



Modelling livestock carrying capacity in montados

Do trees really promote pasture production?

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Why use trees on grazed areas?

First impressions are often that the presence of trees in pasture systems will lead to a reduction in pasture production due to the light and water competition. However, other effects on the system dynamics and water availability may be beneficial to nutrient cycling, yield, and pasture productivity.

Trees affect wind speed and temperature, creating a milder climate by providing shade under the canopies. This microclimate can improve pasture production and availability (more production in winter and delayed drying in early summer), and reduce livestock energy requirements (Moreno et al. 2013, Palma et al. 2016)



During cold winter, grass grows more beneath the trees.
Ref: D. Howlett



Cattle and pigs grazing together in an Iberian dehesa/montado. Ref: G. Moreno

Using models to predict productivity

"Yield-SAFE" is a model that is used for predicting the productivity of agroforestry systems (Palma et al. 2016). One advantage is that it uses easily obtainable variables. The parameters for the main tree and crop species are already available, along with the main soil types, so there is only need to:

- choose the tree and/or crop species and soil type/depth
- select an area for the simulation (current and future climate data are automatically accessed)
- define initial values for biomass, leaf area, soil and water (otherwise default values will be used)
- define the management e.g. tree and/or crop density, days of planting, pruning, thinning and harvesting

The model simulates tree and understory growth, and all the interactions that exist between these two components regarding water use, light competition and the canopy effect on the microclimate. Growth is translated into energy and used to compute the carrying capacity of the system.

For Iberian dehesas and montados, the model can estimate:

- production of pasture and acorns
- the canopy effect on microclimate (temperature and wind)
- the carrying capacity (livestock units per ha)
- the effect of heat stress reduction on livestock weight gain.

The average carrying capacity values in montados/dehesas systems are between 0.3 and 0.5 (ranging from 0.15 to 0.7) livestock units per ha (López-Díaz et al. 2014). The Yield-SAFE model can be used to experiment with different climate, soil quality and tree density values to determine the system's response and the number of days the system produces enough energy to support the determined carrying capacity.



There is a delay in pasture dryness in the summer underneath the trees. Ref: A. Carrara



Advantages

Adult trees compete with the pasture for light and water. The improved microclimate delays the onset of grass dryness in late spring; this increases the number of grazing days in pastures with trees and benefits livestock by reducing their daily energy needs (e.g. less heat stress).

Adjusting the number of trees can increase the number of days when the system can produce enough energy to support the pre-selected carrying capacity.



Cork oak stand characterized by a multispecies shrub layer. Ref: Paulo Firmino

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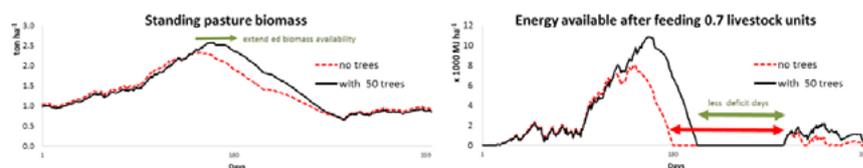
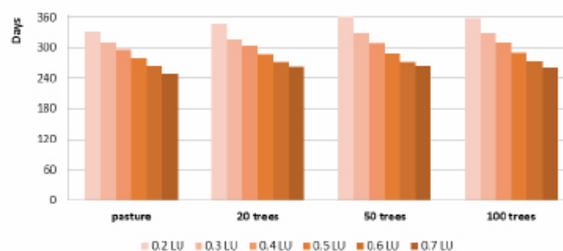
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Number of days supporting livestock



Above: Number of days the system (just pasture and pasture with 20, 50 and 100 trees) produce enough energy to sustain 0.2 to 0.7 livestock units in a year with adult trees that are 82 years old. Below: an example of a simulation (50 trees at age 50), showing the differences in pasture yield and energy availability after grazing.

Trees modify the availability of light, microclimate, soil moisture and nutrient distribution compared to open pasture areas. This affects understory species composition, nutrient quality and phenology (Oliveira et al. in review). The herbaceous understory under the canopy tends to be dominated by grasses (legumes and forbs are more abundant in less fertile spaces) and has higher content of some nutrients (mainly N and K) than plants outside the canopy. There is also a longer growing season under the tree canopy, with an earlier start in winter and less vulnerability to drying in summer. The amount of above ground biomass that is produced can decrease when trees are present, but, if the production is maintained for a longer period, the number of supported livestock units will be greater.

YieldSAFE estimates show that:

- Tree cover reduces temperature in the summer and increases temperature in the winter, leading to increased growing time for the grass and so improves conditions for livestock grazing.
- Above ground biomass (pasture) production can also be greater in the spring and summer seasons, depending on climate and soil quality. The impact of trees is more positive in lower quality soils.
- Increasing the number of trees leads to an increase in the number of days that the system produces enough energy to support livestock.

Further information

- López-Díaz ML, Rolo V, Benítez R, Moreno G (2015) "Shrub encroachment of Iberian dehesas: implications on total forage productivity". *Agroforestry Systems* 89 (4): 587-598.
- Moreno G, Bartolome JW, Gea-Izquierdo G, Cañellas I. (2013). Overstory-Understory Relationships. In *Mediterranean Oak Woodland Working Landscapes* (pp. 145-179). Springer Netherlands.
- Oliveira TS, Crous-Duran J, Graves AR, Garcia de Jalon S, Moreno G, Paulo JA, Palma JHN (under review). Using a process based model to assess trade-offs between different holm oak densities and livestock carrying capacity.
- Palma J, Graves A, Crous-Duran J, Upson M, Paulo J, Oliveira TS, Garcia de Jalón S, Burgess P (2016). Yield-SAFE Model Improvements. Report for Milestone 29 (6.4) of the AG FORWARD project, Lisboa.

Web version of the model (to be used freely): <http://www.isa.ulisboa.pt/proj/ecoyieldsafe>