

Estimation of carbon stock in young sweet chestnut forest and agroforest plantations

Luan Luchese¹, Luís Nunes^{2,3}, Maria S. Patrício^{2,3*}

1 Instituto Politécnico de Bragança, Campus de Stª Apolónia, 5300-253 Bragança, Portugal
 2 Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
 3 Laboratório Associado para a Sustentabilidade e Tecnologia em Regiões de Montanha (SusTEC)
 * sampat@ipb.pt



Introduction

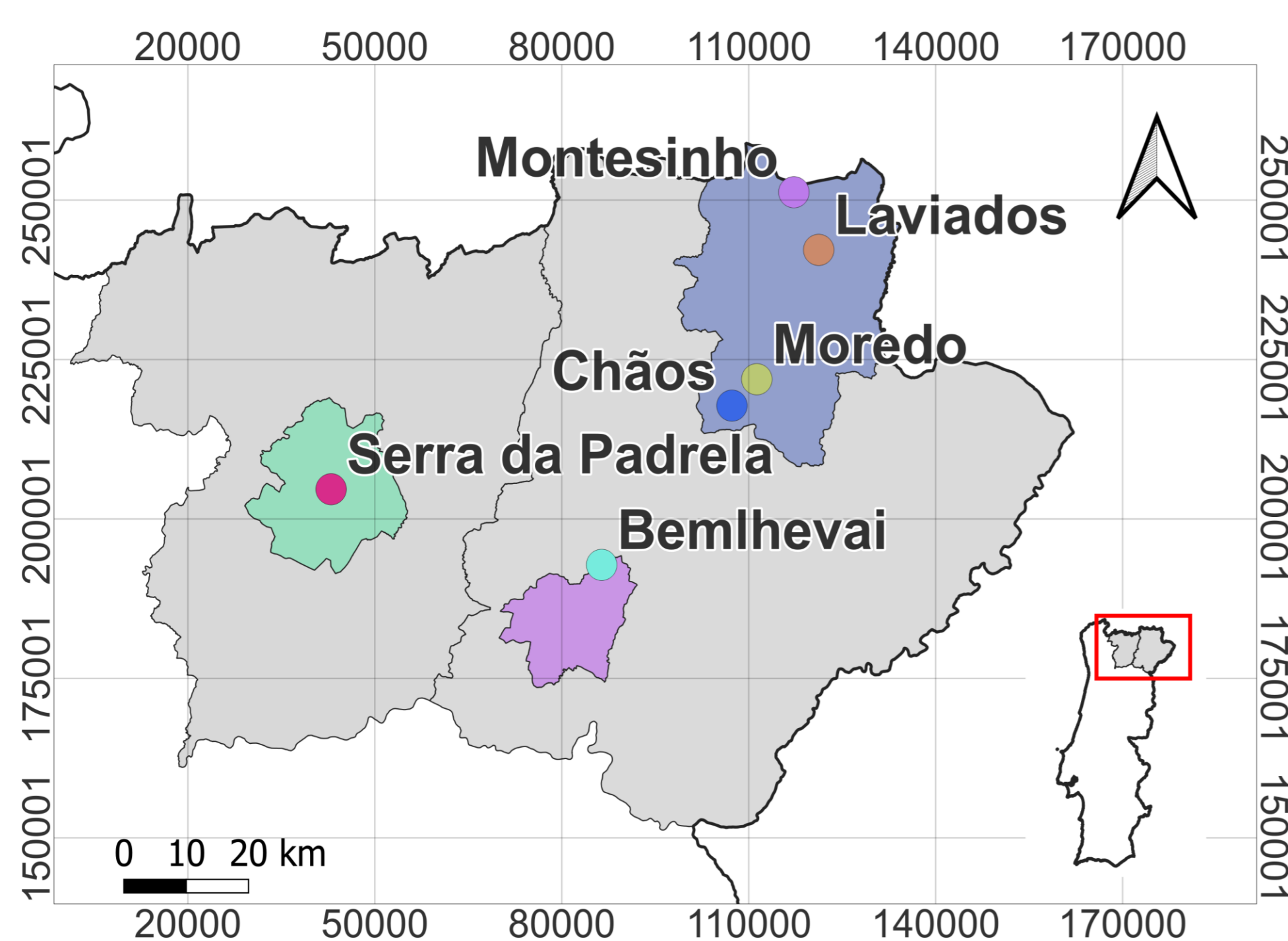
Sweet chestnut (*Castanea sativa* Mill.) plantations provide vital ecosystem services, including carbon removal from the atmosphere and storage in soil and vegetation. Expanding the revenue streams beyond timber or nut production by monetizing carbon storage can enhance the profitability of these areas. However, current estimates of carbon sequestration in chestnut in Portugal lack differentiation between agroforest and forest systems (coppice or high forest) and fail to account for site quality variations.

Objectives: Considering that the capacity for carbon sequestration is strongly dependent on the cultural system, management and site quality, the objective of this study is to evaluate and compare the carbon storage capacity in young stands of chestnut (up to 24 years old) in forest system (high forest and coppice regime) and agroforestry, considering lower, middle and upper site qualities.

The findings will contribute to understanding the carbon sequestration potential of young sweet chestnut forests and agroforestry plantations, contributing to sustainable land management. Additionally, the results can facilitate the incentive for carbon storage and diversification of income sources for chestnut owners.

Variation of carbon stored in biomass

✓ Location of network plots:



Network plots:

High-Forest:

In 2002, research permanent plots were established to monitor the growth and yield of high forest chestnut stands over time. A total of 160 inventories were conducted across 18 high forest chestnut plots, each covering an area of 3000m².

Coppice:

The coppice plots consisted of Plot P1 (management for small diameters), Plot P2 (management for medium diameters), Plot P3 (no intervention), and Plot P4 (management for large diameters).

Agroforestry:

For the agroforestry (high forest grafted for nut production) a stand-level equation was employed to simulate and estimate carbon stock. (Menéndez-Miguélez et al., 2023). Two densities: 7x7m and 10x10m were considered

Site quality:

Upper (SI₁₀ 10-12m)

Middle (SI₁₀ 7-9m)

Lower (SI₁₀ 4-5m)

Coppice: (SI₂₀) 15m

Biomass estimation:

Inventory data were used to estimate biomass using equations from specific literature.

Forest - High forest (Patrício 2006; Montero et al., 2005);

Agroforest - Orchards (Menéndez-Miguélez et al., 2023);

Forest - Coppice regime (Patrício et al., 2020).

Conversions of biomass into carbon:

Biomass was converted into organic carbon using the conversion factor (cf) 0,484;

Organic carbon was converted into CO₂ using cf=3,67;

Valuation of CO₂:

Replacement market method: the emission rights (EU ETS).

CO₂ valuation scenarios (€ Mg CO₂): lower=33.43; middle=70.49; upper = 91.82. (SendeCO2 company website (<https://www.sendeco2.com>), consulted on 06/05/2023)



Agroforestry system (Orchards)

Estimation: at 24 years old
(10x10m and 7x7m)

Estimated C stored (Mg C ha⁻¹):

•SI 11 = 36.7 - 40.8

•SI 7 = 12.3 - 13.7

•SI 5 = 2.1 - 2.2

Accumulation rate (Mg CO₂ ha⁻¹ Year⁻¹):

•SI 11 = 5.6 - 6.2

•SI 7 = 1.9 - 2.0

•SI 5 = 0.3 - 0.3

CO₂ valuation scenarios (€ ha⁻¹ Year⁻¹)

•SI 11 = 208.88; 440.43; 573.71

•SI 7 = 70.14; 147.89; 192.64

•SI 4 = 10.99; 23.18; 30.19

Forest system (high forest)

Estimation: at 24 years old

Estimated C stored (Mg C ha⁻¹):

•SI 10 -12 = 91.7

•SI 7 - 9 = 55.9

•SI 4 -5 = 36.7

Accumulation rate (Mg CO₂ ha⁻¹ Year⁻¹):

•SI 10 -12 = 14.1

•SI 7 - 9 = 8.5

•SI 4 -5 = 5.6

CO₂ valuation scenarios (€ ha⁻¹ Year⁻¹)

•SI 10 -12 = 468.52; 987.90; 1286.84

•SI 7 - 9 = 285.51; 602.01; 784.18

•SI 4 - 5 = 187.51 ; 395.38; 515.02

Forest system (Coppice)

Estimation: at 24 years old

Estimated C stored (Mg C ha⁻¹):

•P1 (small diameters) = 81.9

•P2 (medium diameters)= 89.2

•P3 (no intervention) = 84.7

•P4 (large diameters) = 70.1

Accumulation rate (Mg CO₂ ha⁻¹ Year⁻¹):

•P1 (small diameters) = 12.5

•P2 (medium diameters)= 13.6

•P3 (no intervention) = 12.9

•P4 (large diameters) = 10.7

CO₂ valuation scenarios (€ ha⁻¹ Year⁻¹)

•P1 (small diameters) = 418.47; 882.38; 1149.38

•P2 (medium diameters)= 456.36; 962.28; 1253.47

•P3 (no intervention) = 433.22; 913.48; 1189.90

•P4 (large diameters) = 358.11; 755.10; 983.59

Conclusions

- ✓ In conclusion, this study provides valuable insights into the carbon stock and sequestration potential of high forest chestnut stands, agroforestry orchards, and coppice forests. The findings highlight the significance of quality class, silviculture system, and management practices in determining carbon stocks and sequestration rates in chestnut production systems.
- ✓ This study emphasizes the importance of estimating carbon stock in young sweet chestnut forest and agroforest plantations. Evaluating the potential of carbon storage across different systems and site qualities provides valuable insights for sustainable land management.
- ✓ By recognizing the value of ecosystem services, including carbon sequestration, opportunities arise for implementing sustainable practices and accessing payment for ecosystem services and carbon credits. These findings contribute to the economic viability and ecological integrity of chestnut areas. Further research can build upon this foundation to optimize carbon storage and promote sustainable chestnut management.

Acknowledgements:

The authors are grateful to the Foundation for Science and Technology (FCT, Portugal) for financial support by national funds FCT/MCTES to CIMO (UIDB/00690/2020); AGRO Program, Project 267: Sustainable Management of Chestnut Forested Areas in High-Forest and Coppice Systems; Project PTDC/AGRFL/68186/Mixed forests: Modeling, dynamics and geographical distribution of productivity and carbon storage in mixed forest ecosystems in Portugal; Project PDR2020-101-031671 GO_FTA: Afforestation of agricultural lands with+ value, financial support of FEADER and Portuguese Government.



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