

### Restoration Practices in Mediterranean Habitats Using Native Woody Species

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**Introduction** - Since the beginning of the XXI century, Legambiente (a national environmental association), supported by the University of Palermo, has launched several naturalization projects within three Sicilian nature reserves:

- 1) **Isola di Lampedusa** (Agrigento Province) (1);
- 2) **Macalube di Aragona** (Agrigento Province) (2);
- 3) **Lago Sfondato** (Caltanissetta Province) (3).

Interventions were carried out on bare lands and degraded sites where natural vegetation cover was almost completely disappeared. The main aim was to restore native habitats following the principles of ecological restoration. Accordingly, differently from the classical approach, consisting in the use of preparatory species, usually Pines, native shrubs and trees were selected and used in the field.

#### Study Site 1

The Nature Reserve “Isola di Lampedusa” comprises Lampedusa, the largest Island of the Pelagic Archipelago, that hosts a quite peculiar flora, originated both by natural and anthropic factors. Once widely covered by woodlands, the island has been almost completely cleared from woody vegetation, also favoring in some slopes soil erosion processes. The high scientific and conservation value of its flora is strictly linked to the high number of exclusive endemic taxa (10 species), together with endangered or rare Mediterranean species such as *Caralluma europea* (Guss.) N.E. Br and *Chilidactylus lopadusanus* Brullo, which are strongly tied to Habitats of Community interest (Dir. 92/43/CE).

#### Interventions 1

Interventions were carried out on the “Spiaggia dei Conigli” slope with a dual purpose:

- To control the widespread erosion processes;
- To restore native habitats and contribute to increase the conservation status of some endangered or threatened plant taxa.

Through a massive intervention, about 4000 plants belonging to 43 taxa were propagated (Table 1).

#### Results and conclusions 1

The combination of bioengineering techniques (Fig. 1), peculiar agronomic practices and the use of local genotypes led to a significant increase in vegetation cover and a visible reduction of erosion (Fig. 2). Also, the conservation status of rare native species has significantly improved.

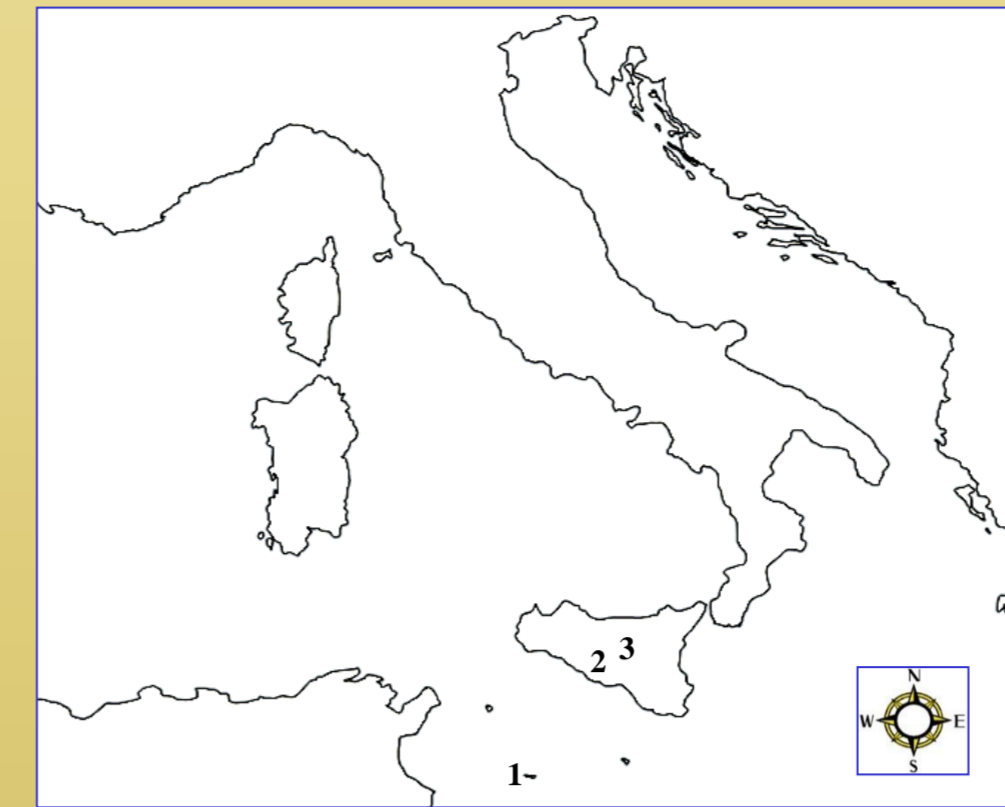


Table 1. Plants used for restoration of the hillside overlooking the Spiaggia dei Conigli

#### Endemics of Lampedusa island or of Pelagic Archipelago

*Dianthus rupicola* Biv. subsp. *lopadusanus* Brullo & Minissale  
*Chilidactylus lopadusanus* Brullo  
*Limonium lopadusanum* Brullo  
*Pancretrium linosae* Soldano & F. Conti  
*Suaeda pelagica* Bartolo, Brullo & Pavone  
**Endemic of Sicily, Sicily and Maltese Archipelago, S Italy and Sicily or central Mediterranean areas**

#### Other rare, endangered, or nationally protected species

*Crucianella rupestris* Guss.  
*Hypericum aegypticum* L. subsp. *webbii* (Spach) N.K.B. Robson  
*Juniperus turbinata* Guss.  
*Limonium monopetalum* (L.) Boiss.  
*Lycium intricatum* Boiss.  
*Periploca angustifolia* Labill.  
*Phagnalon saxatile* (L.) Cass. subsp. *saxatile*  
**Other rare or endangered species at the local level**  
*Anagyris foetida* L.  
*Arbutus unedo* L.  
*Clematis cirrhosa* L.  
*Ceratonia siliqua* L.  
*Coronilla valentina* L. subsp. *glauca* (L.) Batt.  
*Erica multiflora* L. subsp. *multiflora*  
*Myrtus communis* L.  
*Phillyrea latifolia* L.  
*Rubus ulmifolius* Schott



Figure 1 - Some details of the different bioengineering techniques applied at Isola di Lampedusa: woody fences (A), woody fences filled with stones (B), felt mats (C), vegetative pockets made of biomat (D).

#### Study Site 2

The Nature Reserve “Macalube di Aragona” is a small reserve of the inner Sicily with great environmental value and high biological diversity. The Reserve has been established to protect a peculiar geological phenomenon, yet it hosts habitats and plant species of particular interest. For long time it has been strongly affected by intensive farming and grazing, which caused the significant reduction and fragmentation of native habitats, the extinction of some plant species and the strong increase of the desertification risk of large areas. The interventions were carried out to stop soil erosion and restore native habitats, including peculiar temporary and permanent wet environments (Fig. 3).

#### Interventions 2

The main aim of the interventions was to restore native perennial xerophilous *Lygeum* grassland. Such vegetation type plays a major role in protecting native biodiversity as well as representing a strong barrier against soil erosion.

The actions were also addressed to increase the extension of other important habitat types in the Reserve such as:

- *Aster sorrentinii* (Tod.) Lojac. vegetation (endangered species according to IUCN classification);
- Halo-nitrophilous scrubs (*Pegano-Salsolitea*) with the shrubby chenopodiaceae (*Salsola oppositifolia* Desf. and *Suaeda vera* J.F. Gmel.);
- Mediterranean temporary ponds\* (\*Priority habitat);
- Pseudo-steppe with grasses and annuals of the Thero-Brachypodieta\* (\*Priority habitat).

For this purpose, the following native species were used:

- *Lygeum spartum* L.;
- *Aster sorrentinii* (endemic to Sicily);
- *Salsola vermiculata* L., *Salsola oppositifolia* and *Suaeda vera*;
- *Tamarix africana* Poir.;
- *Atriplex halimus* L.

#### Results and conclusions 2

One of the main results of the interventions has been the successful restoration of *Lygeum* perennial grasslands (Fig. 4 and 5). Natural regeneration by *Lygeum* has been increasingly observed next to the interventions areas. *Aster sorrentinii* population is significantly increased, from less than 50 to more than 600 individuals, being more than decupled in less than 10 years (Fig. 5). Halo-nitrophilous scrubs are steadily spreading. The establishment and rapid growth of *Tamarix* individuals are allowing the recovery of important aspects of forest vegetation along the banks of temporary ponds. About 10 *Atriplex* individuals were established; this species was not present before the project has started.



Figure 3 - Interventions at Macalube di Aragona are allowing the native habitat restoration and the reduction of soil erosion (2003 vs. 2014)

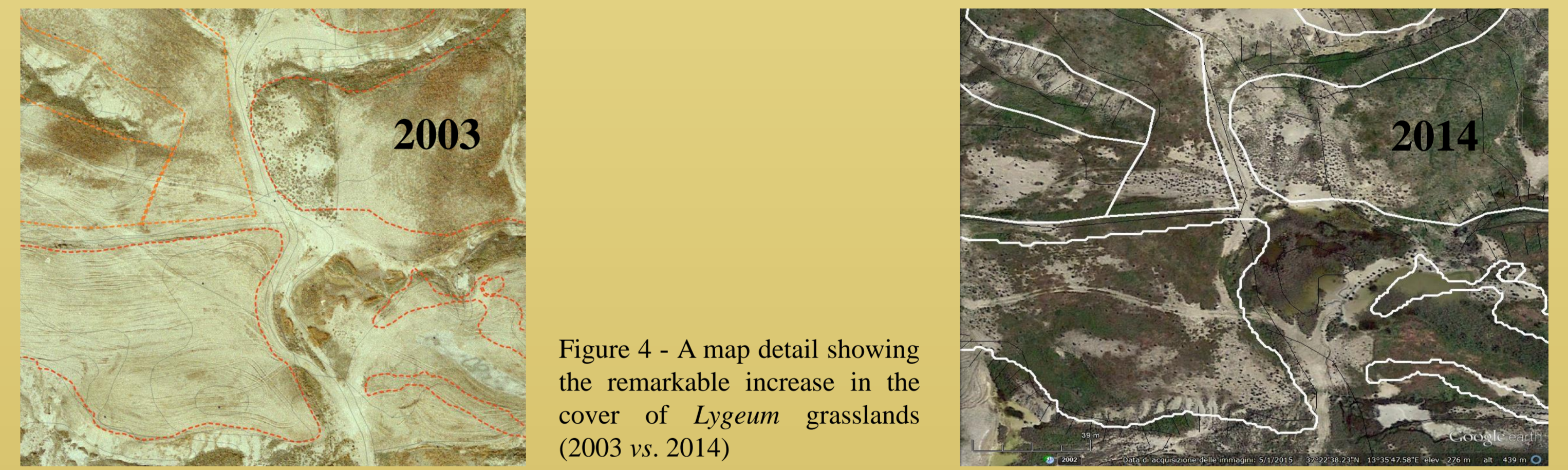


Figure 4 - A map detail showing the remarkable increase in the cover of *Lygeum* grasslands (2003 vs. 2014)

#### Study Site 3

The Nature Reserve “Lago Sfondato” (Fig. 6) was established to preserve a peculiar karstic lake and the surrounding vegetation, hosting a number of plant species of conservation and scientific value, including many orchids.

#### Interventions 3

The interventions were aimed at restoring native habitats with local woody species (*Anagyris foetida*, *Crataegus monogyna*, *Teucrium flavum*, *Pyrus amigdaliformis*, *Quercus pubescens* s.l., *Astragalus huetii*, *Cistus parviflorus*, *Coronilla Valentina*, *Daphne gnidium*, *Ephedra fragilis*, *Phagnalon saxatile*, *Pistacia lentiscus*, *Pistacia terebinthus*, *Prasium majus*, *Quercus ilex*, *Rhamnus alaternus*). For some species the germination percentage has been assessed (Table 1). In a second phase, other woody species have been introduced whereas others have been excluded, not having provided good results (see the view from top of the Reserve). Woody plants were inoculated with symbiotic microorganisms (plant growth promoting bacteria and mycorrhizal fungi), enhancing their chance of survival and establishment after transplanting. Moreover, seeds of woody legumes were also inoculated with selected nitrogen-fixing rhizobia

#### Results and conclusions 3

Apart from the definitive establishment of most of the propagated individuals (fig. 7), active natural evolution process by propagated plants were increasingly observed in the surrounding areas. The choice of ecologically suitable areas together with local ecotypes allowed a good outcome of plant propagation techniques as well as a successful establishment of most the used species. Double inoculation with root symbionts was beneficial for most species (fig. 8, 9).



Figure 7 - Most of the propagated individuals have successfully established.

#### Overall Conclusions

The ecological restoration interventions carried out within three Nature Reserves in Sicily suggest that the use of native woody species, especially local genotypes, should be the best way to restore native Mediterranean habitats. Also, specific propagation techniques are strongly recommended, especially for some woody species. Such interventions seem to prove the possibility to directly use native species to restore Mediterranean biotopes and habitats of particular scientific and conservation interest. The use of symbiotic microorganisms may be crucial exactly when there is the highest possibility of failure of the interventions, that is during the establishment as well as the early growth stages of woody plants. The good results in terms of growth and establishment after fungal or bacterial inoculation observed both in Lampedusa and in Lago Sfondato Reserves in most of the propagated species seem to prove the considerable importance of aboveground symbiotic relationship, a too often overlooked topic in forestation activities.

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Table 3. Woody plants propagated in the Reserve Lago Sfondato

Species	Mode of propagation	Germination (%)
<i>Anagyris foetida</i>	Seed	95
<i>Cistus parviflorus</i>	Seed	25
<i>Coronilla valentina</i> subsp. <i>glauca</i>	Seed	25
<i>Daphne gnidium</i>	Seed	0
<i>Pistacia lentiscus</i>	Seed	10
<i>Pistacia terebinthus</i>	Seed	0
<i>Quercus ilex</i>	Seed	100
<i>Quercus pubescens</i> s.l.	Seed	0
<i>Sambucus nigra</i>	Cutting	100
<i>Populus nigra</i>	Cutting	100
<i>Populus alba</i>	Cutting	10
<i>Salix alba</i>	Cutting	100
<i>Salix</i> cfr. <i>fragilis</i>	Cutting	100
<i>Salix pedicellata</i>	Cutting	100

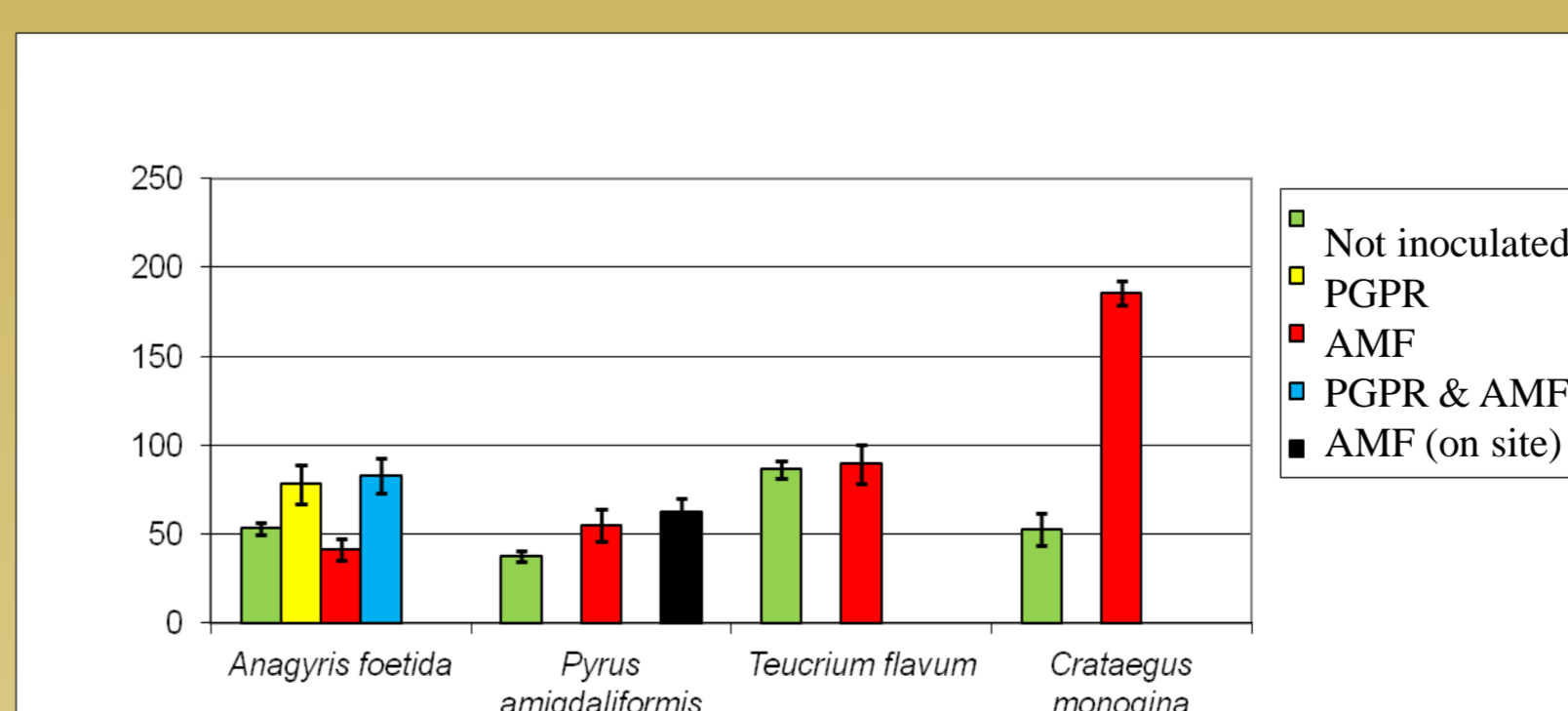


Figure 8 - The effect of beneficial symbionts

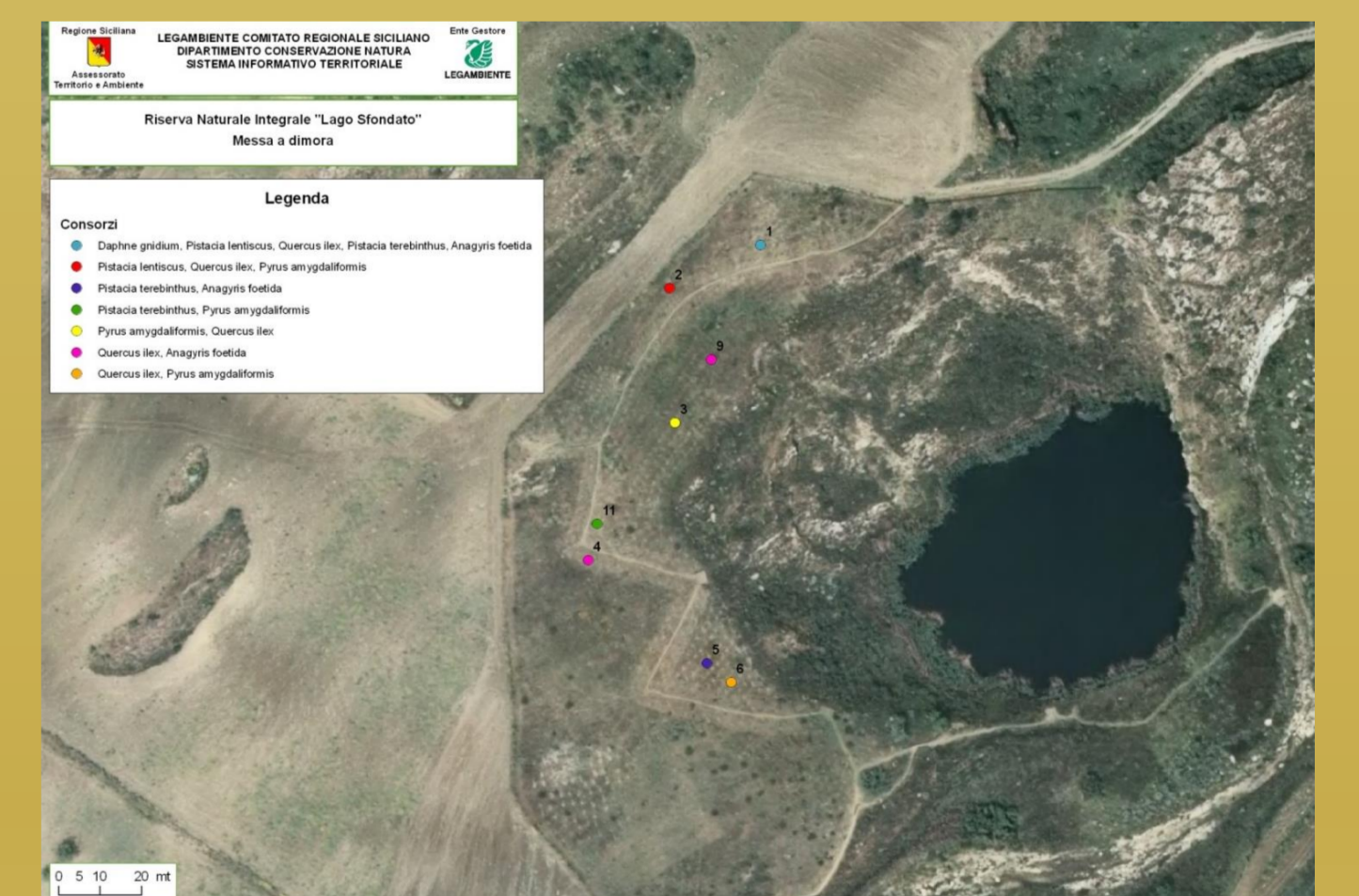


Figure 6 - A view from top of the Lago Sfondato Nature Reserve

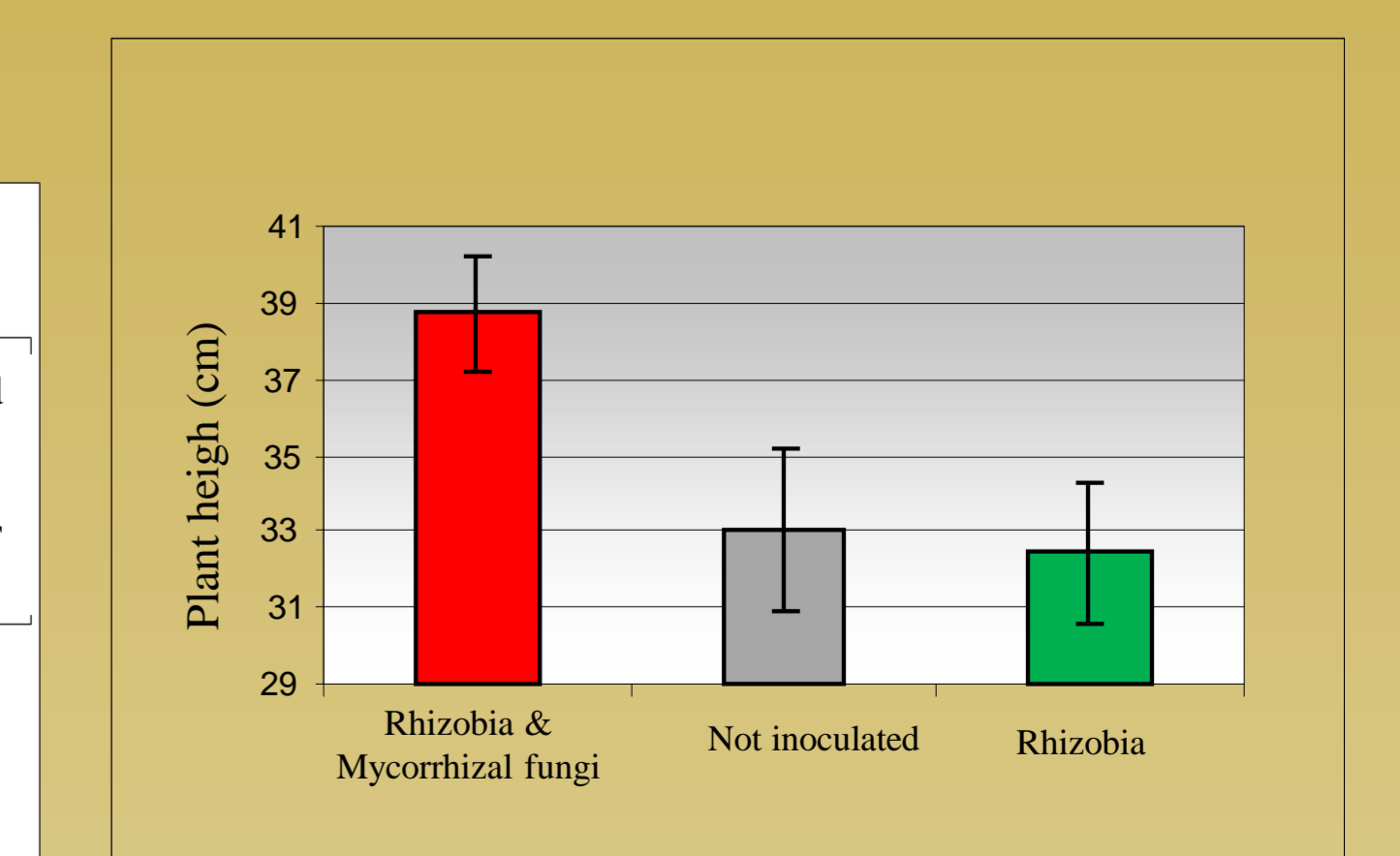


Figure 9 - Double inoculated *Anagyris* plants are taller.