Giacche Verdi Bronte

Manfred-Hermsen-Stiftung
für Natur und Umwelt

Supported by:

Federal Ministry
for Economic Affairs
and Climate Action

on the basis of a decision
by the German Bundestag

European
Climate Initiative
EUKI

Study and comparison of Herb Biodiversity in Pure Pine Forest and Mixed Pine-Oak Forest in Mount Egitto on Mount Etna

Contents

Study and comparison of Herb Biodiversity in Pure Pine Forest and Mixed Pine-Oak forest in Mount Egitto on Mount Etna

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Abstract-

Forest's health depends on various factors and one of them being how biodiverse it is but is now threatened by anthropogenic disturbance. Old and diverse forests are known to be more resistant to changing climate and act as a greater carbon sink. In Mount Egitto, a small forest on Mount Etna where the study was conducted on the status of herb diversity in two major types of forests namely, pure pine forest and mixed Pine-Oak forest. The dominant tree species were *Pinus nigra* and *Quercus pubescens.* We found that mean herb diversity in mixed Pine-Oak forest was significantly higher compared to pure Pine forest. The same trend was seen in herb species richness and evenness both being significantly higher in mixed Pine-Oak forest. It is hypothesised that the following results are due to dense pine plantation and mixed forests that promote more undergrowth species. Further studies are needed to understand current forest conditions and take action to increase forest diversity and combat climate change.

Introduction-

An UNESCO site, Mount Etna is famous for being Europe's biggest and one of the most active volcano on Earth. Mt Etna peak with 3,357m altitude makes it the tallest peak below the Alps in Italy. This also leads to different vegetation types in different parts of Mt Etna. The vascular plant species richness increases till 1000m asl and then starts declining but the endemic richness increases with altitude and highest being at 2,500 up to 2,800 m a.s.l. With 8.7% of all species being endemic (Sciandrello et al., 2020). The forest structure is dominated by *Quercus ilex L, Quercus pubescens, Fagus sylvatica, Castanea sativa, and Pinus nigra* with certain species

dominating at a certain altitude (Maetzke et al., 2017). Sicily just left with a few old forests and among them, one is located at Mount Egitto at an altitude between 1550-1610m asl on Mount Etna with old *Quercus pubescens* (Maetzke et al., 2017). After WW2, there was an increase in natural forests and the reforestation of conifer stands by public authorities which changed the forest structure around Sicily(La Mela Veca et al., 2016). Mount Egitto was affected by *Pinus nigra* which was favoured for reforestation by the regional authorities as an effort to restorative green areas, but with plantation high density of pines started taking over old oak parts of the forest, endangering them and changing the healthy Pine-Oak forest to a monoculture Pine forest (Maetzke et al., 2017).

A healthy forest is characterized by its biodiversity. 77% of terrestrial parts of the planet are altered by anthropogenic activities which cause the loss of half of the plant biomass (IPBES-IPCC report, 2021). The current Italian reforestation practice started in the 1960s and Pine species were primarily favoured (Navarro et al., 2005). There are negative impacts of choosing only a few species for reforestation and often lead to a monoculture forest. The negative impact of monoculture forests is not just the low diversity of tree species but also impacts other flora and fauna diversity. Genera Pinus and Eucalyptus are the most commonly used for forest plantations around the world and account for around 30% of total planted forests (Carnus et al., 2006). Low diversity conifer plantations are associated with low soil pH and less phosphorus and nitrogen content in soil (Firn et al., 2007). A study in Western Himalayas also found that herb species richness, density, total basal area and diversity were lower in pure pine forests than in mixed pine-oak forests (Gurarni et al., 2010). Bird and Bee species are also recorded higher in the natural forests than in monoculture (Hua et al., 2016). Monoculture forests in all climatic regions are more susceptible to insect outbreaks or pathogen epidemics (Carnus et al., 2006) whereas high tree density is more resistant to natural disturbances (Jactel et al., 2017). Recently monoculture conifer forests were being converted into more diverse forests in different parts which can promote biological diversity (Felton et al., 2010, Pukkala et al., 2018), and productivity of forest (de-Dios-Garcia et al., 2015).

The broad objectives of the study are to study the herb biodiversity in the changing forest structure of Mt Egitto on Mount Etna and to highlight the importance of mixed forest on healthy

biodiversity. This study is part of the Giacche Verdi Bronte project "**Humus per la Biosfera**" and contributes to the protection of the ancient oaks of Mt. Egitto (http://etna-monumental-oaks.org/). This study is intended to support the conservation of the multi-centenary oaks on Mt Egitto and to confirm our assumption that biodiversity is higher in an oak-pine forest than in a pure pine forest. It is known that increasing forest biodiversity also sequesters more carbon from the atmosphere. Therefore, the preservation of a species-rich forest is an active contribution to climate protection.

Material and Methods-

The study was carried out in July and August 2022 at Mount Egitto. The site is a small secondary eruptive cone on the north-western slope of Mount Etna at an altitude of around 1600m asl, surrounded by lava fields in zone A of Parco dell'etna and is part of the territory of the Municipality of Bronte (Figure 1). The forest of Mount Egitto is dominated by *Quercus pubescens, Pinus nigra* and *Populus tremula* on the forest edges. Some of the *Quercus pubescens* are older than 500 years old.

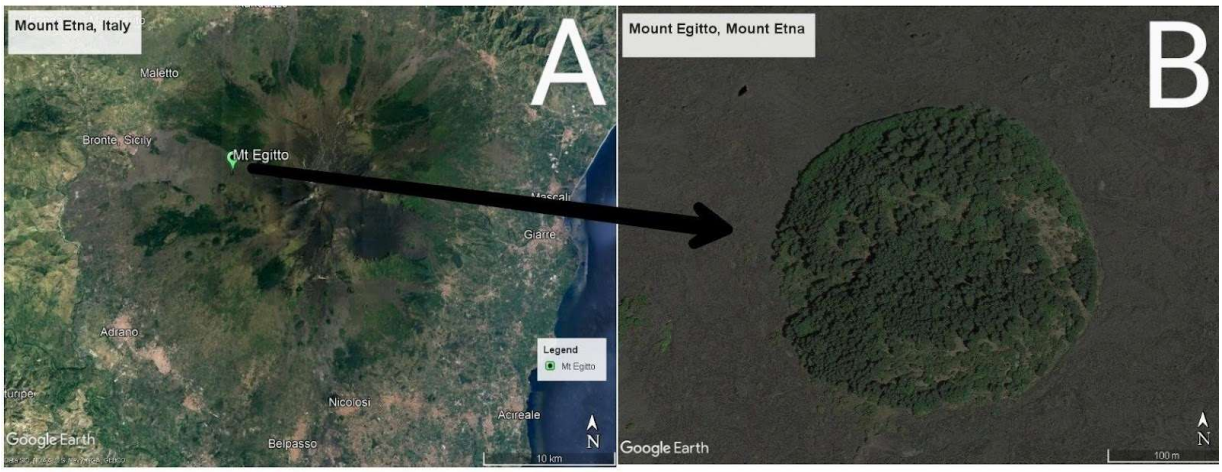

Figure 1. A- Location of Mount Egitto within Mount Etna; B- Studied forest of Mount Egitto surrounded by lava fields.

The forest was thoroughly surveyed to identify sites for pure *Pinus nigra* forest and mixed pine-oak forest. The part of the forest which has monoculture pine forests is not affected by other tree species and the forest ground is littered only with pine needles was considered a pure pine forest. The part of the forest which has interactions primarily by pine-oak with other trees like populus and large shrubs like *Genista aetnensis* was considered a mixed pine-oak forest (Figure 2).

In the forest, a total of 40 quadrates of size $1m^2$ were studied in both types of forest. The quadrates were studied randomly. Brief flora literature was prepared in advance using the flora of Etna and prior flora studies of Mt Egitto (Maetzke et al., 2017). All the plots were studied thoroughly and each herb species was noted with the number of individuals of each herb species present in each plot. Later Shannonwiener information index was used to calculate the herb diversity of every plot:

$H = - \Sigma (ni/n) \log 2 (ni/n)$

(ni is the number of individuals of a species and n the total individual of all species).

And herb species evenness was calculated using:

$E = H / \ln(k)$

(where H is species diversity and k is the number of species)

For the scientific analysis R software was used.

Figure 2. A- The part of the studied forest with only Pine stands; B- Part of forest with mixed Pine-Oak forest

Result-

Herb Species Richness, Herb diversity and Evenness

A total of 22 herb Species were recorded from the 40 studied plots with average species richness of 2.35±0.6708 in plots of Pure Pine Forest and 3.35±0.745 in plots of Mixed Pine-Oak forest (Table 1).

Figure 3. A- Herb Species richness and diversity were lower in Pure Pine forest (A) compared to Mixed Oak-Pine forest (B)

Mean herb species diversity was significantly higher ($P<0.001$) in Mixed Pine-Oak forest compared to Pure Pine forest with a diversity value of 1.0704±0.215 and 0.6849±0.3058 respectively (Figure 4). The same trend was seen with mean herb species evenness with significantly high ($P<0.05$) in Mixed Pine-Oak forest compared to Pure Pine forest with an evenness score of 0.9071±0.0877 and 0.7635±0.289 respectively (Figure 4).

Table 1. Herb Species observed in Pure Pine forest and Mixed Pine-Oak forest

Pure Pine Forest	Mixed Pine-Oak Forest
Brachypodium sylvaticum (Huds.) P. Beauv.	*Allium paniculatum L.*
Daucus carota L. subsp. carota	*Brachypodium sylvaticum (Huds.) P. Beauv.*
Luzula sicula Parl.	*Cachrys ferulacea (L.) Calest.*
Muscari comosum(L.) Mill.	*Lathyrus grandiflorus Sm.*
Orobanche rapum-genistae Thuill. subsp. rapum-genistae	*Clinopodium vulgare L. subsp. arundanum (Boiss.) NymanCastanopsis hystrix*
Pteridium aquilinum (L.) Kuhn	*Crepis leontodontoides All.*
Silene italica (L.) Pers.	*Lathyrus pratensis L. subsp. pratensis*
Tanacetum vulgare L, subso. siculum (Guss.)	*Luzula sicula Parl.*
Teucrium chamaedrys L.	*Daucus carota L. subsp. carota*
Teucrium siculum (Raf.) Guss.	*Festuca heterophylla Lam.*
Trifolium repens L.	*Galium aparine L. subsp. aparine*
Viola alba Besser subsp. dehnhardtii (Ten.) W. Becker	*Galium odoratum (L.) Scop.*
	Muscari comosum(L.) Mill.
	Pteridium aquilinum (L.) Kuhn
	Silene italica (L.) Pers.
	Teucrium chamaedrys L.
	Teucrium siculum (Raf.) Guss.F

	Viola alba Besser subsp. dehnhardtii (Ten.) W. Becker

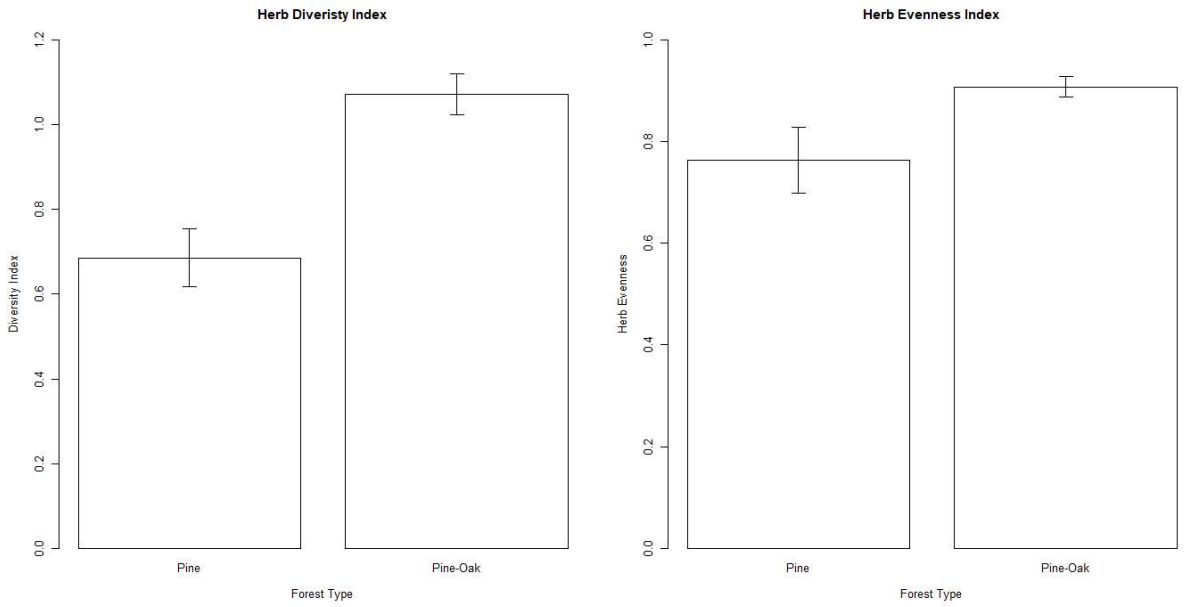

Figure 4. Mean Herb Diversity (P<0.001) and Mean Evenness (P<0.05) were significantly high in Mixed Pine-Oak forest and lower in Pure Pine forest.

Discussion-

Forests on Etna have been changed and threatened by Anthropogenic disturbance in the past century. Although species richness has been increasing for many million years, now we are entering another mass extinction and if the ongoing rate of extinction, recovery doesn't look possible (Spies et al., 1999). In many recent reports, Conservation biologists have warned that around 25% of all species on the planet could become extinct in the next 2-3 decades. In the present study, herb biodiversity is assessed by quantitative analysis of forest vegetation in the two types of parts of the forest on the northwest slope of Mount Etna in Sicily.

The mixed pine-oak forest showed more herb species richness than the pure pine forest. The same was observed with herb evenness and herb diversity being higher in pine-oak forests and

lower in the pure pine forests. There was also a higher standard deviation observed with herb evenness and diversity in the case of pure pine forest and indicating that the herb species composition was not equally distributed in Pure pine forest thus less stable.

Species diversity can be affected by various factors from soil nutrient level to the structure of woody species in a forest. *Pinus nigra,* like the other deciduous areas in the region, is known to hold about 100 species (Quézel et al., 1999) but lower herb biodiversity indicates that monoculture pine forest holds lesser species than mixed pine-oak forests. The pine plantation on mount Egitto is densely and uniformly planted. Uniform plantation is easy to administer but clumped plantation can be beneficial for biodiversity by supporting variation in microclimate, availability of light and plant distribution (Harrington., 1999). An important factor is the properties of soil. The positive impact of the Mixed Pine-Oak stand is that it promotes higher soil microbial activities in the humus layer which help in changing biological, physical and chemical properties of humus layers favourable to undergrowth species (Bargali et al., 2018, Błońska et al., 2013) due to different qualities and quantities of litter (Bargali et al., 2018).

Various forests are being converted from monoculture to mixed forests in recent times and this can increase the biological diversity of various species representing a diverse range of trophic levels, taxonomic affinities, and ecological niches (Felton et al., 2010). Mixed Pine Oak forest also holds higher total ecosystem carbon content than pure pine stands (Lee et al., 2009) with mixed stands having higher carbon stocks than pure oak and pine stands (Alvarez et al., 2014, Wiesmeier et al., 2013) and Mixed forest is more immune to the reduction of C stocks due to climate change and thus better option for C sequestration against climate change (Alvarez et al., 2014).

Conclusion-

Our results indicated that the Mixed Pine-Oak forest holds higher herb diversity compared to the Pure Pine forest on Mt. Egitto. Various factors can be responsible for the result like forest structure, availability of light, and soil properties. The anthropogenic intervention a few decades ago now is not just threatening old Oaks but also the forest diversity. However more studies are

recommended like the study of insect diversity, shrub diversity and soil properties in both types of forest and the introduction of more woody species is necessary to increase the diversity of the forest.

Acknowledgements-

The study was supported by Giacche Verdi Bronte, Sicily, Italy and Manfred-Hermsen-Stiftung für Natur und Umwelt, Bremen, Germany. I thank Salvatore Vinciguerra for supervising the study and for providing supportive flora and species identification keys. Lastly, I thank Loretta Miehle who was a great help during the fieldwork.

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Appendices

Table 2. Herb Species Diversity and Species Evenness of each plot in both types of forests

Herb Species diversity and Species evenness in Mt. Egitto

Plot No.	Forest Type	Species diverity index	Species evenness
1.01	Pure Pine Stand	0.673	0.971
1.02	Pure Pine Stand	0.5	0.722
1.03	Pure Pine Stand	0.956	0.87
1.04	Pure Pine Stand	0.637	0.918
1.05	Pure Pine Stand	0.683	0.985
1.06	Pure Pine Stand	0	0
1.07	Pure Pine Stand	0.655	0.946
1.08	Pure Pine Stand	0	0
1.09	Pure Pine Stand	0.802	0.73
1.1	Pure Pine Stand	1.01	0.921
1.11	Pure Pine Stand	0.637	0.918
1.12	Pure Pine Stand	0.974	0.887
1.13	Pure Pine Stand	0.96	0.873
1.14	Pure Pine Stand	0.41	0.592
1.15	Pure Pine Stand	0.95	0.865
1.16	Pure Pine Stand	0.956	0.87
1.17	Pure Pine Stand	0.802	0.73
1.18	Pure Pine Stand	1.03	0.937
1.19	Pure Pine Stand	0.687	0.991
1.2	Pure Pine Stand	0.377	0.544
2.01	Mixed Pine-Oak	1.04	0.946
2.02	Mixed Pine-Oak	1.36	0.845
2.03	Mixed Pine-Oak	1.2	0.862
2.04	Mixed Pine-Oak	1.33	0.959
2.05	Mixed Pine-Oak	1.04	0.944
2.06	Mixed Pine-Oak	1.05	0.96
2.07	Mixed Pine-Oak	0.683	0.985
2.08	Mixed Pine-Oak	1.24	0.894
2.09	Mixed Pine-Oak	1.27	0.918
2.1	Mixed Pine-Oak	1.09	0.991
2.11	Mixed Pine-Oak	0.703	0.64
2.12	Mixed Pine-Oak	0.947	0.862
2.13	Mixed Pine-Oak	0.652	0.94
2.14	Mixed Pine-Oak	1.29	0.932
2.15	Mixed Pine-Oak	0.824	0.75
2.16	Mixed Pine-Oak	1.08	0.981
2.17	Mixed Pine-Oak	1.05	0.955
2.18	Mixed Pine-Oak	1.18	0.852
2.19	Mixed Pine-Oak	1.29	0.934
2.2	Mixed Pine-Oak	1.09	0.992

Appendices

Some herb Species observed in Mt. Egitto

Teucrium chamaedrys L.

Teucrium siculum (Raf.) Guss.

Muscari comosum(L.) Mill.

Orobanche rapum-genistae Thuill.

subsp. rapum-genistae

Silene italica (L.) Pers.

Brachypodium sylvaticum (Huds.) P. Beauv