LIFE4FIR – Project LIFE18 NAT/IT/000164

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

"List of reforested plots explaining the characteristics of each areas, planting technics adopted including maps of the reforestation in GIS" Action C6.

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1. Introduction

Within the LIFE18 NAT/IT/000164 LIFE4FIR project, the action C6 is aimed at identifying and setting up the plots for reforestation using the *Abies nebrodensis* seedlings obtained from cross-pollinations.

For the choice of the areas on which the new plantations will be carried out, the results obtained with the previous project LIFE2000NAT/IT/7228 Project on "Conservation in situ and ex situ of Abies nebrodensis (Lojac.) Mattei", 2001-2005, have been considered. Starting from the analysis of the data obtained from the experimental plots set up in the latter project, inspections were carried out throughout the territory of the Madonie Park to identify the sites characterized by proper ecological-environmental traits and which gave good results.

Ten sites have been identified in the Madonie Park area, distributed in the municipalities of Polizzi Generosa, Isnello, Petralia Soprana, Petralia Sottana, Geraci Siculo and Gratteri. All sites fall within the perimeter of the Madonie Park within areas managed by the Department of Agricultural and Territorial Development of the Regional Government.

site	municipality	latitude	longitude	elevation
Casa Prato	Polizzi Generosa	37°50'49.79"N	14°1'58.23"E	1610
Sanguisughe (Portella Fatuzza)	Polizzi Generosa	37°48'55.52N	14°1'53.78"E	1140
Quacella	Polizzi Generosa	37°50'51.71"N	14°0'45.07"E	1240
Piano Formaggio	Isnello	37°53'36.80"N	14°0'15.21"E	1220
Favarotta	Isnello	37°54'21.87"N	13°59'11.92"E	820
Savochella	Petralia Soprana	37°50'20.15"N	14°6'39.78"E	1450
Mandarini	Petralia Sottana	37°51'39.69"N	14°5'38.07"E	1290
Fegotti	Geraci Siculo	37°50'26.18"N	14°8'43.18"E	1270
Pantano	Geraci Siculo	37°50'24.47"N	14°9'25.03"E	1110
Serra Arcia	Gratteri	37°57'26.97"N	13°58'6.06"E	750

Table 1 – Localization of the ten reforestation sites of *A. nebrodensis* within the Madonie Park.

2. Vegetation traits of the ten selected sites

The ten sites fall mainly in areas included between 1100 and 1600 m a.s.l. elevation, mainly characterized by mesophilic deciduous formations of the following climax associations: *Quercion ilicis*, *Quercion roboris* and *Geranium versicoloris - Fagion*. Only two plots are located at a lower elevation, between 750 and 850 m a.s.l. In the latter areas, however, the microclimatic conditions appear favorable to the development of *A. nebrodensis* seedlings based on the considerable size of some trees growing in private gardens.

The sites located between 1100 and 1400 m a.s.l. elevation are part of the *Ilici aquifolii-Quercetum austrotyrrhenicae* climax association, a relict forest association of considerable geobotanical interest,

established on the quartz arenites of the Numidian Flysch. These woods are characterized by *Quercus petraea* subsp. *austrotyrrhenica* as main species, associated with *Acer obtusatum, A. campestre* and, to a lesser extent, *A. monspessulanum, Sorbus torminalis* and *Ulmus glabra*. In the cooler sites and at higher elevations, species of the upper belt such as *Fagus sylvatica* and *Acer pseudoplatanus* can be found. The understorey consists mainly of *Ilex aquifolium* which finds here optimal growth conditions, forming a dense layer of vegetation interrupted only by *Malus sylvestris, Crataegus orientalis* subsp. *orientalis, Prunus spinosa, Euonymus europaeus, Daphne laureola, Rhamnus catharticus* and *Ruscus aculeatus*. Among the herbaceous plants, in addition to *Aquilegia vulgaris* typical of this association, there are some species of phytogeographic interest such as, *Anemone apennina, Cyclamen repandum, C. hederifolium, Dactylorhiza romana, Hieracium racemosum* subsp. *pignattianum, Drymochloa drymeia, Lathyrus venetus, Primula acaulis, Symphytum gussonei, Viola reichenbachiana*.

The plots located above 1400 m a.s.l. elevation fall within the woods of beech, related to the *Geranium versicoloris-Fagion* climax association. These woods are dominated by *Fagus sylvatica* which is often associated with aged trees of *Acer pseudoplatanus*. The understorey is characterized by the presence of *Sorbus graeca, Orthilia secunda* subsp. *secunda, Euphorbia meuselii* and, sporadically, *Rhamnus catharticus* and *Ilex aquifolium*. In the more open and less favorable sites, *Astragalus nebrodensis, Crataegus laciniata, Prunus mahaleb* subsp *cupaniana* and *Rosa sicula* are also found. The herbaceous layer is made of a few species, among which the most frequent are: *Allium pendulinum, Anemone apennina, Galium odoratum, Cardamine chelidonia, Cyclamen hederifolium* subsp. *hederifolium, Corydalis solida, Doronicum orientale, Galium odoratum, Geranium versicolor, Lamium flexuosum* var. *pubescens, Luzula sylvatica* subsp. sicula, *Monotropa hypopitys, Lactuca muralis, Neottia nidus-avis, Scilla bifolia* and *Hieracium racemosum* subsp. *pignattianum*.

The Madonie beech woods are subdivided into two different phytosociological associations: the *Anemono apenninae-Fagetum* (=*Anthrisco siculae-Fagetum*) and the *Luzulo siculae-Fagetum*. The first is a mesophilic and acidophilous cenosis characterized by *Ilex aquifolium,* which reflects the oceanic climate of this association, by *Ranunculus lanuginosus, Allium ursinum* and *Anthriscus nemorosa*. The *Luzulo siculae-Fagetum* is a basiphile beech wood, typified by the species *Cephalanthera rubra* and *C. damasonium,* but in the flat sites where the soil is thicker and decalcified, such as in Piano Formaggio, conditions are suited for planting new plots of *Abies nebrodensis*.

Some plots planned between 800 and 1200 m a.s.l. elevation (Quacella, Piano Formaggio, Favarotta), though located on a calcareous substrate, have a deep, decalcified soil. Potentially they are affected by vegetational traits related to the mesophilic holm oak wood (*Aceri campestris-Quercetum ilicis*), an association characterized by the presence of *Ilex aquifolium* and some deciduous tree species such as *Acer campestre, A. monspessulanum, Sorbus greca, Malus sylvestris* and oaks related to *Quercus*

pubescens. In the understorey in addition to the species already cited, many taxa are can be found, as *Euphorbia characias*, *Fraxinus ornus*, *Lonicera etrusca*, *Pyrus amygdaliformis*, *Rubia peregrina*, *Rosa sempervirens*, *Ruscus aculeatus*, *Clematis vitalba*, *Daphne laureola* e *Tamus communis*. The herbaceous layer is represented by *Brachypodium sylvaticum*, *Cyclamen hederifolium*, *C. repandum*, *Lamium flexuosum*, *Asplenium onopteris*, *Thalictrum calabricum*, *Trifolium pratense*, *Viola dehnhardtii*, *Paeonia mascula* subsp. *mascula*.

A plot planned at about 750 m a.s.l. elevation (Serra Arcia) is justified by the consideration that *A. nebrodensis* in the past grew at lower elevations compared to the current residual population, which, due to anthropogenic action, it is restricted to less accessible sites located between 1400 and 1600 m a.s.l. elevation.

Below the main traits of the individual plots.

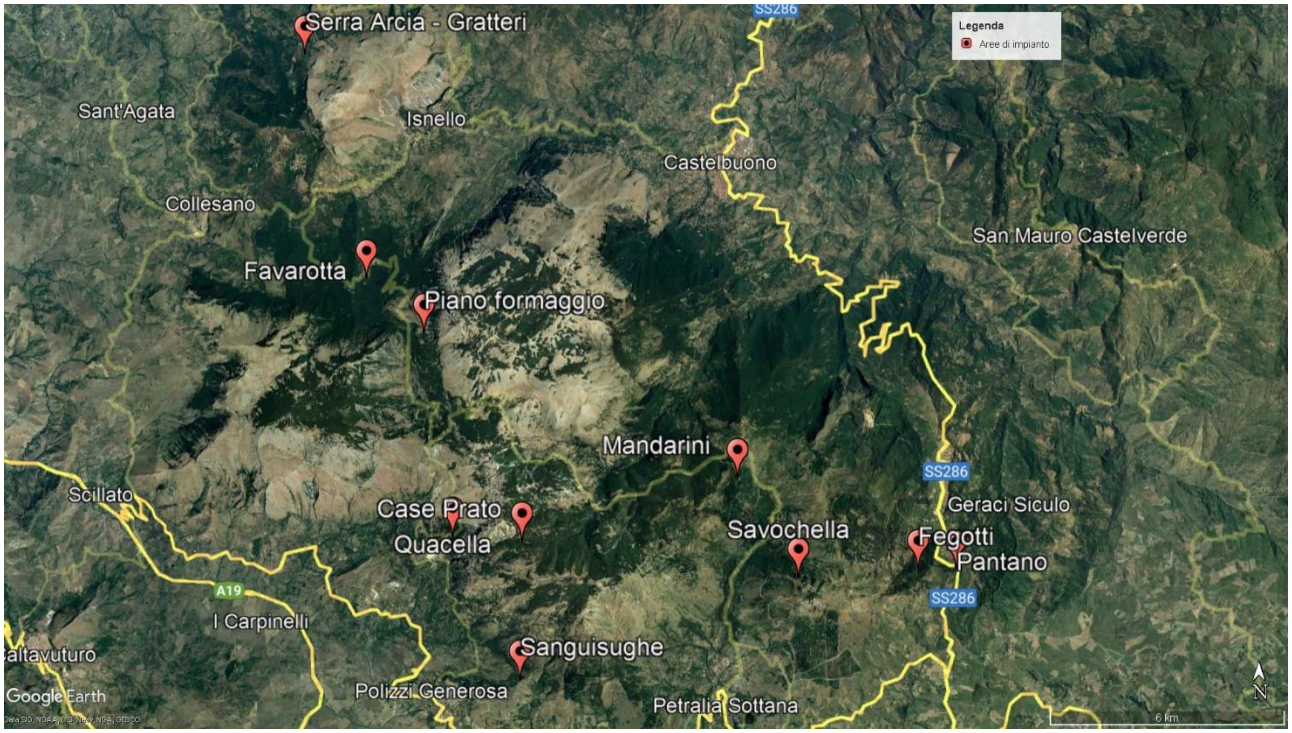

Fig. 1 Map reporting the position of the ten reforestation plots in the Madonie Park territory.

3 Main characteristics of the individual sites

Savochella – Petralia Soprana

The area is located at about 1450 m elevation a.s.l, with a prevailing N-W exposure, an average slope of 20%, and rocky and superficial soils on quartz arenite substrate. It has a fairly continuous vegetation cover, consisting of black pine (*Pinus nigra*), Atlas cedar (*Cedrus atlantica*), sporadic specimens of beech (*Fagus sylvatica*), as well as a more or less continuous shrub layer with *Juniperus hemisphaerica*, and *Genista cupanii*, Sicilian rose (*Rosa sicula*), Sicilian hawthorn (*Crataegus laciniata*) and *Pteridium aquilinum*. Considering the current state of the *A. nebrodensis* experimental plots set up in the same area about 20 years ago, this site is potentially suitable for ensuring the success of the new plot based on exposure, vegetation type and elevation.

Case Prato – Polizzi Generosa

The area identified to host the new plot is located between two experimental plantations set up within the previous Life project, at an elevation of about 1610 m a.s.l. The site has a prevailing S-W exposure, a 25-30% slope, is located on quartz arenitic substrate and shows a scarce tree cover, consisting of sporadic specimens of oak (*Quercus petraea* subsp. *austrotyrrhenica*) and shrubs of *Juniperus hemisphaericae*, which is typically prostrate, and *Genista cupanii*. This vegetation belongs to the *Cerastio tomentosi-Juniperetum hemisphaericae* (class *Pino-Junipereteae*) association, endemic to the Madonie, and is characterized by the prevalence of hemispheric juniper, by *Allium nebrodense*, a rare Sicilian endemism, and by *Cerastium tomentosum*.

Quacella – Polizzi Generosa

The site is adjacent to an experimental plantation set up in previous years. It is located at about 1,240 m a.s.l. elevation and has a prevalent W/N-W exposure, with an average slope of 5%. It is characterized by decalcified calcareous substrate with medium-deep soil. The plot is located near the forest road that goes up to the Vallone Madonna degli Angeli (where is located the *A. nebrodensis* relic population), so it is well accessible and can be easily monitored. The tree cover is mainly characterized by a reforestation carried out about 40 years ago with black pine (*Pinus nigra*) and Atlas cedar (*Cedrus atlantica*) inside which woody and herbaceous species of the local flora can be found such as *Quercus ilex, Fraxinus ornus, Ilex aquifolium, Ruscus aculeatus, Thalictrum calabricum, Geranium versicolor*, etc.

Sanguisughe – Polizzi Generosa

In this site of the Madonie Park, neither experimental plots nor reforestation interventions with *A. nebrodensis* were carried out with in the past. The identified area is located at about 1,140 m a.s.l. elevation, it has a prevailing exposure to N-W, and an average slope of 25%. It is located over a quartz arenite substrate, with medium-deep soil, just a bit stony. It has a continuous tree cover due to reforestation measures carried out about 40 years ago with black pine (*Pinus nigra*), Atlas cedar (*Cedrus atlantica*) and, to a lesser extent, common cypress (*Cupressus sempervirens*).

Fegotti – Geraci siculo

This area is located in the vicinity of a previous experimental plantation of *A. nebrodensis*. It is located at about 1,270 m elevation a.s.l., with a prevailing N-E exposure, an average slope of 3%. The area is located on a quartz arenitic substrate, with fairly deep soil, a bit stony. The tree cover is mainly due to species of a past afforestation intervention with black pine (*Pinus nigra*), Atlas cedar (*Cedrus atlantica*), associated with *Quercus petraea* subsp. *austrotyrrhenica*, *Ilex aquifolium*, *Genista cupanii*, *Cytisus scoparius*. The flat disposition and the northern exposure are further favorable conditions for the growth of *A. nebrodensis* seedlings, as observed in the plots previously set up in the proximity.

Pantano – Geraci siculo

The area is located at about 1,110 m a.s.l. elevation, a bit lower than the previous area. It has a prevailing N-E exposure, an average slope of 10%, and is located over a quartz arenitic substrate, a bit stony, with medium-deep soil. It has a continuous tree cover due to reforestation measures carried out about 40 years ago with black pine (*Pinus nigra*), Atlas cedar (*Cedrus atlantica*), which are rather continuous, in association with *Ilex aquifolium*, *Fraxinus ornus*, *Acer campestre*, *Hedera helix*, *Genista cupanii*, *Prunus spinosa*, *Cytisus scopariuus*, *Pteridium aquilinum*, etc. The flat disposition and the northern exposure are favorable conditions for the growth of the *Abies nebrodensis* seedlings.

Mandarini – Petralia Sottana

The site was identified near the small reservoir in the Mandarini place, at a lower elevation than nearby the experimental plot set up by the previous LIFE project. The area is located at about 1,290 m a.s.l., elevation and has a prevailing E / N-E exposure, with an average slope of 15% and a quartz arenitic substrate, medium-deep soil, a bit rocky. It has a rather continuous tree cover consisting mainly of *Pinus nigra* plantations and, to a lesser extent, *Cedrus atlantica*, associated with *Fraxinus ornus*, *Ilex aquifolium*, *Quercus petraea* subsp. *austrotyrrhenica*, *Genista cupanii*, *Crataegus laciniata*, *Ruscus aculeatus*, *Clematis vitalba*, *Euphorbia characias*, *Daphne laureola*, *Pteridium aquilinum*. Recently, some thinning operations have been carried out on the exotic reforestation species.

Piano Formaggio – Isnello

The area is located at about 1,220 m elevation a.s.l., with a prevailing N exposure and an average slope of 2%. The substrate is calcareous, the soil is fairly deep, a little rocky. The vegetation cover is rather continuous and consists of plantations of *Pinus nigra* and other conifers, especially *Cedrus atlantica*, which are associated with *Quercus ilex*, *Acer campestre*, *Ilex aquifolium*, *Ruscus aculeatus*, *Clematis vitalba*, *Paeonia mascula* subsp. *mascula*, etc. These site conditions can be considered optimal for *A. nebrodensis*, as showed by the size of the plants which are growing in the nearby experimental plot set up in the previous Life Project (despite the calcareous substrate which, however, is decalcified in the upper layers). Some of these plants has reached maturity and are producing fertile cones. These characteristics are promising for the success of the new plots which will be established in the proximity.

Favarotti – Isnello

The area was chosen in the vicinity of a previous experimental plantation of *A. nebrodensis*, located at about 820 m elevation a.s.l.. It has a prevailing N exposure with an average slope of 15%, and it's located over a calcareous substrate, with medium-deep soil, a bit stony. It has a rather discontinuous tree cover made by holm oak (*Quercus ilex*), field maple (*Acer campestre*), minor maple (*A. monspulanum*), virgilian oak (*Quercus virgiliana*), *Quercus dalechampii*, *Q. amplifolia*, *Fraxinus ornus*, *Malus sylvestris*, which are associated with several shrubs such as *Crataegus monogyna*, *Ilex aquifolium*, *Ruscus aculeatus*, *Cytisus villosus*, *Daphne laureola*, *Clematis vitalba*, *Euphorbia characias*. In this context, the experimental plot of *A. nebrodensis* previously established gave good results.

Serra Arcia – Gratteri

Within the previous LIFE project, an experimental parcel of *A. nebrodensis* had been set up on the slopes of Pizzo Sant'Angelo, in the territory of Cefalù, in the northernmost part of the Madonie territory. Since the *A. nebrodensis* in the past was settled on the lower mountain slopes and plants of this parcel are exhibiting excellent growth (with some trees having reached maturity), it was considered appropriate to select here a new planting site. This area is located in Serra Arcia, about 750 m elevation a.s.l., and can be reached via the road that leads from the village of Gratteri to the Abbey of San Giorgio. It has a prevailing N-W exposure, an average slope of 30%, and is located on a quartz-arenitic substrate with a medium-deep soil. The plot will be established within a wood of holm oak (*Quercus ilex*), cork oaks (*Quercus suber*) and deciduous oaks belonging to the polymorphous group of *Quercus pubescens* s.l., to which some other species are associated: flowering ash (*Fraxinus ornus*), the narrow-leaved ash (*Fraxinus angustifolia*), the butcher's broom (*Ruscus aculeatus*), the common hawthorn (*Crataegus monogyna*), *Cytisus villosus*, *Daphne laureola*, the Nebrodi broom (*Genista aristata*), etc.

4. Planting procedure

As regards the planting of the *A. nebrodensis* seedlings in the individual plots, the procedure will take into due account the positive results obtained with the plantations carried out in the previous LIFE project.

Planting should be done following the contour lines and the exposure of the site. Adequate spacing is necessary to let young plants to grow properly, and eventual selective thinning of both the tree and shrub story will be carried out. In some case, removal of the herbaceous layer will be considered, taking care not to damage any rare and/or endemic species present.

Based on the objectives of the Life4fir project, the individual plots will have an area between 3000 and 4000 m^2 and the number of plants that will be planted is 400 per each.

For each single plot, the following measures will be implemented stepwise: fencing, opening of the holes, planting of enhancing legumimous species, planting of *A. nebrodensis* seedlings.

5. Fencing

The fences will be installed along the perimeter of the area, following the same procedure used for the fences set up to protect the relic trees of the natural population (Action C1.1). Chestnut poles with a diameter of 8-10 cm and a length of 2.40 m will be used. They will be inserted into the ground for about 40 cm and placed at a distance of 2 m each other (Fig. 2).

Fig. 2 – Installation of the gate

Fig. 3 – Installation of the fence

The height above ground will be about 2 m. Four orders of galvanized wire anchored to the poles will be fastened to a progressive metal mesh having a height of 1.65 m and an overlying wire. Access to the parcels will be allowed by gates 1.5 m wide and 1.80 m high (Fig. 3). Once installed, gates will be maintained through iron gaiters anchored to the chestnut poles.

6 Digging the holes for planting

The opening of the holes will be carried out in the soil both with mechanical devices and with specific agricultural equipment. The holes will not have a well-defined spacing pattern but will be dug based on the characteristics of the site. Generally, they will be spaced about 3-4 meters from each other. In order to ensure the young seedlings of *A. nebrodensis* a harmonious development of the root system and a greater water reserve, the holes will have a well-defined shape. Truncated-cone holes and pyramidal holes will be preferred.

The former will have a lower diameter of about 80 cm and an upper diameter of about 50 cm, with a depth between 50 and 60 cm (Fig. 4). The pyramidal holes will have the lower side of 80 cm, the upper one of 50 cm, while depth will be 60 cm (Fig. 4).

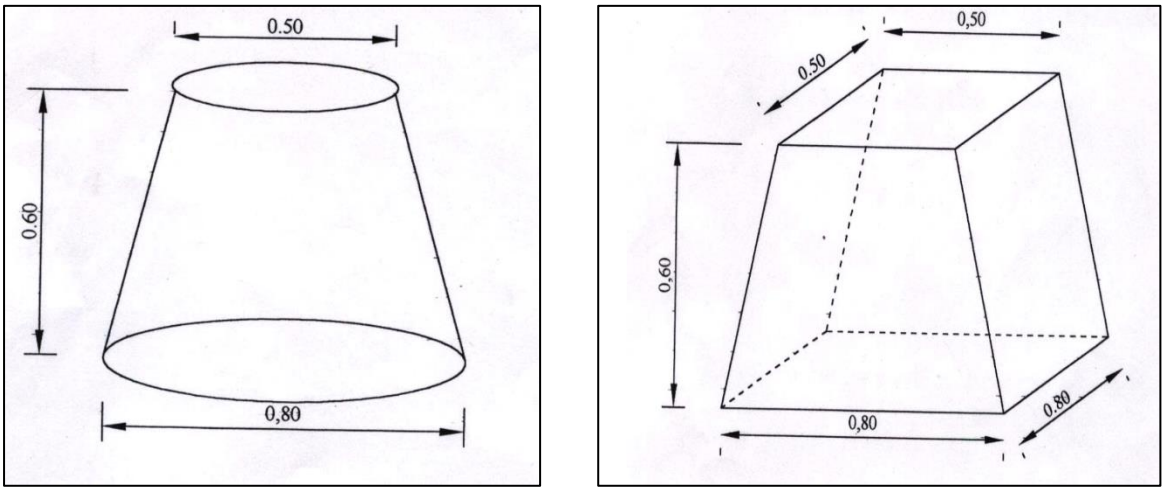

Fig. 4 – Scheme of a truncated-cone shaped hole (left) and of a truncated-pyramid shaped hole (right).

7. Planting of enhancing *Leguminosae*

The planting of shrubs belonging to the *Fabaceae* familiy, is aimed at improving soil fertility and ensuring adequate protection to the *A. nebrodensis* seedlings from both excessive sunlight, heat and summer drought after having been transplanted. The fast-growing shrubs will help to maintain suitable microclimate conditions for the development of *A. nebrodensis* seedlings in the spring-summer period and to protect them from strong winds. The shrubs that will be used belong to the genera *Genista*, *Spartium* and *Cytisus*. They will be 2-3 years old and will be planted near the *A. nebrodensis* seedlings at a distance of about 50 cm. Generally, two shrubs will be planted for each single *A. nebrodensis* seedling.

8. Planting of *Abies nebrodensis* seedlings

For each single plot, 400 seedlings raised in 9x9x20 cm containers in the nursery will be planted out. The seedlings will be about 3 years old. In the nursery, they were transplanted after 1 year and were subjected to mycorrhization. Planting, as mentioned above, will not follow a geometric pattern but will be performed according to the morphology of the soil and in compliance with the vegetation settled. If in an area there are plants of *Ilex acquifolium*, *Quercus ilex*, *Quercus virgiliana*, *Q. petraea* subsp. *austrotyrrhenica* or *Fagus sylvatica* the seedlings of *A. nebrodensis* will be planted north of the trunk. In the reforested areas with a geometric spacing of the trees, the *A. nebrodensis* seedlings will be positioned according to quincunx system. During planting, phosphorus-rich organic fertilizer will be added to the hole to help the transplanted seedlings. After planting, a dip in the ground will be created around each single plant to favor the accumulation of water. Furthermore, in order to reduce evaporation from the ground around the hole, a mulching with plant material obtained from the herbaceous species present in the immediate vicinity of the plots will be made in spring.

Within the plots, about 50 holes of 40x40x40 cm will also be created for the direct sowing of *A. nebrodensis*, placing the seed at a depth of about 3 cm. Five seeds will be sowed per hole.

9. Conclusions

The setting up of the new plots is ultimately aimed at the numerical increase of the *A. nebrodensis* population within the territory of the Madonie Park, and at the increase of genetic diversity of the species, thanks to the use of outbred seedlings obtained from manual pollination among the trees genetically more distant of the extant natural population. This action, therefore, will help stop genetic erosion, reduce homozygosity and loss of biodiversity. If this measure is successful, it will favor a better adaptability of the species to environmental stresses and climate change in the future. This action will significantly contribute to further increasing the overall consistency and vitality of the A. *nebrodensis* population.

To increase the average survival rate of *A. nebrodensis* seedlings, native shrubs of the *Fabaceae* family will be planted next to each of them to improving the nitrogen supply of the soil and ensure protection from direct solar radiation to seedlings in the first years of life.