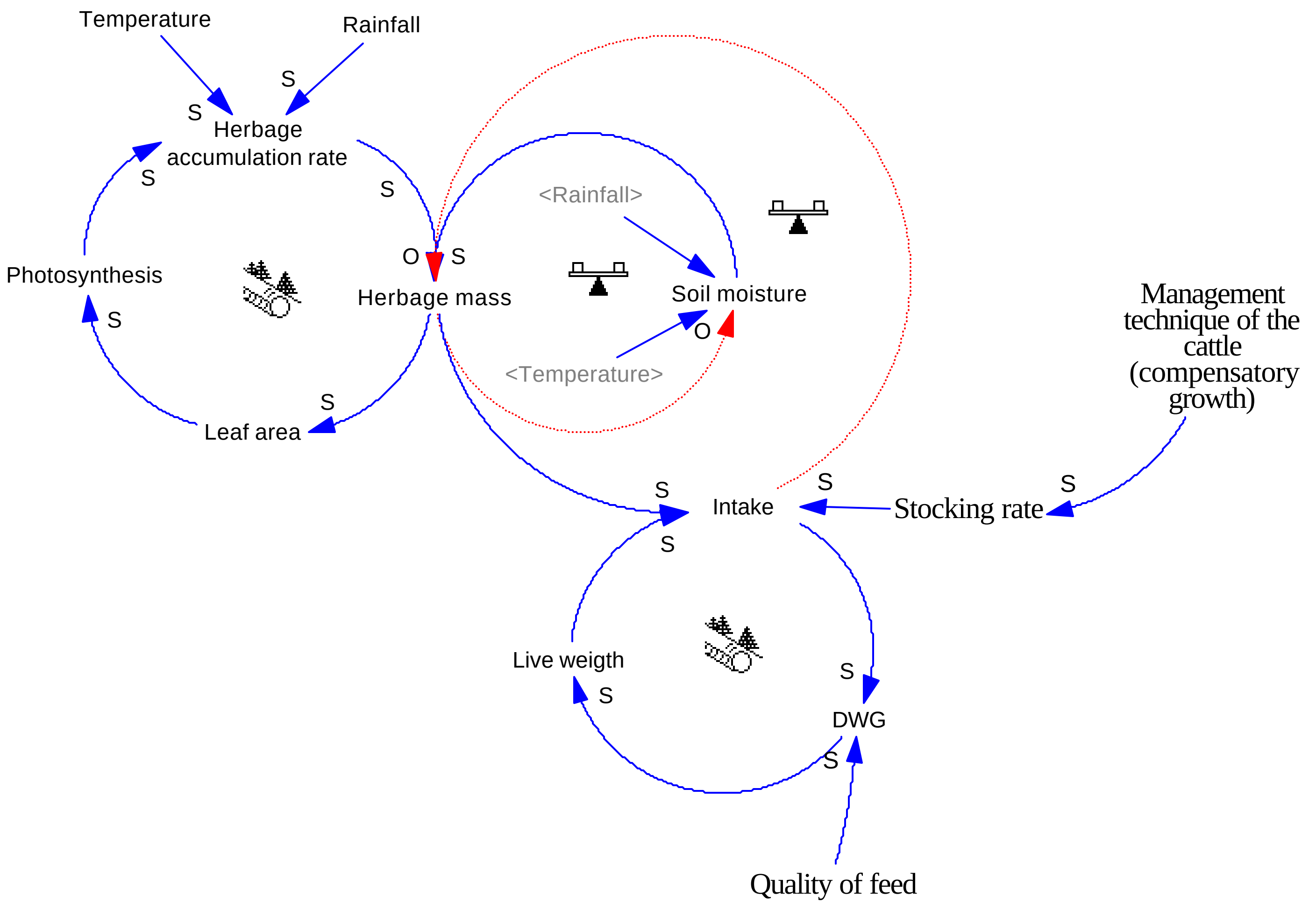
Appendix

CONCEPTUALIZATION



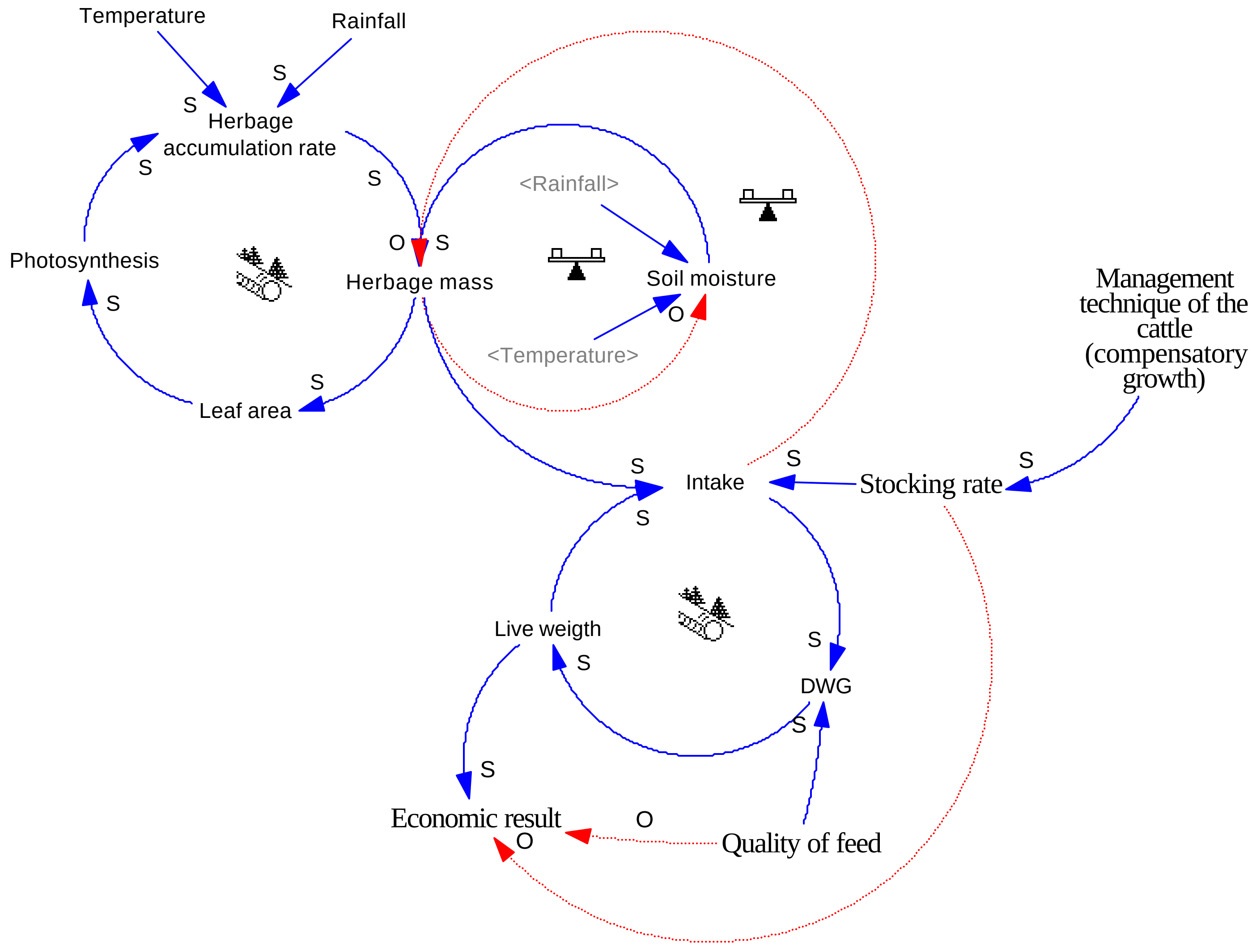
CAUSAL DIAGRAM

CONCEPTUALIZATION

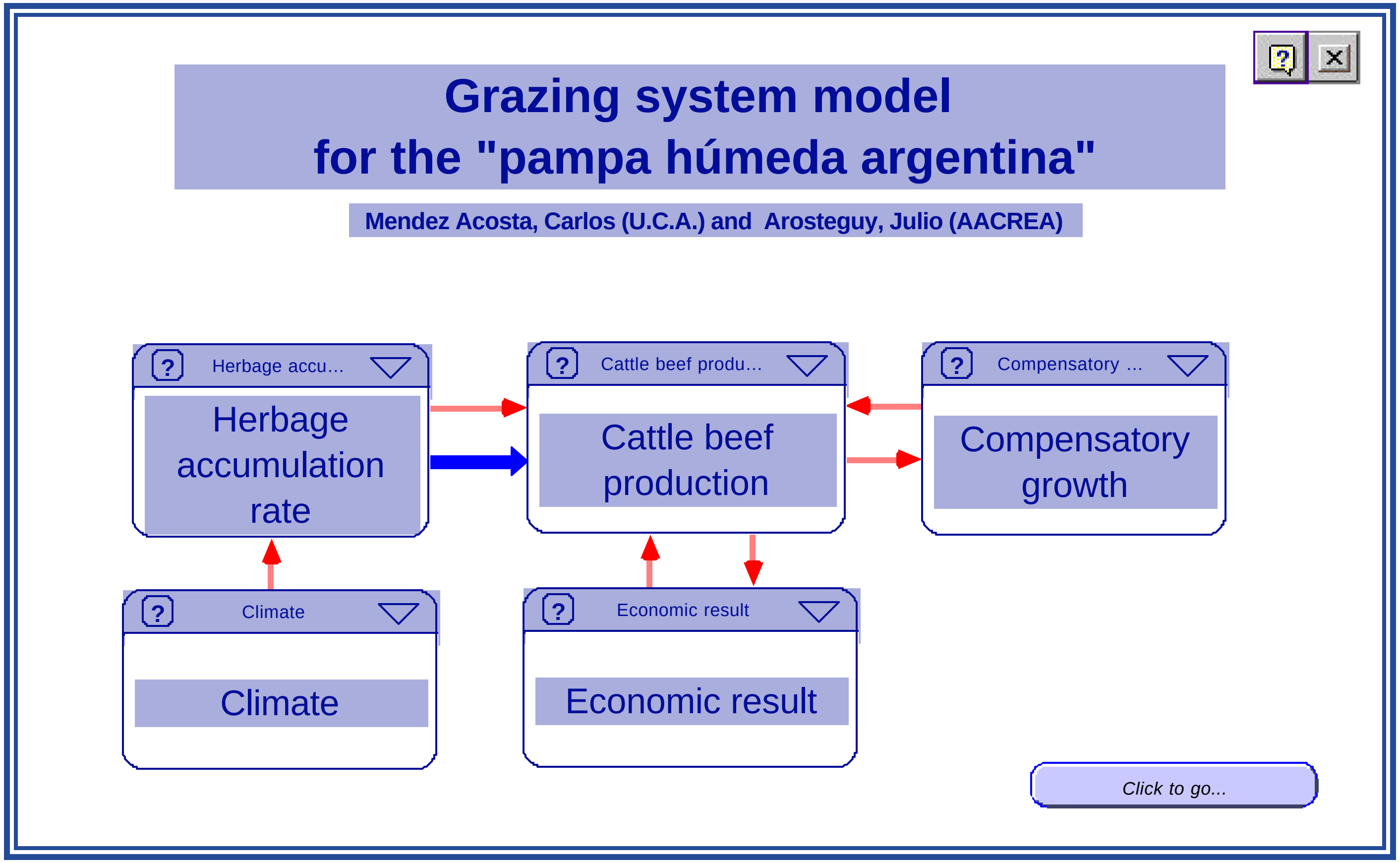


CAUSAL DIAGRAM

CONCEPTUALIZATION



CAUSAL DIAGRAM

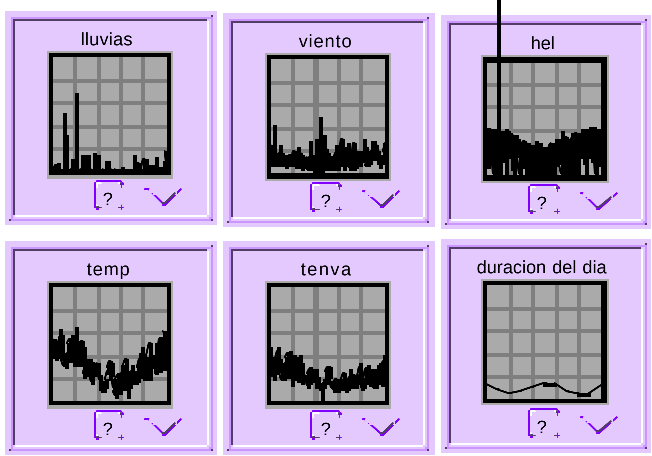

Grazing system model
for the "pampa húmeda argentina"
Mendez Acosta, Carlos (U.C.A.) and Arosteguy, Julio (AACREA)
Herbage accu...
Herbage accumulation rate
Cattle beef produ...
Cattle beef production
Compensatory ...
Compensatory growth
Climate
Climate
Economic result
Economic result
Click to go...

DESIGN OF THE MODEL

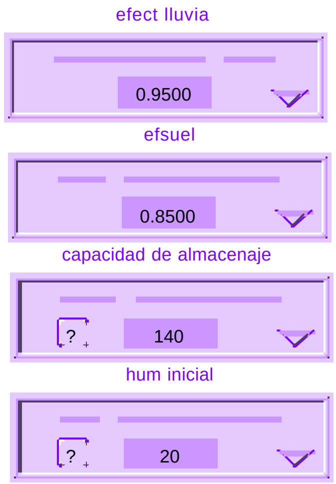
Back

Parameters of climatic and soil conditions

Las funciones gráficas permiten ingresar los datos de manera manual. El modelo corre un año. El intervalo es diario. De esa forma se deben informar, por ejemplo la lluvia, de forma diaria.
Para ello hay que hacer doble "click" sobre el gráfico a modificar.



Se debe informar el efecto suelo y el efecto lluvia. Para ello se debe emplear los "sliders" ubicados más abajo.
Asimismo, se debe informar la humedad inicial y la capacidad de retención de agua del suelo.



DASHBOARD: CLIMATIC AND SOIL CONDITION

Back

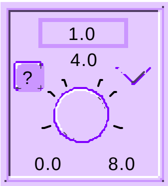
Parameters of cattle management

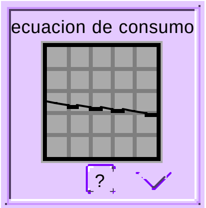
Se debe informar cuántos animales por hectárea van a pastorear la pradera.
Esta información solamente se suministra al comienzo de la simulación

A medida que el animal aumenta su peso, el mismo reduce porcentualmente su ingesta. Esta relación se puede modificar haciendo dobre "click" sobre el gráfico.
Esta información solamente se suministra al comienzo de la simulación.

Con estos dos "sliders" se debe informar los pesos de inicio y fin del engorde.
Esta información se puede suministrar en cualquier momento de la simulación.

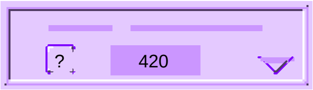
carga





peso inicial

peso de venta



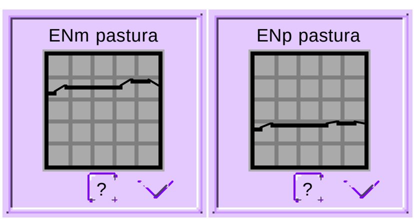
El modelo permite emplear el concepto de crecimiento compensatorio. Para ello debe ingresar cierta informacion en l asiguiente pantalla.

Compensatory growth

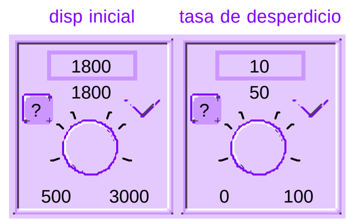
Back

Parameters of food management, pasture conditions and type of suplement

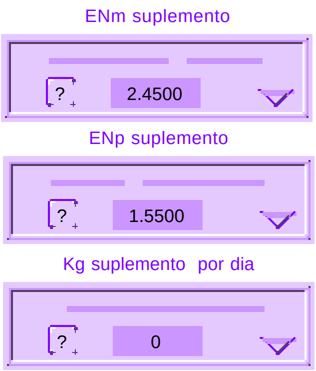
Se debe informar la energía neta para mantenimiento y para ganancia de la pastura.
Las funciones graficas permiten trabajar con valores estacionales correspondientes a distintos estados vegetativos de la misma.
Esta información solamente se suministra al comienzo de la simulación



Se debe informar la disponibilidad inicial de forraje.
Asimismo, se puede informar la tasa de forraje no aprovechable.
Esta información solamente se suministra al comienzo de la simulación



Mediante estos tres "sliders", se informa la concentración energética del suplemento, y la cantidad del mismo empleada durante la simulación.
Esta información se puede suministrar, y cambiar, a lo largo de la simulación.



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Economics data and financial budget

Con este "slider" se debe informar el precio del kilo vivo de venta. Los valores de estos sliders pueden variarse durante la simulación.

precio kg carne

2.0

Con este "slider" se debe informar el precio del suplemento: maíz, rollos, etc.

precio kg suplemento

0.4

Con este "slider" se debe indicar el costo de la mano de obra ganadera, informada por cabeza y por año.

costo mano de obra por cab por año

40

Con este "slider" se debe indicar el costo de sanidad, informada por cabeza y por año.

costo sanidad por cab por año

20

Con este "slider" se puede informar otros costos directos de la invernada. Los valores de estos sliders pueden variarse durante la simulación.

otros costos por cab por año

0

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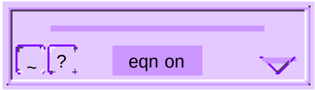
Stochastic parameters

A las condiciones climáticas informadas se las puede "mejorar " o "empeorar" mediante el "slider" que está abajo.
Para ello debe "clickear" el botón de la izquierda hasta que desparezca la leyenda "eqn on", y entonces debe informar el porcentaje de "mejora" o "desmejora" en las condiciones climáticas.

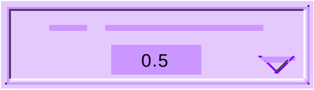
El modelo se transforma en estocástico con el "swtch" que se encuentra más abajo.
Para ello debe asegurarse que el "slider" de la primer columna se encuentra con la leyenda "eqn on".

La aleatoriedad surge de la generación de números aleatorios que afectarán las condiciones climáticas.
Se debe informar el límite inferior y el superior de tal generación. Por defecto las condiciones empeorarán un 50% y mejorarán un 30%.

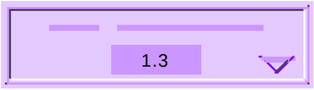
cambio en las condiciones



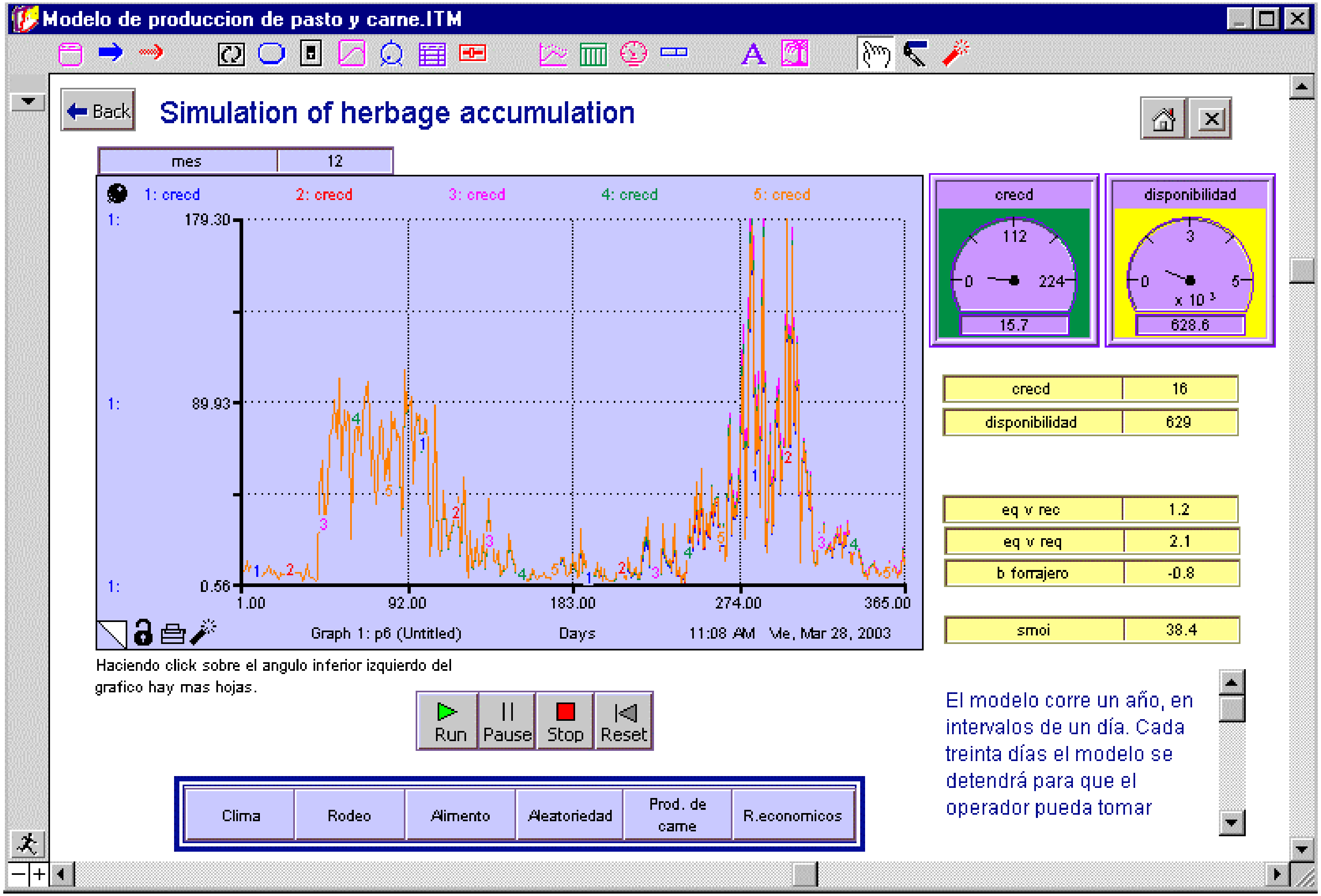
lim inf rdm



lim supr rdm

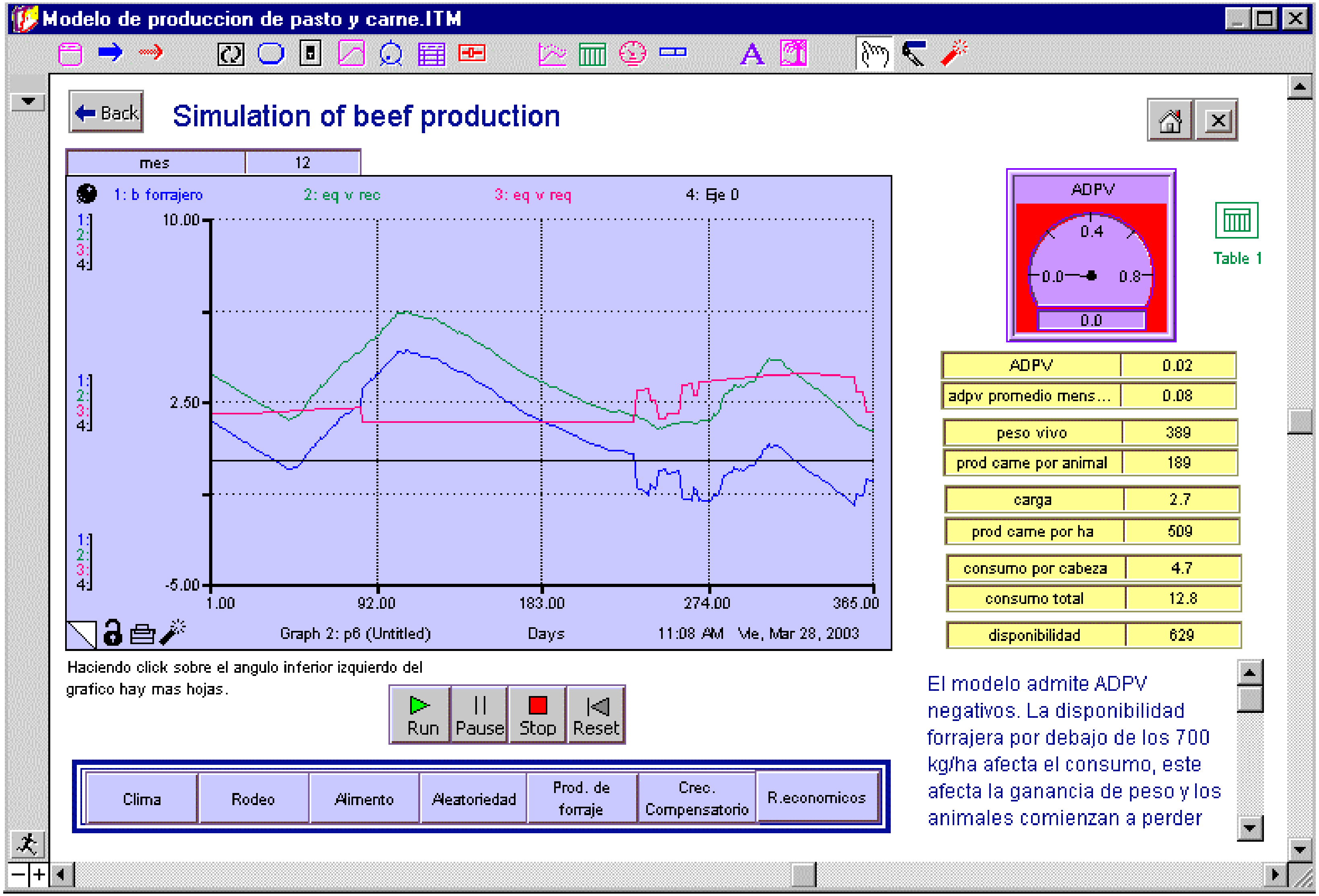


DESIGN OF THE MODEL



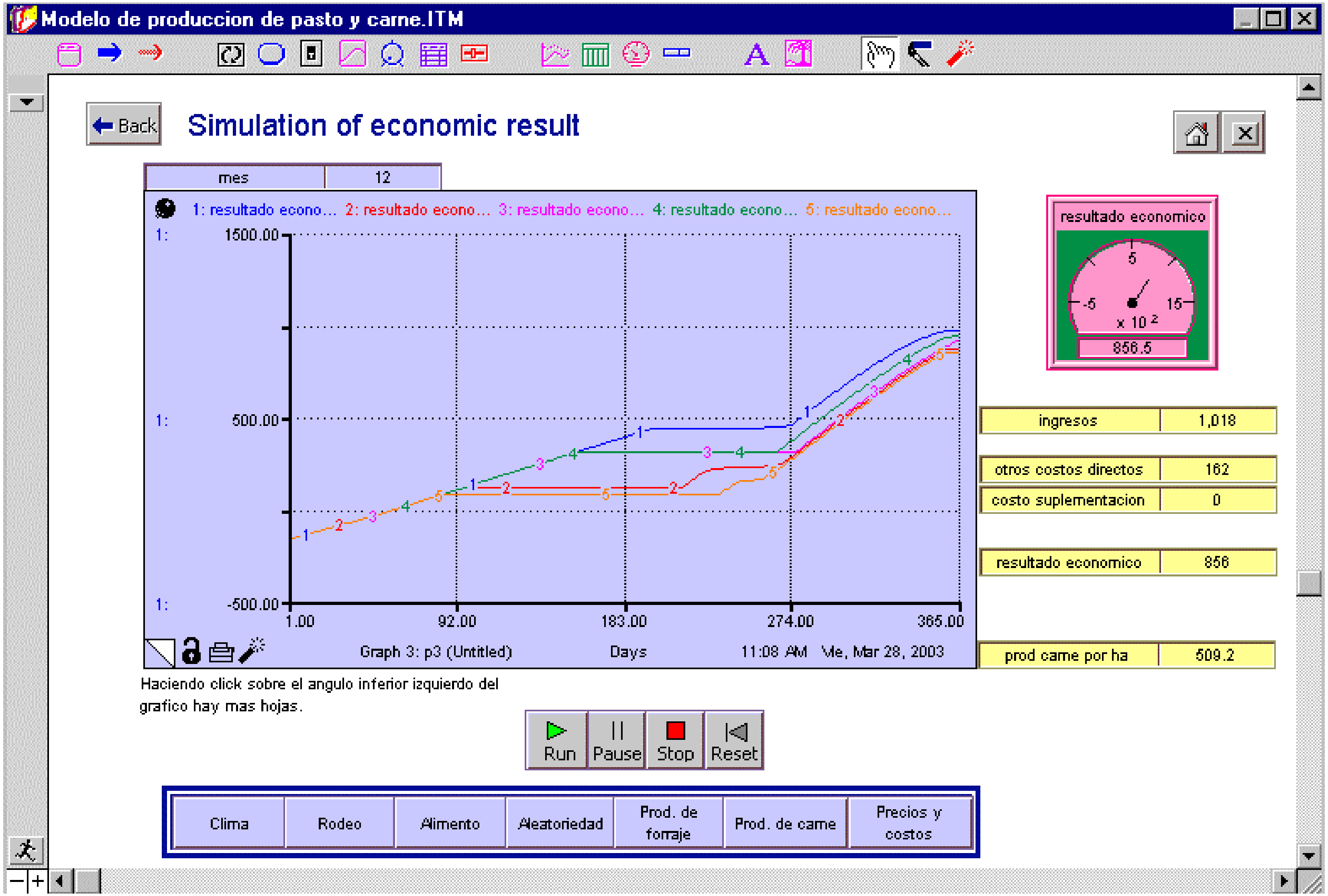
RESULTS OBTAINED: HERBAGE ACCUMULATION

DESIGN OF THE MODEL



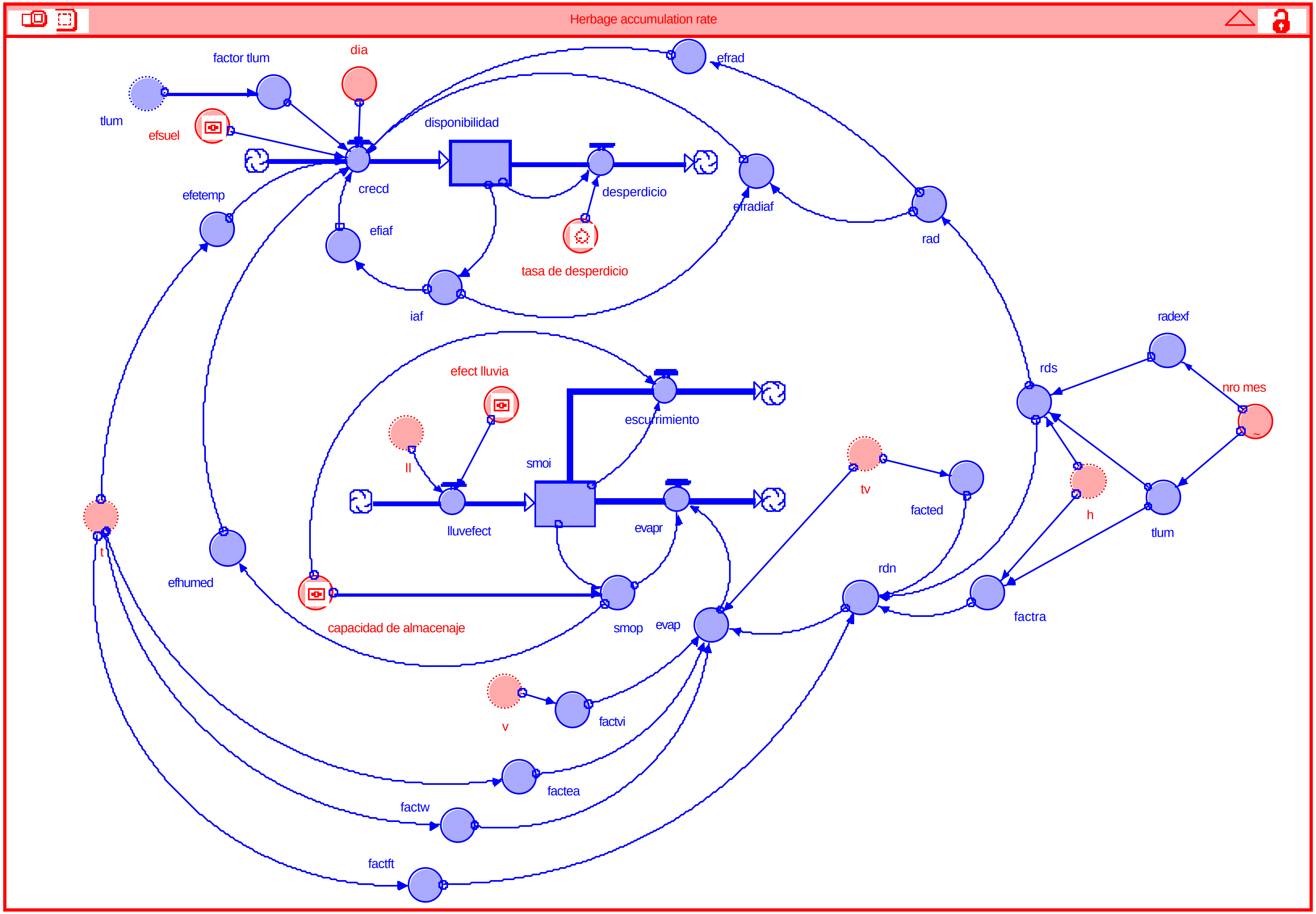
RESULTS OBTAINED: BEEF PRODUCTION

DESIGN OF THE MODEL



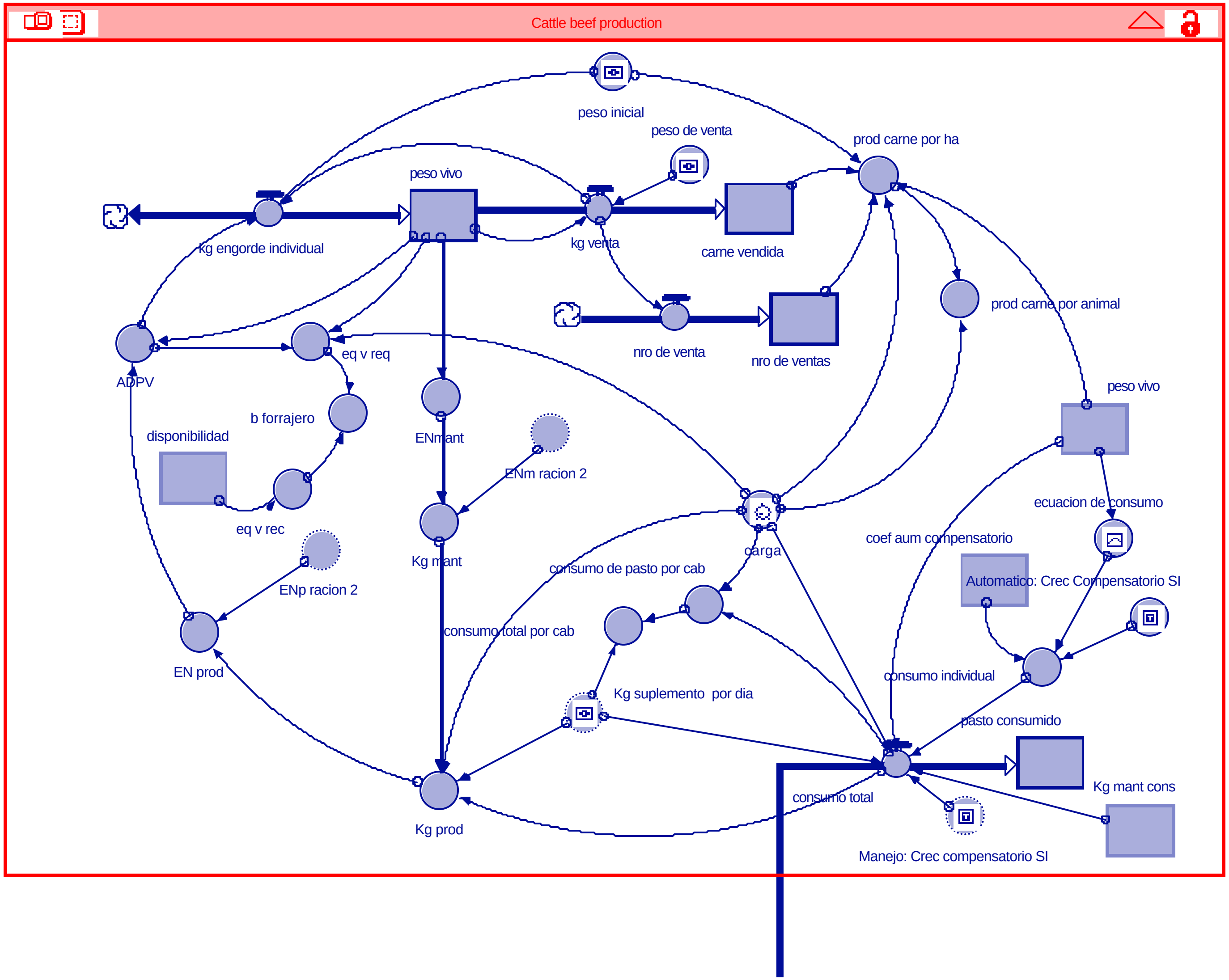
RESULTS OBTAINED: ECONOMICS RESULTS

DESIGN OF THE MODEL



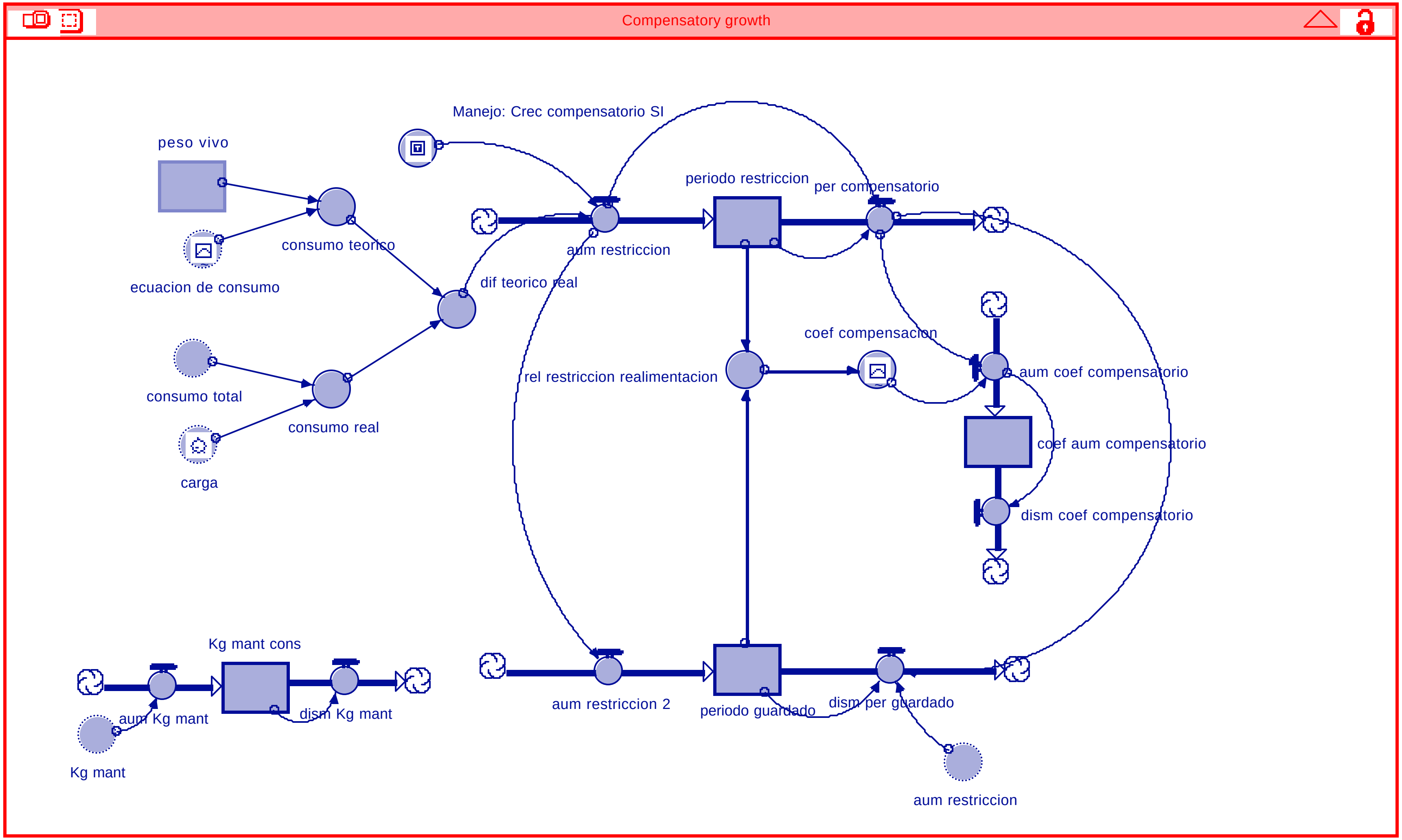
STOCKS AND FLOWS DIAGRAMS : HERBAGE ACCUMULATION RATE

DESIGN OF THE MODEL



STOCKS AND FLOWS DIAGRAMS : CATTLE BEEF PRODUCTION

DESIGN OF THE MODEL



STOCKS AND FLOWS DIAGRAMS : COMPENSATORY GROWTH

Notice

Further information on the System Dynamics model (model equations) and subsequent steps of model development are available on request.

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