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# Factors affecting tree growth in bauxite mining wastes

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# Contents

- New legislative framework
- Common used herbaceous and woody species for restoration
- Bauxite
- The project
- Materials and Methods
- Results
- Conclusion



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# Restoration

- Restoration of bauxite mining areas constitutes a difficult issue to address due to the destruction of the vegetation and soil decay of the excavated area. The traditional approach to reclamation has been to sow grass and legumes and plant trees to minimize financial and human resource expenditures. In general, the establishment of woody species on degraded lands is highly variable due to the many soil conditions factors that affect vegetation's success.



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# Common used Herbaceous species for restoration

## graminaceous plants

- *Agropyrum cristatum*
- *Lolium rigidum*
- *Dactylis glomerata*
- *Phalaris aquatica*

## leguminous plants

- *Medicago sativa*
- *Medicago lupulina*
- *Onobrychis sativa*

## broad-leaved herb

- *Sanguisorba minor*
- *Phacelia tanacetifolia*



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# Commonly used Woody species for restoration

## Indigenous species

- *Pinus brutia*
- *Pinus nigra*
- *Cupressus sempervirens*
- *Medicago arborea*
- *Spartium junceum*
- *Nerium oleander*
- *Pyracantha coccinea*
- *Cercis siliquastrum*

## Non-Indigenous species

- *Cupressus arizonica*
- *Robinia pseudoacacia*
- *Ailanthus altissima*



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# New Legislation Framework

- Directive 2006/21/EC of the European Parliament and of the Council of 15 March 2006, on the management of waste from extractive industries and amending Directive 2004/35/EC.
- Directive applies to waste resulting from the extraction, treatment and storage of mineral resources and the working of quarries. Waste covered by this Directive no longer falls within the scope of Directive 1999/31/EC on the landfill of waste.



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# Bauxite

Bauxite is:

- the principal raw material used in the production of aluminium,
- the world's second most used metal, after iron.

All around the world, aluminium is in increasing demand with a world annual production of 141 Mt. The aggregate output from the five largest mines worldwide was nearly 70 Mt in 2002. More than 98% of the total reported bauxite is mined by open-cast/open cut methods



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## Bauxite (continued)

- Greece is the leading bauxite producer in the EU having production outputs of 1.99 Mt for 2001, compared to 1.82 Mt in 1998 and 3.1 Mt in 1980, while for 2005 the production was 3.315 Mt. The major bauxite deposits in Greece are located within the Parnassos-Ghiona geotectonic zone that includes Giona, Elikonas, Parnassos, and the Oeti mountain site. The reserves are of diasporic and boehmitic type





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# The project

Project duration: 26 months

Start up: November 2005

Partners:

- Department of Forestry (Lead partner)
- Department of Mechanical Engineering (LHTEE)

Project objective: Study of ecological and aesthetical restoration of mines and quarries through herbaceous and woody vegetation overlying mining and quarrying waste.



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# Location

- This research was implemented on Mount Ghiona and Parnassos of the Fokida Prefecture in Central Greece, in an area covered with piles of calcareous spoils derived from bauxite mining.
- These sites were located in three different elevations and the restoration took place in two phases, namely in 2001 and 1996.



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Varios



Agia Anna



Kounouklia



Grias Horafi



Palio Ilorio



Experimental area

elevation: 850 m  
restoration year: 2001

elevation: 500 m  
restoration year: 2001

elevation: 420 m  
restoration year: 1996

elevation: 550 m  
restoration year: 1996

elevation: 1200 m  
restoration year: 1996



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# Tree species

The common tree species that were planted in these sites were:

- *Robinia pseudoacacia*,
- *Pinus brutia*
- *Cupressus sempervirens*.

During June 2006, the height of these species was measured for twenty individuals of every species randomly selected in every experimental site. The tree height was measured by using Bitterlich's relaskop.



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# Materials and Methods

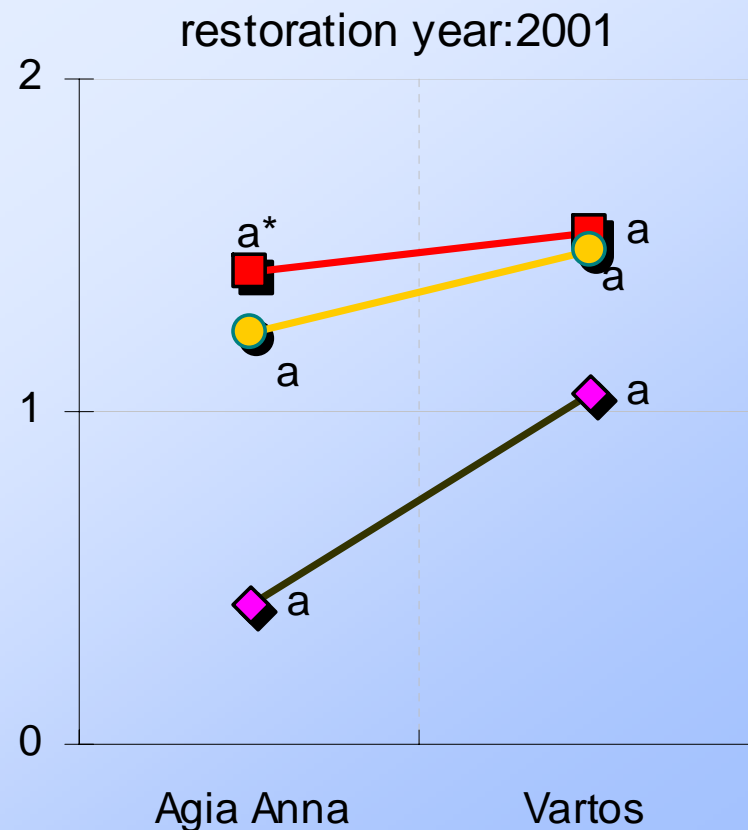
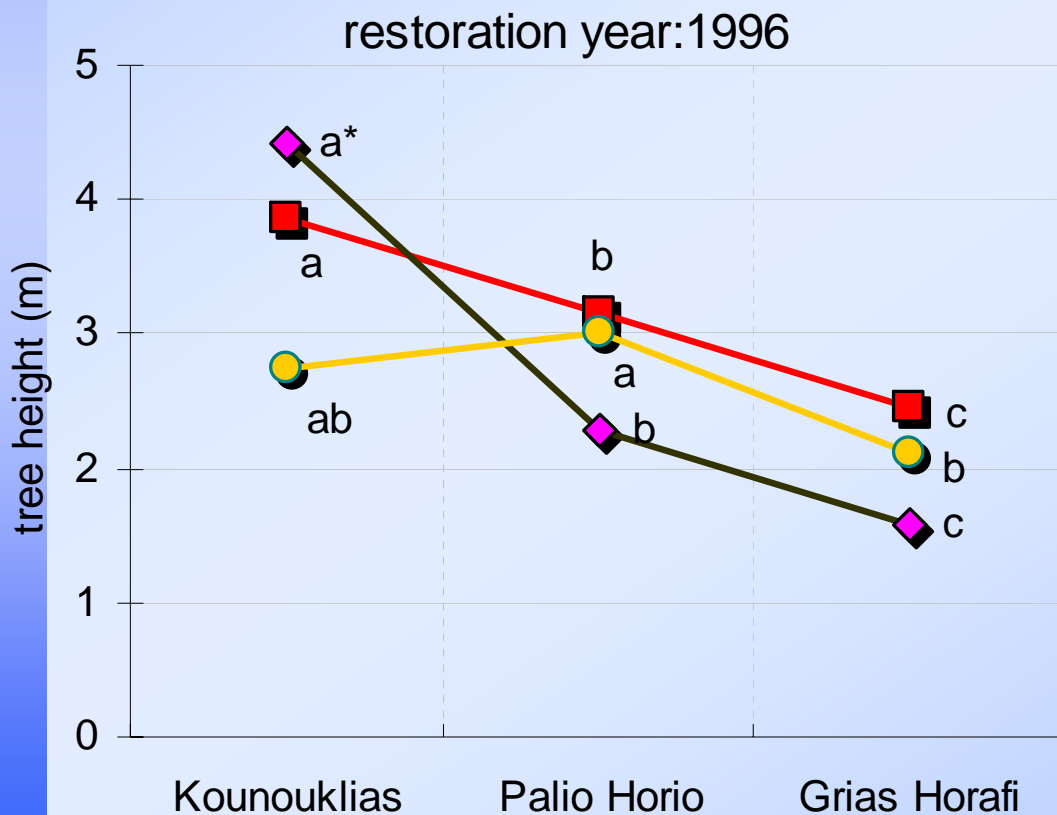
- Mechanical texture analysis was performed according to the Bouyoucos hydrometer method.
- Total content of Ni, Cu, Zn, Cd, Cr and Pb in soil samples were determined on filtered extracts obtained from 2g of grated samples, which were digested by 12.5 ml 4M HNO<sub>3</sub>, at 80°C overnight. Following samples' preparation, the total concentration of heavy metals (Cd, Cr, Cu, Ni, Pb and Zn) was measured via atomic absorption spectrophotometry.



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# Tree height (m) of species in the experimental sites

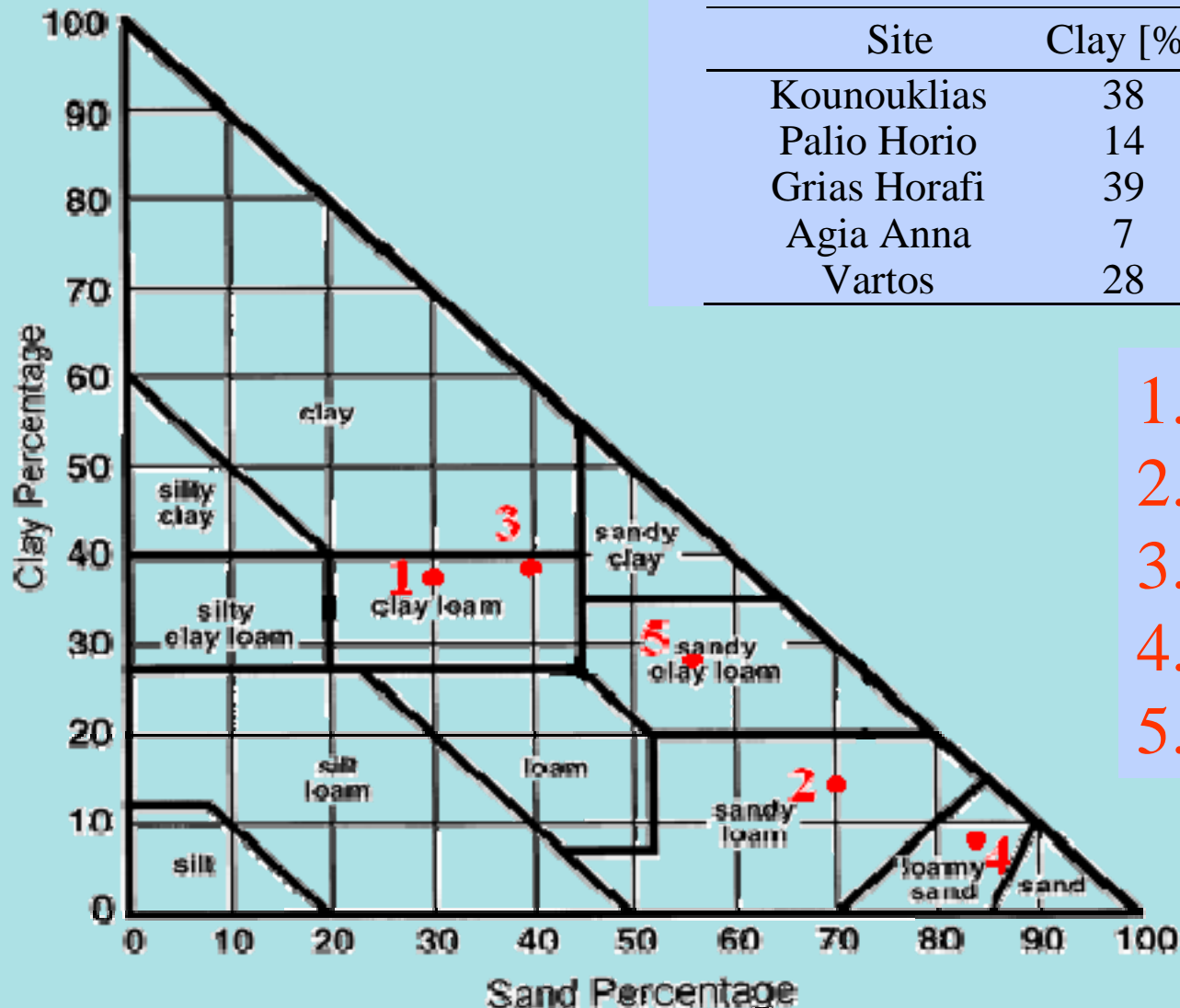
- Robinia pseudoacacia
- ◆— Pinus brutia
- Cupressus sempervirens





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# Mechanical Texture

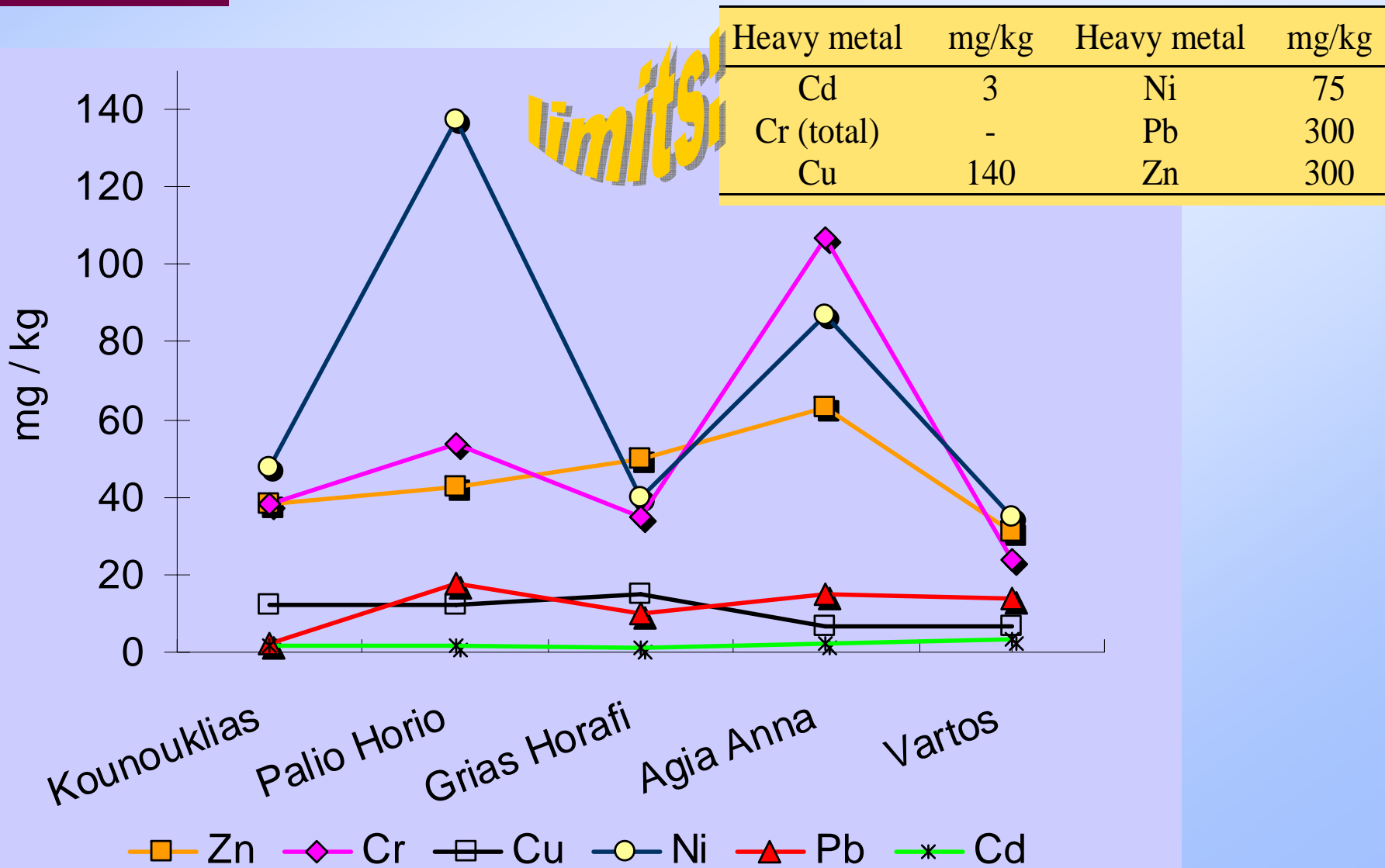


1. Kounouklias
2. Palio Horio
3. Grias Horafi
4. Agia Anna
5. Vartos



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# Heavy metals in the soil (mining waste)







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# Conclusions

- This study indicated that the current replanting of the examined bauxite mine area is yielding desirable results in the sustainable restoration process. Probably the altitude affected negatively the establishment of the three tree species. Perhaps, other species should be tested in such an environment.



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## Conclusions (2)

- It was concluded that the altitude probably act as a growth setback. The planted species prefer the thermo- and meso-Mediterranean vegetation belt and probably are not appropriate for revegetation of high altitude sites.



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## Conclusions (3)

- *Robinia pseudoacacia* and *Cupressus sempervirens*, could be considered as proper species for restoration of degraded bauxite mining areas with increased heavy metal concentration, due to their adaptability to poor sites.







INDICATION  
BETWEEN BETH  
LEMON - DISTINGUISHABLE























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# Acknowledgements

- *The (still on-going) study is funded by “Pythagoras II programme, Operational Programme for “Education and Initial Vocational Training” (EPEAEK) Hellenic Ministry of National Education and Religious Affairs (2005-2007).*
- *Greatfull thanks are due to the “DELFI – DISTOMON” bauxite mining company in Fokida, for their prompt permission and support in conducting the present research.*





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*Thank you for your attention*