



«ΧΡΗΜΑΤΟΔΟΤΙΚΟ ΠΡΟΓΡΑΜΜΑ LIFE & ΔΑΣΗ:  
ΠΡΑΓΜΑΤΙΚΟΤΗΤΑ, ΠΡΟΚΛΗΣΕΙΣ και ΑΝΑΓΚΕΣ ΣΤΗ ΔΑΣΙΚΗ ΔΙΑΧΕΙΡΙΣΗ ΣΤΗΝ ΕΛΛΑΔΑ του 21ου ΑΙΩΝΑ»  
Παρασκευή 27 Νοεμβρίου 2020



# CONSERVATION OF PRIORITY SPECIES AND HABITATS OF ANDROS ISLAND PROTECTED AREA INTEGRATING SOCIOECONOMIC CONSIDERATIONS

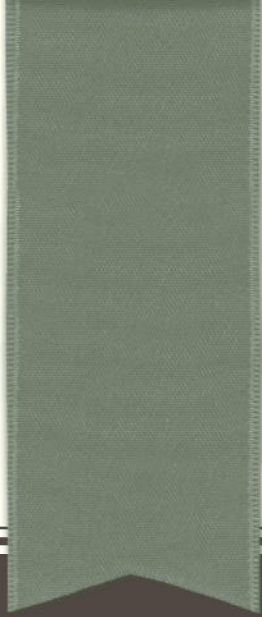
## “The Forest Element”

Georgios I. Zervakis and Panayiotis Trigas  
Agricultural University of Athens



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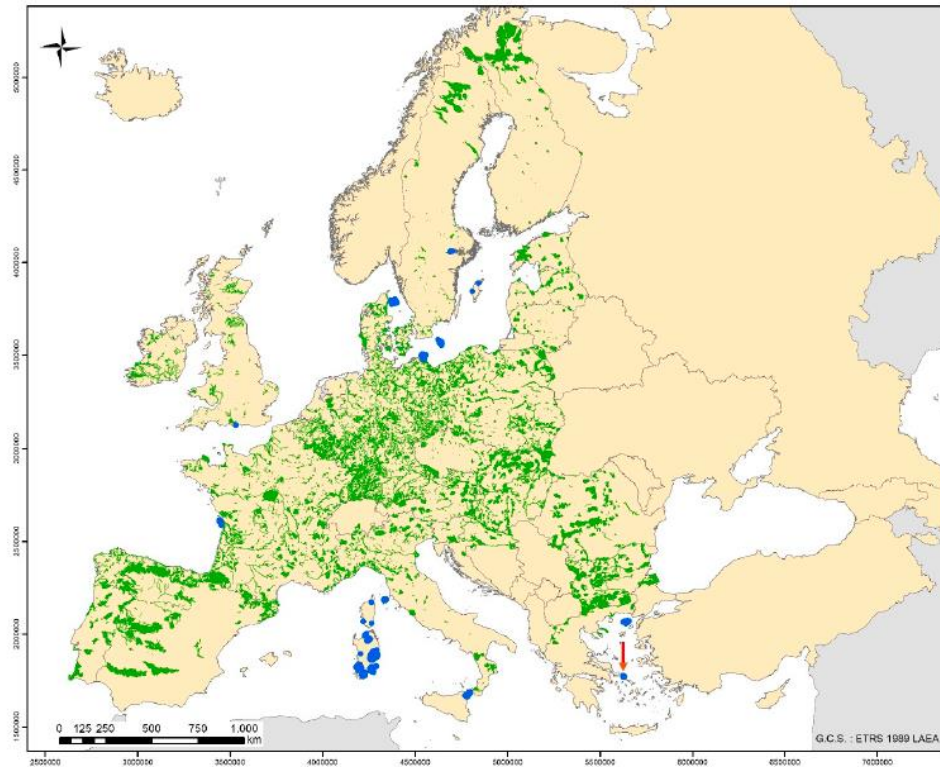
# “THE FOREST ELEMENT” - AN INTRODUCTION

## I. The Habitat

The priority habitat type \*91E0  
(Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*) in Andros

# Distribution of alluvial forests with *Alnus glutinosa* in Europe

- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (priority habitat 91E0\*; Annex I, Directive 92/43/EEC) are distributed throughout Europe, but they are generally rare and threatened since only remnants exist, mainly in central and northern Europe.
- Alder stands are considerably less frequent in the Mediterranean region, where the repercussions of changes in the hydrological cycle caused by global warming and climate destabilization are much more evident.
- The southernmost limit of the priority habitat 91E0\* in the Balkan Peninsula is located in Andros island.



Map presenting Natura 2000 sites, which include the priority habitat 91E0\* in continental Europe (in green) and in islands (in blue); Andros island is indicated by the red arrow. Data from <https://www.eea.europa.eu/data-and-maps/data/natura-6>



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## Distribution of alluvial forests with *Alnus glutinosa* on Andros

- *A. glutinosa* demonstrates a patchy distribution on Andros, predominantly occurring along the main streams and in altitudes ranging from sea level to as high as 850 m above sea level (a.s.l.) close to the highest peaks of the island.
- In many cases black alders are mixed with *Platanus orientalis*, *Fraxinus ornus* and/or *Nerium oleander* (in lower altitudes), while they also form pure stands, as it is the case at the estuaries of the Vori stream and along the riverbanks of Lefka in NE Andros.



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# The degradation of the alluvial *Alnus glutinosa* forests of Andros



Several factors have led to the degradation of the alluvial forests of Andros, the most important being:

- Wildfires and the succeeding flooding events
- Overgrazing
- Abandonment of traditional cultivation practices
- Absence of any type of management practices



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# “THE FOREST ELEMENT”

II. Technical studies regarding the priority habitat type \*91E0

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# Study of hydrogeological parameters of the Vori stream

The hydrogeological study includes:

- detailed topographic map of the wetland
- aerial photography using drone
- flow modeling using SWAT hydrological model



## LIFE ANDROS PARK

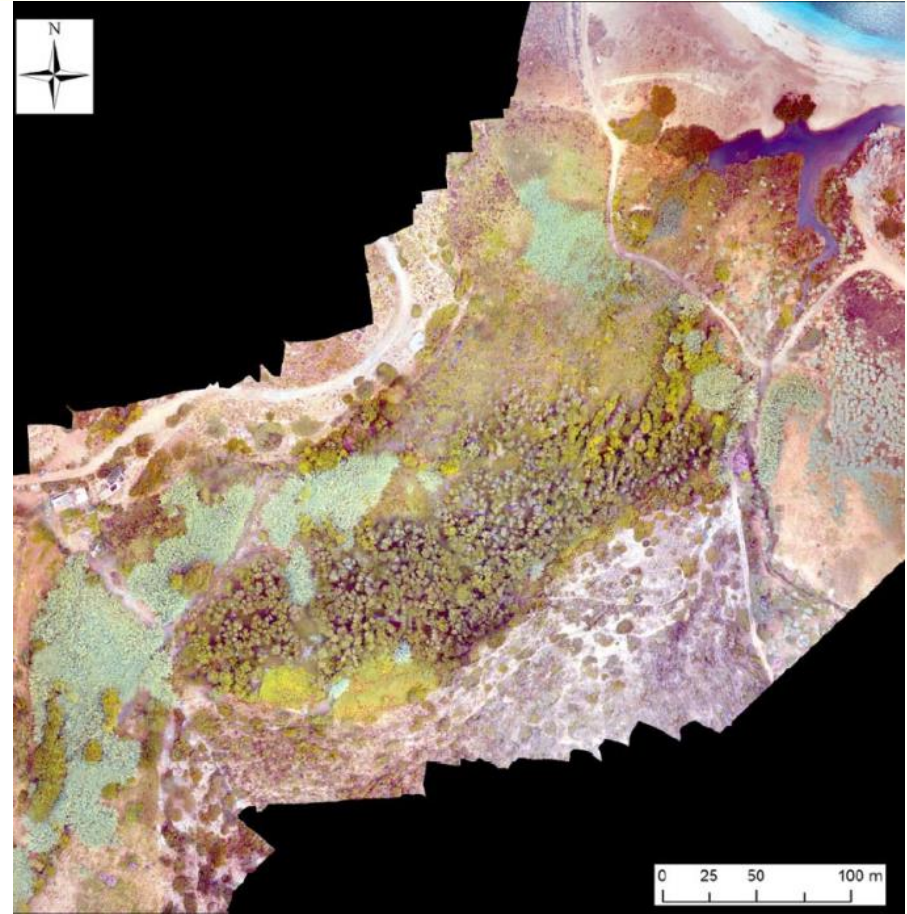
«Διατήρηση των εθνικών και οικιστικών προτεραιοτήτων της προστατευόμενης περιοχής της Ανδρού με την ενσωμάτωση κοινωνικοοικονομικών παραμέτρων»  
LIFE16 NAT/GR/000606



## ΔΡΑΣΗ Α3

Μελέτη υδρογεωλογικών παραμέτρων στην λεκάνη απορροής της Βόρης της Ανδρού

Μάρτιος 2019

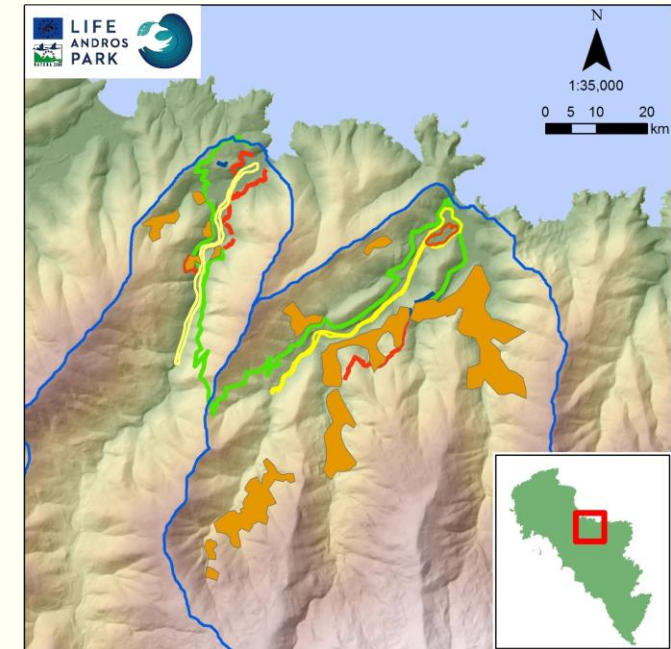
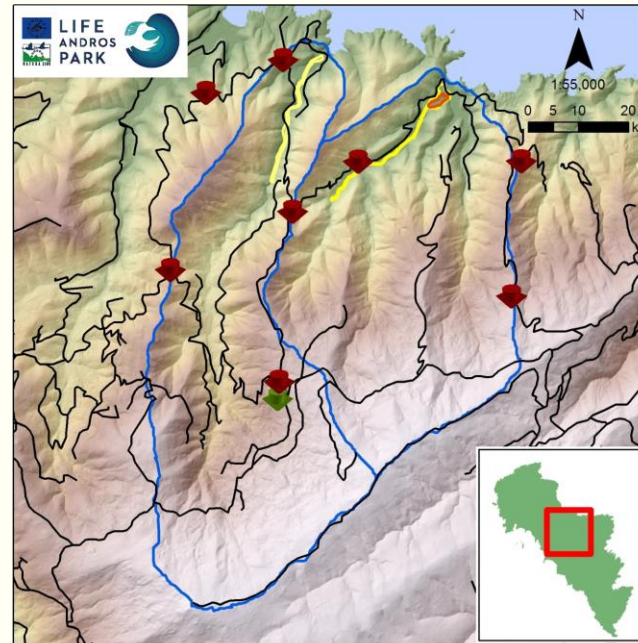
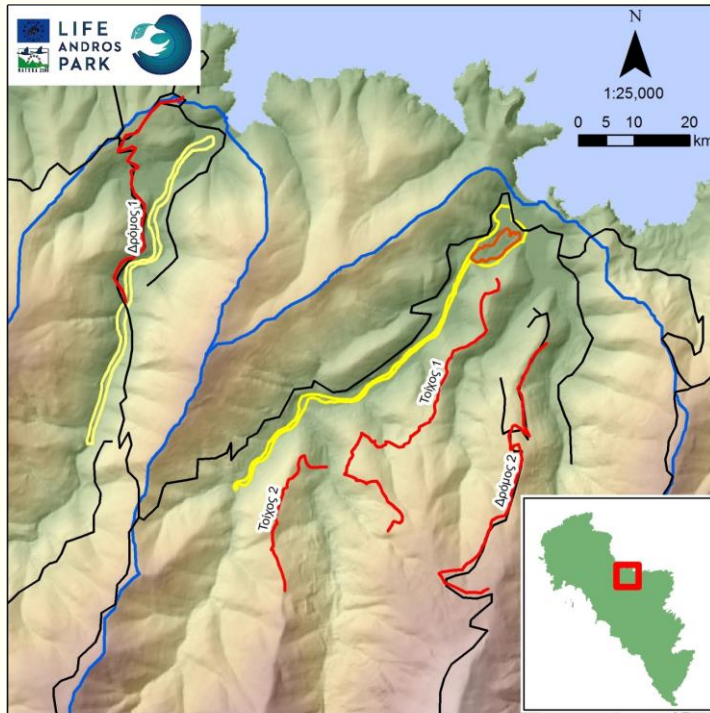


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# Preparatory technical studies for conservation actions

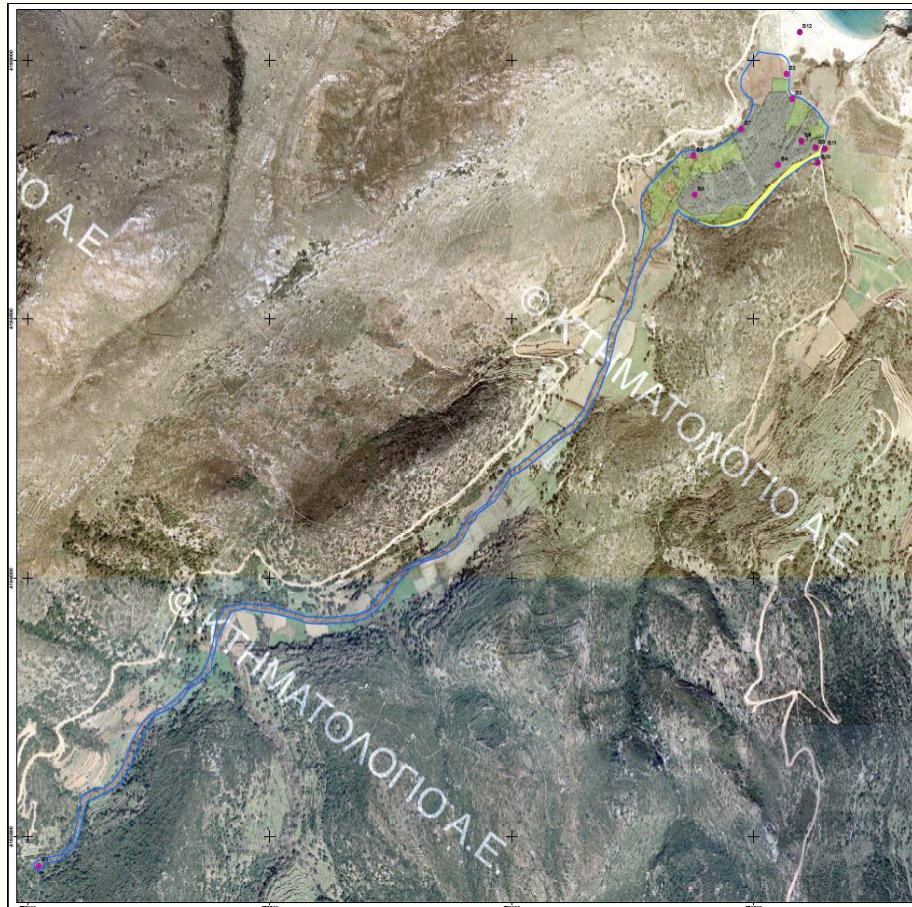


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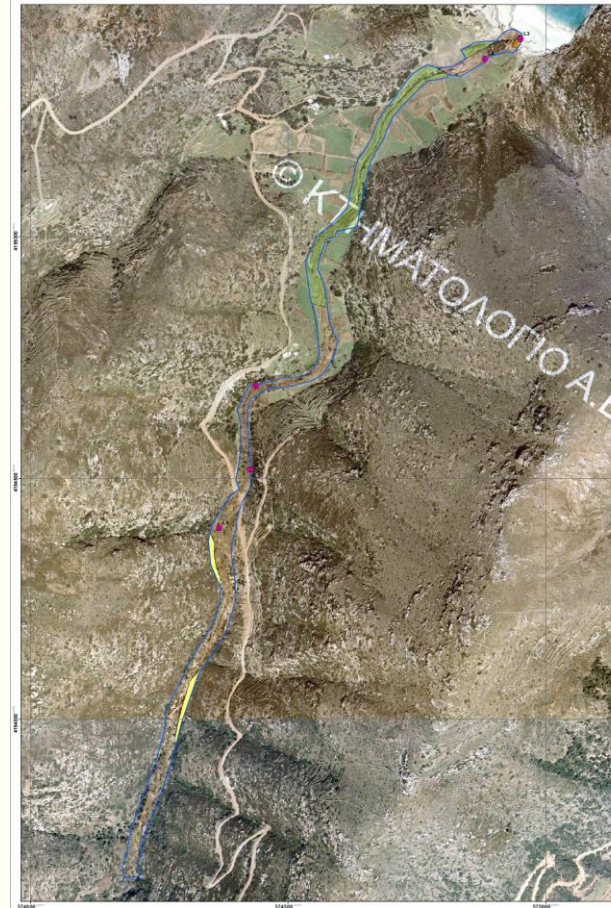
# Habitat types and vegetation units within the study areas



- Legend**
- PLOTS
  - VORI STUDY AREA
  - Alnus glutinosa
  - Evergreen shrubs
  - Platanus
  - Reed
  - Sedge

Cartographic Base: Orthophotomaps of the Hellenic Cadastre Service in the Greek Grid System

<b>Project:</b> LIFE Andros Park – Conservation of priority species and habitats of Andros Island protected area Integrating socioeconomic considerations (LIFE16 NAT/GR/000606)	
<b>Interim Report</b> on the plant communities and their seasonal and spatial variation of the target habitat including the results of the base study	
<b>Editor:</b> Theodoriki Adamantou, Forester on behalf of the Agricultural University of Athens Work Team	
<b>Map:</b> Vegetation type in Vori	
Map Number: 2a	Signatures
Date: October 2018	
Scale: 1:2,500	



- Legend**
- PLOTS
  - LEFKA STUDY AREA
  - Alnus glutinosa
  - Nerium
  - Phryganea
  - Platanus
  - Reed
  - Sedge

Cartographic Base: Orthophotomaps of the Hellenic Cadastre Service in the Greek Grid System

<b>Project:</b> LIFE Andros Park – Conservation of priority species and habitats of Andros Island protected area Integrating socioeconomic considerations (LIFE16 NAT/GR/000606)	
<b>Interim Report</b> on the plant communities and their seasonal and spatial variation of the target habitat including the results of the base study	
<b>Editor:</b> Theodoriki Adamantou, Forester on behalf of the Agricultural University of Athens Work Team	
<b>Map:</b> Vegetation type in Lefka	
Map Number: 2b	Signatures
Date: October 2018	
Scale: 1:2,500	



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# “THE FOREST ELEMENT”

III. The Plants (*Alnus glutinosa* and other species of importance)

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# The study of *A. glutinosa* associated plants in Andros: Results

## Floristic analysis and important plant species

The flora of the study areas consists of 234 vascular plant taxa. The majority of the plant species have a wide distribution in the Mediterranean region or even larger areas.

The endemic element is represented by 12 taxa, most of them inhabiting dry slopes close to the streams. Two flagship plant species of Andros Island (i.e., *Galanthus ikariae*, *Scilla andria*) grow within the priority habitat 91E0\* in Lefka and Vori stream, respectively.



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# The study of *A. glutinosa* associated plants in Andros: Results

## NORDIC JOURNAL OF BOTANY

### Research

A new *Hypericum* (sect. *Drosocarpium*, Hypericaceae) from the Cyclades Islands (Greece)

Panayiotis Trigas

P. Trigas ([trigas@aua.gr](mailto:trigas@aua.gr)), Lab. of Systematic Botany, Dept of Crop Science, Agricultural Univ. of Athens, Athens, Greece.

Nordic Journal of Botany

2018: e02205

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Subject Editor: and

Editor-in-Chief: Torbjörn Tyler

Accepted 18 October 2018

*Hypericum cycladicum* Trigas sp. nov. (Hypericaceae) from the Cyclades Islands (Greece) is described and illustrated. It belongs to *H. sect. Drosocarpium* and its closest relatives appears to be the Cretan endemic *H. trichocaulon* and the widespread Mediterranean *H. perforatum*. The new species is currently known from Andros, Paros and Naxos islands, but probably has a wider distribution within the Cyclades island group.

Keywords: Aegean Islands, Greek flora, *Hypericum cycladicum*, taxonomy, vascular plants

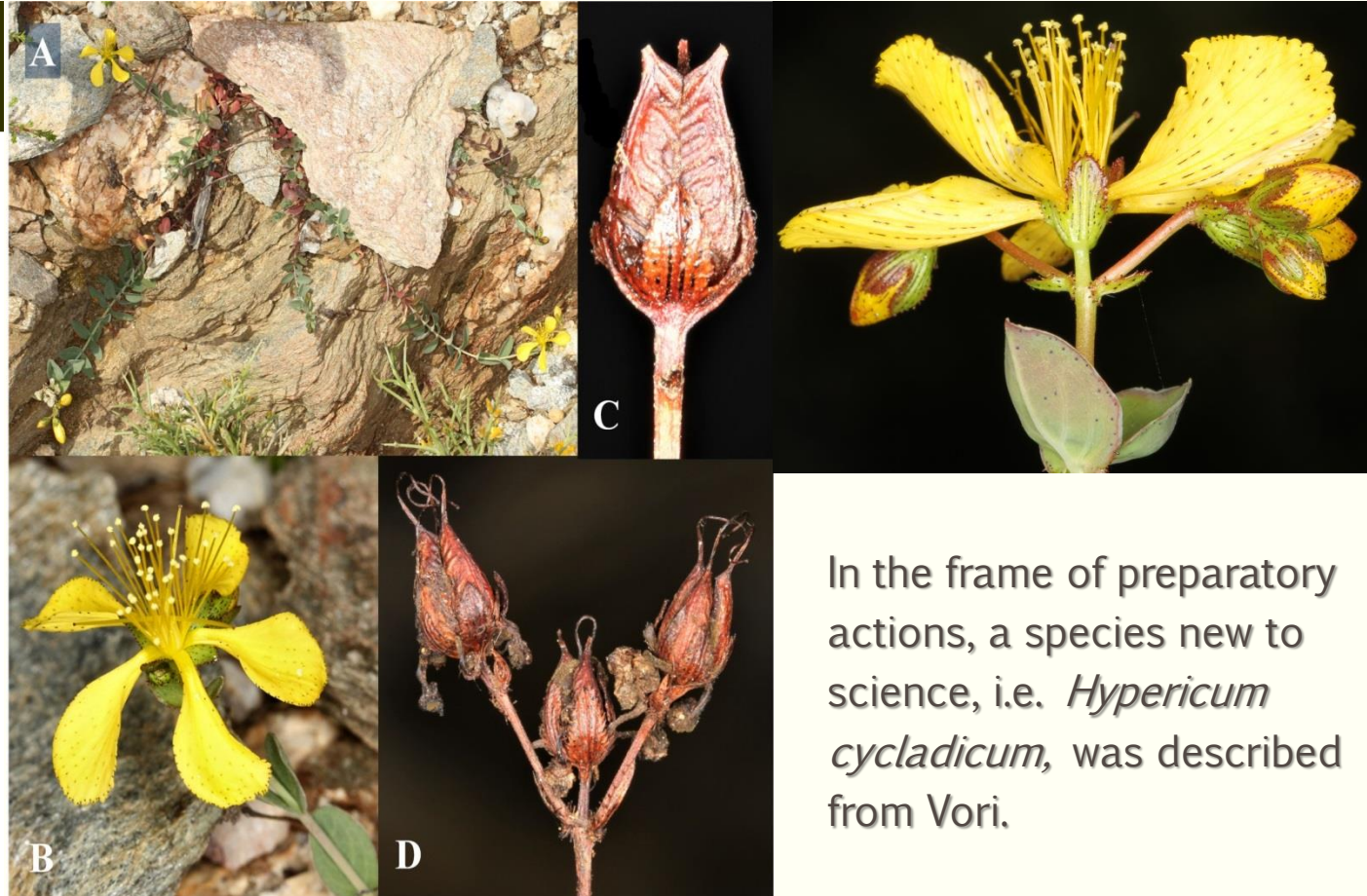
### Introduction

*Hypericum* L. is the largest genus of the family Hypericaceae and includes 490 species of herbs, shrubs or trees distributed almost worldwide (Robson 2012). It is a relatively old genus dating back to the Early–Mid Tertiary (Meseguer and Sanmartín 2012). It is mainly distributed in the temperate regions of the Northern Hemisphere, but also in high-altitude tropical and subtropical areas, and in a large variety of ecosystems (Meseguer et al. 2013). Robson has prepared a detailed taxonomic treatment of the genus in a series of monographs (Robson 1977, 1981, 1985, 1987, 1990, 1996, 2001, 2002, 2006, 2010a, b, 2012). In these, the main diagnostic characters for the classification of the genus were identified, numerous new species were described and an infra-generic classification into 36 sections was proposed.

The Mediterranean Basin is an important diversification center for *Hypericum*: 14 sections have a mainly Mediterranean distribution (Meseguer et al. 2013). *Hypericum* sect. *Drosocarpium* Spach includes 11 species mainly distributed in the east Mediterranean, nine of which occur in Greece (Robson 2010a, Dimopoulos et al. 2013). *Hypericum perforatum* L., distributed from the Iberian Peninsula and northwest Africa eastwards to Anatolia, is the most widespread species of *H. sect. Drosocarpium*. The related *H. trichocaulon* Bois. & Heldr., which is considered a derivative of *H. perforatum* (Robson 2010a), is endemic to Crete. Robson (2010a) identified plants from the Cyclades as *H. perforatum*, but also noticed that plants collected from the islands Naxos and Paros appear intermediate between these two species. Robson

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In the frame of preparatory actions, a species new to science, i.e. *Hypericum cycladicum*, was described from Vori.



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# The study of *A. glutinosa* associated plants in Andros: Results

## *Allium stamatiadae*, a new species of *A. sect. Codonoprasum* (Amaryllidaceae) from Andros island (Aegean Archipelago, Greece)

PANAYIOTIS TRIGAS<sup>1</sup>\* & PEPY BAREKA<sup>2</sup>

<sup>1</sup>Laboratory of Systematic Botany, Department of Crop Science, Agricultural University of Athens, Iera Odos 75, 118 55, Athens, Greece.

<sup>2</sup>trigas@uoa.gr, @ https://orcid.org/0000-0001-9555-7722

<sup>3</sup>bareka@uoa.gr, @ https://orcid.org/0000-0002-3045-4826

\*author for correspondence

### Abstract

*Allium stamatiadae* from Andros island (Cyclades, Aegean archipelago, Greece) is described and illustrated. It belongs to *A. sect. Codonoprasum*, and its closest relatives are *A. orestis*, a local endemic species of southern Peloponnese (Greece) and *A. dirphianum*, another local species from Evvia island (West Aegean, Greece). The new species grows in the understory of riparian forests and is currently known from two localities. The chromosome number of *A. stamatiadae*,  $2n = 2x = 16$ , is reported and a metaphase plate is illustrated.

**Key words:** Greek flora, karyology, Mediterranean flora, plant taxonomy

### Introduction

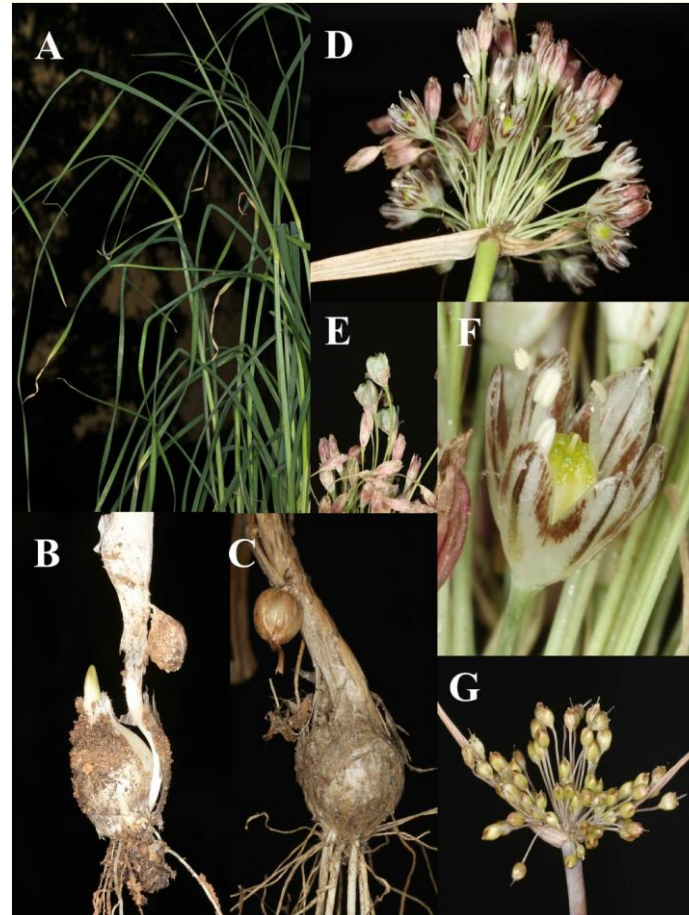
*Allium* Linnæus (1753: 294), comprising about 970 species (Han *et al.* 2020) distributed in the northern hemisphere, is one of the most species rich genera of flowering plants. Its impressive morphological and evolutionary diversity is reflected by the current recognition of 15 subgenera and 80 sections within the genus (Friesen *et al.* 2006). Greece is rich in *Allium* species, as approximately 104 species belonging to 10 sections have been described or recorded from the country.

*Allium sect. Codonoprasum* Rehb. in Mössler (1827: 538) is one of the largest sections of the genus, including numerous species widely diversified in the Mediterranean region. About 23 late summer-autumn flowering species, forming a distinct species group within *A. sect. Codonoprasum* distributed from Italy eastwards to the Middle East, have been described, mostly during the last decades (Ozhatay *et al.* 2018). The members of this group superficially resemble *A. paniculatum* Linnæus (1759: 978), but they are characterized by a distinct ontogenetic cycle which is characterized by a long-lasting vegetative phase and almost a total absence of bulb dormancy (Boğdanović *et al.* 2009, Kalpoutzakis *et al.* 2012, Ozhatay *et al.* 2018). The Aegean archipelago seems to be the main diversity center of this group, as ten species are endemic to the Aegean Islands.

During a botanical survey on Andros island (Cyclades, Central Aegean), conducted for the Life Andros Park (LIFE16 NAT/GR/000606) project, an interesting *Allium* species was collected in the summer 2017. The species was located in a wet riparian forest along Vourkoti stream and it was in early stage of development, both features unusual for an *Allium*. The Vourkoti population was monitored during the coming months, while a second population was discovered in a neighboring stream. Flowering individuals were collected for the first time in September 2018. A careful morphological examination revealed that plants from Andros belong to *A. sect. Codonoprasum* and they are morphologically distinct from all other members of this section known from Greece and the Mediterranean region. This species is described here as *Allium stamatiadae*. It is the second vascular plant species described from Andros during Life Andros Park project, after *Hypericum cycladicum* Trigas (2018: 2). Plants similar to the new *Allium* species from Andros were collected from southern Evvia in 2013 by P. Trigas, and were initially considered to belong to *A. orestis* Kalpoutzakis *et al.* (2012: 196) (Sind 2016). Plants from Evvia, however, have been shown to be tetraploid, with a distinct karyotype, and further research is needed to determine their taxonomic status.

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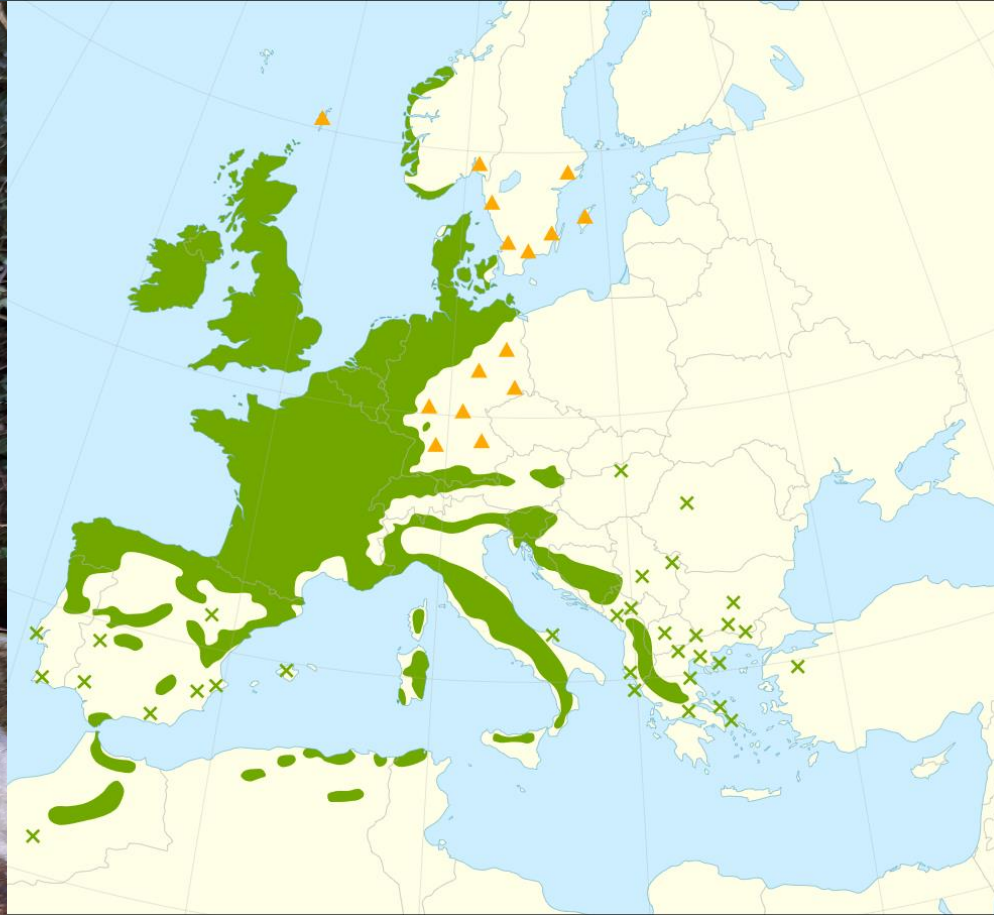
A new plant species (*Allium stamatiadae*) was described from *Alnus glutinosa* and *Platanus orientalis* forests along the Vourkoti and Apoikia streams.



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## The study of *A. glutinosa* associated plants in Andros: Results



An *Ilex aquifolium* population was discovered in the *Alnus glutinosa* forest of Vourkoti stream.

This is the first record of this important plant species in the Cyclades and the southernmost record in the Balkan Peninsula.



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# Establishment of the Botanic Garden and ex-situ conservation actions for selected plants deriving from the habitat 91E0\*, and of macrofungi associated with *Alnus glutinosa*



140 plant species have already been established in the Botanic Garden (Kaireios Library) at Apoikia. Three plant species (*Galanthus ikariae*, *Scilla andria* and *Hypericum cycladicum* distributed in the study areas face increased extinction risk and they have been included in the ex-situ conservation action plan.

Ex-situ conservation actions include establishment of living collections in the Botanic Garden and seed accessions deposited in the AUA's seed bank.



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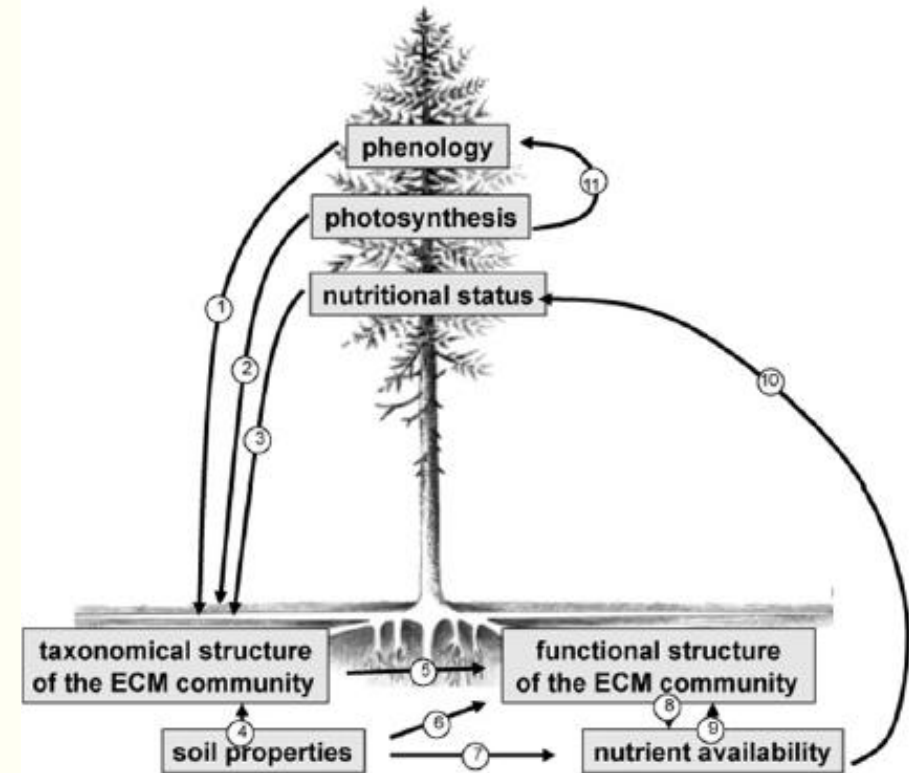
IV. The Fungi (those associated to *Alnus glutinosa*)

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# Plant – Fungi interactions: the ectomycorrhizae

- The fungal symbionts forming ectomycorrhizas, as well as their associated bacteria, benefit forest trees in a number of ways although the most important is enhancing soil nutrient mobilization and uptake.
- This is reciprocated by the allocation of carbohydrates by the tree to the fungus through the root interface, making the relationship a mutualistic association.
- Ectomycorrhizal fungi contribute to a number of key ecosystem functions such as carbon cycling, nutrient mobilization from soil organic matter, nutrient mobilization from soil minerals, and linking trees through common mycorrhizal networks.



Synthetic representation of the causal relationships in an ectomycorrhizal forest ecosystem (source: Courty et al. 2010)



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# Fungi associated with *Alnus glutinosa* – The case of Andros island

- Alder trees are known to form symbiotic relationships with nitrogen-fixing actinomycetes of the genus *Frankia*, with arbuscular mycorrhizal fungi (AM) of Glomeromycota and with various ectomycorrhizal (ECM) fungi of Ascomycota and Basidiomycota.
- ECM fungi of *Alnus* spp. exhibit a remarkably high degree of host specificity compared to other tree species, while alders have a low number (<50) of ECM symbionts worldwide.
- Limited knowledge is available on the diversity of fungi associated with alders in Greece, and only preliminary data have been reported so far.
- On the other hand, Andros is the only Greek island where a systematic inventory of macrofungi is in progress for more than 20 years.
- In the past, 37 mushroom species were reported from *A. glutinosa* habitats in Andros, among which *Entoloma alnicola* was described as a new species for science still known from the type locality only.



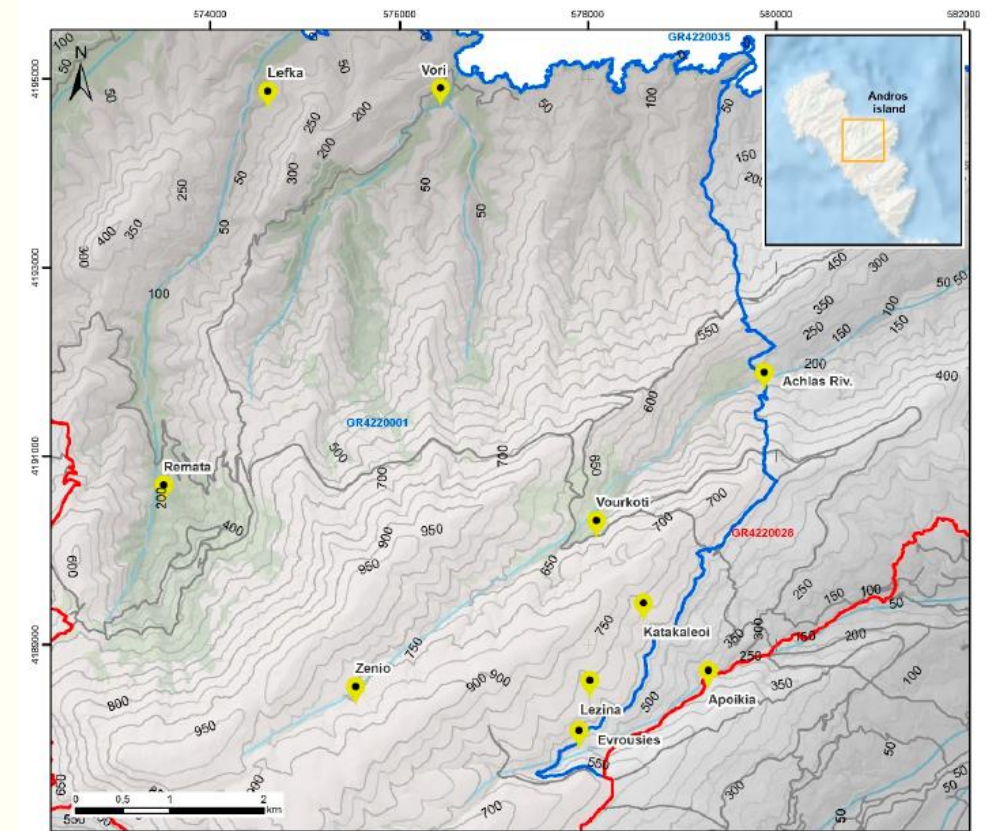
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# The study of *A. glutinosa* associated fungi in Andros: Set-up

- Fungal specimens were collected from 10 sampling sites covering almost the entire area of *A. glutinosa* distribution in Andros island, which appears mainly within (or marginally out) the SCI GR4220001, extending from sea-level to an altitude of ca. 850 m a.s.l.
- The biological material examined was sampled in 38 forays; more than half of those (23) were conducted in the period of the LIFE project (i.e., from 2017 to 2020).
- In total, 187 specimens found exclusively under alder trees or directly on their wood, woody residues or leaf-litter were collected; specimens are deposited in the Fungarium of AUA (ACAM).
- Taxonomically important microscopic morphoanatomical features were studied by high resolution optical microscopy.

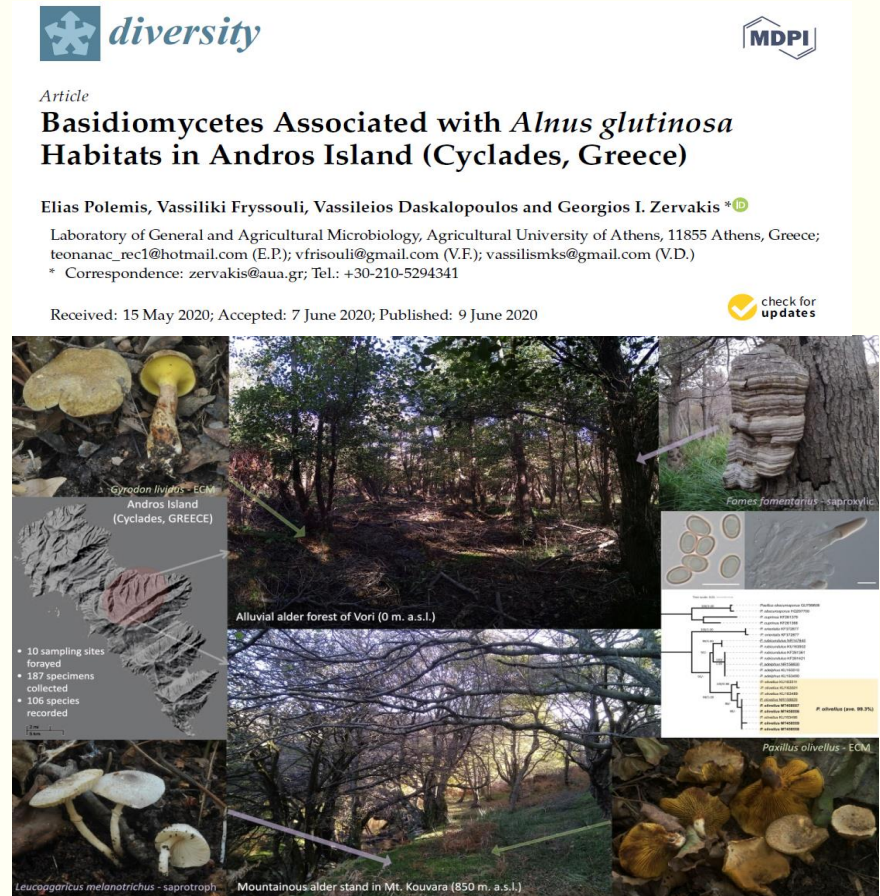


Sampling sites (in yellow marking) in the *Alnus glutinosa* habitat and relative position/size of the area under investigation within Andros island (source: Polemis et al. 2020)



# The study of *A. glutinosa* associated fungi in Andros: Results

- As a result of the forays and subsequent studies, 106 mushroom species were recorded; 92 are saprotrophic and 14 form ectomycorrhizae (ECM) with alders.
- Twenty-one species are first national records, while 68 other species are reported for the first time from this habitat in Greece.
- Several findings are of particular interest due to their rarity, ecological preferences and/or taxonomic status.
- The updated compilation of available data on the basidiomycetes of *Alnus glutinosa* stands of Andros was published in the peer-reviewed scientific journal “Diversity”.

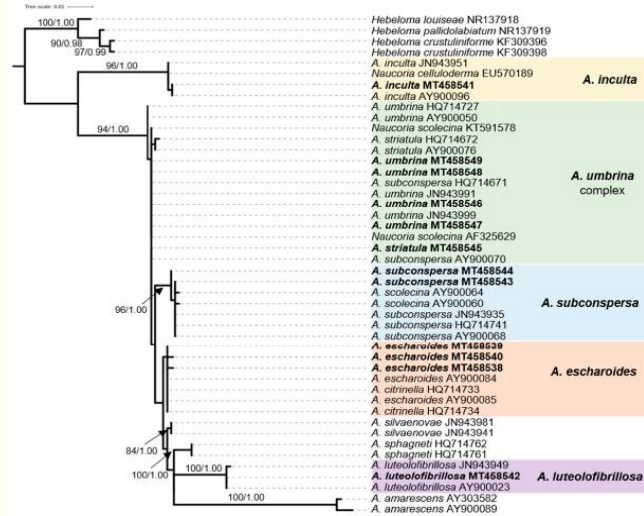


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# Highlights of the Results – Alder-associated ECM species



- 6 ECM species belonging to the genus *Alnicola* (= *Naucoria*), which are exclusively associated with alder trees, were identified in the respective habitat of Andros.
- In total, 14 alder-associated ECM species were recorded on the island, among which 10 are recorded for the first time in Greece.
- The first alder-specific *Cortinari* species (i.e., *C. americanus*) in Greece was found in Andros!



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# Highlights of the Results – New records of saprotrophs and wood-rotting species



- 92 saprotrophs (including wood-rotting) species were found in alder stands of Andros.
- The best represented genera of saproxylic fungi were *Hyphoderma* (three spp.), *Mycena* (four spp.), *Pluteus* (four spp.) and *Psathyrella* (four spp. on woody residues or buried wood). In total, seven species recorded on dead wood or bark of living alder trees are recorded for the first time in Greece.
- The presence of a rare European species was confirmed, namely *Entoloma uranochroum* recorded for the first time in an alder habitat, while it was reported so far from subalpine meadows in Austria and the French Alps.



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# The study of *A. glutinosa* associated fungi in Andros: Future work

- A small number of studied specimens remain unidentified to species level and phylogenetic analyses conducted so far suggest that some of them could represent new species for science.
- Additional forays are planned in the upcoming seasons to assess the diversity of hypogeous mushroom species in Andros alder stands.
- Below-ground fungal diversity research activities, including ECM-root tips (#174), are in progress for detecting more ECM mushroom species that are not recorded yet in the form of epigeous sporocarps.
- The checklist will be regularly updated with the new findings until the end of the project (as well as during After LIFE) in the frame of monitoring the macrofungi associated with the key-plant element.



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# “THE FOREST ELEMENT”

V. The Outcome (*Alnus glutinosa* coexistence with fungi!)

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# Exploitation of the results from the Preparatory Actions – Restoration of the *A. glutinosa* priority habitat (1)

- Restoration of approx. 11 ha of degraded/destroyed alluvial alder stands in Andros is in progress by preparing approx. 15000 (vs. 11000 initially foreseen) inoculated seedlings.
- Pertinent activities began by implementing the early phases, e.g. seed collection, nursery establishment, seedlings production and fungal inocula preparation followed by the seedlings plantation at the restoration sites in two consecutive years (2018-19, 2019-20) to be followed by a third one (2020-21).
- The initial development and inoculation of alder seedlings was accomplished at AUA for better control over plant growth and maintenance.
- Alder seeds germination followed their wet stratification in sterilized silica sand at 4 °C. Intermediate germination tests were performed to determine the seeds germination index (ca. 50%).



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# Exploitation of the results from the Preparatory Actions – Restoration of the *A. glutinosa* priority habitat (2)

- In parallel, collection of ectomycorrhizal fungi was performed in alder habitats of Andros.
- Pure cultures were established from basidiomata of ECM fungi to serve as inocula for the alder seedlings.
- Moreover, three additional inoculation methodologies were examined: (a) by suspensions of various ECM spores deriving from basidiomata of various ECM species, (b) through the use of *Paxillus olivellus* hymenophore-slices used in the form of suspension in water, and (c) by using natural rhizosphere-soil from the priority habitat as substrate-component for the growth of seedlings.
- All methodologies were applied either before sowing or just after alder seeds first transplantation.



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# Exploitation of the results from the Preparatory Actions – Restoration of the *A. glutinosa* priority habitat (3)

- Sowing of alder seeds, inoculation with ECMs and initial development of young plants was accomplished at AUA's premises, and then the young plants remained for a few months at the Agadaki Estate (Apoikia, Andros) before being transferred at the restoration areas (Vori and Lefka, Andros).
- The assessment of mycorrhizal colonization was performed six months after inoculation.
- Four ECM morphotypes were detected: on the roots of colonized alder seedlings: (a, b) two dominant and abundant *Tomentella* spp., (c) one paxilloid form, (d) one whose identity is currently under study.



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# Exploitation of the results from the Preparatory Actions – Restoration of the *A. glutinosa* priority habitat (4)

- Three consecutive lots of approx. 15000 inoculated alders seedlings were produced at AUA's nursery facilities.
- Approx. 11000 have already been planted at the restoration areas (Lefka and Vori). In addition, other 4000 plants are growing in AUA's nursery.
- At the end of hot/dry seasons, many plants did not survive adverse weather conditions and overgrazing.
- However, 10+5 fenced 'alder nuclei' grow well at Vori and Lefka. These will be exploited in future transplantations and maintenance.



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## Exploitation of the results from the Preparatory Actions – Restoration of the *A. glutinosa* priority habitat (5)

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# Restoration of the alluvial alder forests in Andros – Conclusions

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- The environmental conditions at Vori seem to be favorable for the establishment of alders, especially after the successful intervention which resulted at draining most of the stagnant water at the estuary. Plants growth rate and robustness are satisfactory. The already existing web of symbiotic microorganisms seem to highly support seedlings establishment and well-being. It is estimated that a complete restoration will be achieved within the next 5-10 years.
- On the basis of the observations made so far, suitable sites for alder establishment in Lefka stream are limited in number. Consequently, only a few hundred plants can survive at favorable positions characterized by small-scale alluvial deposits along the stream and always inside fences. Therefore, the realistic goal is to create some healthy and robust ‘alder nuclei’ which will help re-introduce alder trees in the area, and subsequently form the basis of the their long-term establishment.



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Thank you for the attention!

Key-members of AUA's research team: V. Daskalopoulos, V. Fryssouli, P. Georgiou, I. Kefalogianni, E. Polemis, P. Trigas and G. Zervakis



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