LIFE4FIR – Project LIFE18 NAT/IT/000164

"Decisive in situ and ex situ conservation strategies to secure the critically endangered Sicilian fir, *Abies nebrodensis*"

"Report of both fences installation including the surveillance system".
Action C1.1, C1.2, C1.3.

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1. Introduction

From a floristic point of view, the area of the Madonie Regional Park, is one of the areas of greatest interest in Sicily and in the Mediterranean basin, both for the high degree of biological diversity and for the quality of the species settled there. The Park includes environments of considerable naturalistic value that are configured as a bridge between the African continent and the Italian and the Balkan peninsulas.

Botanical diversity is testified by over 120 syntaxonomy defined associations. In addition to an marked phytocenotic diversity, the Park territory has a high biological diversity. As far as the only vascular plants are concerned, about 1500 taxa have been recognized, corresponding to 1.55% of the entire Sicily island. Many endemic species are represented, such as: *Allium nebrodense*, *Astracantha nebrodensis*, *Bupleurum elatum*, *Dianthus gasparrini*, *D. minae*, *Festuca pignattiorum*, *Genista cupanii*, *Genista demarcoi*, *Genista madoniensis*, *Heliantenum oelandicum subsp. nebrodense*, *Helichrysum nebrodense*, *Hieracium symphytifolium*, *H. pignattianum*, *Laserpitium siculum*, *Peucedanum nebrodense*, *Rhamnus lojaconoi*, *Senecio candidus*, *Viola nebrodensis*, ecc. Among the endemic species, those representing paleo-endemisms such as *Abies nebrodensis* and *Zelkova sicula* are particularly important to understand the evolutionary and biogeographical processes.

The Madonie fir (*Abies. nebrodensis* (Lojac.) Mattei) is the best-known forest species in Sicily, included in the IUCN Red List of plants, with the status of "Critically Endangered" (CR) and reported in Annexes II and IV of the Habitat Directive (92 / 43 / EEC) concerning to species of Community interest whose conservation requires the designation of special protection areas and rigorous protection measures. Actually, *A. nebrodensis* is the most emblematic Madonie endemism and it represents the most famous species among the conifers that characterize the forest heritage of Sicily.

2. State of the art of *A. nebrodensis* conservation

The Madonie Fir represents an important example of critically endangered endemic forest species. The natural population of the species currently consists of thirty (30) trees, of which only 24 in the maturity phase, distributed discontinuously in a small area (84 ha) (Habitat 9220*) of the territory of Polizzi Generosa (PA), between Vallone Madonna degli Angeli, Monte Cavallo (1,757 m asl), Monte dei Pini (1,673 m asl) and Monte Scalone (1,654 m asl), within the integral reserve area (zone A) of the Madonie Regional Park. In figure 1 the distribution of the trees in the *A. nebrodensis* natural range is reported.

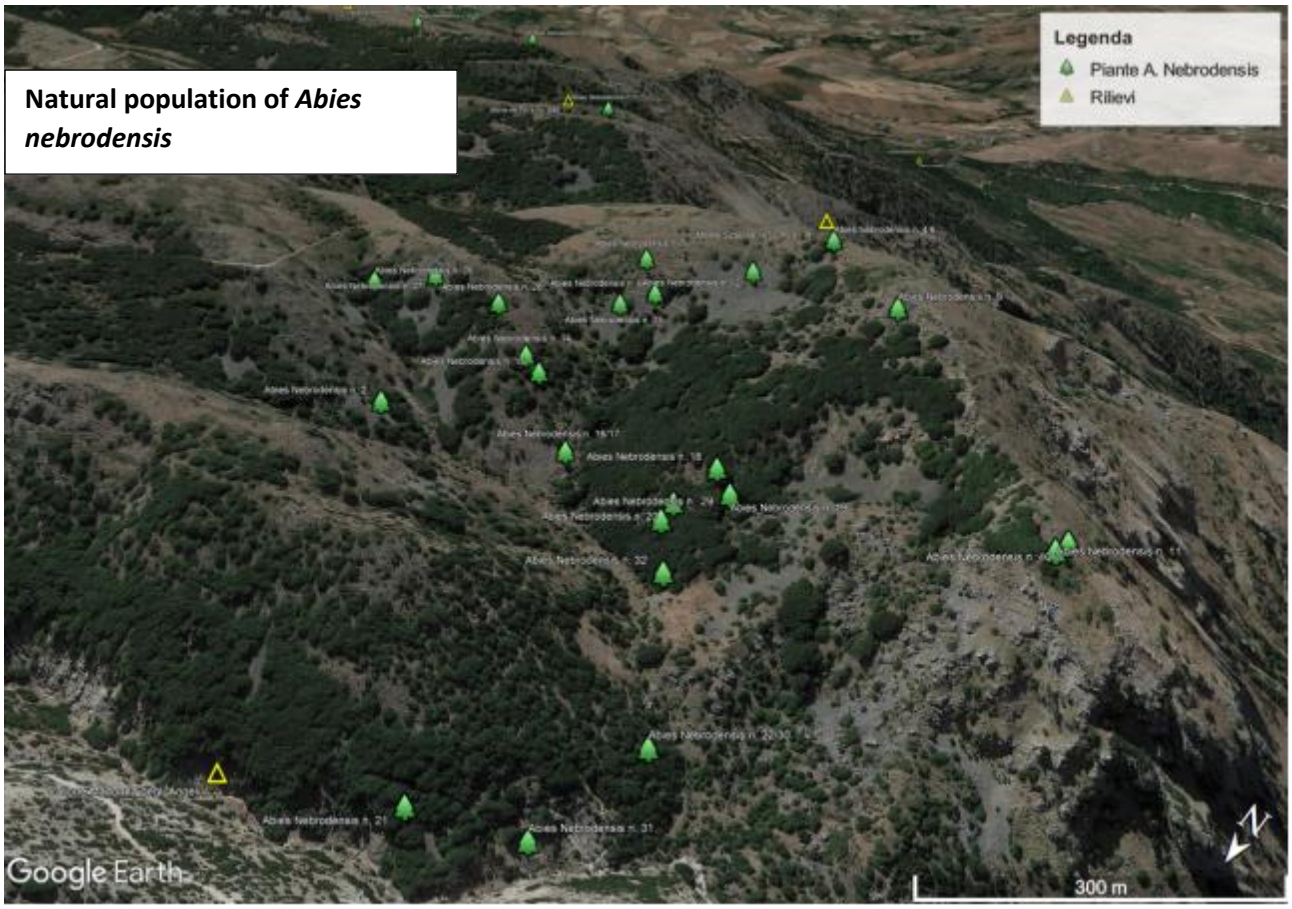


Fig. 1. Distribution of the trees of the *A. nebrodensis* population in a satellite image

Before the XVIII century, *A. nebrodensis* was widely spread to the highest mountains of northern Sicily, but its population decreased progressively over the last 200 years, mainly due to anthropogenic activities. According to many authors and as confirmed by the investigations carried out, the wood of *A. nebrodensis* had been massively exploited to provide the beams of numerous churches and buildings. Today, a small, isolated population has remained on the Madonie range, considered as vicarious of the other species of the genus *Abies*, native of the Mediterranean and the Black Sea. To increase the *A. nebrodensis* population, since the 1970s the Forest Department of the Sicily Region has carried out a series of reforestation measures in some sites of the Madonie, using non selected open-pollinated seedlings generated from seeds produced by the few trees of the natural population. Most of the plantations had no or low success. Other fir species (*A. chephalonica*, *A. alba* and *A. nordmanniana*) were also introduced in the Park. In the following years these fir plantations have reached maturity, becoming a risk for the genetic integrity of *A. nebrodensis*. The LIFE Natura project (carried out in between 2001 and 2005), led to the construction of new fences around the adult trees, and favoured the natural regeneration process, particularly abundant around some trees, allowing an increase in the number of seedlings from 29 to 80 units. This suggested that the natural population of *A. nebrodensis* seem to be able to significantly increase, if adequately supported.

A second project, APQ (funded by CIPE), promoted by the Regional Department of the Territory and the Environment, was aimed at using the large number of exotic firs as rootstocks to propagate *A. nebrodensis* by grafting, with the aim of sustaining the trees actively fruiting, by supporting their natural regeneration.

3. Main issues for *A. nebrodensis* conservation

Small and fragmented population

The small population of *A. nebrodensis* is characterized by a marked genetic erosion and high rates of inbreeding, as most trees are related. Furthermore, every year only a small number of trees is able to produce fertile cones, and this significantly limits the natural dissemination. The fragmentation of trees in the native range does not favor cross-fertilization and the rate of self-fertilization recently detected (through genetic analysis conducted within the Life4fir project) in the natural regeneration is very high (94.5%). However, over the years there has been a progressive increase in the number of seedlings surveyed, testifying a certain regenerative vigor of the species despite the high rate of selfing as in Fig. 2

Fig. 2 Some plants of natural regeneration.

Damage due to grazing and wild herbivores

Grazing is one of the main types of land use in Sicily. Its pressure has become increasingly heavy following the abandonment of the territory by the resident populations which led to the establishment of transhumant farmers. Although in some cases being considered as a factor

promoting plant biodiversity (as for the habitat 6220 - sub-steppe made of grasses and Thero-Brachypodietea annuals plants), the action of grazing can be one of the main causes of degradation of forest ecosystems over time. The most deleterious effects occur on the natural regeneration of *A. nebrodensis*, already severely limited by the poor and fluctuating production of fertile cones. The practice of grazing without defined control rules, can contribute considerably to the reduction of tree growth to the point of causing their deterioration. A further risk is represented by the out-of-control presence of herbivores such as wild boars and fallow deer, which is critical for both the natural regeneration and the adult trees of *A. nebrodensis* as in Figure 4.

Fig. 4. The bites of the fallow deers are clearly recognizable on the bark of trees and even on the tags affixed to the plants of natural regeneration.

The context described has prompted the institutions involved to plan a series of measures to be implemented in the LIFE4FIR project. The main purpose of the project is, in fact, is to increase the genetic diversity and improve the conservation status of the critically endangered *A. nebrodensis* population.

The novel points that characterize this project are mainly:

1. the protection system of double fences (traditional plus electric) around existing trees and the natural regeneration growing around;
2. localized naturalistic engineering measures to control of soil erosion;
3. reforestation in suitable areas with selected *A. nebrodensis* seedlings;
4. the involvement of associations of shepherds and hunters to reduce the grazing of wild herbivores (fallow deer and wild boar) and abandoned cattle and goats, for supporting and protecting the relic population (adult trees and natural regeneration);
5. implementation of a seed bank and a cryobank for the conservation of the *A. nebrodensis* germplasm.

The project provides for the control of biotic, abiotic and anthropic disturbances such as pathogens, localized erosion, grazing of wild herbivores and cattle and goats through a system of fences (both traditional and electrical), a video surveillance system, bioengineering, monitoring of processes and functions of vegetation by the UAV (drone), regular surveys of pathogens and parasites.

4. Protection of the relic population. A new system of fences

The relic trees and the natural regeneration of the *A. nebrodensis* population have over time been protected from the herbivores by metal fences built around them. The first forms of protection date back to the 1950s and were set up jointly with the arrangement of the ground around the trees for the control of erosive processes. However, fences were subjected to deterioration over time, loosing their functionality, so new fences were built in the following years. The last ones date back to the previous LIFE-Natura 2000 project "Conservation in situ and ex situ of *Abies nebrodensis* (Lojac.) Mattei" carried out between 2000 and 2005.

The current Life4fir Project planned the extension and strengthening of the fences around the *A. nebrodensis* trees to meet two basic needs: 1) most of the current fences showed again signs of deterioration and were damaged by the massive population of fallow deers and wild boars, having lost much of their functionality; 2) seedlings of the natural regeneration are currently growing outsides the perimeters of the extant fences and need adequate protection against bite and soil compaction by herbivores. So, a new fence system has been planned and installed to better protect the natural regeneration on a broader surface and to enlarge the 'protected area´ for the relic trees of the population. The new fences are meant to protect the *A. nebrodensis* population also from anthropogenic pressure and from the numerous visitors who walk the paths of the park (and the surrounding space) reaching the trees.

To support the natural regeneration and the conservation of the microhabitats around the thirty relict trees, the area protected by the new fences from wildlife and human pressure has been increased (from 1420 m^2 to 2144 m^2). In fact, a new system of fences has been established to protect natural regeneration over a larger surface in order to increase the area of respect. This will ensure the maintenance of optimal vegetative conditions, will preserve the biocenosis around each tree and will consequently favor the development of the natural regeneration.

The new fences are made of chestnut poles with a top diameter of no less than 7 cm and a length of no less than 2.40 m. Before installation, they were caulked for the lower 60 cm portion with cold tar, and were then put in place 2 m away one another, and inserted for 40 cm in the ground.

The metal net is made of 1.60 m height galvanized iron wire with a degrading mesh, with a minimum weight of 0.70 kg per linear meter. It was fixed (by means of galvanized wire) on four orders of galvanized iron wires with a diameter 2.70 mm, which were anchored to the poles by means of staples and placed respectively at ground level, at 1.40 m, at 1.60 m and at 1.90 m from the ground. Each fence is equipped with a 1.5 m wide gate entrance, built according to the scheme planned by the project as shown in Figure 5.

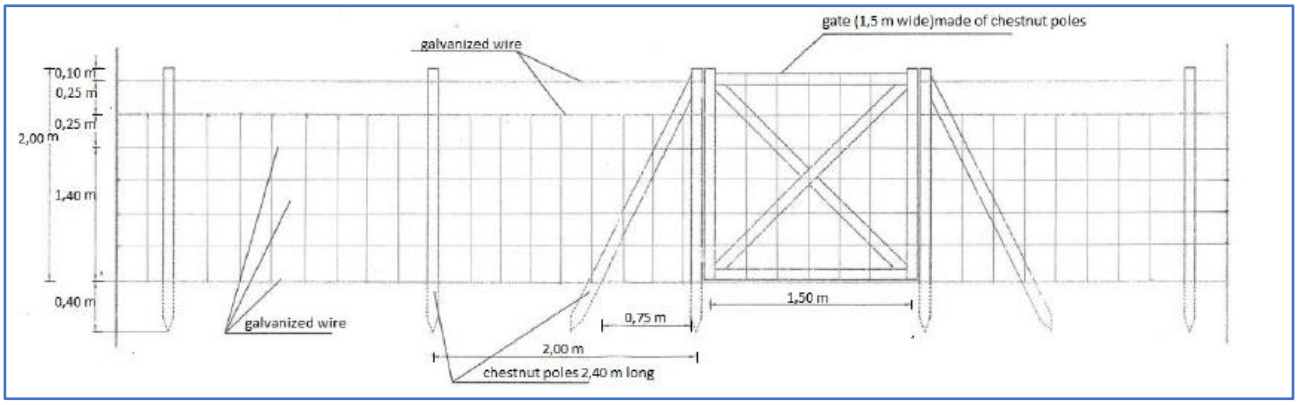


Fig. 5 Design of the fences as reported in the project.

For fences installation, 1800 chestnut poles, 5000 kg of galvanized iron wire, 3750 m of wire mesh and 24 wrought iron joints for the wooden gates were purchased. Other hardware consisting of hinges and side and ground locks for gates was also bought. Perimeter (in linear meters) of the fences installed around the 30 *A. nebrodensis* trees is reported in table 1.

Tree Id. #	**Fence perimeter (m)**	**Tree Id. #**	**Fence perimeter (m)**	**Tree Id. #**	**Fence perimeter (m)**
1	100	**12**	72	**22 e 30**	230
2	82	**13**	90	**22 bis**	80
4 e 6	72	**14**	80	**23**	56
7	80	**15**	80	**24 e 25**	80
8	105	**16 e 17**	112	**26**	32
8 bis	50	**18**	120	**27**	98
9	60	**19**	40	**28**	28
10 e 11	150	**20 e 29**	100	**31**	24
10 e 11 bis	8	**21**	98	**32**	40

Tab. 1 Perimeter in linear meters of the fences installed around the relic trees of the A. nebrodensis population.

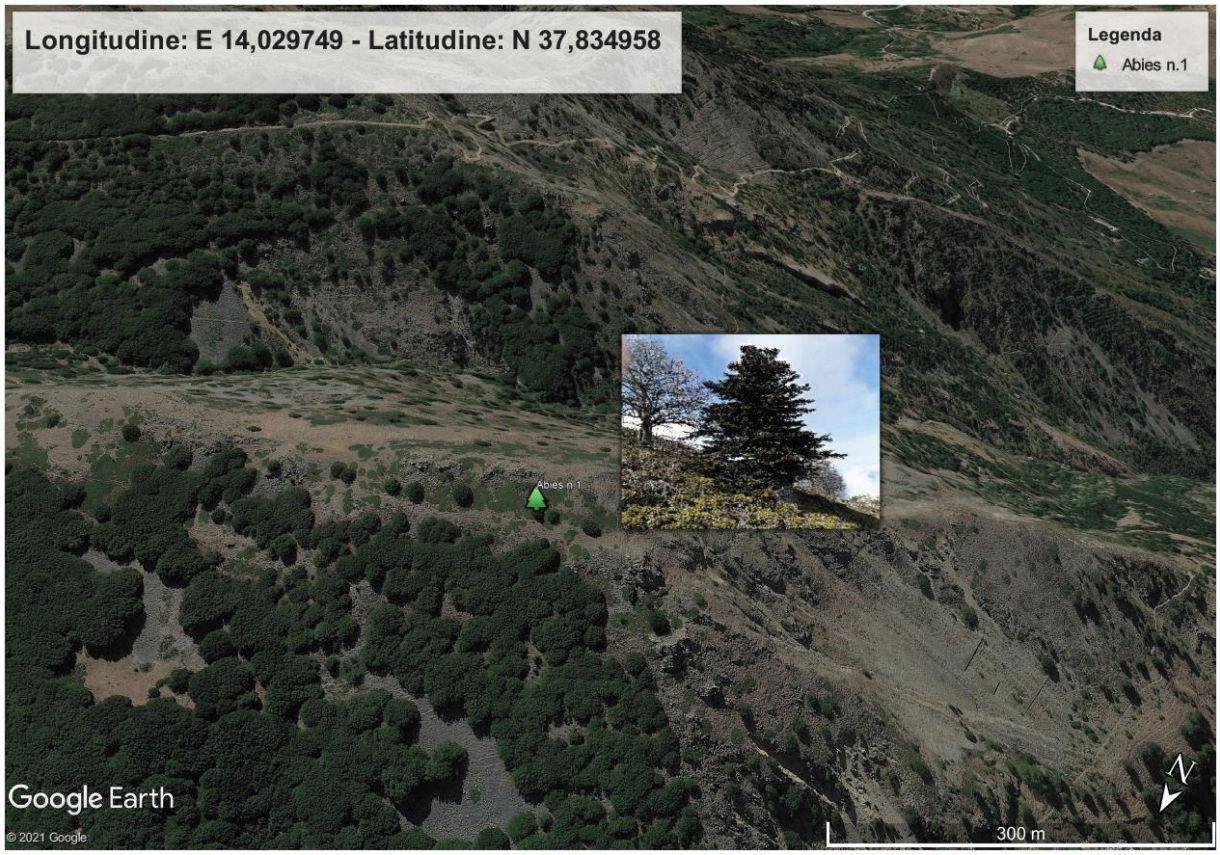
The work started in spring 2021. The first phase concerned the restoration or opening of paths to reach the *A. nebrodensis* trees. It was a very time-consuming work and required a great effort as many trees are in inaccessible places where mechanization is ruled out. Indeed, sites cannot be reached by 4x4 vehicles and the distance from the forest road ranges from a minimum of about 120 m to a maximum of about 1200 m with an average of about m. 400-500 m. Then it was possible to transport the material necessary for the construction of the fences. The assembly of the fences began in June 2021 and the works were longer than expected. In fact, the fence was built *ex-novo* for some *A. nebrodensis* trees because they are located in particularly difficult sites (and therefore fence had never been built before), or because the hard weather conditions and wildlife practically had completely destroyed the previous fences. Installation of the new fences around the 30 *A. nebrodensis* trees was completed by the 30 September 2021. Figures 6 and 7 show the phases of construction of the fences, while the Figure 8 shows the new installed fence around the tree no. 8. It is clear that the characteristics of the terrain, which is mostly rocky or stony, makes the insertion of poles to the ground particularly difficult and the execution of the entire work very hard.

Fig.6. Insertion of poles to the ground (above and left) and fences installed on different kind of terrains.

Fig. 7 Fences installed to protect a larger area around the relic *A. nebrodensis* trees

Fig. 8. The new fence installed around the Tree no. 8

Figures 9, 10 and 11 show, as example, the position of the trees no. 1, 16/17 and 18, respectively, within the *A. nebrodensis* native range with satellite imagery. The photographic detail of each tree allows to perceive the orographic conditions in which we must operate.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Abies n.1
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© 2021 Google
300 m
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Fig. 9

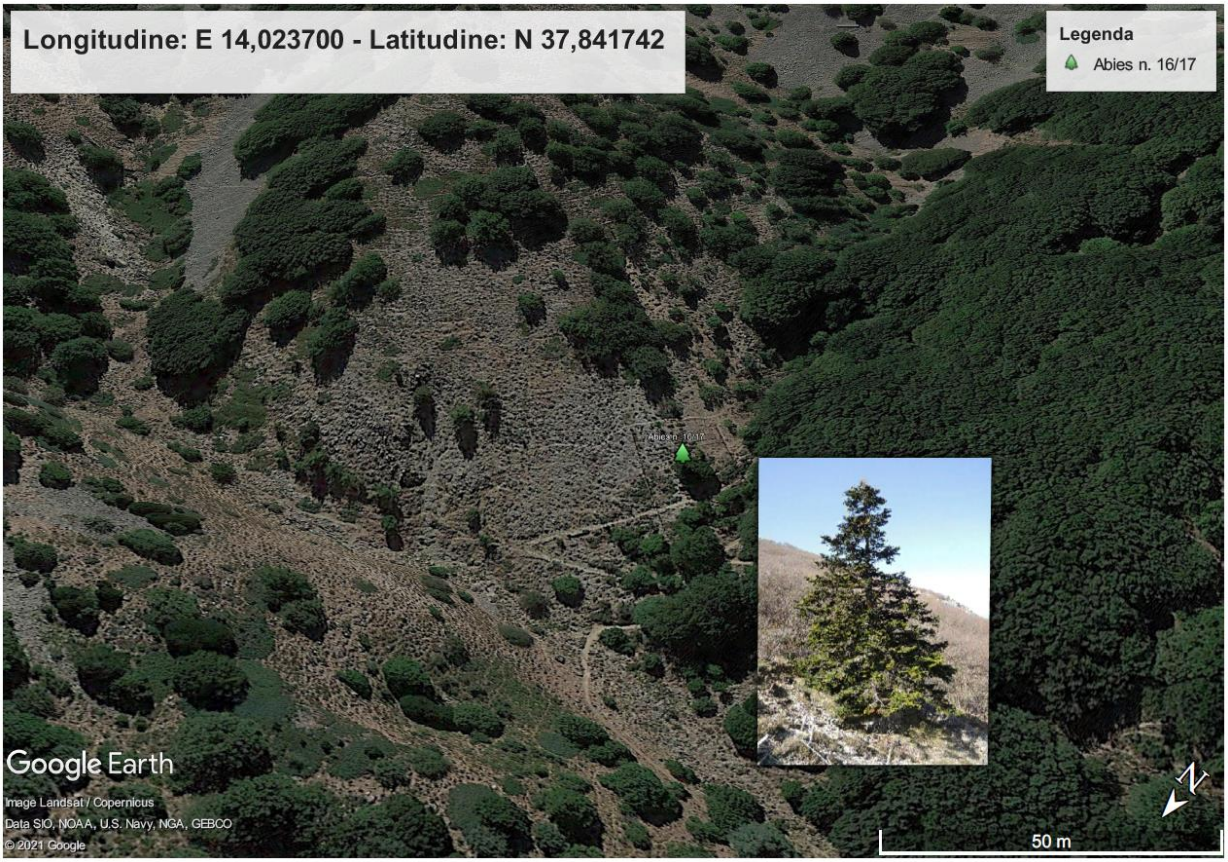
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Fig. 10

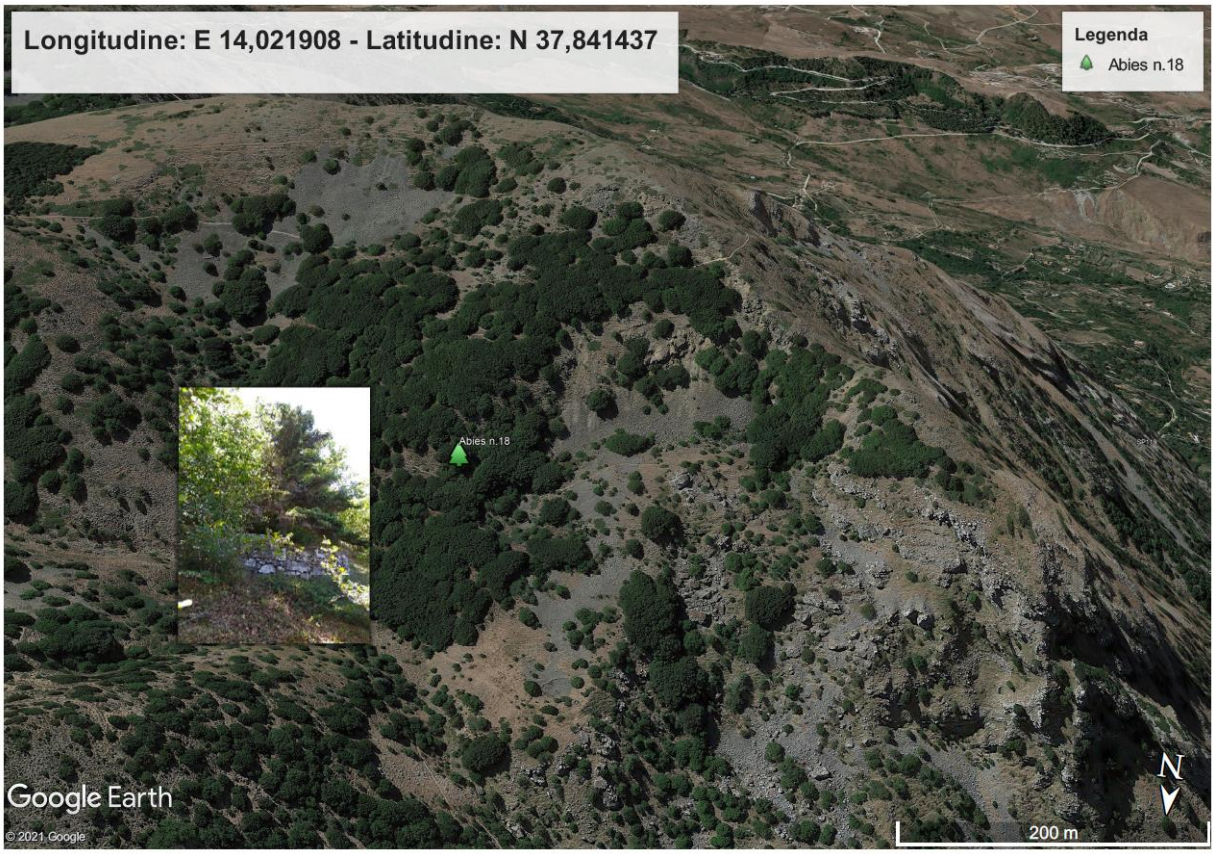

Fig. 11

5. Installation of the video-surveillance system.

The installation of the video-surveillance system has been planned in the C1.3 subaction ‘Installation of 5 camera system with motion sensor, powered by photovoltaic panel, as grazing prevention of wild herbivores and of abandoned cattles and goats’.

The video-surveillance system installation was firstly affected by a 12 month delay due to Covid-19 restrictions which impeded the access to the natural site for part of 2020 and 2021. Some issues also occurred with the tender too, as the funds allocated for this measure were not sufficient to cover the costs for the support poles and the installation of the solar panel and video camera kit. The harsh environment where this system must work has also complicated finding companies available to carry out the work. Anyway, the work was completed in July 2022, two years later than the original deadline.

The video surveillance system consists of 5 self-powered stations which will positioned in key points of the park.

Fig. 12

Each station is made up of a high-quality image camera, water and dust resistant, a camera battery, image sensor (also infrared), a 40 W photovoltaic panel, LTE/4G router to send images to cellphones connected by SIM cards. Images will be saved also in a local SD memory, as reported in Fig.12.

Each workstation has been installed on a chestnut tapered pole (18-22 cm in diameter at the base and 12-16 cm in diameter at the top) of 5 m in length, buried for 1 m.

In Fig. 13 the video surveillance points set up in the *A. nebrodensis* population are shown on the map, while Fig. 14 illustrates the installation of the workstations in the 5 positions indicated. The video surveillance points have been positioned in the places where the presence of visitors is most

frequent: at the entrance gate to the natural population area of *A. nebrodensis* (camera 1); at the beginning of the path that runs through the Madonna degli Angeli Valley (camera 2); near plants 22 and 30, the first reached by the path (camera 3); and in the frthest places of the population, on Mount Scalone in the upper part of the path that descends towards the Madonna degli Angeli Valley (camera 4); on the Monte dei Pini where the path leading to tree no. 1 starts from the road leading to the trees no. 23, 24 and 25 located on Mount Cavallo, at the south-east end of the *A. nebrodensis* range (camera 5).

The installed cameras are able to take pictures in full light and as well as in total darkness thanks to the infrared sensor (Fig 15a, b).

Fig. 13

Camera 1, entrance gate

Camera 2, starting of the path

Camera 3, trees 22-30

Camera 4, Monte Scalone

Camera 5, Monte dei Pini

Fig. 14 Installation of the workstations at the 5 selected positions in the Park.

a) Camera 1, entrance gate: IR image taken in the darkness

b) Camera 1, entrance gate: image in full light

Fig. 15

6. Considerations about the electric fence

This deliverable should have included a report on the installation of the electric fences planned in the subaction C1.2 'Setting up an electric fence'. This measure has not been implemented, as the impact that this structure would have had in the area A of the Park (integral reserve) would have been excessive. The Madonie Park Authority has advanced a series of considerations on the uneven and rocky places, and above all on the presence of dense vegetation that should have been thinned out or pruned to avoid contact with the wires, that consequently would have made the fence ineffective. Any thinning of the beech trees, which already live in harsh conditions, would have been detrimental for the conservation of this species. Moreover, the *A. nebrodensis* natural population is located in the area A of the Park (integral reserve), so the visual impact of the installation must also be considered. Lastly, the installation of the electric fence close to the metal fence by using spacer poles would have reduced its effectiveness.

We also emphasize that, in addition to the 2-meters high metallic fences already installed, a novel "Management plan for the fallow deer population in the Madonie Regional Park for the period 2021-2025" has been recently authorized and funded, with decree 28/2021 by the Regional Agriculture Department. This plan provides for scheduled interventions to capture the fallow deers even in the native range of *A. nebrodensis* (area A, integral reserve).

A second monitoring and control plan has been launched for wild boars with captures and culls planned in the Vallone Madonna degli Angeli. The novel plan extended the use of the movable fences for captures even to the area A of the Park. Their installation in the vicinity of the *A. nebrodensis* population has already been planned as a priority. According to the previous regional law, the personnel to be used in the interventions had to be essentially institutional personnel (forest rangers, park employees, hunting agents, etc.) and excluded local hunters, as in the rest of Italy. Only the latest LR 1/2019 law arranged for the involvement of local hunters in the control of wild boars and therefore this year (2021) 65 people were trained to implement the interventions. Ten more movable fences have been recently purchased in addition to the eight ones and to the 6 cages already available. So, this action has been boosted by purchasing new movable fences and by the involvement and training of local hunters.

That said, considering that with the implementation of the new fence system and of the two new control plans against fallow deers and wild boars, the damage due to wild herbivores will have less impact, we prefer to avoid affecting this fragile habitat by introducing materials such as wires, plastics, panels, batteries, etc which the installation of the electric fence would require.

These considerations were discussed and endorsed by the technical committee during the monitoring meeting held in November 2021 in Polizzi Generosa and it was decided to use the funds

allocated for electric fencing for other expenses. This decision was recognized by CINEA in the letter dated 21.01.2022 signed by the project advisor.

7. Conclusions

The Life4fir project provided for the use of a more efficient and functional fencing system than the previous one. The new fences are taller, reaching 2 m above ground, as some herbivores have been observed to be able to jump very high and are designed to prevent wild boars from being able to overtake them by burrowing underneath.

The implementation of the new fencing system is a particularly useful measure for the protection and support of the *A. nebrodensis* population. In fact, census and mapping of the natural regeneration recently carried out within the Life4fir project (spring 2020, sub-action C1.4) have highlighted a clear increase in the number of growing seedlings and young plants compared to the previous survey conducted in 2014 (484 and 274 plants detected, respectively). This shows that *A. nebrodensis* maintains a certain regenerative capacity despite the fragmentation and the high rate of inbreeding and selfing occurring in the population. The new fences will support this process by strengthening and widening the protected area around each fertile *A. nebrodensis* tree. In addition, the new fences represent an important measure to stop the occurrence of damage to adult trees caused by wild herbivores and grazing, as highlighted in the recent surveys carried out in the sub-action C1.4 of the Life4fir project.

The video surveillance system will allow for further control of the natural population, limiting the damage caused by anthropogenic pressure, exerting a deterrent effect. It will also make it possible to keep abandoned livestock under control.

Alongside the other measures undertaken, such those aimed at increasing the genetic variability of the progenies and at using outbred seedlings for the new reforestation nuclei, at implementing the seed bank and cryobank, the new fencing system and the video surveillance system are an essential measure to protect and support the relic *A. nebrodensis* population and improve its state of conservation.

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