OPERATIONAL PROGRAMME EDUCATION AND LIFELONG LEARNING investing in knowledge society
MINISTRY OF EDUCATION & RELIGIOUS AFFAIRS MANAGING AUTHORITY
Co-financed by Greece and the European Union
European Union European Social Fund
NSRF 2007-2013 EUROPEAN SOCIAL FUND

Mediterranean Forests in Transition (MEDIT): Deliverable No2

Title: Report on the results of the functional traits meta-analysis

Due to Project Month 6, Date: 30/09/2012

Introduction

This manuscript summarises the work done during the first 6 months of the Medit Project, dealing in particular with the functional traits database developed and analysed within component C1 ("Literature Review and Metadata Collection"). This report summarises the development and analysis of the functional traits database. An accompanying report (Deliverable No1) summarises the tree-rings dataset development and meta-analysis.

Within Deliverable No2 I have gathered and analysed functional traits data for 50 forest species commonly found in forest along Greece. The aim of this analysis was to a) develop a start-up dataset to identify data-gaps regarding the functional traits of interest, with particular interest to the Mediterranean basin, b) to use this database in conjuction to the functional traits data gathered in Medit component 4 , and to identify potential trait inter-relationships of interest. These data will be used for the initial parameterisation of the GREFOS and the LPJ model.

Methods

Dataset Development

In total around 300 trait suites have been gathered for 50 woody forest species commonly found in Greece, classified to 20 families and 28 genera. The geographic extent of this dataset is across Europe covering above 50 scientific publications. The functional traits of interest are leaf longevity (LL [months]), leaf thickness (Lth [mm]), leaf mass per area (LMA [g m^{-2}]), leaf nitrogen concentration (N [mg g^{-1}]), leaf phosphorous concentration (P [mg g^{-1}]), leaf net photosynthetic rate at light saturation (A_{max} [μmol m^{-2} s^{-1}]), leaf dark respiration (R_d [μmol m^{-2} s^{-1}]) and wood density (WD [g cm^{-3}]).

Statistics

I first estimated the mean value per family and species for the eight functional traits of interest. These values would be used as reference for the fieldwork and lab work envisaged in C4 of the Medit project. In addition these estimates will be used for the initial parameterisation of the small and large scale models envisaged in C2 and C3.

I also explored for trait intercorrelations that could potentially reveal important axis of plant functional strategies and trade-offs, as discussed in the literature. I used a correlation analysis and a standardised major axis regression for this purpose.

Furthermore, I estimated the taxonomic variation, i.e the apportion of variance at the Family, Genus and Species level for the 50 forest species. I used a hierarchical multilevel model for this purpose.

Finally I used a principal components analysis followed by a clustering algorithm to identify potential species groupings as revealed by their functional characters to numerically define functional groups.

Results

Table 1 summarises the mean value of the eight functional traits of interests for the 50 taxa. The mean family level values of the functional traits of interest are summarised in Figure 1.

Figure 1: Mean Family level trait values.

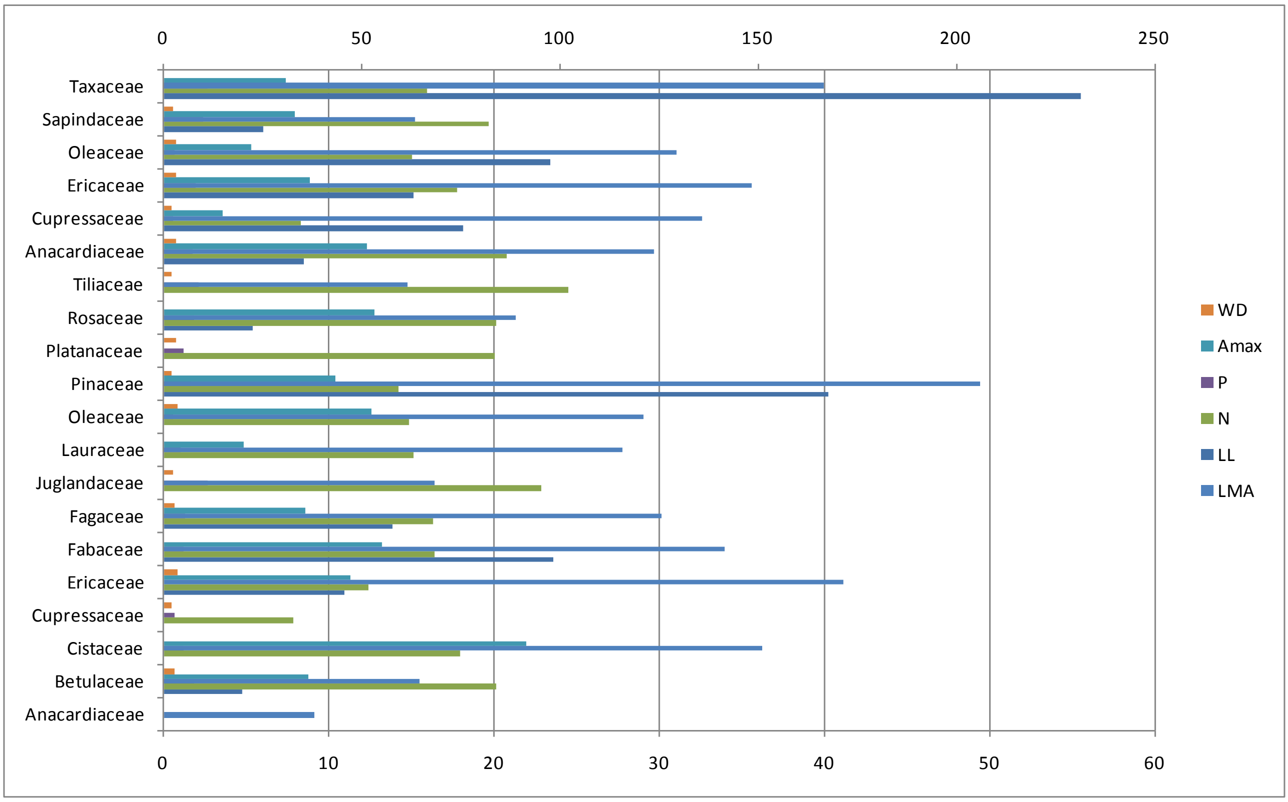


Table 2 summarises the trait intercorrelations with bold values indicating a statistically significant Pearson correlation coefficient. As expected LMA correlates with most leaf traits underling it central role in the leaf economic spectrum. WD did not showed any significant relationship with the rest of the leaf traits.

Table 2: Species Pearson correlation coefficient between the functional traits of interest. Bold values indicate a statistically significant relationship.

	LL	Lth	LMA	N	P	Amax	Rd	WD
LL	1.00	**0.74**	**0.63**	**-0.49**	0.04	-0.24	1.00	-0.37
Lth		1.00	**0.50**	-0.19	-0.15	-0.06		-0.07
LMA			1.00	**-0.58**	**-0.30**	0.10	**0.62**	-0.13
N				1.00	**0.66**	**0.33**	**-0.68**	0.19
P					1.00	-0.06	**-0.98**	-0.09
Amax						1.00	**-0.50**	0.25
Rd							1.00	0.28
WD								1.00

Species	LL	Lth	LMA	N	P	Amax	Rd	WD
Abies alba			130.3	19.21	2.51	13.75	0.46	0.46
Abies borisii-regis								0.41
Abies cephalonica			171.8	12.10		6.69		0.42
Acer campestre		0.293	95.2	20.20	3.66			0.60
Acer monspessulanum	6.1		53.9	19.80	1.14			0.59
Acer platanoides	6.0		51.0	19.02	2.25	7.10		0.58
Acer pseudoplatanus	6.0		70.2	19.95	2.62	8.45	0.60	0.57
Arbutus andrachne		0.390	174.9	25.63	2.60	10.10		0.77
Arbutus unedo	15.1	0.373	131.8	13.07	1.23	8.46		0.79
Betula pendula	4.8		71.7	20.15	1.86	8.80		0.54
Carpinus orientalis			43.9					0.79
Castanea sativa			98.6	18.19	1.25	6.45		0.53
Ceratonia siliqua	23.6		167.1	14.20	0.70	13.23		
Cercis siliquastrum			64.4	23.10	1.80			
Cistus monspeliensis			174.9	19.64	1.30	24.15		
Cistus salvifolius			115.4	15.83	1.10	19.71		
Cotinus coggygria			38.0					
Crataegus monogyna	5.4	0.233	89.0	20.13	1.90	12.80		
Cupressus sempervirens				7.90	0.70			0.51
Erica arborea	12.0		127.8	12.39		11.90		0.84
Erica multiflora	10.0		259.0			10.80		
Fagus sylvatica	6.0	0.371	72.2	19.47	1.54	8.48		0.66
Fraxinus ornus		0.163	80.6	20.20		5.28	1.44	0.66
Juglans regia			68.5	22.92	2.69			0.62
Juniperus communis			137.1	9.33				0.63
Juniperus oxycedrus	18.1		122.5	8.25	0.70	3.55		0.45
Juniperus phoenicea			158.2	7.51	0.50			0.45
Laurus nobilis			115.7	15.10	1.00	4.90		
Olea europaea	23.4		178.4	14.02	0.70			0.80
Ostrya carpinifolia								0.80
Phillyrea latifolia			121.2	14.91	0.60	12.58		0.84
Picea abies	103.2		235.2	11.90	1.73	6.89		0.49
Pinus brutia			123.5			13.40		0.56
Pinus halepensis	36.9	0.454	181.4	12.60	1.39	6.38		0.55
Pinus nigra	26.5		209.6	17.30	1.23	16.41		0.58
Pinus pinaster	34.4		255.3	10.40	0.69	10.91		0.48
Pinus pinea	36.3		185.7	10.40	0.85	7.82		0.60
Pinus sylvestris	41.1		260.8	13.67	1.68	9.75	1.82	0.50
Pistacia lentiscus	11.3		162.5	17.73	1.77	8.43		0.83
Pistacia terebinthus	5.7		92.6	23.93		16.26		0.79
Platanus orientalis				20.10	1.20			0.79
Quercus cerris			88.1	20.19	1.34			0.72
Quercus coccifera	15.4	0.380	166.3	10.65	0.85	7.11		0.94
Quercus frainetto			82.3					0.68
Quercus ilex	22.8	0.340	167.4	15.21	1.75	11.92		0.88
Quercus petraea				14.80	1.50			0.60
Quercus pubescens	6.8	0.228	88.8	17.84	1.22			0.71

Quercus trojana			85.4					
Taxus baccata	55.6		166.7	16.00	2.66	7.40		
Tilia cordata		0.417	61.4	24.55	2.09			0.50

Table 1: Species specific mean trait values for the eight functional traits of interest.

Figure 2 summarises some of the most interesting relationships between the functional traits of interest that could be eventually used in the parameterisation of both the small and large scale vegetation dynamics model. In all cases a standardised major axis regression line was fit. We note that the values used here are the species level means.

Figure 2: Standardised major axis regression between key functional traits.

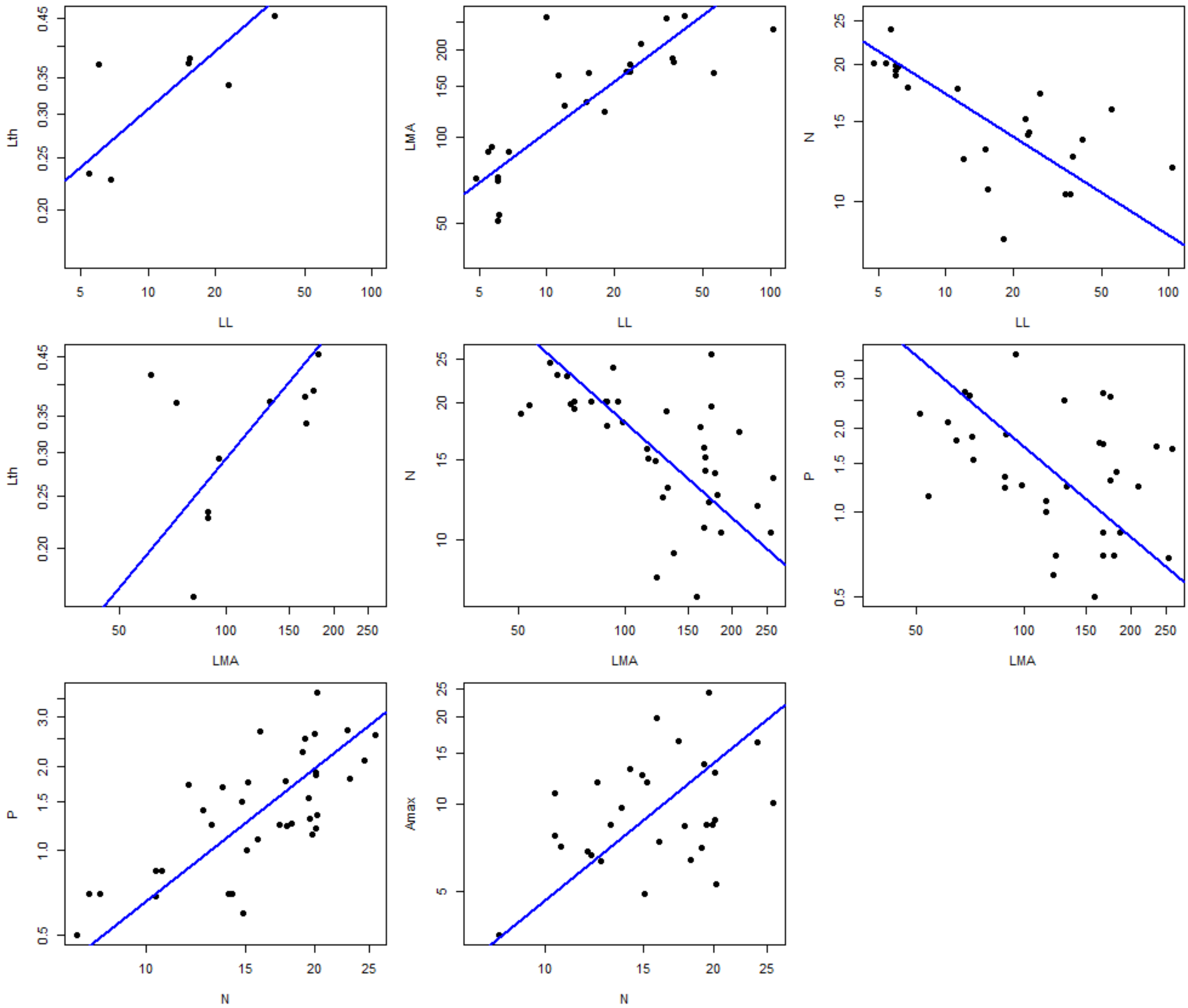
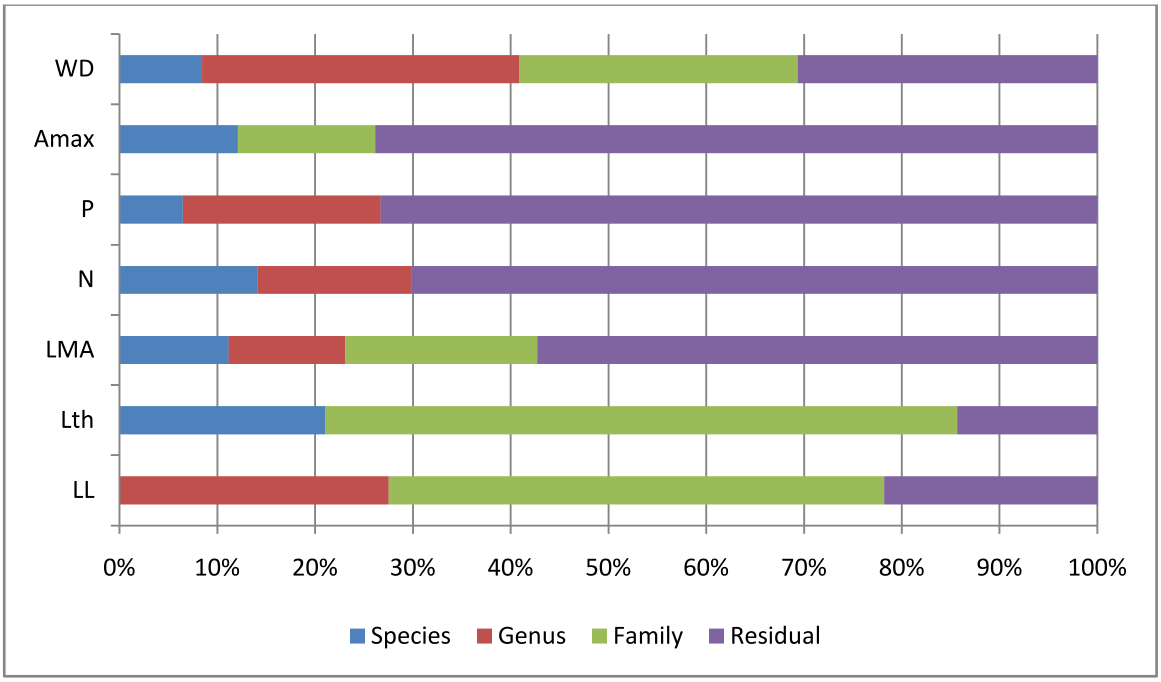


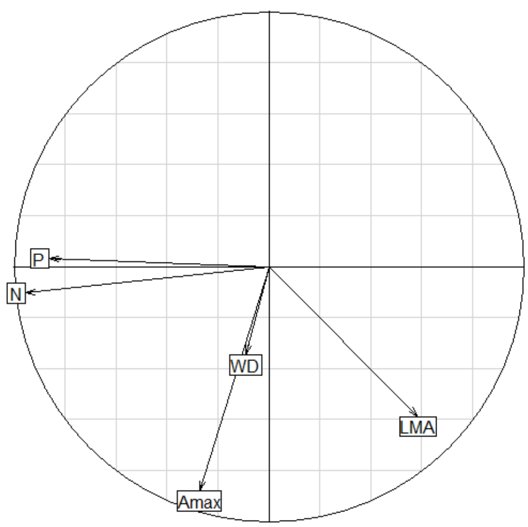
Figure 3 summarises the variance partitioning at the family, genus and species level for seven of the functional traits of interest. We excluded here Rd as there were not enough values recorded in the dataset. For leaf longevity and leaf thickness most of the variation is apportioned at the family level. For LMA, Amax, P and N we note a large portion of the variance being is unexplained suggesting that there could be a strong environmental effect on those traits. WD is a more conservative character with family and genus explaining most of the variation.

Figure 3: Variance partitioning for seven of the functional traits of interest, using a hierarchical multilevel mode.



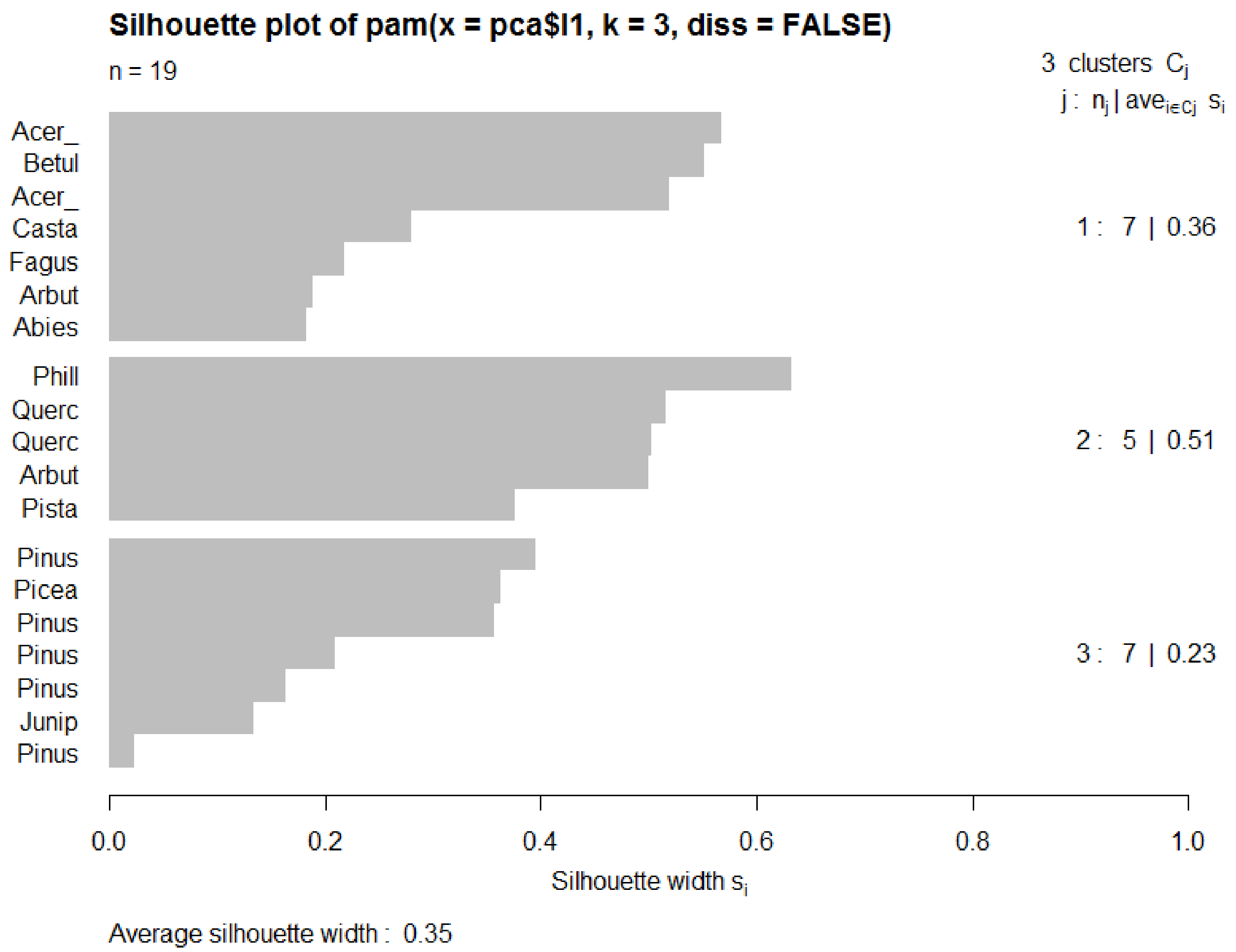
The principal component analysis on the correlation matrix of identified 3 important axes of functional variation in our dataset. A summary of the PCA analysis is presented in table 3. PCA1 represents the leaf economic spectrum with higher N and P concentrations found in smaller LMA leaves.

eigen values	2.09	1.26	1.05
variance explained	0.42	0.25	0.21
	PCA1	PCA2	PCA3
LMA	**0.59**	**-0.59**	-0.36
N	**-0.96**	-0.10	-0.01
P	**-0.86**	0.03	-0.29
Amax	-0.27	**-0.88**	-0.12
WD	-0.09	-0.35	**0.90**



The second PCA axis indicates at higher area based gas exchange rates achieved from leaves with higher LMA. PCA3 seems to point at a growth vs. Tolerance trade off with more active leaves relating with lower wood densities and an overall less tolerant strategy. This analysis will be repeated with the actual MEDIT data gathered and analysed from the fieldwork in C4.

Finally a "clustering around medoids" procedure was implemented to the PCA scores of each species. This clustering identified 3 groups, that could be used a plant functional types in initial parameterisation of the vegetation dynamics models. The three groups nicely classified coniferous, evergreen broadleaves and deciduous broadleaves species, with the only exception of *Abies alba*.



Conclusions

Analysis of the dataset gathered from the literature identified interesting patterns of functional traits intercorrelations and grouping of species to functional types. This analysis will be further implemented in the MEDIT data, gathered in C4.