LAND SUITABILITY ANALYSIS FOR EMERGING FRUIT CROPS IN CENTRAL PORTUGAL USING GIS

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Objetives

The objective of this study is to determine the suitability for the cultivation of emerging fruit crops in the Beira Baixa region, based on the analysis of the soil and climate limiting factors. For this purpose, the biophysical criteria determining the cultivation of **pistachio tree** (*Pistacia vera* L.), **strawberry tree** (*Arbutus unedo* L.), **almond tree** (*Prunus dulcis* (Mill.) DA Webb) and **walnut tree** (*Juglans regia* L.) were processed using a Geographic Information System.

The analysis was performed by the **Analytical Hierarchy Process (AHP)**. After divide the problem into hierarchical levels of decision making, a pairwise comparison of criteria was performed to evaluate the weights of these criteria, based on a scale of importance.

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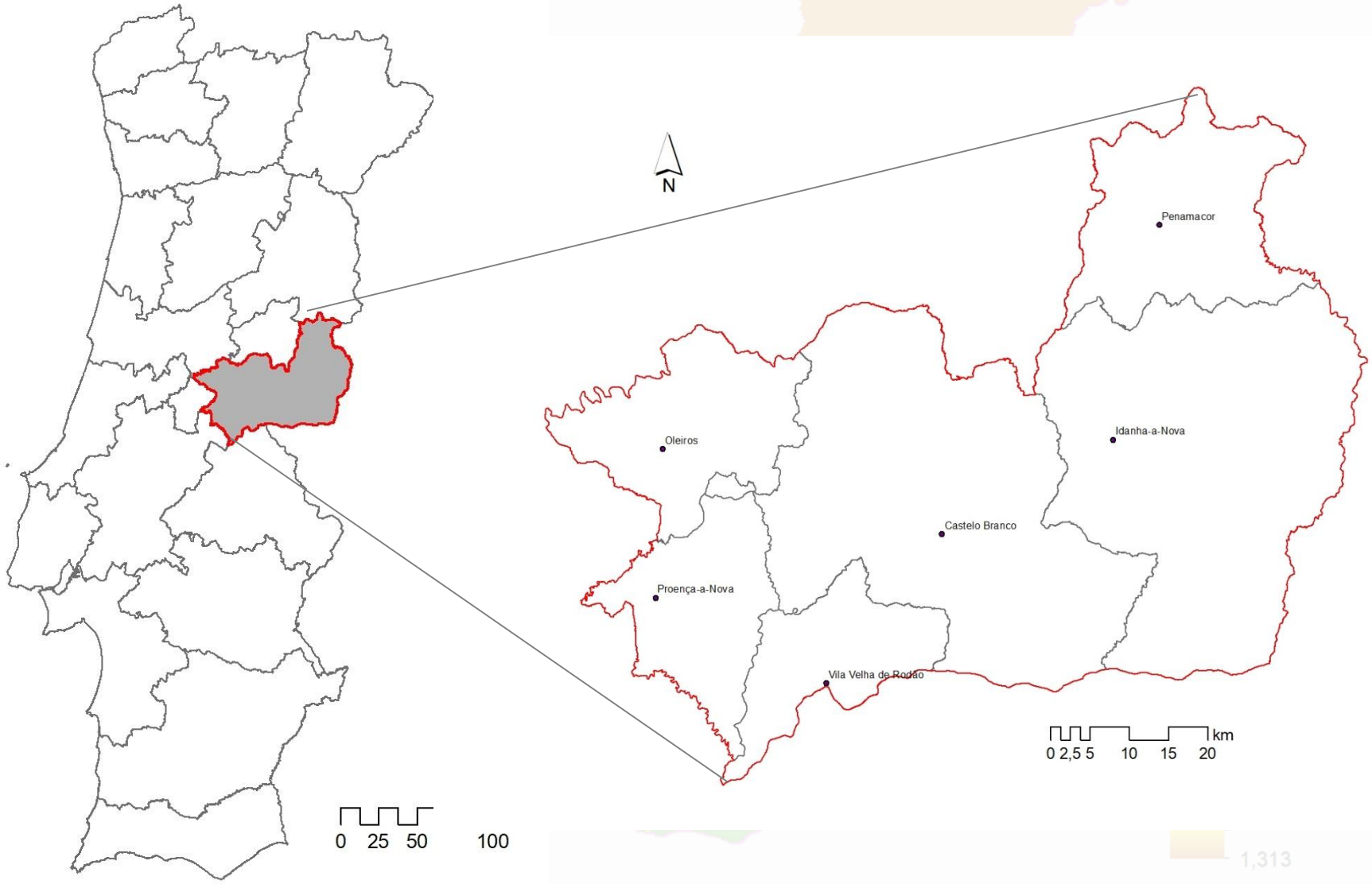
Study area

The Beira Baixa region is an administrative division in eastern Portugal

The region covers an area of 4,614.6 km² and has a population of 84,046 inhabitants.

The area is mainly occupied by forest and agroforestry uses (60.8 %) and agriculture (36.2 %).

The climate is mainly characterized by a warm temperate, mediterranean climate with a distinct wet season in winter.



Análise espacial multicritério para a determinação da aptidão

Processo Analítico Hierárquico (AHP)
(Saaty, 1970)

- A AHP consiste na **comparação dos critérios par a par** para a avaliação dos pesos e da importância relativa atribuída a cada critério.

- O cálculo dos ponderadores foi realizado com recurso ao plugin **Spatial multi-criteria analysis** desenvolvido por Marinoni (2018).

Material and Methods

The classification of the crops suitability resulted from the integration of a set of biophysical criteria based on the climate and soil requirements of crops and the optimal operating conditions associated with different uses. Geoprocessing and spatial analysis was performed to geographic data, namely soils, climate and elevation. In this study all the criteria are reflected in the corresponding GIS layers.

Criteria considered in determining crop suitability.

Criteria	Description
Mean annual temperature	Average of the 12 mean monthly temperatures (ºC)
Mean total annual rainfall	Total annual depth of precipitation from a given precipitation time series (mm)
Chilling hours	Sum of hours with temperature ≤ 7.2 °C (h)
Crop heat units	Influence of temperature on a crop's growth and development (h)
Mean relative humidity	Ratio of the actual amount of water vapour present in a volume of air at a given temperature to the maximum amount that the air could hold at that temperature (%)
Biogeography	Portugal biogeographic units and adapted species
Elevation	Height above the Earth's sea level (m)
Soil pH	Measure of the acidity or alkalinity of a soil
Soil Organic Matter	Fraction of the soil that consists of plant or animal tissue in various stages decomposition (%)

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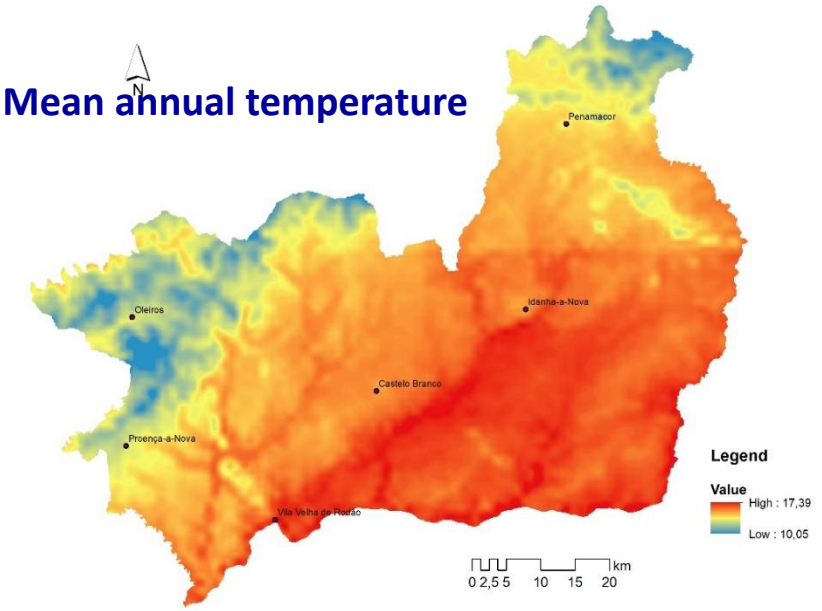
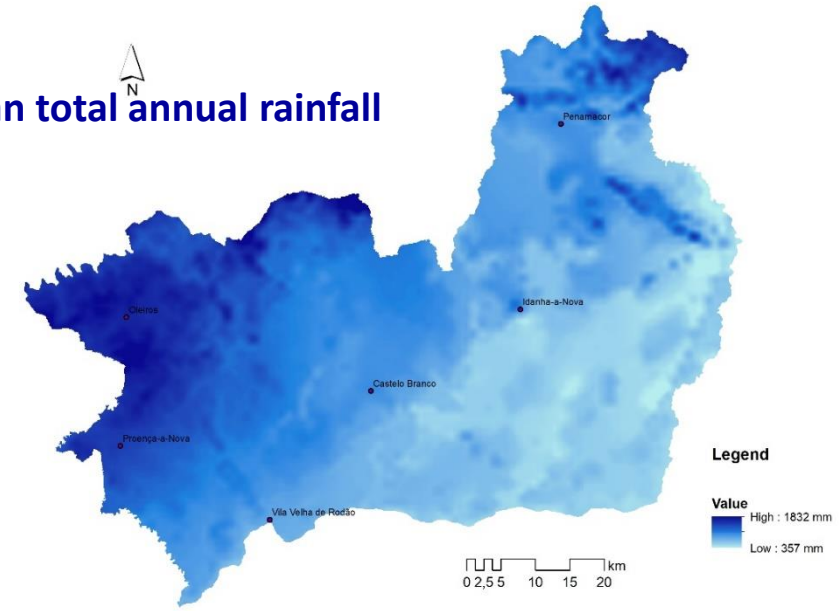
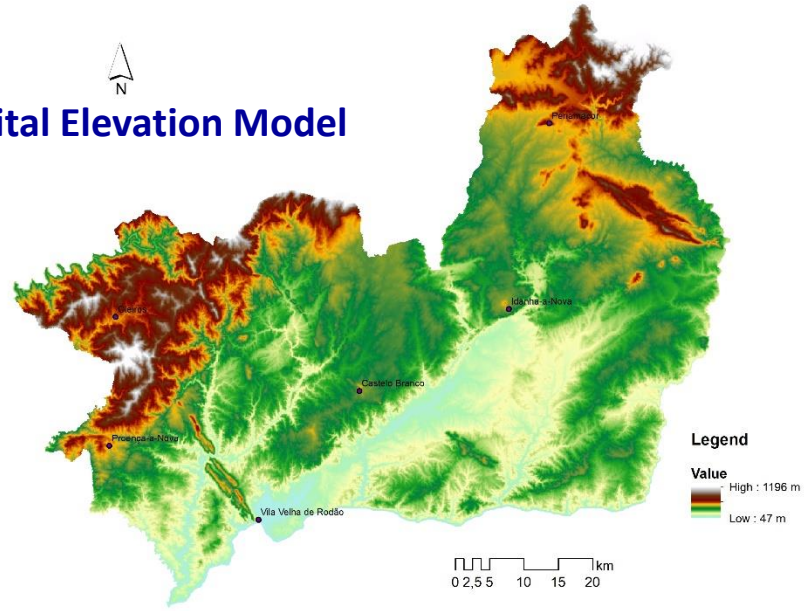
Mean annual temperature



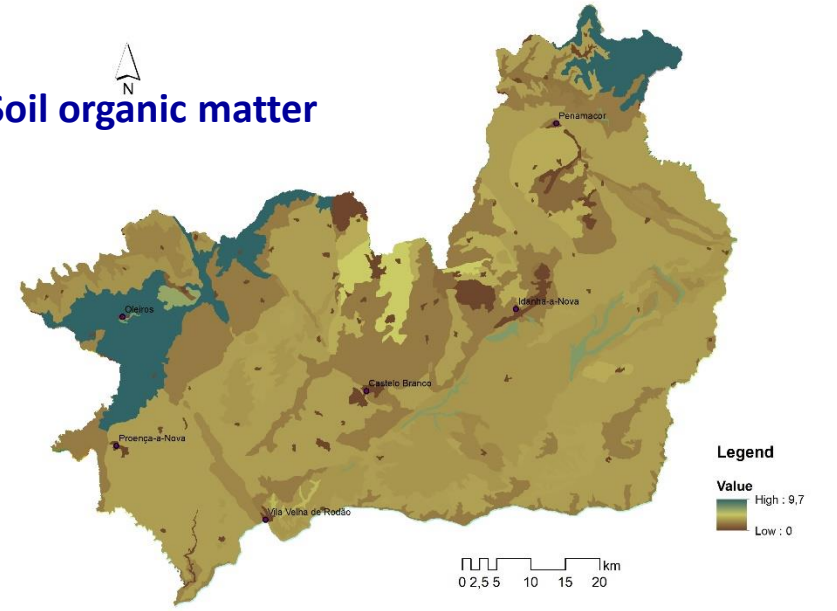
Mean total annual rainfall



Digital Elevation Model



Soil organic matter



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Criteria weights and consistency ratios

Crop	Criteria weights	Consistency ratio (CR<0.1)
Pistachio tree	Mean total annual rainfall (25.08%) Chilling hours (25.08%) Crop heat units (25.08%) Mean relative humidity (10.97%) Elevation (4.60%) Soil Organic Matter (4.60%) Soil pH (4.60%)	0.008
Strawberry tree	Biogeography (47.86%) Mean total annual rainfall (21.13%) Mean annual temperature (21.13%) Soil Organic Matter (4.94%) Soil pH (4.94%)	0.021
Almond tree	Mean total annual rainfall (26.48%) Mean annual temperature (26.48%) Chilling hours (26.48%) Elevation (10.94%) Soil Organic Matter (4.81%) Soil pH (4.81%)	0.009
Walnut tree	Mean total annual rainfall (35.95%) Chilling hours (26.48%) Elevation (15.35%) Soil Organic Matter (6.38%) Soil pH (6.38%)	0.012

Crop suitability maps

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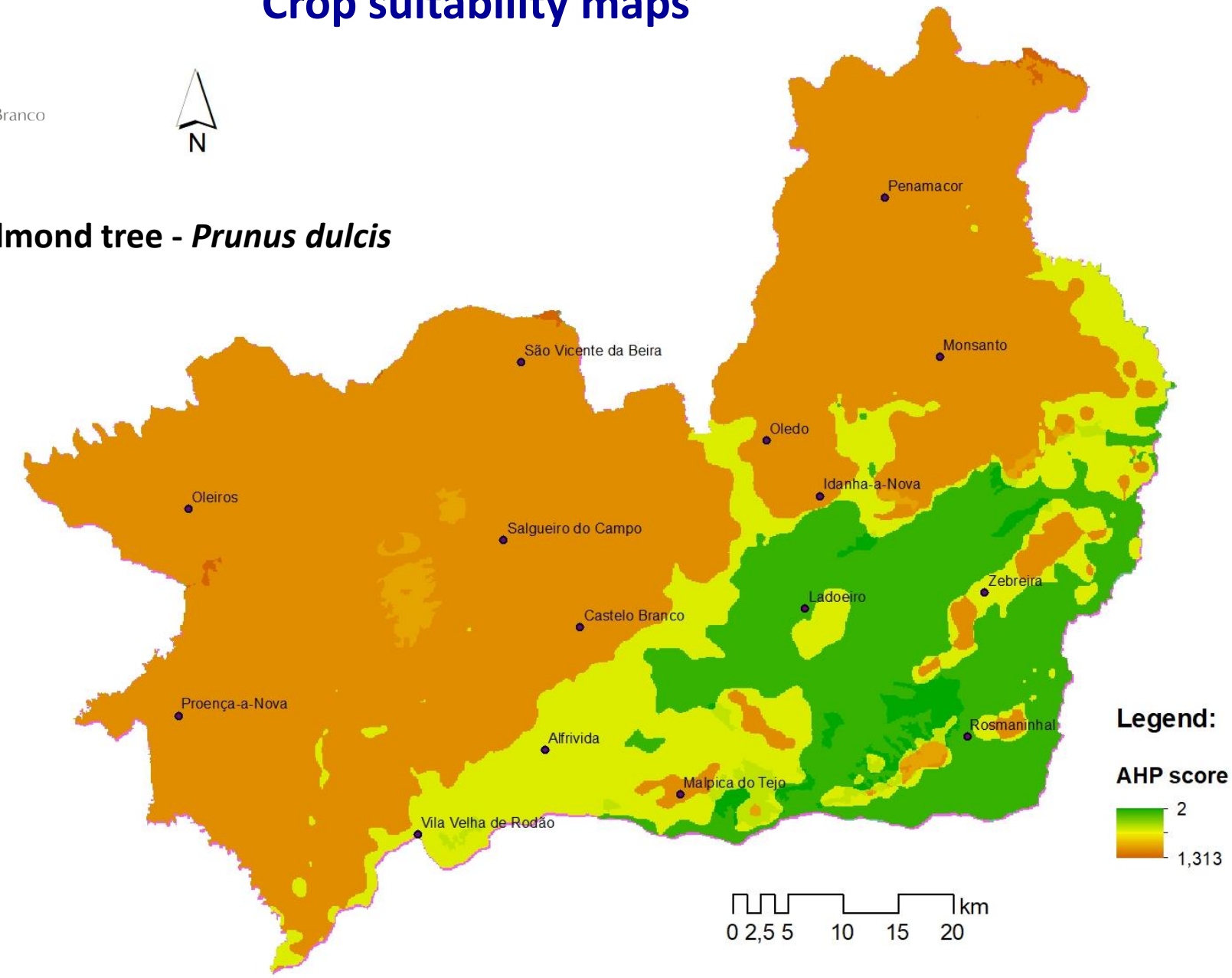
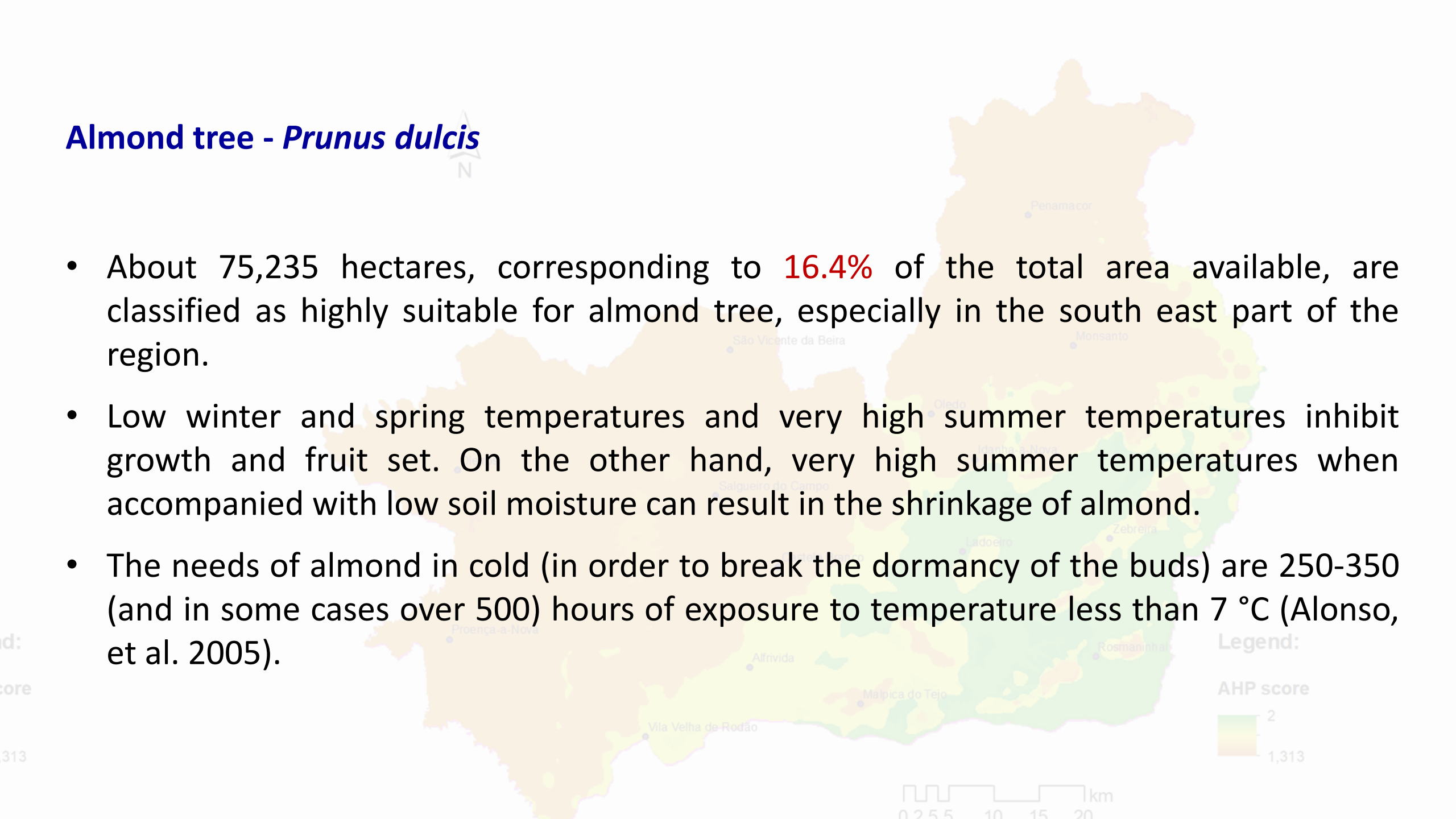
Almond tree - *Prunus dulcis*



Almond tree - *Prunus dulcis*

- About 75,235 hectares, corresponding to 16.4% of the total area available, are classified as highly suitable for almond tree, especially in the south east part of the region.
- Low winter and spring temperatures and very high summer temperatures inhibit growth and fruit set. On the other hand, very high summer temperatures when accompanied with low soil moisture can result in the shrinkage of almond.
- The needs of almond in cold (in order to break the dormancy of the buds) are 250-350 (and in some cases over 500) hours of exposure to temperature less than 7 °C (Alonso, et al. 2005).



Crop suitability maps

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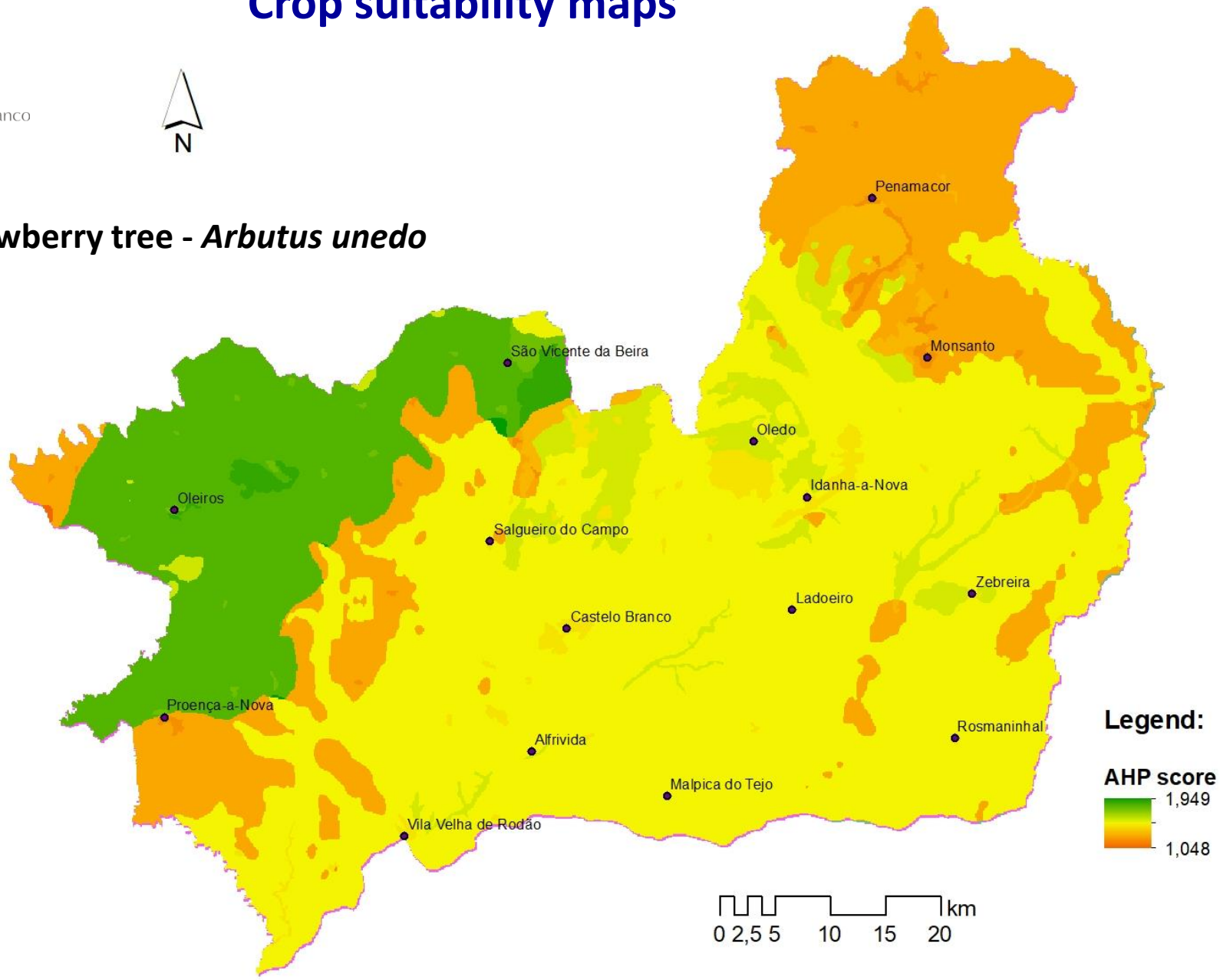
Strawberry tree - *Arbutus unedo*



Strawberry tree - *Arbutus unedo*

- Strawberry tree is one of the most common fleshy fruited species in the Mediterranean region. The area with high suitability to strawberry tree crop is 72,423 hectares, corresponding to 15.8% of the total area available, corresponding to northwest of the region, in an area with higher altitude (around 600-800 m) with more suitable climatic conditions and topographic adaptation.

Pistachio tree - *Pistacia vera*

- The area with higher potential to pistachio tree crop is 72,679 hectares, corresponding to 15.9% of the total area available and overlaps the potential almond tree crop area, resulting from natural conditions, especially the climatic influence.
- That plants are known as drought tolerant and are able to survive and even produce fairly yield with very little water (Ferguson et al., 2002). An annual rainfall of at least 300 to 450 mm has been reported as the optimum amount of precipitation for this tree (Goldhamer, 2005).

Crop suitability maps

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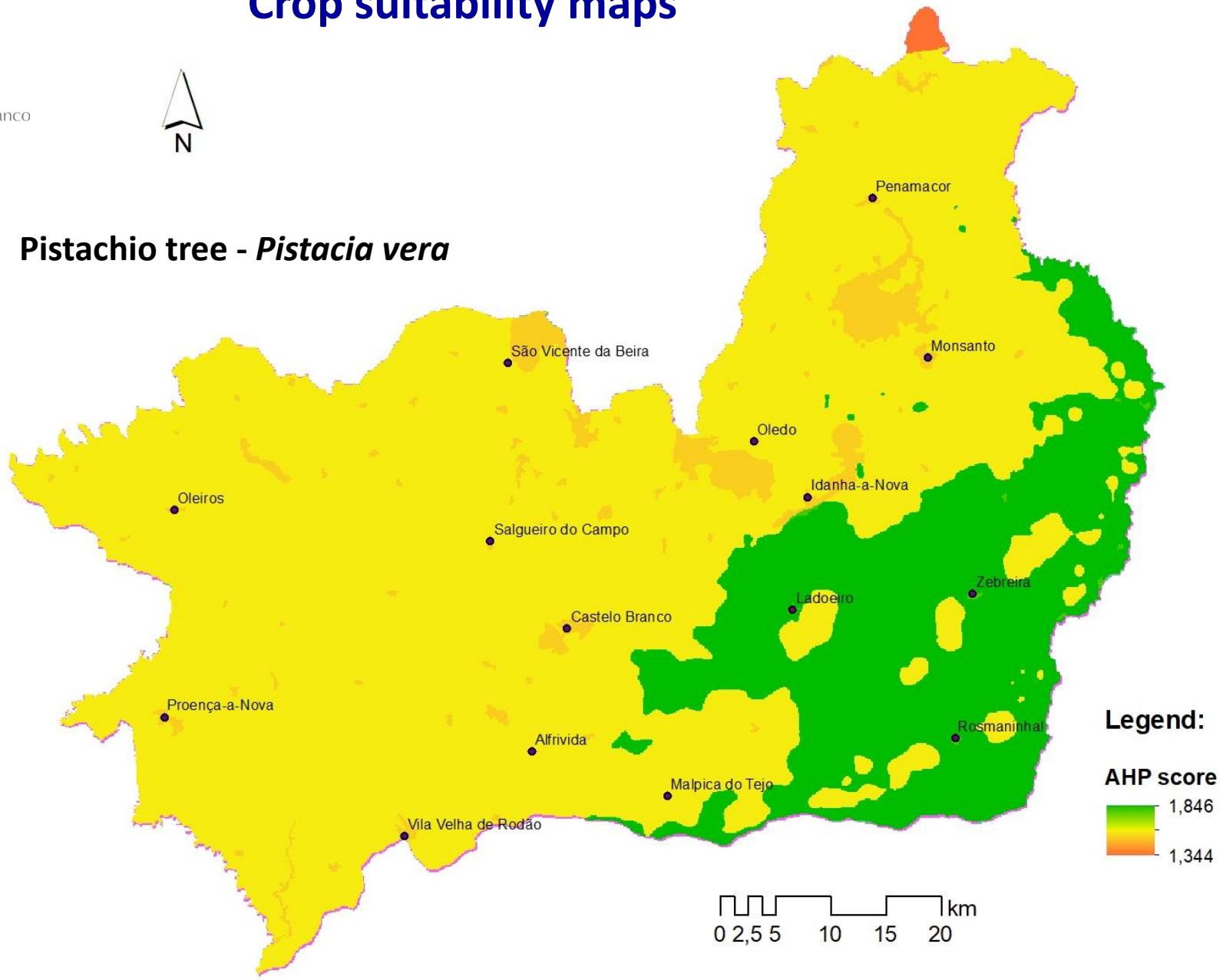

Walnut tree - *Juglans regia*

- In the case of walnut tree crop, highlighting the total 288,983 hectares, corresponding to 63.2% of the total area available. .
- Higher precipitation (minimum of 600 mm) during the winter and the temperature are the main parameters that compromise this crop, especially in the last case, during the opening of male flowers.

Crop suitability maps

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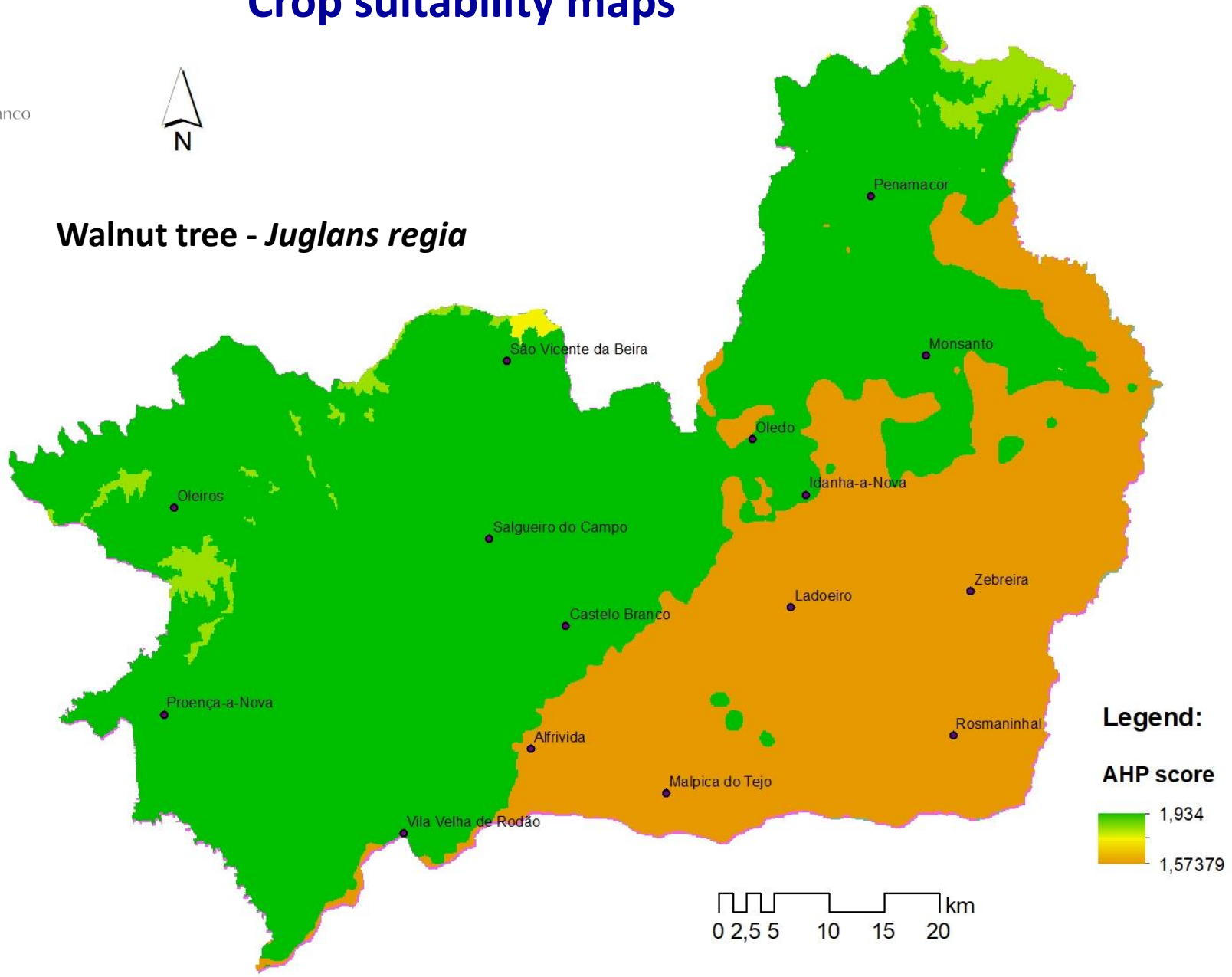
Walnut tree - *Juglans regia*



Conclusions

- This methodological approach allowed us to assess the suitability of four emerging fruit crops (Almond tree Strawberry tree, Pistachio tree and Walnut tree) in the Beira Baixa region of Portugal.
- The AHP was based on a set of criteria contributing to a reflection on the adequacy of those crops for the climatic and soil characteristics of the region. The crops suitability maps thus obtained enable decision making.
- The main results obtained indicate that the methodology used, using AHP and GIS, could provide a guide map for decision makers in order to achieve better agriculture productions facing their ecological limitations.

Conclusions

- The results put on evidence the biophysical evaluation of territory and provide information at a local level that could be used by farmers to select their crops.
- For further study is recommend to select other factors, like irrigation facilities and socio-economic factors, and other parameters which influence the sustainable land use. However, further investigation is needed to integrate the impact of climate change in crops planning to assist in supporting future national strategies for agriculture.