Analyzing Changes in Productivity and Carrying Capacity under Planned Grazing in Madiama Commune, Mali (West Africa)

Oumar Badini[*1], Claudio Stockle[1], Jim W. Jones[2], McNair Bostick[2],
Amadou Kodio[3] and Moussa Keita[3]

----

[1] Washington State University, Pullman, Washington (WSU)

[2] University of Florida, Gainesville, Florida (UF)

[3] Institut du Développement Rural (IER), Bamako, Mali

RESEARCH CONTEXT

Western Sahara (Morocco)
Mauritania
Algeria
Mali
Niger
Burkina Faso
Senegal
Guinea
Ghana
Togo
Benin
Nigeria
Taoudenni
Araouane
Tessalit
Kidal
In-Tebezas
Tombouctou
Goundam
Gourma Rherous
Baurem
Gao
Niafounké
Niger R.
Gossi
Ansongo
Ménaka
Nara
Goumbou
Nampala
Konna
Douentza
Kayes
Mourdiah
Niono
Mopti
Mahina
Banamba
Markala
Ségou
Kita
Koulikoro
Bla
San
Bamako
Koutiala
Kouri
Bougouni
Koualé
Sikasso
Niamey
Ouagadougou
Madiama
10°
0°
20°
0
250 km
150 mi

Problem

- **Overgrazing and degradation of pasture lands**
  - **Poor pasture management (prolonged stay on pastures)**
  - **Decline of soil and pastoral productivity.**

Policy issues

How to:

- Increase pasture productivity?
- Improve pasture carrying capacity?
- Improve soil quality and carbon sequestration potential?

Hypothesis

- It is hypothesized that planned rotational grazing will increase both pasture biomass production and soil carbon.
- Regrouping animals on small parcels for limited time periods will improve plant re-growth.
- By allowing more biomass to grow during periods (days or weeks) with no livestock grazing, plants will grow more roots and more aboveground mass will be added to the soil.

Why simulation modeling?

- It could take several years to experimentally evaluate whether plant production and soil carbon levels are indeed increasing as hypothesized.

- Therefore, a simulation analysis was performed to:
  - Improve understanding of productivity and soil carbon in West African pasture conditions.
  - Explore grazing management options and predict potential changes in pasture production and soil carbon .

Objectives

of today's presentation

- Report preliminary results from a simulation analysis of the potential changes in productivity and carrying capacity under planned rotational grazing.

- Determine optimal grazing intensity and grazing intervals (rotation) for optimum pasture production and carrying capacity of annual pastures in a large grazing area (Torokoro site).

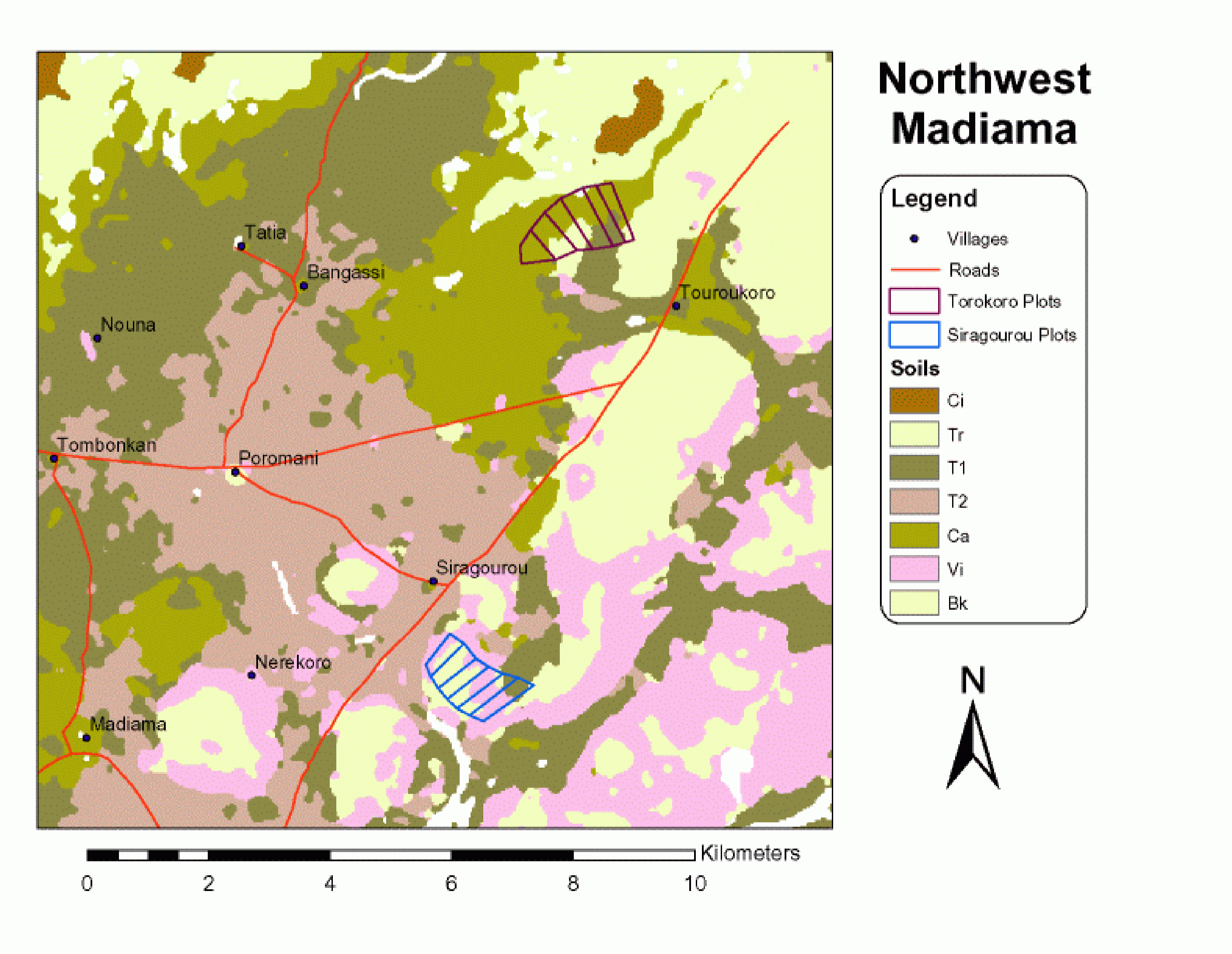
METHODOLOGY

Overview of the grazing sub-model

The CropSyst model was adapted and a grazing sub-model developed for simulating pastures.

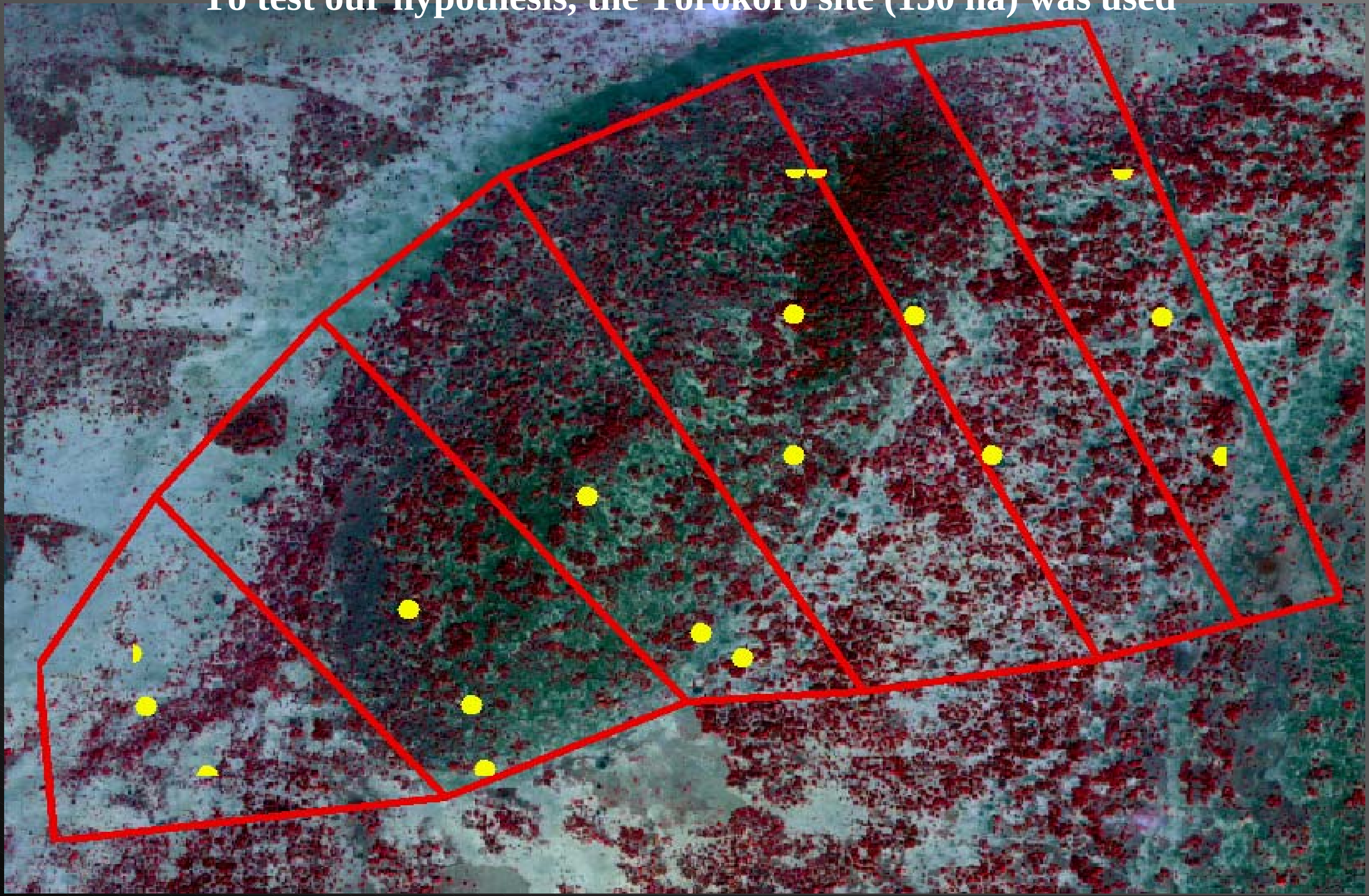
- Scheduling grazing events
  - Grazing events may be scheduled to repeat daily (or weekly) for a period corresponding to the time the animals are on the field.
- Percent biomass removed
  - At each grazing event, the percent biomass to remove determines the grazing intensity.
- Residue trampling operation
  - The model simulates the rapid incorporation of all surface residues into the top (shallow) soil layer.

Study area


Northwest
Madiama
Legend
Villages
Roads
Torokoro Plots
Siragourou Plots
Soils
Ci
Tr
T1
T2
Ca
Vi
Bk
N
Tatia
Bangassi
Nouna
Touroukoro
Tombonkan
Poromani
Siragourou
Nerekoro
Madiama
Kilometers
0
2
4
6
8
10

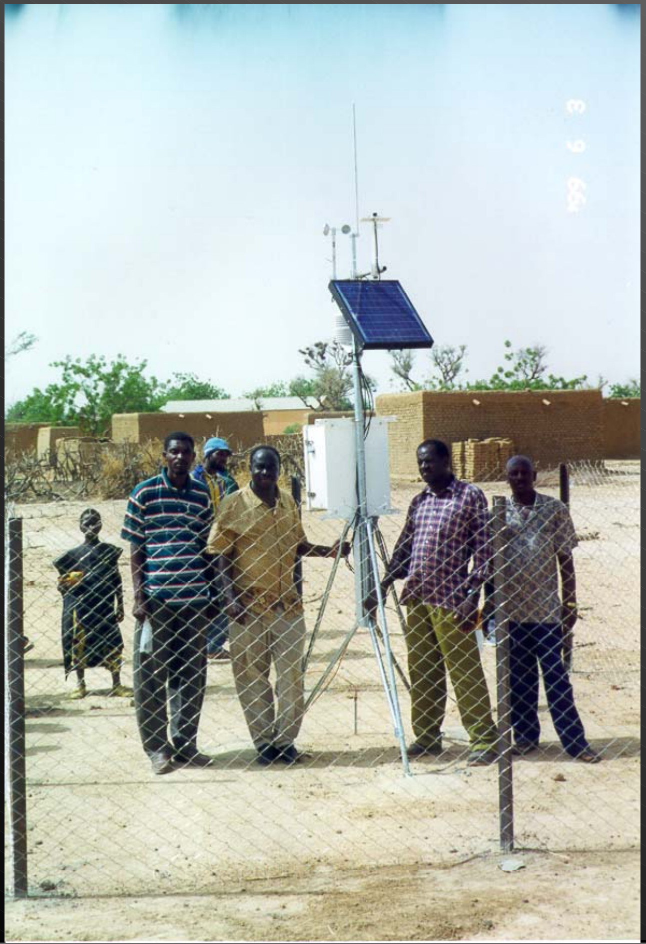
Rotation plot design

To test our hypothesis, the Torokoro site (150 ha) was used

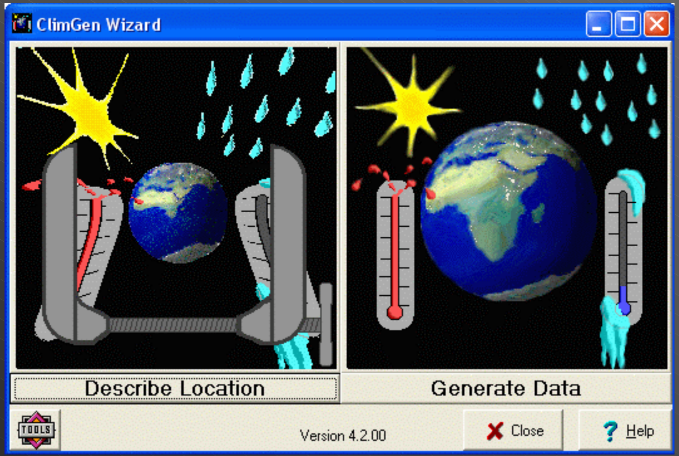


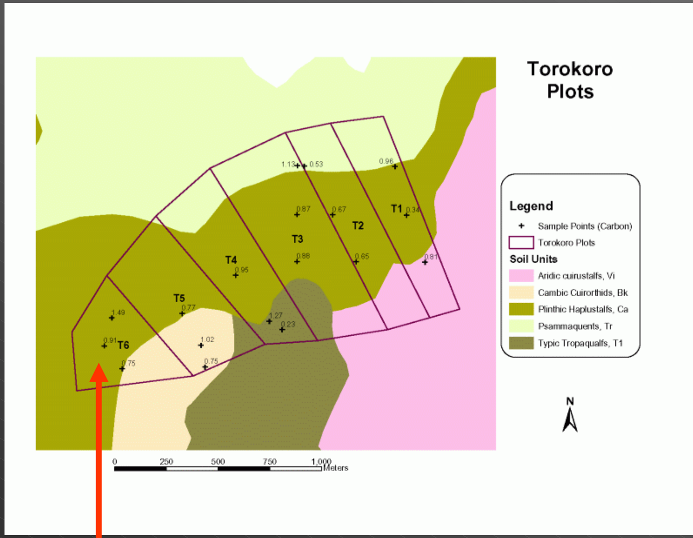
Data used

Weather Station in Madiama



Actual rainfall, temperature, and radiation data from the Meteorogical Service in Bamako, and from our weather station in Madiama, were used with ClimGen to generate 50 years of weather data for the simulation.





Land Use: Pasture and Rice

Dominant soil unit: **cuvette ancienne (Ca)**

Deep Silty and Loamy Soils with plinthite

Soil type: Plinthic haplustalfs (sols ferrugineux lessives a pseudogley)

Pasture type: Loudetia t. and Schoenefeldia g.

Biomass sampling (cut and weigh method) by Keita, Sept. 2003

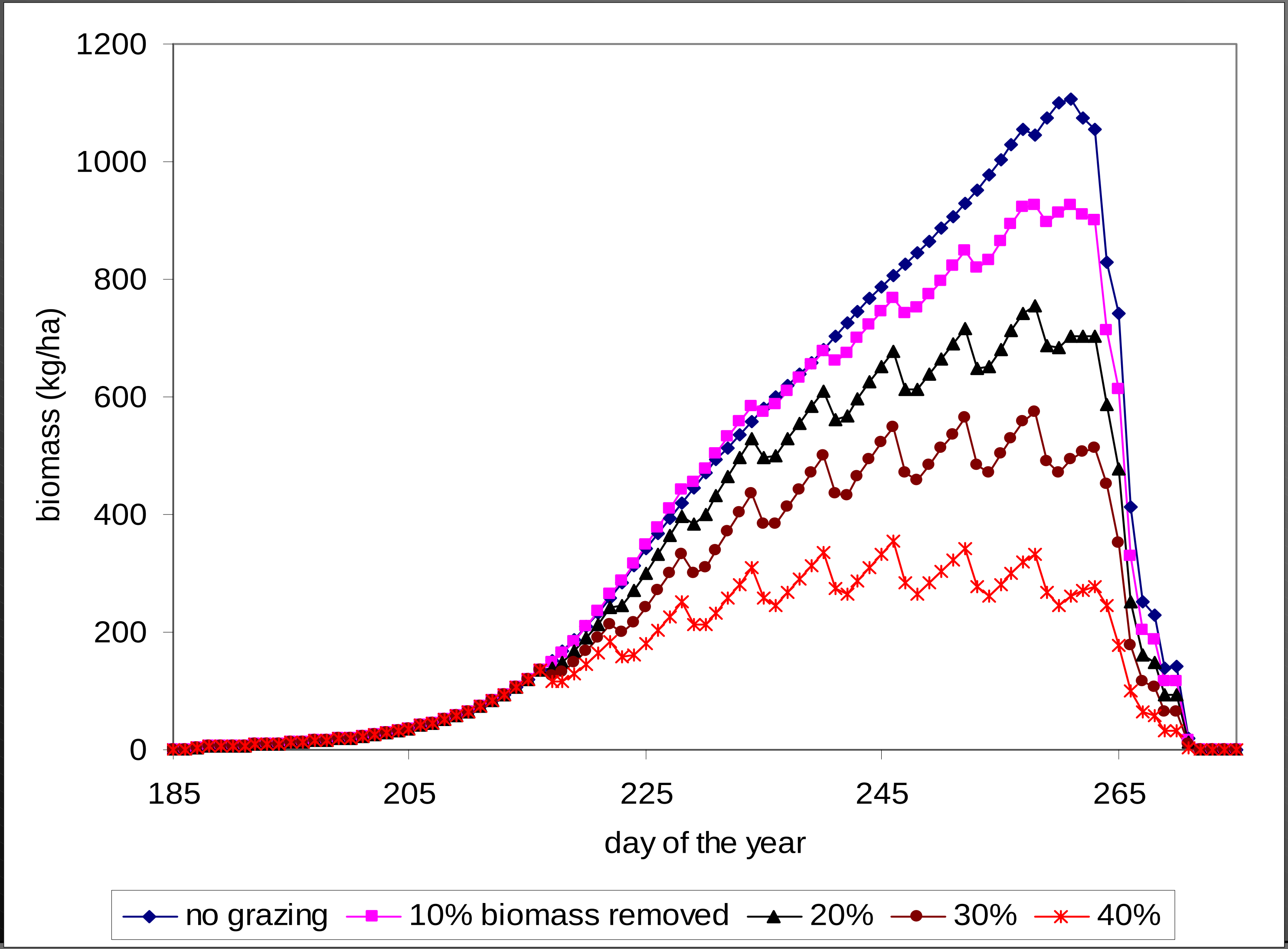
Species composition sampling (points quadrants method) by Kane and Toure, Sept. 2003

Grazing and rotation management scenarios

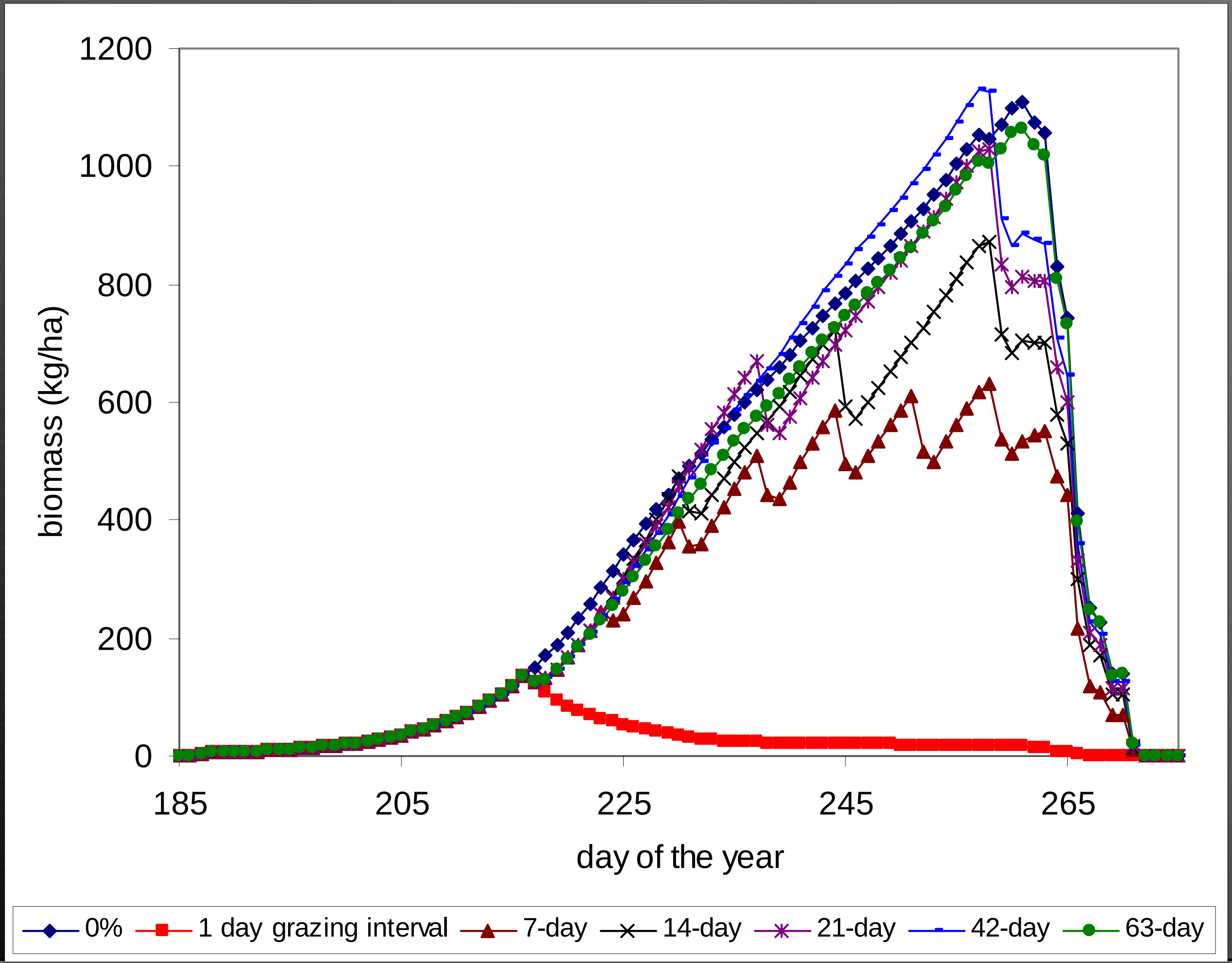
- Grazing intensities compared were :
  - 0 percent (no grazing), 10, 20, 30 and 40 percent (biomass removed)
- Grazing intervals compared were:
  - 1-14 days grazing intervals with respective number of parcels varying from 1 to 14.
- Simulation results compared were:
  - Biomass taken up (grazed) by animals and used to evaluate carrying capacity.
  - Biomass remaining on land and available for decomposition and carbon sequestration.

RESULTS

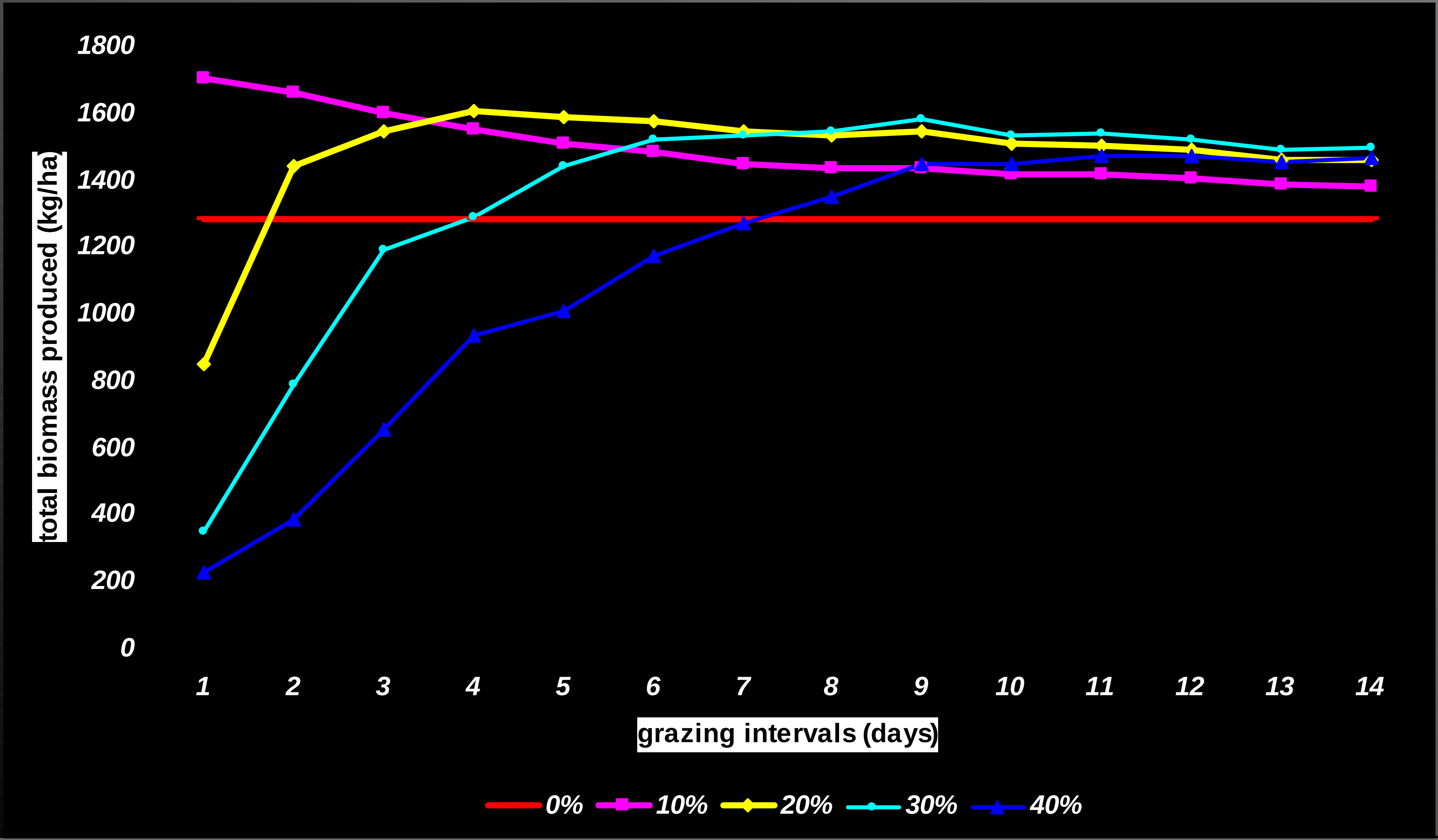
Effect of grazing intensity on pasture biomass accumulation



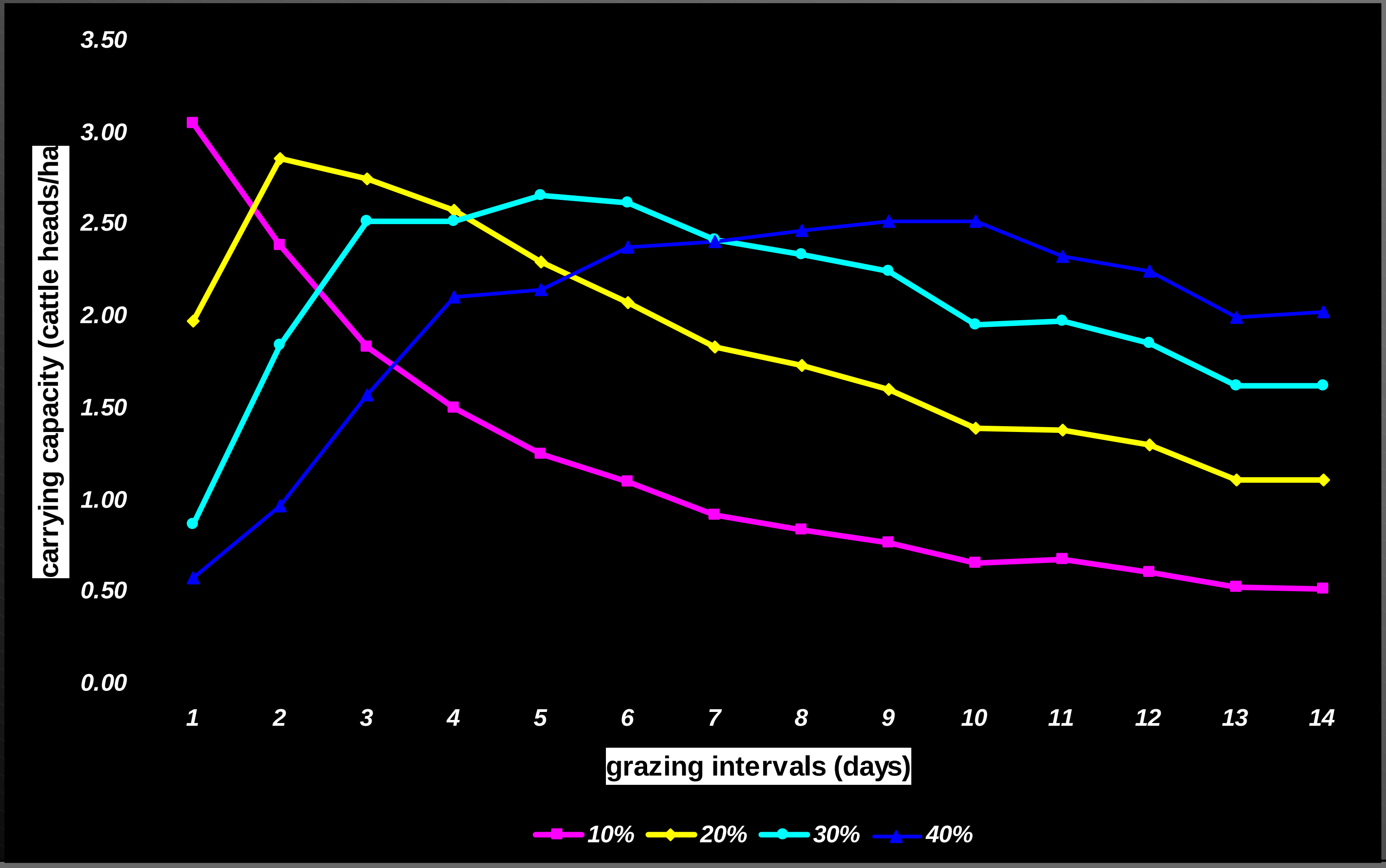
Effect of grazing management (rotations) on biomass accumulation



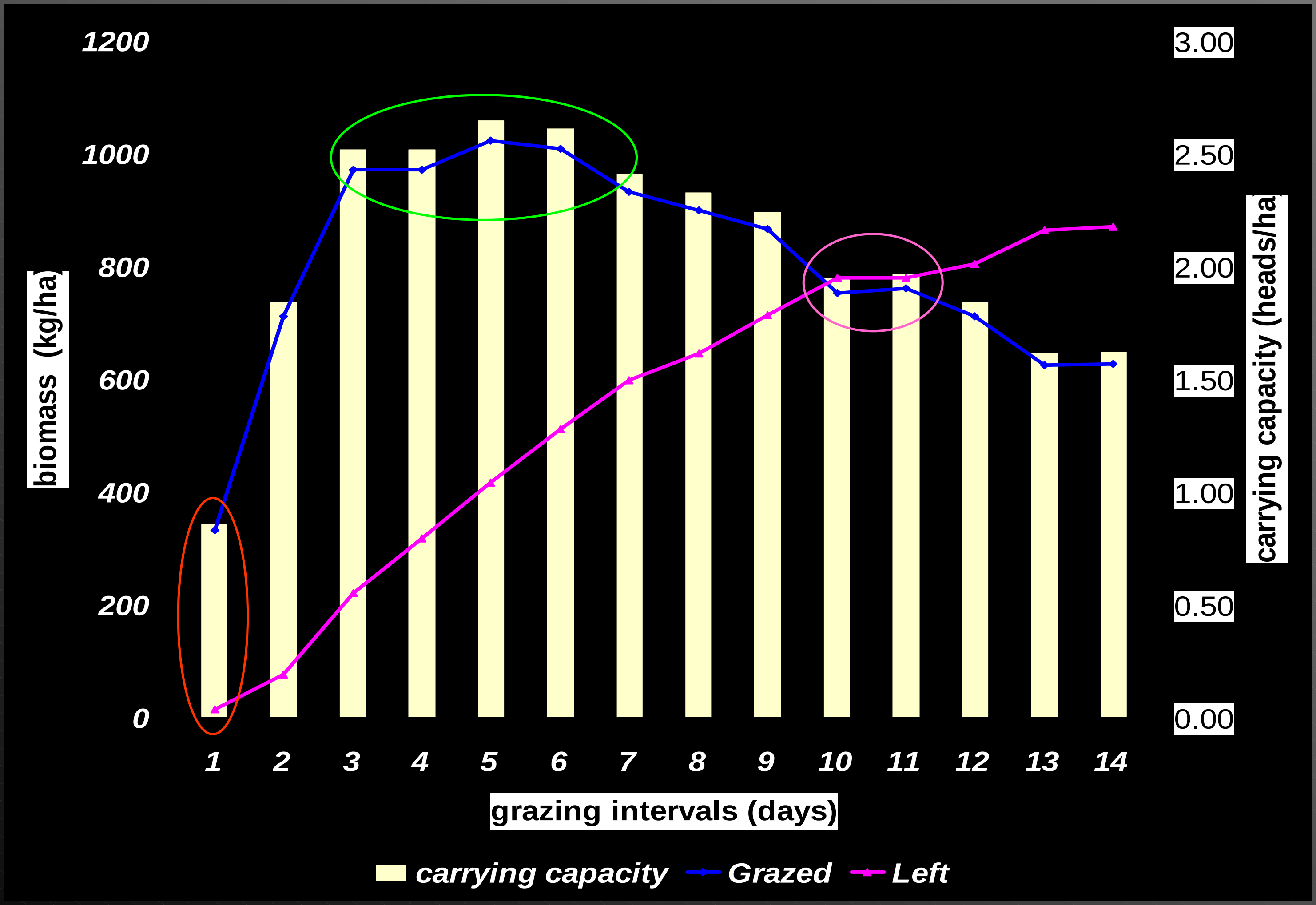
Effect of grazing intervals and intensity on total biomass production (grazed + left) during active period



Effect of grazing intensity and grazing intervals on carrying capacity during active period



Biomass production and carrying capacity during active period (30% grazing intensity)

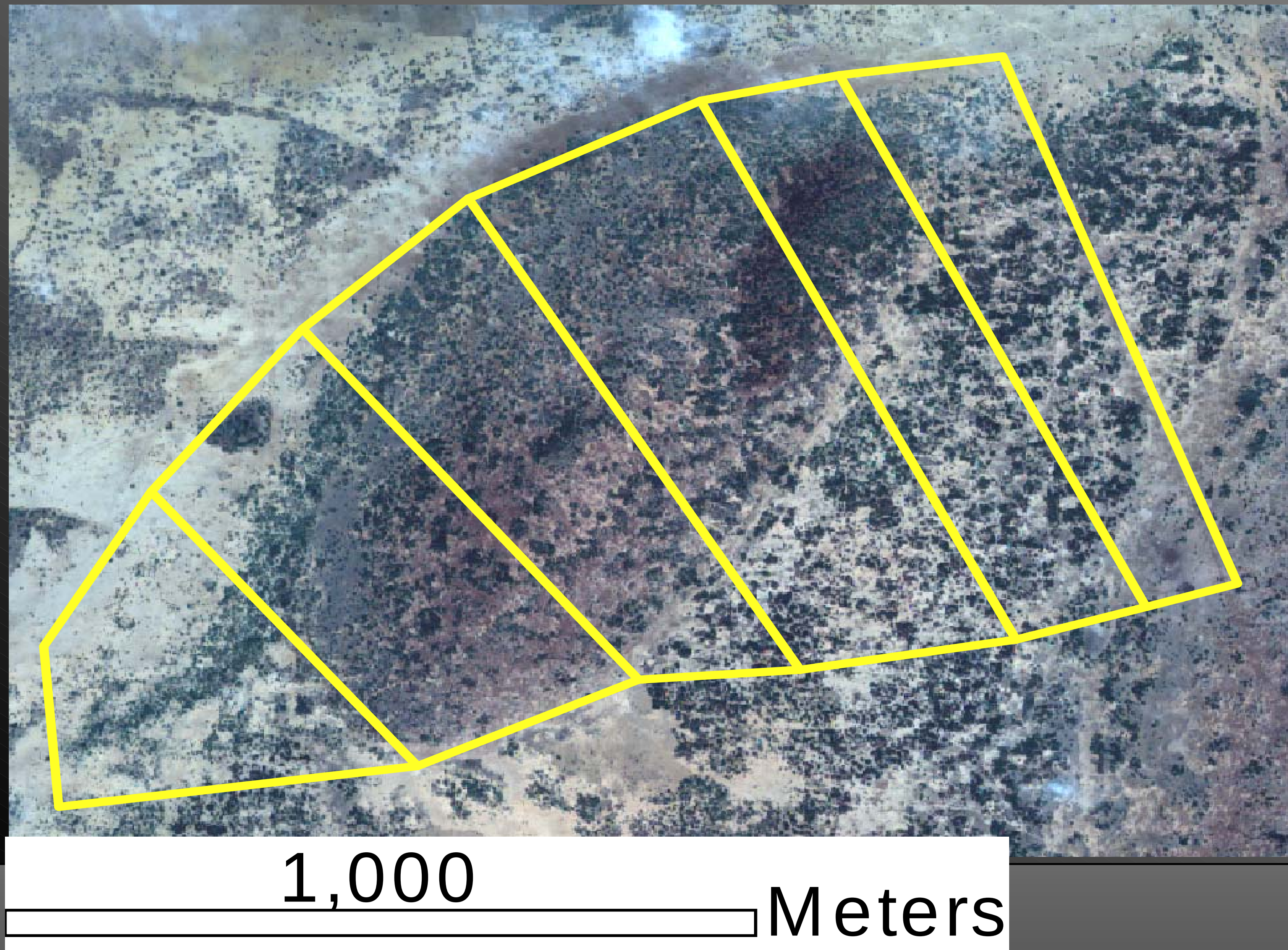


Conclusions

- These preliminary results agree with our initial hypothesis that stated that more biomass will be allowed to grow by rotating animals with no livestock grazing during days or weeks to permit re-growth.
- Overall, for an optimum grazing intensity of 30%, the 5 and 6 days grazing intervals seem to be the most adapted systems for annual pasture grazing in the study zone.
- However, grazing intervals of 10 and 11 days are the optimum management scenario for both carrying capacity and soil improvement through higher residue levels returned to the soil for carbon sequestration.

Future work needs

- Future work will include:
  - Determination of growth functions for the main pasture species found in the zone to improve model predictions,
  - Carbon sequestration analysis,
  - Combine model simulations, in-situ and remote measurements to optimally estimate spatio-temporal dynamics of pastures production and soil carbon changes,
  - Scale up estimates over space.

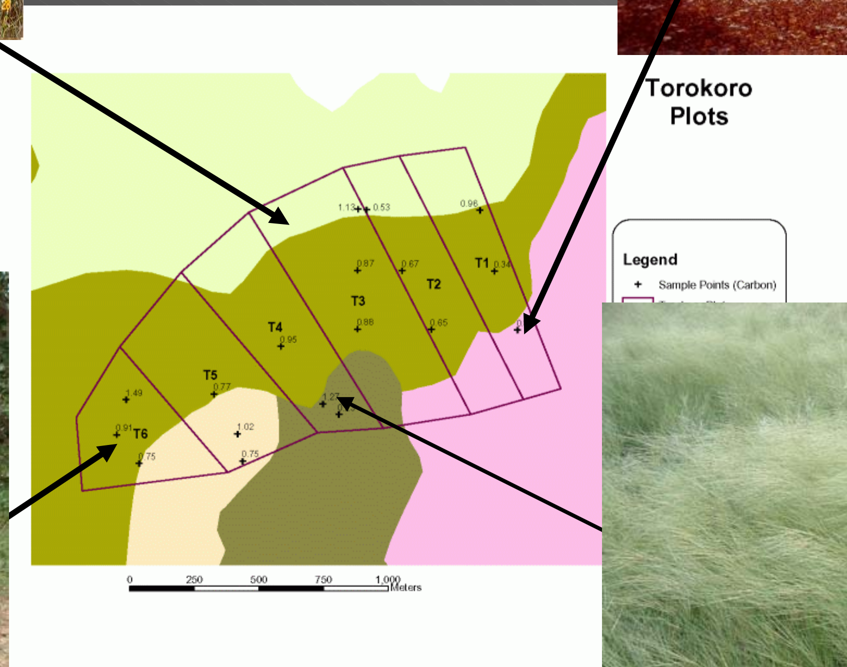

1,000
Meters

Thanks for your attention

THE END

Pastures: Vetiveria nigritana, Elionorus elegans ..

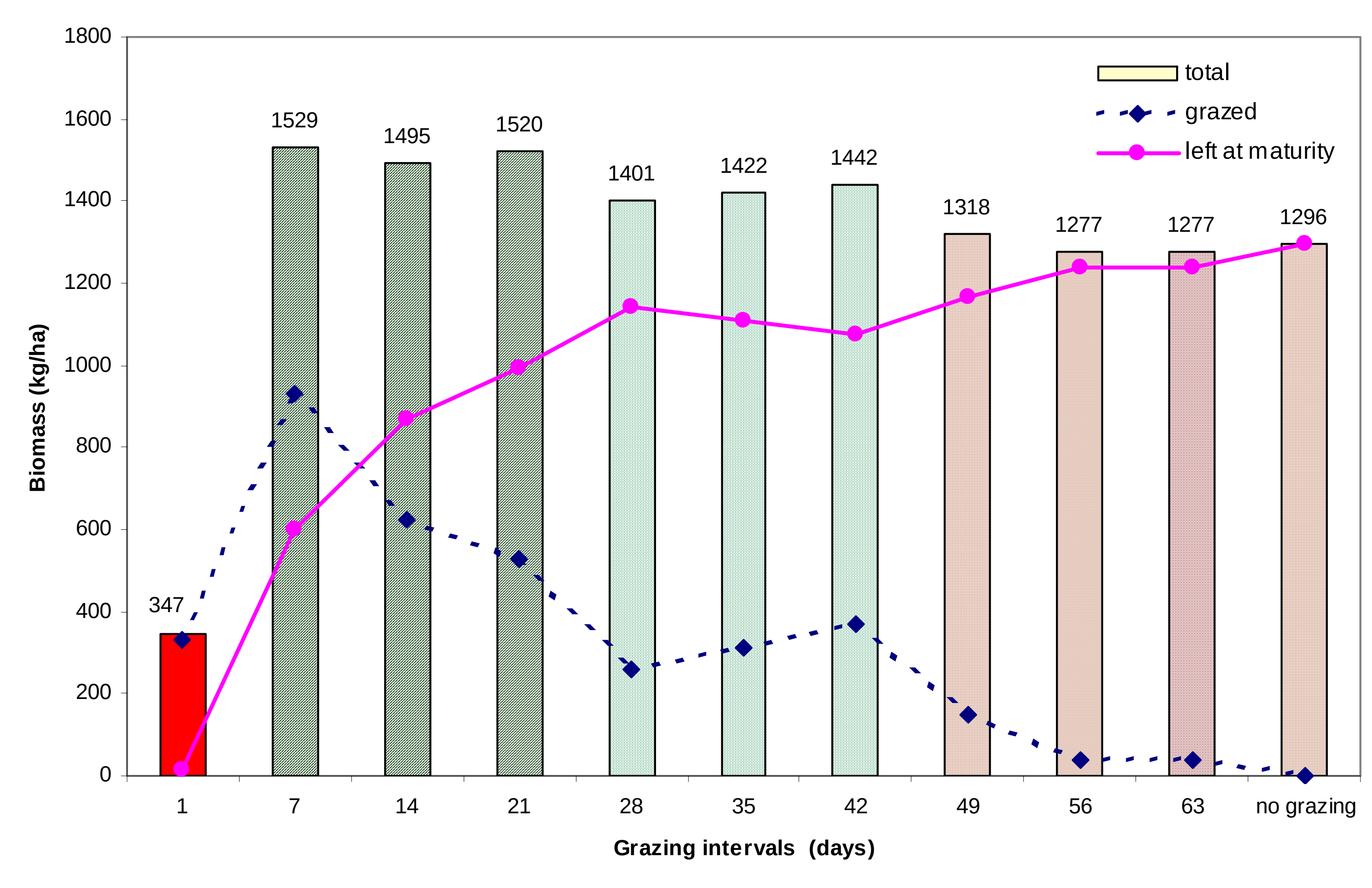
Pastures: Loudetia togoensis, Cassia tora



Pastures: Scheoenefeldia gracilis, and Zornia glochidiata..

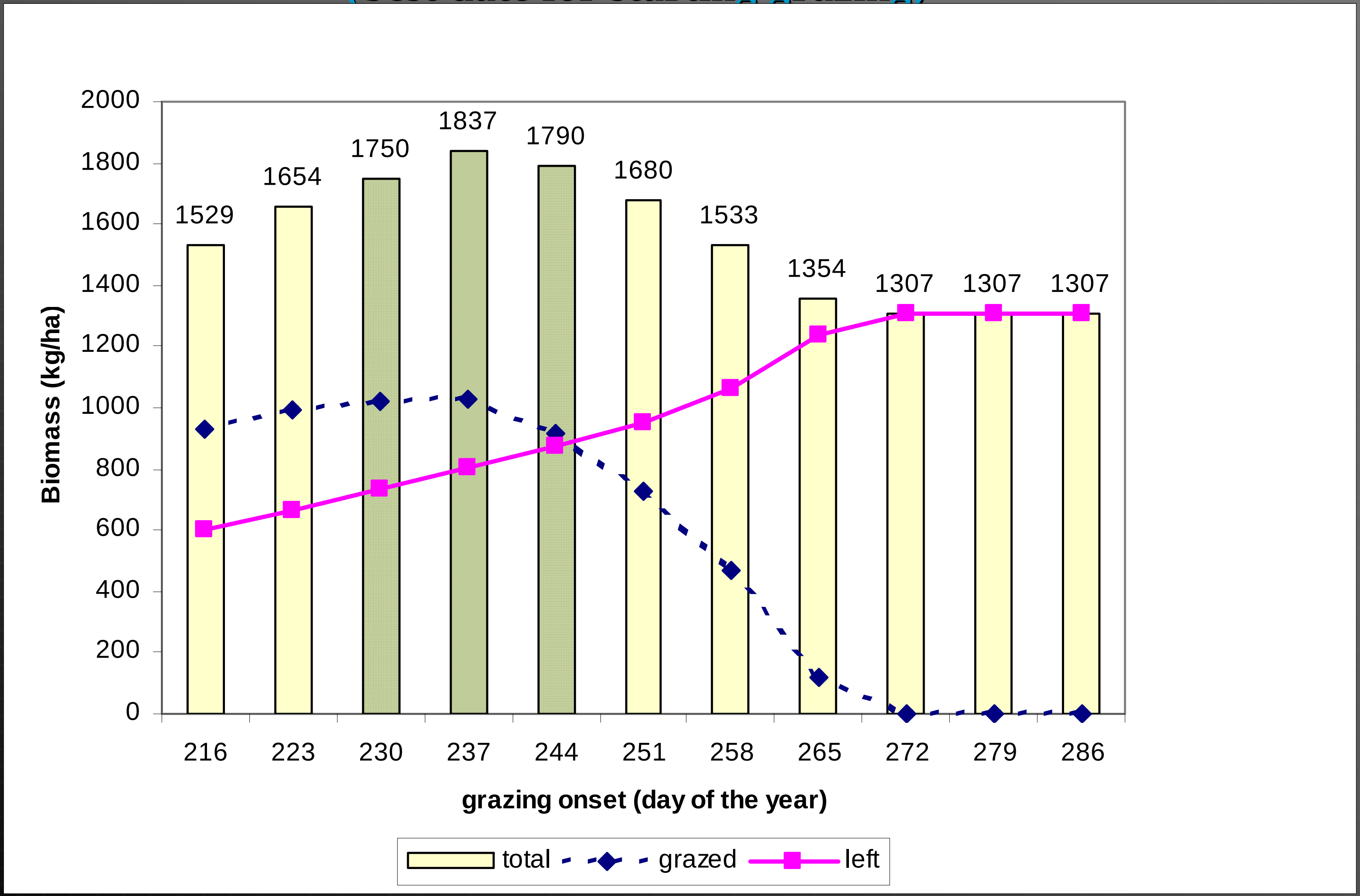
Pastures: Loudetia t. & Schoenefeldia g.

Effect of grazing intervals on biomass (grazed, left and total) during active period

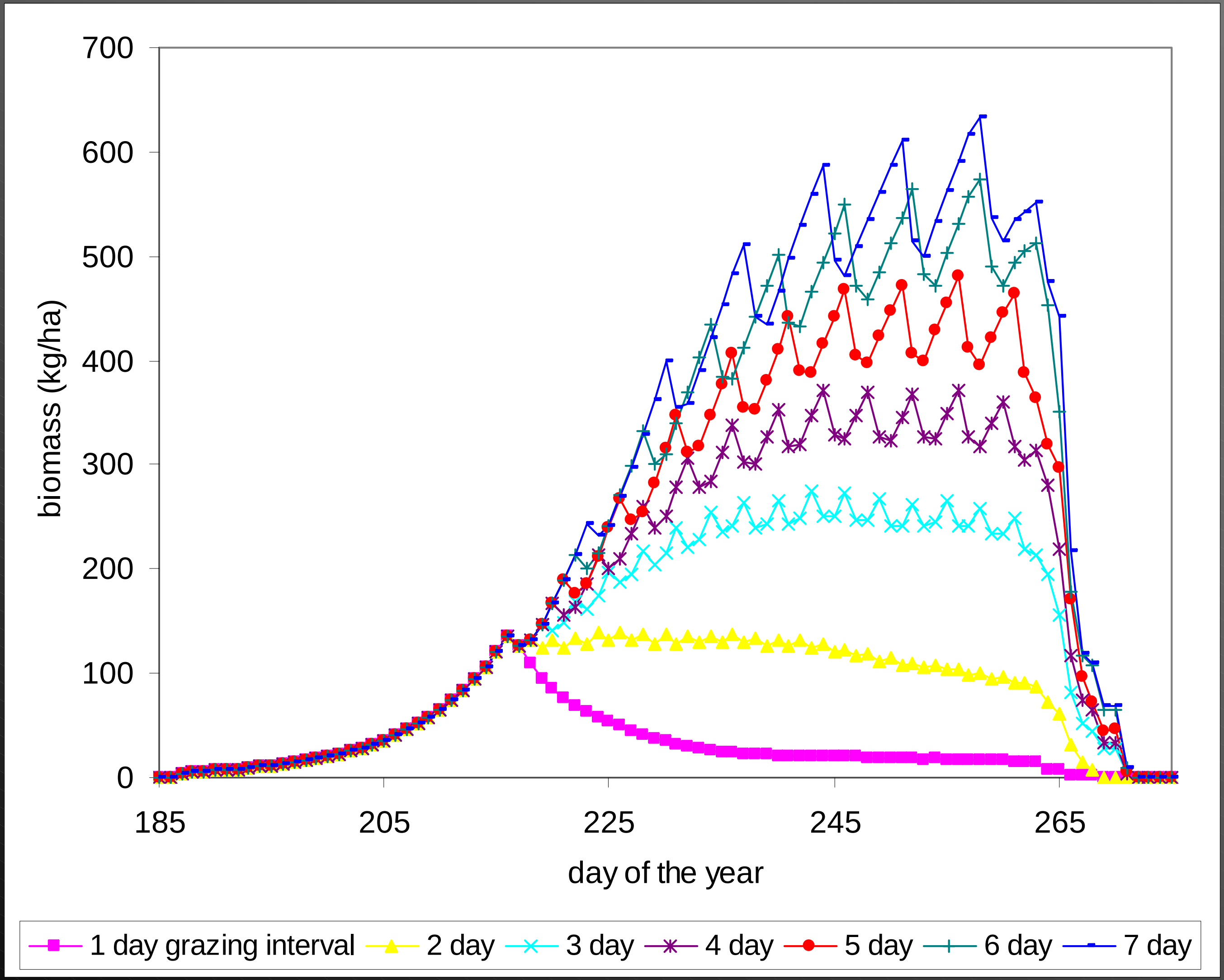


Effect of grazing onset date on production

(best date for starting grazing)



Effect of grazing intervals (frequency) on biomass accumulation



Effect of grazing intensity and grazing intervals (rotation) on residue left for decomposition and C sequestration