



## Few, yet enough: conservation of white crowberry, an endemic plant in regression at Camarido Forest. A landscape revisited throughout its history and actual conservation challenges

Pocas, pero suficientes: conservación de la camariña, una planta endémica en regresión en el Bosque de Camarido. Un paisaje revisitado a lo largo de su historia y desafíos actuales de conservación

M. ALEXANDRA ABREU LIMA <sup>\*1,3,4</sup>, ANA ISABEL LOPES <sup>2,5</sup>

<sup>1</sup> MARE - Marine and Environmental Sciences Centre, ARNET - Aquatic Research Network Associate Laboratory, NOVA School of Science and Technology, NOVA University Lisbon, Portugal

<sup>2</sup> CITCEM – Transdisciplinary Research Center «Culture, Space and Memory», Faculty of Arts and Humanities of University of Porto, Portugal

<sup>3</sup> INIAV I.P - Instituto Nacional de Investigação Agrária e Veterinária, Oeiras, Portugal

<sup>4</sup> alexandra.a.abreu@gmail.com

<sup>5</sup> lopes.anaisabel1003@gmail.com

\*AUTOR DE CORRESPONDENCIA



M. ALEXANDRA ABREU LIMA



ANA ISABEL LOPES

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### ABSTRACT

According to the European Forest Genetic Resources Programme, European forests cover 157 million hectares of land and provide a vast array of products, socio-economic benefits and ecosystem services (EUFORGEN 2024). This paper describes the Portuguese Camarido Forest, with an area of 146 hectares, classified within European Forests in the category 'Atlantic Maritime pine forest'. Camarido Forest relevance for local coastal populations is presented through a historical perspective. Future challenges for its biodiversity conservation, namely of white crowberry plant (*Corema album*, Ericaceae), an coast Iberian endemic in clear regression throughout its distribution area are discussed. Findings point out that coastal forests are reservoirs for biodiversity conservation prone to several threats, ranging from habitat fragmentation, invasive species and climate change. We suggest that the conservation of forests benefits from young students' engagement in environmental education initiatives and requires collaboration between civil society entities and stakeholders dealing with forests and conservation. Additionally, forests as cultural landscapes are increasingly valued as a mean to ensure that the relationships between people and nature are nurtured, fostering the vitality of both cultural and biological diversity.

**Keywords:** Biocultural; Biodiversity; *Corema album*; Phytotoponomy

### RESUMEN

Según el Programa Europeo de Recursos Genéticos Forestales, los bosques europeos cubren 157 millones de hectáreas de tierra y proporcionan una amplia gama de productos, beneficios socioeconómicos y servicios ecosistémicos (EUFORGEN, 2024). Este artículo describe el Bosque Portugués de Camarido, con una superficie de 146 hectáreas, clasificado dentro de los Bosques Europeos en la categoría 'Pinar Marítimo Atlántico'. La relevancia del Bosque Camarido para las poblaciones costeras locales se presenta a través de una perspectiva histórica. Se discuten los retos futuros para la conservación de su biodiversidad, en concreto de la camariña (*Corema album*, Ericaceae), una planta endémica costera ibérica en clara regresión en toda su área de distribución. Los hallazgos señalan que los bosques costeros son reservorios para la conservación de la biodiversidad propensos a varias amenazas, que van desde la fragmentación del hábitat hasta las especies invasoras y el cambio climático. Sugerimos que la conservación de los bosques se beneficia de la participación de los estudiantes en iniciativas de educación ambiental y requiere la colaboración entre entidades de la sociedad civil y partes interesadas para su uso sostenible y gestión para su conservación. Además, los bosques como paisajes culturales se valoran cada vez más como un medio para garantizar que se fomenten las relaciones entre las personas y la naturaleza, fomentando la vitalidad y la preservación de la diversidad tanto cultural como biológica.

**Palabras clave:** Biocultural; Biodiversidad; *Corema album*; Fitotoponimia

## INTRODUCTION

According to the European Forest Genetic Resources Programme, European forests cover 157 million hectares of land and provide a variety of products, socio-economic benefits and ecosystem services (EUFORGEN, 2024). This paper describes the Portuguese Camarido Forest, with an area of 146 hectares, classified within European Forests in the category 'Atlantic Maritime pine forest' (Barbati *et al.*, 2014). This category is defined as "Atlantic coastal forest of *Pinus pinaster* subsp. *atlantica* of southwestern France and western coasts of the Iberian Peninsula; many forests were originally established by reforestation on sandy coastal dunes (e.g. France, Massif Landais; Portugal, National Pine Forest of Leiria)" (Barbati *et al.*, 2014).

Data from the European Information System on Forest Genetic Resources (EUFGIS) reveal that Europe has an extensive network of more than 3200 genetic conservation units, which harbour 4000 different populations of about 100 different species. However, it is known that this network suffers from gaps in coverage and more than 80% of the conservation units only represent five economically important species (EUFORGEN, 2024). This pro-

gramme also points that other species relevant for the proper functioning of a forest ecosystem are not at all well conserved, and even among well-conserved species, detailed information on genetic diversity in the conservation unit is often lacking. Among the forest species for which detailed studies are lacking, this paper focuses on the white crowberry plant - *Corema album* (L.) D. Don referred as an autochthonous, threatened and of high conservation value species, in the Portuguese Public Administration Operational Program for Conservation and Breeding of Forest Genetic Resources (INIAV and ICNF, 2018). *Corema album* (Ericaceae), 'Camarinha' in Portuguese, 'Camariña' or 'Camarina' in Spanish, or the 'white crowberry', is a dioic white-berried perennial adapted to sandy soils in the Iberian Peninsula which has been consumed by humans for many centuries (Oliveira & Dale, 2012) (Figure 1). Currently, it occurs naturally on sand dunes and cliffs of the Atlantic coast from Gibraltar to Finisterre, and in the Azores on volcanic lava and ash fields. The occurrence of *C. album* plant macro-remains in archaeobotanical records was studied and results by López-Dóriga (2018) suggest that its distribution area was much larger in the past and decreased rapidly in recent times.



Figure 1. White crowberry (*Corema album*) female plant with fruits (Photo: A. Abreu).

Gil-López (2011) highlighted recent decades studies which revealed that due to several factors, there has been a regression of the white crowberry plant, with their disappearance in different areas of the Iberian Peninsula western coast. In Spain, already in the 1980s, it was considered a Vulnerable species on the Red List of Vascular Flora (Izco, 2004). In the North of Spain, in Galicia, it was considered, in 2004, in clear regression with presence in only six localities (Izco, 2004) and the cataloguing of this species for its inclusion in the Vulnerable Category in the Galician Catalog of Threatened Species has been requested by the Galician Society of Natural History (GSNH, 2019), after compilation of scientific-technical information concerning several criteria. In the South of Spain, it was considered a Vulnerable species in the Red List of the Vascular Flora of Andalusia (Gil-López, 2011). For mainland Portugal *C. album* subsp. *album* has not yet been evaluated. However, in the Forestry Management Plan of the Camarido Forest (Caminha) a regression of this plant species population was reported (ICNF, 2010), based upon data from 1995 and 2007. According to this report, white crowberry plant distribution in the Camarido Forest occurs mainly in the Protection Series, close to the coast. In the past its presence was much more abundant. According to Ferreira-Rodríguez (2012), the large number of toponyms that refer to this plant, Camariñas and Proba do Caramiñal, in Galicia; Pinhal do Camarido, in Caminha (Portugal), or Punta Camarinal, in Cádiz (Spain), indicate that this species was very abundant in the past. The recent evaluation of the geographic distribution of phyto-toponyms, places named after a native local flora, in Galicia, NW Spain, by Fagúndez & Izco (2016), led them to conclude that place names of natural elements depict human's interaction with the environment. They argue phyto-toponyms are stable, spatially explicit elements that may be used as indicators of bio-cultural diversity and represent an intangible cultural heritage that should also be preserved. In the Portuguese context it is worth mentioning the study of Pinho (2007) about trees in Portuguese toponymy.

In a study of Clavijo *et al.* (2002) entitled '*Fragmentation as the main cause of the reduction of the habitat of Corema album in its distribution area*' the authors reported that in Iberian Peninsula only existed two zones with extensive populations of *C. album* presenting individuals of all age classes. One of them was on the Portuguese coast between 'Nazare' and 'Ovar', and the other on the coast of 'Huelva' (Spain) in the 'Asperillo' dune system (Doñana Natural Park), with another well-preserved population in the dunes of 'Tróia' (Portuguese coast). Despite this ecological value, since 2020, in Tróia dunes area, white crowberry habitat fragmentation is occurring due to an increasing trend of urban development and human occupation pressure along this coastal zone (LPN, n.d.). Clavijo *et al.* (2002) highlighted that for the fragmented populations of *C. album*, such as the populations of the 'Foz Rio Minho', at Camarido Forest, which are reduced to sand islands without natural regeneration, and formed by old individuals, their survival in the future depends on measures of protection and regeneration of habitats. Habitat loss and fragmentation are major sources of biodiversity loss, as they cause species declines and extinctions, hampering population viability of threatened species (IPBES, 2019; Pereira *et al.*, 2002). Another threat to white crowberry populations, and other endemic plant species, relates with invasive species spreading as an indirect consequence of climate change (Pereira *et al.*, 2002).

At Portuguese national context, among agronomic and genetic studies about *C. album*, it is worth mentioning that during the decade of 2010, a *C. album* germplasm collection from ten origins was established at INIAV Experimental farm at Fataca (INIAV, n.d.) and, in June 2024, a ground-breaking project to improve the genomic annotation of the white crowberry (*C. album*) was launched in a partnership between the CE3C Research Centre (University of Lisbon) and Biodiversity Genomics Europe (BGE), within the European Reference Genome Atlas initiative (ERGA, 2024).

This study focuses on addressing the two following questions: (1) What has been the use and conservation of the Camarido in past centuries? and 2) Are environmental educational initiatives a component of conservation for forests of biocultural richness?

Although the Camarido National Forest has been part of the national forests for almost 200 years, it has always seemed to have a peripheral character. It could be questioned whether its smaller size and economic importance compared to other public forest areas or its geographical position in the far north, on the natural border between Portugal and Spain can explain this situation. The question can be presented of whether its limited knowledge is the result of more localised information and management, the evolution of which is not always possible to know diachronically due to the challenges of historical documentation or because the history of public forest management in Portugal is a recent trend (Trápaga Monchet *et al.*, 2023). As part of the development of research into these issues, some historical data is presented.

In this paper, it is therefore discussed the status of Camarido forest in Caminha Municipality, Northern Portuguese mainland coast, in terms of its biological, cultural and historic richness. From the results obtained from historical and biological data collection and fieldwork environmental education we present challenges to increase this biocultural forest protection and its white crowberry (*C. album*) population conservation.

## METHODOLOGY

### *Characterization of the study area*

Administratively, Portugal is divided into districts and municipalities. The Camarido forest study area is in Viana do Castelo district and Caminha municipi-

pality, located in the northern mainland Portuguese coast (GPS: 41.864 528 N / -8. 854 411 W) close to the River Minho estuary, which consists of an international river boundary between Galicia (North of the river, in Spain) and Minho (South of the river, in Portugal) (Figure 2).

From 1999 onwards, the Camarido Forest has been integrated, practically in its entirety, into the Natura 2000 site, code PTZPE0001 - Estuários dos Rios Minho e Coura (<https://eunis.eea.europa.eu/sites/PTZPE0001>) and Site of Community Interest SIC Litoral Norte, code PTCON0017. Camarido Forest has a total area of 146 hectares with 127 ha of pine forest (Figure 3).

### *Data collection*

This work uses historical sources, namely landscape descriptions and administrative sources produced by the institutions that regulated and managed the Camarido National Forest over time. The documents produced by the Infantado House (1654-1834), available at the National Archive of Torre do Tombo and the Municipal Archive of Caminha, and by the General Administration of the Woodlands (1836-1886), the Library and Archive of the Ministry of Public Works (*Biblioteca e Arquivo do Ministério das Obras Públicas*) and the Navy Library (*Biblioteca Central da Marinha*) were consulted. We also reviewed some of the literature produced by local historians and forest engineers.

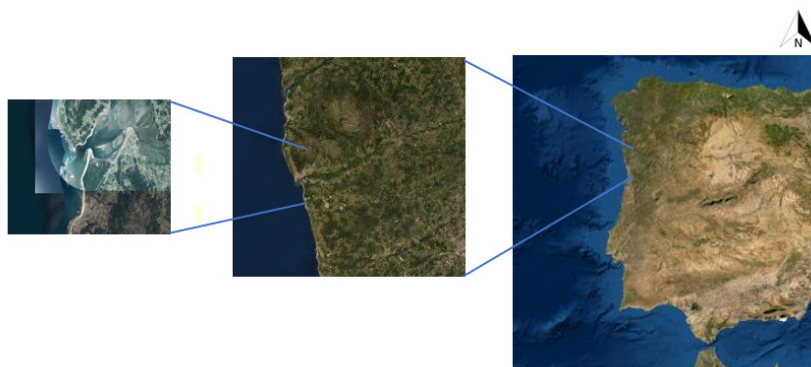


Figure 2. Camarido National Forest in southern margin of River Minho estuary (left) located in Portuguese northern mainland coast (centre) in Iberian Peninsula (right). Source: adapted from GIS maps.

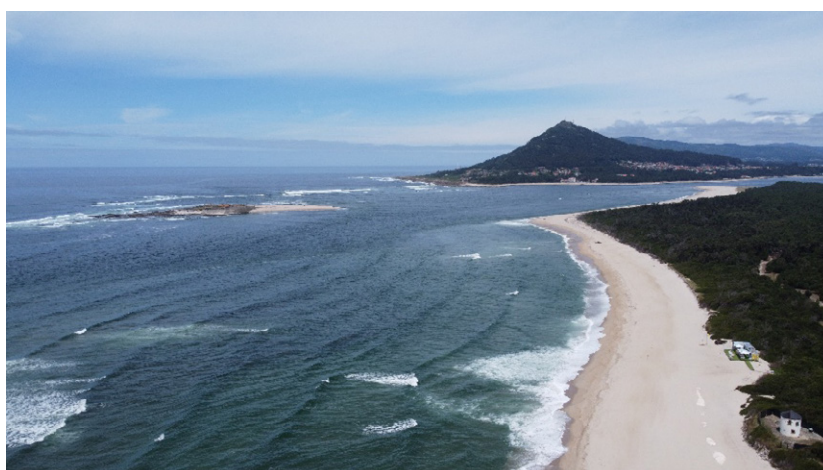


Figure 3. Aerial view of Moledo do Minho beach, part of Camarido National Forest (right) and Minho River mouth [Drone M. Lima (2021)].

### *Environmental education initiatives*

Since 2016, in an early basis, two or three groups of 30 students each, aged 7-11 years, with their teachers, are invited to participate in environmental education initiatives at Camarido Forest. The main aim of these initiatives is to engage young students in white crowberry plant conservation. Planned initiatives about the white crowberry are: 'Field Trip', 'Botany and Art' and 'Conservation'. This third initiative is only implemented whenever a white crowberry population is defined to be in regression.

In the 'Field Trip' initiative, students participate in a visit to the coastal forest area with white crowberry plants for about 2 hours, in which they see the white crowberry plant and other plants. During the visit, students become aware of white crowberry worldwide geographic distribution and of the concepts of endemic plant and invasive plant. An example of invasive species is the hottentot fig – *Carpobrotus edulis* (L.) N.E.Br.

In the 'Botany and Art' initiative, at classroom, students draw the landscape or the plants they observed during the field trip visit. An Herbarium *C. album* specimen image, from the Camarido Forest, is shown to students.

In the 'Conservation' initiative the propagation of the white crowberry is implemented at greenhouses, at a Research Institute, through rooting of stem cuttings, pieces of stem with leaves, previously

collected from wild plants. Students' participation in this initiative occurs in a latter phase, during the plant reintroduction at Camarido Forest, within a partnership with an environmental local Non-Governmental Organization and the Union of Parishes of Moledo and Cristelo.

## RESULTS

### *The Camarido National Forest and its economic, social, and environmental importance throughout history*

The local documentation about the evolution of administration, biodiversity and management of Camarido National Forest consists of dozens of records, most never before published. Some historians such as Pinho Leal (1873-1890) and more recent bibliography (Lopes 1986; Bento *et al.*, 2009) attribute the debut of the Camarido National Forest, concurrently to the Leiria National Forest, to the reign of King Dinis (1279-1325), commonly known as 'The Farmer', to fix the drift sands. However, there are no historical documents to prove this. As elucidated by Luís Brito (1987), a careful analysis reveals the absence of explicit references to the planting of trees or the toponym "Camarido" both in the charter of Caminha (foral), on 24 July 1284, granted by King Dinis and in the

records of the monarch's Chancellery. The existence of that forest would necessarily imply mention of the destination of the timber and firewood produced. This author, therefore, suggests that the emergence of this woodland could only have occurred, at the very least, during the reign of King Fernando (1369-1383) as part of his policy of agricultural and forestry promotion, which included the distribution of land for cultivation. However, it is more plausible that this took place at the end of the Middle Ages, between the reigns of King Afonso V (1438-1481) or King João III (1521-1557), with the consolidation of the power of some of Portugal's prominent noble families. This forestry endeavour, which involved significant investment and maintenance costs, was probably carried out by a large noble family, such as House Sotomayor, of Galician origin and with a matrimonial union in Portugal, who would receive the title of Dukes of Caminha and Marquises of Vila Real and held the position of Mayors of Caminha. Although it did not reach the proportions of the 19th century, this afforestation project had as its primary objective the exploitation of forest resources, to the detriment of ecological consideration for the protection of the mobile dunes. This interpretation is reinforced by the absence of any mention of a royal forest area in the charter (foral) granted by King Manuel I (1495-1521) in 1512, contrary to popular belief that such a woodland date from the 13th-14th centuries, under the reign of King Dinis. However, Eusébio Furtado Coelho (1861), a military officer in the service of the Civil Government of the Viana do Castelo district, presents a brief history of the Camarido National Forest in which he states that the purpose of planting this forest, sown by the inhabitants of Cristelo and Moledo, was to protect houses and arable land from the drift sands coming from the great headland at the mouth of the River Minho, but doesn't mention the exact date of its beginning. Its management was ceded to the Dukes of Caminha and Marquises of Vila Real, who were then, in the 16th and 17th centuries, lords of the town of Caminha so that they could take care of the management of Camarido. There is still some doubt as to the original purpose of the grove, but we can place its existence as early as the Early Modern Age (Figure 4).



Figure 4. Dunes and Camarido Forest in 1620's [Source: Vigo Transancos (2003)].

However, with the end of the Iberian Union and Portugal's independence after 60 years under the Spanish Crown, and these local nobles having been accused of conspiring against D. João IV, who would become the monarch of Portugal, the descendants of this family, D. Luís de Meneses, Marquis of Vila Real, and Rui de Meneses, Duke of Caminha, lost their titles and property, which included Mata do Camarido. In 1652, it was integrated into the assets of the Casa do Infantado, a newly created manor house, as a guarantee of subsistence for the king's second sons, in parallel with the Casa de Bragança, at the disposal of the Prince (Link 1808; Coelho 1861; Brito 1987). The administration was the responsibility of the municipality of Caminha. For almost two centuries, this entity presented the nominees to the local elite for to be appointed by the Casa do Infantado and the guards of the parish of Moledo to the position of *Couteiro* (The Forest and Hunting Ranger). This figure was responsible for the management and conservation of the forest

and all the resources provided, acting as a moderator between the local institution, the nobility and the local communities, a theme explored below. Through his reports it is possible to observe this long period, although sometimes analysing them is made impossible by the poor state of conservation of the historical documentation (Purificação, 1878; Capela, 2005; Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1159).

During the 18th and early 19th centuries, the forest vegetation remained densely populated with cork oaks in the vicinity of the sandpit in the south of the mouth of Minho River, where a variety of species such as rabbits, hares (Leporidae) and partridges playing a significant role in local hunting. However, the lack of protective measures resulted in the gradual extinction of these animals throughout this period (Costa, 1706-1712; Purificação 1878). It is documented the presence of maritime pine (*Pinus pinaster*) (Link, 1808; Biblioteca e Arquivo Histórico do Ministério das Obras Públicas, MMR 31) (Figure 2). To this data, the local parish priests added, in 1758, the existence of scrubland, but without mentioning any species, lentisks or mastic trees (*Pistacia lentiscus*), considered a medicinal tree, and Portuguese crowberry (*C. album*), which bore grape-like fruit that was eaten when ripe (Capela, 2005). As it is a product that is consumed occasionally and collected without much economic value or purpose other than self-consumption, its mention in historical documentation means that this example is one of the few pieces of information that exist.

In 1834, with the abolition of aristocratic privileges and the definitive establishment of the constitutional monarchy in Portugal, which extinguished the House of the Infantado, the Camarido Forest became part of the Royal Treasury. Between 1834 and 1836, forest management was a responsibility of Caminha municipality. On 26 March 1836, by order of the Ministry of the Navy, Camarido became managed by the General Administration of the Kingdom's Woods and Forests (*Administração Geral das Matas*), which directly appointed and paid a forest guard (Coelho, 1861; Mendia, 1881; Bento *et al.*, 2009). In 1852, the General Administration of the Kingdom's Woods and Forests was transferred

to the Ministry of Public Works, Commerce, and Industry, and two decades later, management was transferred to the Northern Forestry Division.

Concerning the biodiversity present in the Camarido National Forest, at the turn of the 16th century, the region's forest cover was dominated by cork oaks (*Quercus suber* L.), whose usefulness extended to the shipbuilding and feeding wild animals and by pine trees (*Pinus*), which played a crucial role in stabilizing the soil (Bento *et al.*, 2009). In the following century, the predominance of cork oaks comprised more than a quarter of a league. Records of local fauna included the presence of wolves (*Canis lupus* L.) (Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1137).

In the second half of the 19th century, the cork oaks reached similar numbers to the pine trees, as implemented by the forestry campaigns of the 1860s and 1870s. However, the pine trees, *Pinus pinaster* and *Pinus pinea* (Coelho, 1861) were considered more vulnerable due to diseases and their geographical location. The quality of pine firewood was inferior due to its slow and limited growth, associated with its exclusive presence on the first coastal strips affected by the north and north-west winds, as well as its propensity to develop mosses on the bark and infestation by the pine mushroom (*Macrolopiota procerata* (Scop.) Singer), which contributed to the deterioration and spread of internal wood. Henrique Mendia (1881) also described other species present in the area, including: *Dianthus galicus* Pers.; Nottingham catchfly (*Silene nutans* L.); Sea kale (*Crambe maritima* L.); Grassleaf pepperweed (*Lepidium graminifolium* L.); Sea holly (*Erygium maritimum* L.); Sea fennel (*Crithmum maritimum* L.); Mediterranean strawflower (*Helichrysum stoechas* (L.) Moench); Jersey cudweed (*Pseudognaphalium luteo-album* (L.) Hilliard & B.L.Burtt); *Sonchus maritimus* L.; Sand bedstraw (*Galium arenarium* Loisel.); Spiny cocklebur (*Xanthium spinosum* L.); Dog's tongue (*Cynoglossum officinale* L.); *Omphalodes littoralis* Lehm.; Inkbush (*Suaeda fruticosa* Forssk. ex J.F.Gmel.); White grass (*Halimione portucaloides* (L.) Aellen); Sand sedge (*Carex arenaria* L.); *Agrostis maritima* Whit.; Creeping bentgrass (*Agrostis stolonifera* L.) and Sand-couch grass (*Triticum junceum* L.).

One of the reasons that suggests that the Camarido National Forest arose exclusively in the Early Modern Age is the scarcity of early records on its use and management until the 16th century. The management and preservation of this woodland were constantly marked by a tense relationship, sometimes manifested in physical violence (Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1159). This occurred due to its use by different groups belonging to society who obtained essential resources for their subsistence and the local authorities, who often promoted alarmist discourses about the forest degradation or planning, similar to many institutions and scholars of that chronology.

Nevertheless, it does not always correspond to historical reality (Mendes, 1980; Trapaga Monchet *et al.*, 2023). In Camarido National Forest, the two main concerns with its conservation, from the 16th century until at least the end of the 19th century, were: 1) the stabilisation of the sandpit in the south of the mouth of the Minho River to prevent the harbour from silting up and drift sands; 2) the supply of pasture, fertilisers, firewood and timber for the population, the military and shipbuilding. This forest also served all social strata in Caminha municipality, from the poorest peasants and fishermen, who had no access to firewood, fertilisers, or pasture for their livestock, to the military, and local elites, who exercised their superior social position by acting as forest guards (Arquivo Municipal de Caminha, Câmara Municipal de Caminha, 1. 6.1.5; Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1137). However, due to its locations, it also served the foreigners, Galician people crossed

the river at night to collect firewood (Purificação, 1878; Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1141) (Figure 5).

Due to its geographical characteristics, the Camarido has always been vulnerable to drift sands and silting up (Figure 4). In the second half of the 19th century, dunes with height variations of 11-16 meters between the sea and the pine forest were observed, advancing more than 160 meters in two years. So, it is not surprising that the discourse on the need to conserve and increase afforestation is a constant throughout history and in the documentation produced, as well as in the legislation enacted and the settlement actions established in the early days of the National Forestry Services (Ribeiro & Delgado, 1868; Mendia, 1881; Bento *et al.*, 2009; Radich, 1996; Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1137). In 1562, requests began to reach the King from the Caminha municipality to prohibit the cutting of timber in Camarido, namely cork oaks, and firewood (unspecified species). The previous year, a large amount of woodcut led to the silting up and clogging of the Minho estuary bar (Pinto, 2008; Pinto & Silva, 2016).

Since the 16th century, documents from the Royal Chancellery attest that the pastures in Camarido were available for free use by the inhabitants of Cristelo and Moledo (Neves, 1983). However, this right was contested by the Casa do Infantado in favour of forest conservation. In the mid-18th century, the local inhabitants demanded that the Camarido continue to serve as a grazing area for pigs

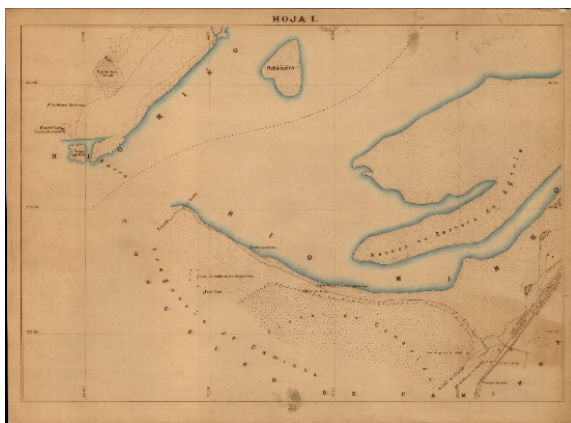


Figure 5. Representation of the Camarido pine forest by the International Boundary Commission between Portugal and Spain in the last decades of the 19th century [Source: Meira & Correa (1898)].



(one pig for each house in Moledo and Cristelo), arguing that no other common land was available for this ancestral custom. In addition, the animals that fed on the acorns from the cork oaks also contributed to the natural spread of this same species (Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1141).

Another ancestral custom observed in the Camarido Forest was the permission granted to the poorest inhabitants of Cristelo and Moledo, as well as the fishermen of Misericórdia Street, in Caminha village center, to collect gorse (*Ulex*), pine needles, and dried pine branches, as long as they used wooden rakes to collect it, and firewood for domestic purposes. However, the main perpetrators of abuses of this practice were the fishermen, who often acted in groups when the guards were not present, cutting and splitting firewood on Camarido and then carrying it on their backs to the centre of the town (Coelho, 1861; Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1157).

The Camarido Forest was also a place for timber exploitation. Between the 16th and 19th centuries, the wood from Camarido, as in other regional harbours, was used for basketry and specific components of bows and cooperage. In addition, the most abundant species in this forest, such as the pine and the cork oak, were traditionally used for shipbuilding, as mentioned in the following centuries and defended by the Portuguese Central State (Mendes, 1980; Pinto, 2008; Trapaga Monchet, 2023). At the end of the 18th century, some measures were implemented to increase the productivity of the Camarido Forest. However, the poor quality of the trunks and fruit resulted in insufficient financial returns and below expectations. It was proposed to commercialise various products, including pastures, acorns from cork oaks and oaks (*lande* and *bolota*), oak and pine branches, wood and cork, as well as expanding the area susceptible to reforestation by draining the wetlands (Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1146).

The proximity of Camarido Forest to the main military centres in Minho, such as Caminha and Valença, together with the war background of the Early Modern Age, seems to have played a significant role in conservation. Detailed records from the 18th

century reveal how the military used the forest to fulfil their needs. Traveling from the Caminha fort, the soldiers, in large numbers, resorted to using axes to cut firewood while also arming themselves to face possible resistance from the forest's guards. There are specific reports, such as what happened on 11 March 1762, when the guards from the parishes of Moledo and Cristelo were arrested and treated disrespectfully (Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1141). During periods of war, especially in the first half of the 19th century (Napoleonic invasions and Portuguese Civil War), the demand for wood resources increased, requiring the Camarido to supply the main military centres in the north of Portugal (Coelho, 1861; Biblioteca Central da Marinha, Arquivo Histórico, box 422; Arquivo Municipal de Caminha, Câmara Municipal de Caminha, 1.2.2.2.).

Preventive measures were implemented to prohibit certain activities threatening forest sustainability in the Camarido Forest. For example, the installation of lime kilns was occasionally prevented in the vicinity of the forest. However, the private owners of these "factories" argued that they had sufficient wood resources to supply these small industries. This situation was documented throughout the first decades of the 19th century (Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1155).

Anthropic and natural factors influenced the success of reforestation and forest conservation. The development of trees such as pines and cork oaks were often hampered, and it was reported that the storms and strong winds characteristic of the region often felled the trees. In addition, there are indications that the base of trees was clandestinely mined with holes, known as "oratórios", to facilitate their fall, as documented in 19th century (Coelho, 1861; Bento *et al.*, 2009; Arquivo Municipal de Caminha, Câmara Municipal de Caminha, 1.2.2.2.). In addition to these manoeuvres, the destruction of the forest has also been attributed to extreme climatic events, such as what happened on 11 July 1758, when a storm severely damaged old pine and cork trees (Antunes, 1996) or significant thunderstorms in the 1870s, which considerably affected the trees along the coast of the Caminha municipality (Pinho Leal, 1873-1890). Forest fires

also contributed significantly to the loss of woody vegetation, many of which were caused by negligence in clearing forest areas (Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1157; Arquivo Municipal de Caminha, Câmara Municipal de Caminha, 1.2.1.46.). The Viscount of Balsemão and minister responsible for the forestry promotion at the beginning of the 19th century, Luís Máximo de Sousa Coutinho, suggested preventative measures, including creating firebreaks in the direction of the Minho River mouth, which residents and the House of Infantado should be obliged to carry. These firebreaks would transport decayed sticks, prevent the spread of disease between trees, and export suitable timber (Mendes, 1980).

Alongside the descriptions of the ruin and lack of firewood, efforts to punish harmful behaviour from the "hungry for firewood" (Biblioteca Pública Municipal do Porto, Ms. 294) also intensified, with annual or biannual (January and July) inquiries being drawn up to accuse the culprits and take them to the local courts. However, only the poorest were found out during the raids, but due to their condition and the sympathy of local officials, they were not penalised. The soldiers who caused the most damage were not included as culprits in the inquiries. However, the raids sometimes ended up jeopardising local wood supply chains. The local elites often looked for cut timber and needed carpenters, carters, or other labourers. Nevertheless, they had been accused and sanctioned for improperly cutting the Camarido's firewood and prevented from returning, drastically reducing the supply of qualified people (Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1146).

Once the culprits had been identified, fines were imposed, considering repeat offenses. Anyone found in the woods with an axe, scythe, or hoe would be arrested and taken to prison, pay a fine, and the stolen goods (firewood, brushwood, pinecones, or pine needles) would be confiscated. At certain times, the cutting of undergrowth and the collection of pine needles, which affected the growth of young pine trees, was forbidden (Capela, 2005; Bento *et al.*, 2009; Arquivo Nacional da Torre do Tombo, Casa do Infantado: box 1137, box 1157) or their collection was limited to the summer

months (Arquivo Municipal de Caminha, Câmara Municipal de Caminha, 1.6.1.5). Cycles for cutting or trimming the trees were also determined (Mendia, 1881; Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1157; Arquivo Municipal de Caminha, Câmara Municipal de Caminha, 1.2.2.2.). At the same time, the guards were granted certain privileges, such as using firearms and exemption from military and hunting duties (wolf and fox hunting - control species), since the forest would be unattended at those times. However, they were obliged to report men, women, soldiers' servants, and enslaved people and to promote afforestation (Arquivo Nacional da Torre do Tombo, Casa do Infantado, box 1137). Simultaneously, from the 16th century onwards, the inhabitants of Moledo and Cristelo were still obliged to plant pine nuts (Bento *et al.*, 2009; Coelho, 1861; Mendia, 1881; Arquivo Municipal de Caminha, Câmara Municipal de Caminha: 1.11.4.39, 1.6.1.4, 1.11.4.29.).

With the establishment of the Portuguese Republic in 1910, the Camarido National Forest came under the remit of the Ministry of Development. In 1918, it was transferred to the Ministry of Agriculture, with various management plans being drawn up over the following decades (1919, 1939 and 1951). From 1999 onwards, the Camarido Forest has been integrated, practically in its entirety, into the Natura 2000 site, code PTZPE0001 – Estuários dos Rios Minho e Coura (DL 384-B/99 of 23 September) and Site of Community Interest SIC Litoral Norte, code PTCO0017 (Resolution of the Council of Ministers 76/00 of 5th July) (Bento *et al.*, 2009). With the inclusion of the Camarido National Forest in the Natura 2000 Network, the objective of conserving habitats and biodiversity in this area is reinforced and highlights the necessity to make different objectives compatible, including conservation and recreation.

During the period of 2000-2011, Camarido Forest management included actions of afforestation, vegetation control, pruning, as well as thinning. The most recent Camarido Forest Management Plan, approved in 2010 (ICNF, 2010), includes as main objectives the promotion of biodiversity, promotion and framing of recreational and leisure activities, protection against biotic and abiotic agents, control

of invasive species, implementation of sustainable forest management certification and the recovery and conversion of forest arboreal and shrubby cover (Bento *et al.*, 2009), with *C. album* as part of the Camarido Forest shrub community.

From 2011 onwards, the forest management and planning include continuous interventions to reforest and rejuvenate the oldest pine forest, eliminate invasive species and plant native species, such as cork oaks (Martins, 2012).

### *Environmental education initiatives*

Since 2016, in an early basis, two to three groups of 30 students each, with their teachers, are invited to environmental education initiatives at Camarido Forest.

During 'Field trip visit' initiative, students explore coastal dune and forest habitats and see white crowberry plant shrub with its fruits. They also know other plants and become aware of worldwide geographical distribution of white crowberry plant and of concepts of endemic plant and invasive plant, such as the hottentot fig – *Carpobrotus edulis* (L.) N.E.Br., a non-native species which can out compete native plants. In all field trip visits students' enthusiasm for exploring nature and discovering new plants is evident. This is illustrated in students replies about

what pleased them much in the Camarido Forest field trip, as described in the following sentences: 'To see with the magnifying glass the white crowberry and the hottentot fig'; 'To feel the acid taste of the white crowberry fruits'; 'Being connected to nature'; 'I liked to search for the white crowberry female and male plants which I didn't know at all' (Figure 6).

In the 'Botany and Art' initiative, students draw at classroom the landscape and/or the plants they have seen. They also see an image of white crowberry plant herbarium specimen, previously collected in the same coastal area, in a 'Place Based Education- PBE' approach. The extirpation of white crowberry plants, which is the phenomena of its local disappearance in an area, can be inferred by comparing their current occurrence in nature and the specimens of herbarium collections. According to Flannery (2023), Herbaria are crucial to plant science as specimens are the anchor for knowledge about plants. Besides this, this author considers that specimens document climate and habitat change and are useful to identify species in biodiversity studies, essential for the conservation of the world's plants. Drawings made by students of Caminha Schools, about the white crowberry they have visited at Camarido Forest and adjacent dunes, have been shown at a Drawing Exhibition, at Caminha (Figure 6)

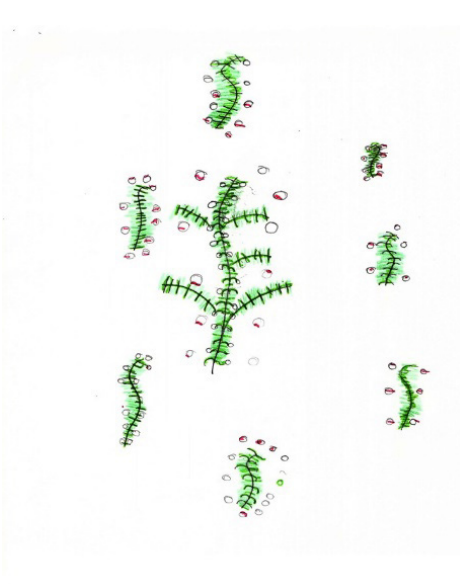


Figure 6. Field trip to Moledo beach dune (left) and Caminha School student drawing about white crowberry (right).

A 'Conservation' initiative began in 2017, following the identification of 'Foz do Minho' white crowberry plant population as a declining one, in regression at Moledo beach dune and adjacent Camarido Forest. This initiative included the collection of stem cuttings, which after rooting, are reintroduced at wild with the participation of students. Reintroduced plants, 30 in 2018/19 and 14 in 2021, have adapted to wild conditions, with stem growth and fruit formation, in a positive action to halt this plant population extirpation. Students monitor reintroduced plants development with stem growth evaluation (Figure 7).

Two students' groups have written these brief reports of their field work:

Group 1 work report - *After 6 months, it was time to go and observe the characteristics of our white crowberry plant, we photographed it from different angles. It measures 33 cm, it is the largest, it is a female plant but still without fruit. Conclusion: this work was very interesting because we were able to understand what a white crowberry plant is, its characteristics and development.*

Group 2 work report - *In the first observation, our group's plant measured 24 cm. In this observation, in November 2018, we saw how white crowberry plants are fascinating. On 28th may 2019, we had a field class that, in our view, was very important for our learning. We were very pleased to know that our plant that once measured 24 cm has grown to 28 cm tall. Conclusion - it was an activity: 1) more enriching than a normal class; 2) it was a really funny class.*

## DISCUSSION

The Camarido Forest economic, social, and environmental aspects throughout history described in this paper enrich the existing literature and reassures it as a forest of biocultural richness. The study of the compiled documentation about this Forest highlight how, in the past, Man and Forest have interacted, co-evolved, and mutually transformed in the face of the ever-present idea of inexorable destruction and degradation (Silva *et al.*, 2022). Throughout history, for more than four centuries, some preventive measures were implemented to prohibit certain activities threatening Camarido Forest sustainability. In the past, besides some anthropic negative factors that affected Camarido Forest, natural extreme climatic events also contributed to destruction of this forest, such as a storm on July 1758. Nowadays, in terms of its biodiversity, awareness raising about the value of white crowberry shrub (*C. album*), as an endemic plant population in regression, and the need to act in their conservation is a challenge. Although it used to be rarely mentioned, the white crowberry played an important role in local communities. This agrees with EUFORGEN (2024) data revealing that, for Forest conservation purposes, it is a must to better study other species beyond trees, for which there are knowledge gaps. It is worth mentioning that, in this paper, within Camarido Forest historical data presented, for more than two centuries ago, the local parish priests stated, in 1758, the existence of scrubland, but without mentioning any species, among which the *C. album* (Capela, 2005). Recent



Figure 7. Reintroduction of propagated white crowberry plants in Camarido National Forest (left); plant development monitoring (centre); reintroduced female plant with fruit (right).

decades have witnessed ecosystem destruction and habitat fragmentation which can lead to extirpation or extinction of endemic plant species, even before they are known. Therefore, awareness raising about endemic plant species, such as white crowberry, is a relevant educational challenge for young people. Their participation allows them to become aware about the need to better adjust the use(s) of forest ecosystems with nature conservation and landscape values. According to ICNF Report (2010), the social pressure on Camarido Forest intensified for the purposes of recreation use, from 1974 onwards, due to its location close to the confluence of the River Minho with the Atlantic Ocean, near good beaches, both at sea and river sides. In the 1980s and 90s, intentions to develop real estate projects in the Camarido Forest area, propelled public campaign against its development, which helped to prevent its construction. From 1999 onwards, the Camarido Forest has been integrated, practically in its entirety, into Natura 2000 site, code PTZPE0001 - Estuários dos Rios Minho e Coura (<https://eunis.eea.europa.eu/sites/PTZPE0001>) and Site of Community Interest SIC Litoral Norte, code PTCON0017. The most recent Camarido Forest Management Plan, approved in 2010, aims to make compatible the promotion of biodiversity with the promotion and framing of recreational and leisure activities (ICNF, 2010).

Further studies are recommended on the biodiversity of forest areas, with endemic species under threat due to invasive species, climate change and habitat fragmentation. In addition, whenever a regression of endemic plant species is identified, it is useful to plan and manage its propagation in plant nurseries and/or research institutions. The plants propagated in the nurseries are useful for ecological restoration purposes in previously defined conservation areas. For the Camarido Forest *C. album* population, since 2019-2020, it has been established a propagation protocol of white crowberry plants by stem cuttings, within a partnership between research centres, an environmental organization and a local plant nursery, with collaboration of school communities for the plant reintroduction phase. Historical knowledge of endemic plants also provides insight

into the human-flora relationship and how it has evolved over time, whether in terms of exploitation or conservation. And it is this in-depth research and its dissemination to society that could also guarantee their conservation or ecological restoration.

## CONCLUSION

*Stewardship of nature requires the commitment and will of billions of people around the world (...). It can unleash a new sense of agency and responsibility through a connection with nature, with the planet and all living things»*

Human Development Report 2020 (UNDP, 2020)

In this study we identified and confirmed the existence of a rich cultural history of Camarido Forest. This Forest has always been an area of great environmental and cultural importance in Portugal. It has a great biological diversity and is the habitat of several species of plants and animals. As we have tried to show, the Camarido National Forest has played a fundamental role in the economic, social and administrative relations of local communities and institutions. Over time, there has been an attempt to make the use of the Camarido National Forest as 'sustainable' as possible, to guarantee the economic and environmental survival of the people living there.

However, in recent decades, with the development of coastal tourism and the growing occupation of this woodland, some of this sustainability has been lost, particularly as regards the endemic species that guarantee the maintenance of healthy ecosystems, protect biodiversity and promote the wellbeing of local communities and visitors who enjoy this area natural beauty. It is therefore essential that we continue to value and protect the Camarido National Forest, recognizing its importance as a precious natural heritage that must be preserved for future generations.

Within the United Nations Decade for Recovery of Ecosystems (2021-2030) we argue that initiatives to strengthen plant conservation benefit from young students' engagement. The implementation of the

three educational environmental initiatives, as a complement to formal education, are inspired by a perspective of education that considers it as more than the acquisition of knowledge. In a changing world, education must contribute to improving young people's understanding, skills, values and personal development.

This paper highlighted that environmental education is part of plant conservation and must build on local understanding of forests as biocultural landscapes. The lack of recognition of biological and cultural richness of forests at local level imperils its due conservation.

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