6th International Conference on Sustainable Development in the Minerals Industry 30 June – 3 July 2013 Milos Island

Biodiversity Programme in two quarries in the Volos area

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There are 5 basic criteria for succesful rehabilitation:

- *Sustainability*
- *Resistance to the invasion of new species*
- *Productivity*
- *The availability of nutrients*
- *Bio-exchanges*

When quarry rehabilitation is planned, the required end results and the method used should be known beforehand

The most common target for the rehabilitation of an area is to re-establish the ecosystem as it existed before any disturbance took place. For this reason, the following data concerning the original ecosystem are required :

- *A study for the flora of the region samples of botanic areas.*
- *Aerial photographs of the region*
- *A study of an area with a similar ecosystem.*

The most practical method of rehabilitation is to use as a guide the existing vegetation in the surrounding areas before replanting in the quarry

The aim of the research

The aim of the study was to both record and observe the biodiversity as well as to make proposals which could be the basis of a rehabilitation plan and the enhancement of the local biodiversity, for the two quarry.

- *University of Thessaly*
- *National Institution for Agricultural Research (ETHIAGE)*
- *Botanical University of Athens*

Areas of study

The study was carried out on the two Lafarge quarries in Agria and Anavra.

- *The Agria quarry*

Areas of study

The Anavra quarry

BIRDS

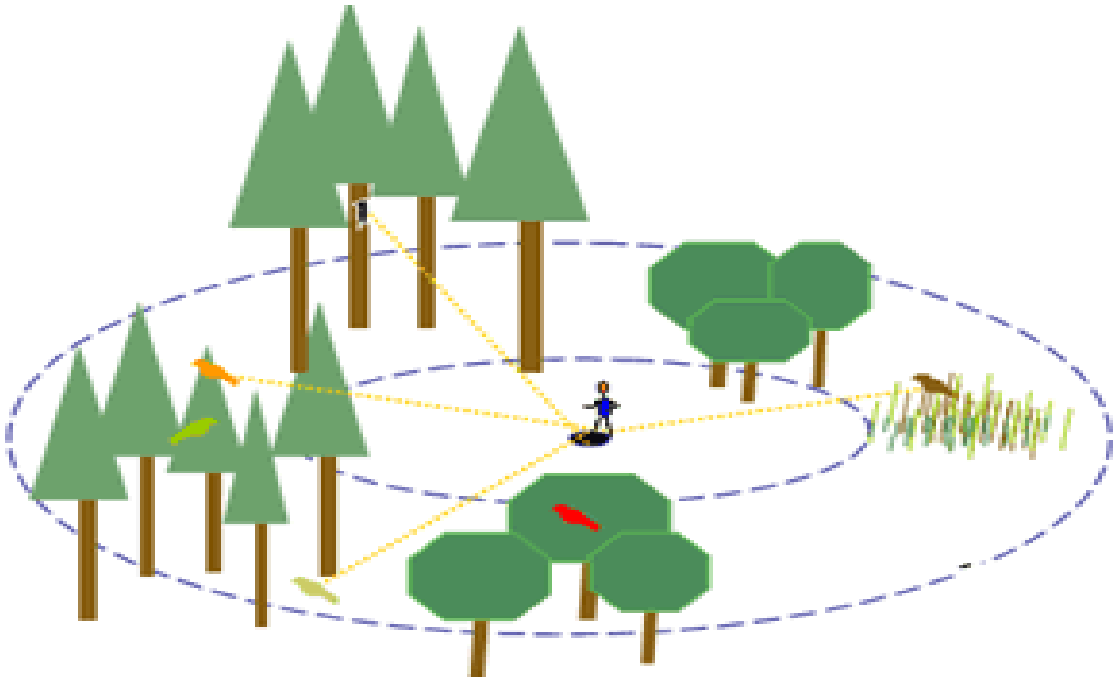
The study of birds took place between May and June of 2011 and 2012 in order to include the breeding season of birds

The diversity and abundance of birds was studied first since they are considered very representative indices of the structure and composition of the ecosystem

Observations were performed

- *during the early hours of the morning until 10.30 a.m*
- *When was no rain or wind*

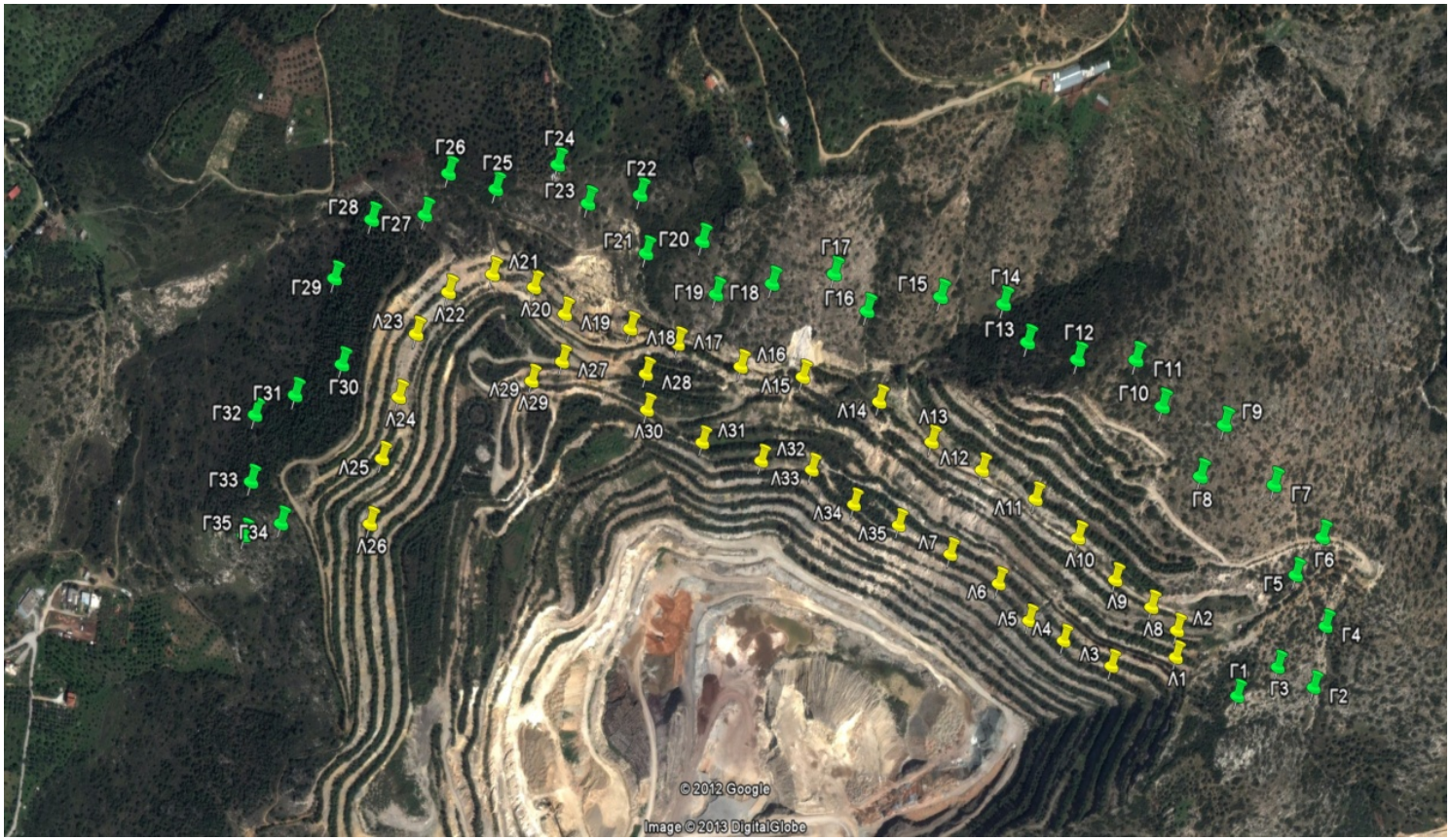
The Point Count Method was employed by two observers



The number of sampling areas was 35 for the quarry and

Birds

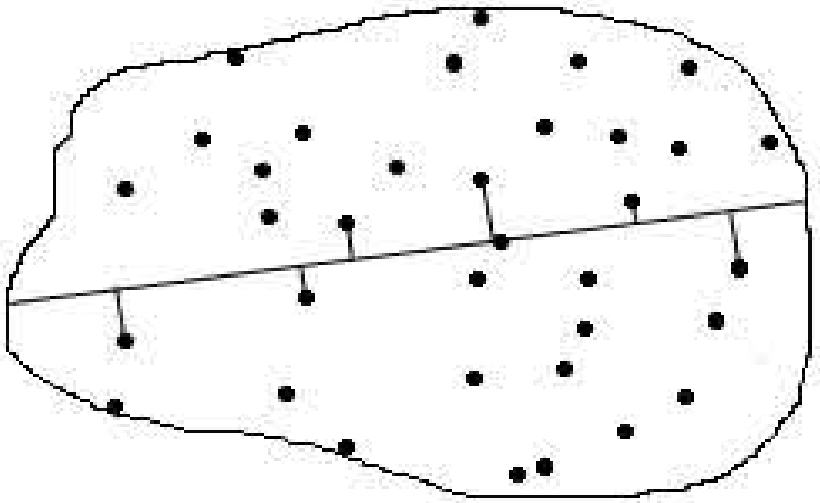
- *The number of sampling areas was 35 for the quarry and 35 for the surrounding area*



Mammals

The study of mammals was based on bio traces – *line transects method* –

e.g footprints, excrement, broken branches etc



Statistical analysis

For the analysis of the data regarding birds, the following tests were used:

- *The ANOVA method*
- *HSD or Tukey test*

With the aid of indices, the disturbance, the type and homogeneity of each species were calculated .

FLORAL DIVERSITY

Regarding the diversity of flora samples were taken both from the quarries and surrounding areas.

Sampling areas, a frame of 5 X 5 m was used for trees and bushes and another one of 0,5 X 0,5 m for shrubs.

- *The sampling areas outside the quarry were set randomly and the number of trees and bushes, the different types and the height of each one were recorded*.
- *In the quarry, the sampling areas were placed along the benches (top, middle and bottom benches*

128 samples wre selected in total in both quarries (64 for trees and bushes and 64 for shrubs)

The flora existing in the Agria quarry includes 207 types of taxa plant.

This number is quite high and indicates that the floral diversity is quite developed in the quarry

Table : Trees and Bushes in the Agria quarry

Diversity index	Reference area	Upper benches	Middle benches	Lower benches
Number recorded	22	14	14	10
Shannon-Wiener index	2.012	1.644	1.797	1.240
Simpson index	0.816	0.681	0.783	0.557
Pielou in-dex	0.651	0.623	0.681	0.539

Regarding Shrubs

In general, the rehabilitated areas have fewer types of shrubs compared to the surrounding areas.

Table : Shrubs in the Agria quarry

Diversity index	Reference area	Upper benches	Middle benches	Lower benches
Number recorded	49	39	14	15
Shannon-Wiener index	2.735	2.728	1.907	1.878
Simpson index	0.875	0.878	0.741	0.762
Pielou in-dex	0.703	0.745	0.722	0.693

Flora “of note” in Agria

The term “of note” includes rare, endemic, or plants which tend to disappear, the presence of which in the quarry could be attractive for environmental reasons as well as educational .

A list of such plants:

1. *Centaurea pelia DC*
2. *Dianthus haematacalyx*
3. *Bolanthus thymifolius*
4. *Nigella arvensis*
5. *Crepis hellenica kamari*

Diversity of flora in the Anavra quarry

On the benches of the Anavra quarry, 107 taxa were recorded (18 trees and bushes and 89 shrubs)

Diversity index	Reference area	Upper benches	Middle benches	Lower benches
Number recorded	13	8	6	4
Shannon-Wiener index	2.735	1.339	1.480	1.381
Simpson index	0.895	0.612	0.750	0.761
Pielou index	0.907	0.644	0.826	0.996

Biodiversity on Shrubs

The number of shrubs is higher in the lower, followed by the outside area and the higher and middle benches respectively

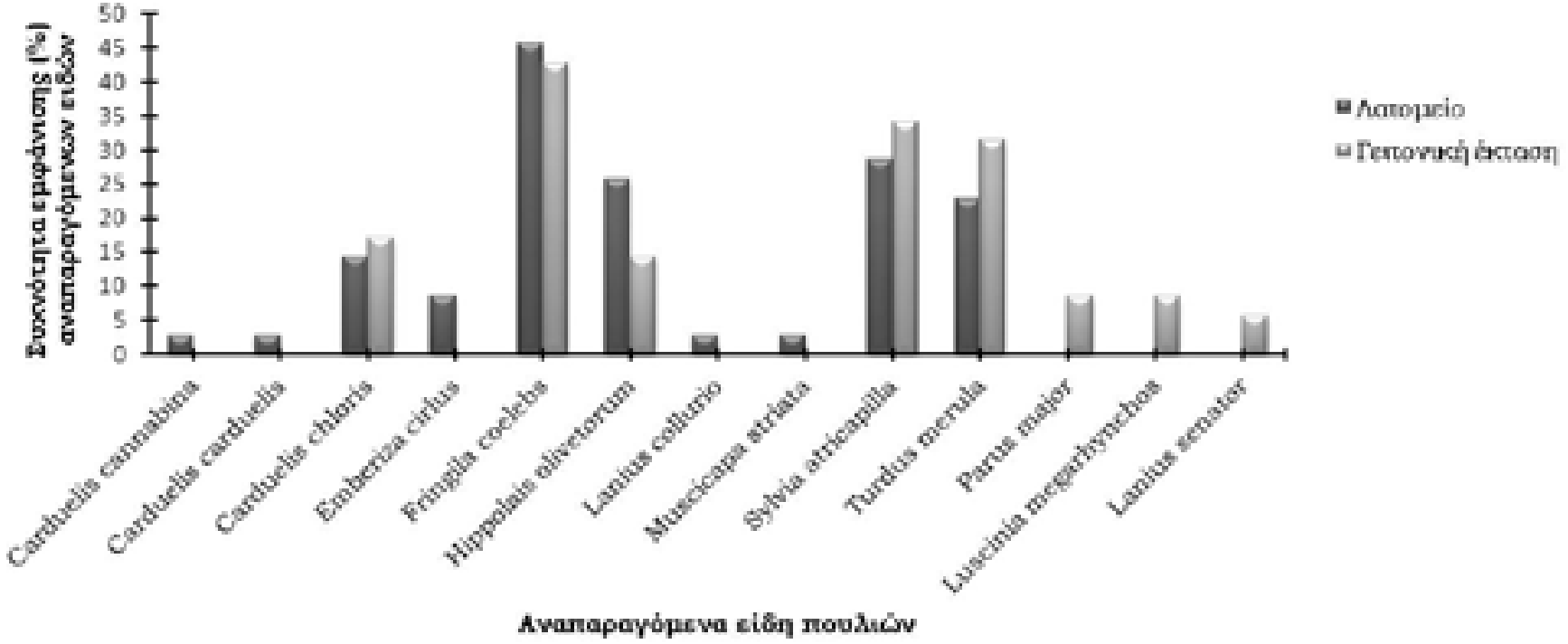
Diversity index	Reference area	Upper benches	Middle benches	Lower benches
Number recorded	53	33	34	67
Shannon-Wiener index	3.295	1.541	2.848	3.179
Simpson index	0.942	0.698	0.917	0.927
Pielou in-dex	0.830	0.441	0.808	0.756

In the area of Agria, 13 different types of birds were obseved while in the nearby area, 8 different types were noted

Type of bird	Quarry	Surrounding area
Carduelis cannabina	+	
Carduelis carduelis	+	
Carduelis chloris	+	+
Emberiza cirlus	+	
Fringilla coelebs	+	+
Hippolais olivetorum	+	+
Lanius collurio	+	
Muscicapa striata	+	
Sylvia atricapilla	+	+
Turdus merula	+	+
Parus major	+	
Luscinia megarhynchos	+	
Lanius senator	+	
TOTAL	10	8

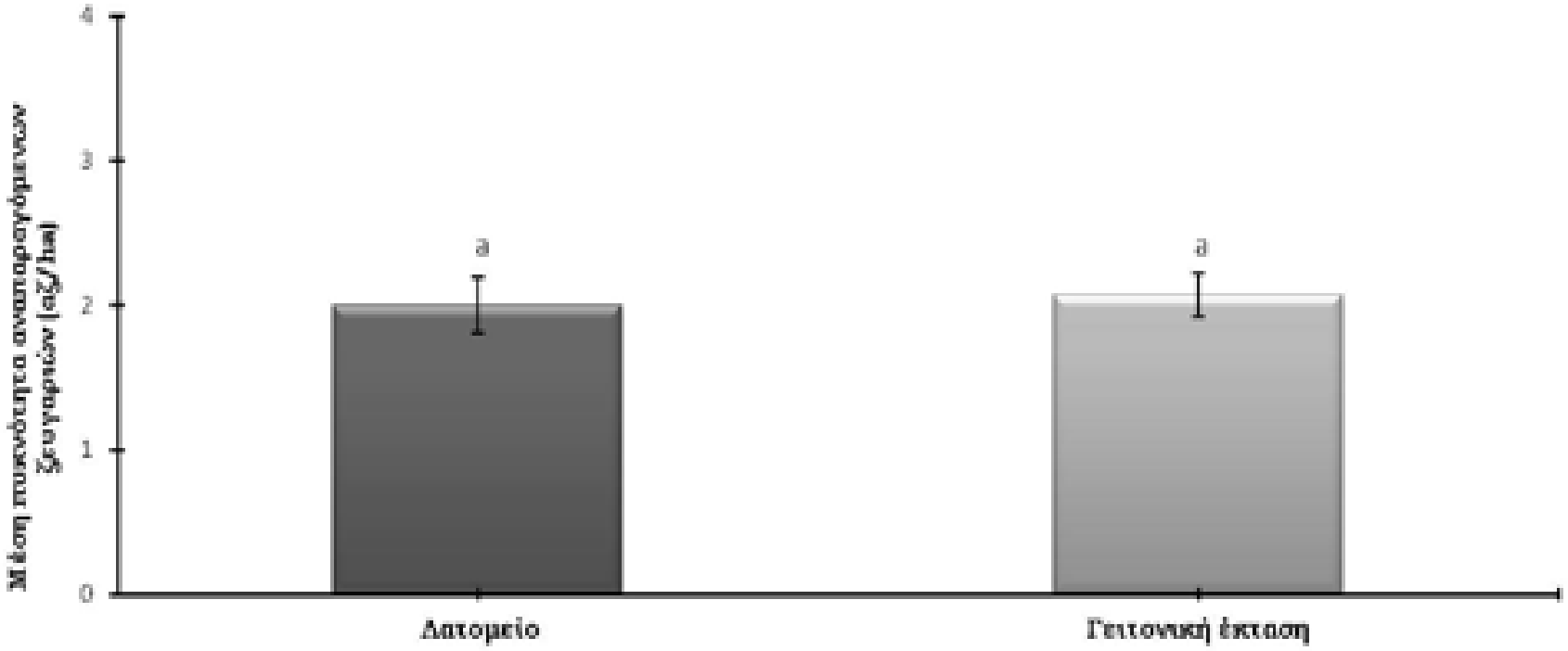
Aria quarry

Frequency of the appearance of reproductive birds.



Agria quarry

Density of types of reproductive birds



Reproductive birds recorded in Anavra, 3 types in the quarry, 10 on the quarry borders and 13 in the outside area

SPECIES	QUARRY	QUARRY BORDER	OUTSIDE AREA
Carduelis chloris		+	+
Cuculus canorus		+	+
Emberiza cirlus		+	+
Erithacus rubecula		+	+
Fringilla coelebs		+	+
Garrulus glandarius		+	+
Luscinia megarhynchos			+
Oenanthe oenanthe	+		
Parus caeruleus		+	+
Parus lugubris	+		+
Parus major		+	+
Sitta europaea			+
Streptopelia turtur		+	+
Turdus merula	+	+	+
TOTAL	**3**	**10**	**13**

Mammals

In Agria, 5 types of mammals were recorded in the quarry and 6 outside. The mammals recorded were :

- *By sight, (the fox)*
- *By footprint traces in wet ground (the badger, wildcat & fox)*
- *In resting places (the boar)*

SPECIES	QUARRY	OUTSIDE
Felis silvestris		+
Lepus europaeus	+	+
Martes foina	+	+
Sus scrofa	+	+
Vulpes vulpes	+	+
TOTAL	**5**	**6**

Mammals in Anavra

In Anavra, 3 types of mammals were observed in the quarry and 4 in the neighbouring area.

SPECIES	QUARRY	OUTSIDE
Lepus europaeus	+	+
Martes foina	+	+
Sus scrofa		+
Vulpes vulpes	+	+
TOTAL	**3**	**4**

Agria

Some of the proposals on how to improve the floral diversity are:

- *To continue the rehabilitation work,*
- *To avoid using non-local plants*
- *At the top benches where the growth of coniferous trees is dense to create areas where local plantation can be frown*
- *Areas with natural vegetation , to be used as a :source" of natural plantation in the quarry*
- *To use climbing plants in the slopes (hedera helix, capparis spinosa, centranthus rubber etc)*

Some of the proposals are:

- *Rehabilitation works should be carried out carefully in order not to disturb the small ponds.*
- *To avoid non-local taxa since their longevity is unknown*
- *The material at the slope of the lower benches is very fine and prone to erosion. The local plants which have a tendency to cover the surface of the soil should be used (clematis vitalba, rosa spp, rubus spp etc)*
- *To continue monitoring the progress of the rehabilitation and to intervene when needed*

- *In order to offer "nesting" and resting facilities to mammals some of the following plants should be grown (pinus brutia, cupressus sempervirens, medicago arborea, spartium junceum, cercis siliquastrum etc)*
- *To build a form of natural fence around the quarry in order to provide security during breeding periods, and shelter for small mammals.*
- *Some shrubs (agropytum cristatum, lollium rigidum, medicago sativa etc) attract different types of birds and small mammals.*
- *In order to improve the quarries' as habitat, it is necessary to carry out same small works to improve the life of mammals.*
  - *To provide water in the dry summer months*
  - *Food in the winter time*
- *To create artificial nests*
- *To strategically place materials such woods, stones leaves etc to help mammals and birds*