Field Research of Dominant Vegetation and Environmental factors on the Basis of Projection on the Vegetation Change after Global Warming in the Eastern Mediterranean Region of Turkey

Junji SANO [1] , Makoto ANDO [2] and Shigenobu TAMAI [3]

[1] *Forest Ecology and Ecosystem Management Laboratory, Field Science Center, Faculty of Agriculture, Tottori University,*
4-101 Koyama-minami, Tottori 680-8553, JAPAN
[2] *Field Science Education and Research Center,Kyoto University,*
Kitashirakawa, Sakyo-ku, Kyoto 606-8502, JAPAN
[3] *Arid land Research Center, Tottori University,*
1390 Hamasaka, Tottori, 680-0001, JAPAN

1. Introduction

Climate changes especially global warming are increasingly threatening natural ecosystems as well as human-induced disturbances (Evrendilek and Wali, 2004). Our purpose is to clear the relationship between global warming and vegetation change in relation to anthropogenic impact in the eastern Mediterranean region of Turkey. We researched the species composition and structure of dominant vegetation types and some environmental factors from the coastal line to the timber line. There are various vegetation types along the climatic and topographic gradient in Turkey (Yilmaz, 1998). In this region, the most frequently occurring evergreen forests are *Pinus brutia* secondary forests. Other confers are *Pinus halepensis* in the coastal regions, and *Abies cilicia* and *Cedrus libani* in the higher part of mountains. The most commonly occurring deciduous forest trees are various kind of *Quercus* species such as *Q. coccifera, Q. infectoria and Q. cerris*. Other common trees, mostly seen in mid-altitude mixed forests, are *Carpinus, Fraxinus, Styrax* and some maquis species such as *Arbutus andrachne* and *Q. coccifera* (Sano et al. 2003; Ando et al. 2004). Steppe-type vegetation is widespread in the dry and cold climatic zone, although anthropogenic, or man-made destruction is clearly visible as well as the lowlands of Central and Western Europe (Vera 2000).

2. Study area and methods

In 2003 and 2004, species composition, stand structure and environmental factors were measured at fourteen plots (Table 1 and 2) under relatively good conditions left from the Mediterranean coast to the mountain (ca. 0-2000 m a. s. l.) in the following regions; (1) Yumurtalik and Adana, (2) Catalan, (3) Karatepe, and (4) Aladag. We measured DBH and tree height for each individual, and slope direction, inclination, altitude, latitude and longitude for each plot. Cores with increment borers and hemispherical photographs using NIKON Coolpix 950 digital camera with a fisheye converter were taken in each plot.

Table 1 Stand characteristics of research plots in 2003

Plot	1	2	3	4	5	6	7
	Yumurtalik	Catalan	Karatepe 1	Karatepe 2	Aladag 2	Aladag 3	Aladag 1
Dominant species	*Pinus halepensis*	*Pinus brutia*	*Pinus brutia*	*Arbutus andrachne*	*Pinus brutia*	*Abies cilicica*	*Cedrus, Abies*
Size mxm	50x40	20x20	30x20	15x6	50x30	40x40	30x20
Inclination	2	10	21	21	10	26	12
Direction	N50W	N40W	N45E	N30W	N65W	N60W	S35E
N	36°44′49.2	37°12′04.4	37°17′45.4	37°15′48.4	37°33′32.9	37°28′06.4	37°36′20.8
E	35°37′40.4	35°15′22.4	36°15′02.7	36°13′35.5	35°23′31.7	35°19′10.1	35°29′17.3
Altitude	3	151	253	559	793	1223	1532

Table 2 Stand characteristics of research plots in 2004

Plot	8	9	10	11	12	13	14
	Catalan 1	Catalan 2	Aladag 1	Aladag 2	Aladag 3	Aladag 4	Adana
Dominant species	*Pinus brutia*	*Pinus brutia*	*Pinus nigra*	*Pinus nigra*	*Cedrus libani*	*Abies cilicica*	*Quercus coccifera*
Size mxm	20x20	20x20	20x40	20x20	20x40	20x40	10x10
Inclination	18	22	18	20	10	15	32
Direction	S70W	S55W	N60E	N70W	N80E	N80W	N80E
N	37°16′47.9	37°16′03.4	37°37′28.6	37°37′31.7	37°36′28.8	37°36′25.9	37°03′51.1
E	35°11′16.6	35°11′37.6	35°28′13.7	35°28′43.2	35°28′53.7	35°28′51.0	35°21′18.2
Altitude	263	329	1951	1840	1403	1379	102

3. Results and discussion

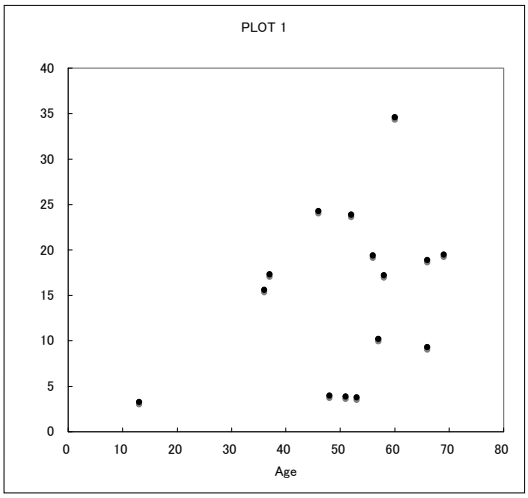
Tree species composition with relative basal area (BA%) in each plot is shown as Table 3. There were 22 species occurred in our research plots. Dominant tree species were *Quercus coccifera* with many maquis species in low land area, *Pinus brutia* in the mid-altitude regions, *Abies cilicica*, *Cedrus libani* and *Pinus nigra* in the subalpine region. *Pinus nigra* was found on relatively high-altitude area, which formed pure stands.

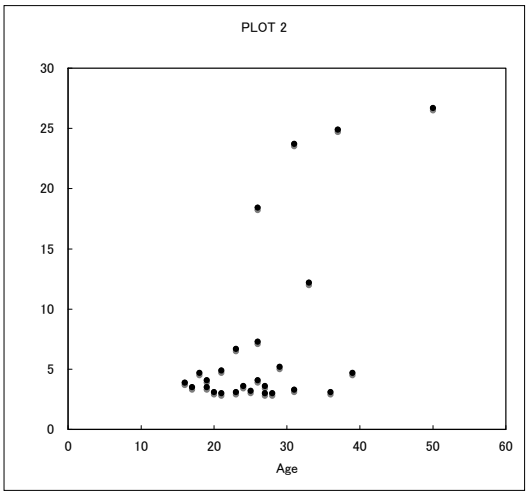
Table 3 Species composition and dominance (BA %) of trees in each plot along elevation

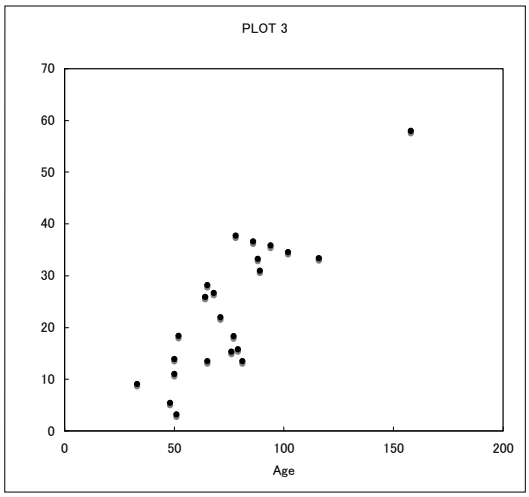
Plot	1	14	2	3	8	9	4	5	6	13	12	7	11	10
Altitude m	3	102	151	253	263	329	559	793	1223	1379	1403	1532	1840	1951
Pinus halepensis	100.0													
Quercus coccifera		78.6	0.5	2.1	0.0		20.3							
Cistus creticus		3.1												
Pistacia terebinthus		1.6												
Phillyrea latifolia		2.4			0.3									
Pinus brutia		14.3	98.9	95.2	99.6	100.0		100.0						
Fontanesia phillyrioides			0.5											
Olea europea			0.2											
Arbutus unedo					0.1									
Arbutus andrachne				1.8			57.7							
Myrtus communis					0.1									
Quercus infectoria				0.3			13.6							
Styrax officinalis				0.5			2.8							
Fraxinus sp.							5.6							
Carpinus betulus									3.3					
Carpinus orientalis									2.0					
Quercus cerris									1.9					
Abies cilicica									92.5	35.5	2.4	43.9		
Juniperus oxycedrus									0.3			14.3		
Juniperus excelsa										11.8				
Cedrus libani										24.9	87.2	35.1		
Pinus nigra										27.9	10.4	6.8	100.0	100.0
BA (m2/ha)	8.8	1.2	16.0	42.4	31.1	8.1	20.6	36.5	36.4	40.1	40.8	43.0	73.3	46.6

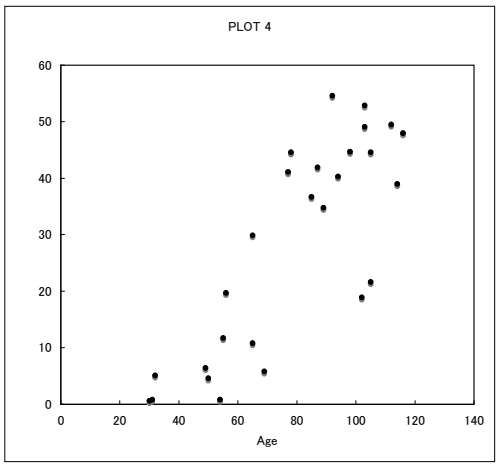
Relationship between tree age and size (DBH) in each plot is shown as Figure 1. Generally showing positive relations that size increased along

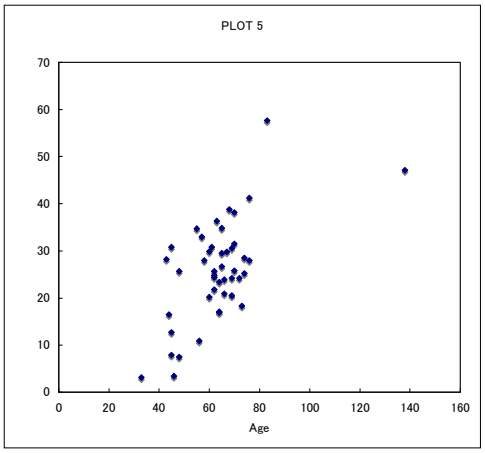
age, it had great variance of size for a given age, which means difference of growth in each tree.

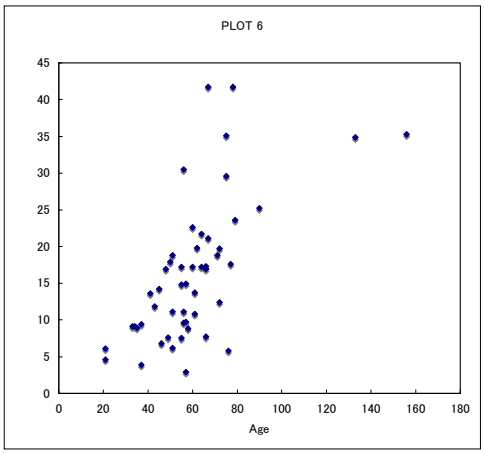












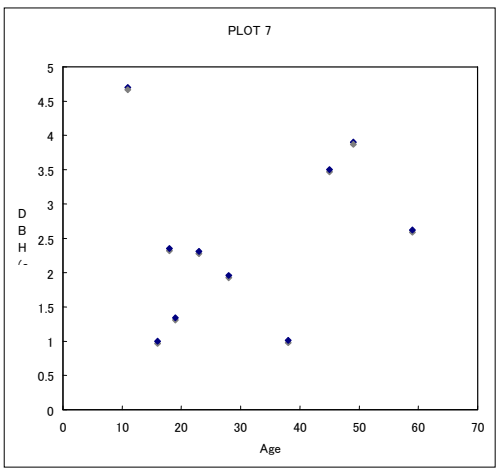
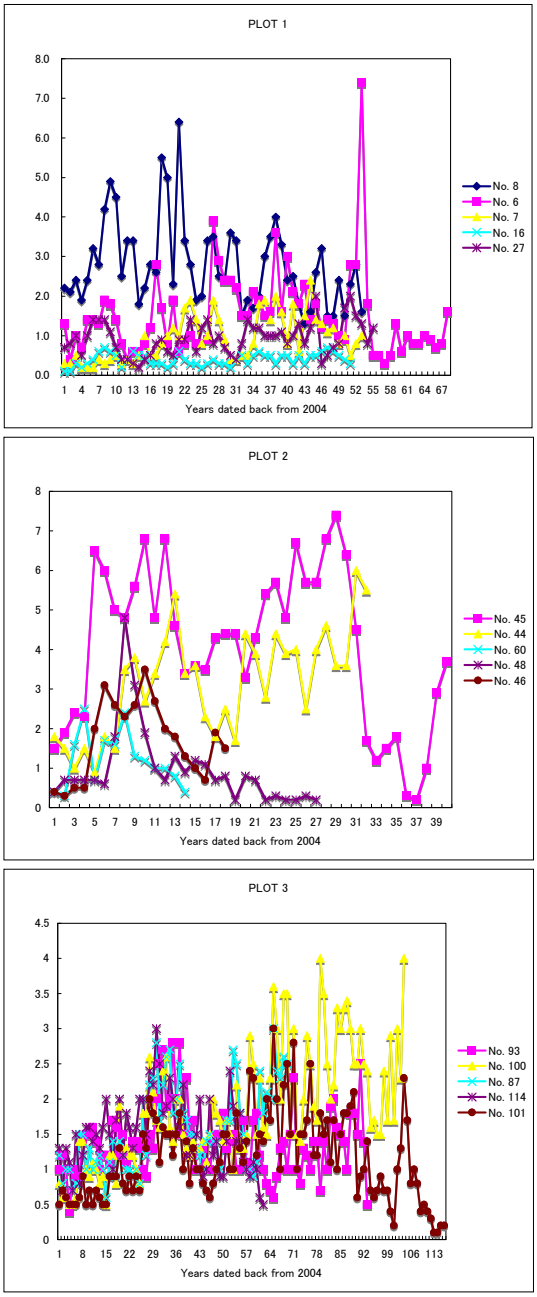


Fig. 1. Relationship between tree age and DBH in each plot

Annual tree growth of radius in each plot is shown as Figure 2. It had growth variations year by year. The fluctuation, however, did not show the obvious pattern of the evidence of climate change. Further research and analysis are required to reveal the issues on the relationship between tree growth and climate.



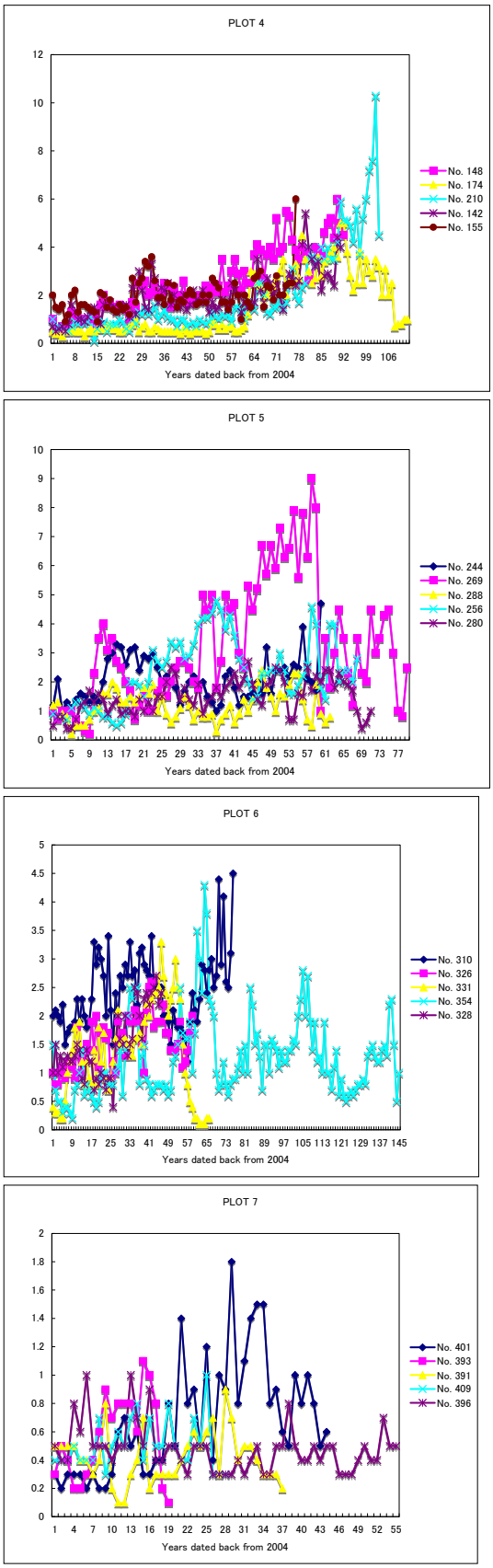


Fig. 2. Annual growth of radius along age in each plot

Table 4 Canopy cover (%) in each plot

Plot	1 Yumurtalik	2 Catalan	3 Karatepe 1	4 Karatepe 2	5 Aladag 2	6 Aladag 3	7 Aladag 1
Date	20030823	20030829	20030827	20030828	20030825	20030825	20030824
Mean	49.024	72.587	71.745	78.139	64.862	84.502	80.718
SD	12.111	2.642	3.638	4.957	3.593	3.082	3.870
CV	24.704	3.640	5.070	6.344	5.540	3.648	4.794
Max	62.190	76.021	76.735	86.375	71.074	88.626	87.878
Min	24.698	69.642	67.141	73.160	57.988	81.607	77.497

Canopy cover in each plot is shown as Table 4. It seems to be depend on elevation.

Canopy cover was extremely low at Plot 1 in Yumurtalik because of scarce distribution of canopy trees dominated by *Pinus halepensis* (Figure 3a). On the other hand, relatively high covers of canopy trees were shown at Plot 6 and 7 in Aladag, higher part of this region (Figure 3b).

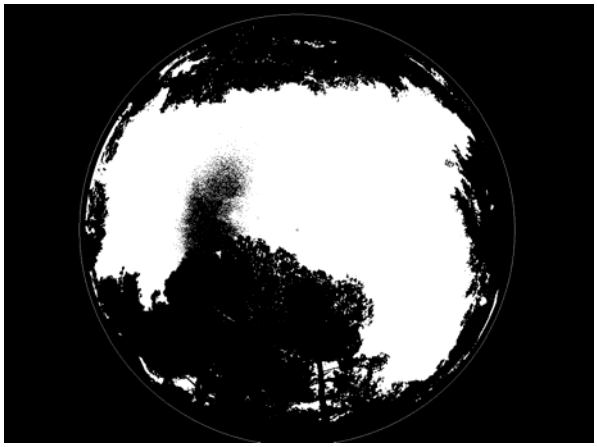


Fig. 3a. Hemispherical photograph at Plot 1 in Yumurtalik

Fig. 3b. Hemispherical photograph at Plot 7 in Aladag

Long-term monitoring and sustainable management of natural resources are required for future generations (Kilik et al. 2003). We should pay attention to the vegetation change with climate change in future.

4. Acknowledgements

We sincerely thank to Professor Dr. Tuker Altan, Dr. Mustafa Altar and their student Volkan Deneri at the Cukurova University; Drs. Ekrem Aktoklu, Mustafa Atmaca and Kayhan Kaplan at the Mustafa Kemal University; Dr. Meryem Ayik at the Akdeniz University: Mr. Ramazan Gokdemiraglu at the Forest Office in Aladag, and many people in Turkey for their arrangement and help of our field research and useful discussion. Also we greatly thank to Professor Dr. K. Tuluhan Yilmaz, Dr. Hakan Alphan and Yuksel iZcankurtaran for their help to our preliminary research; Professor Dr. Tsuguhiro Watanabe, the Project leader of ICCAP, Drs. Takanori Nagano, Yoichi Fujihara, Ms. Noriko Sasaki, Naho Kawadura and many staff of RIHN, Dr. Fujio Kimura at Tsukuba University and Dr. Kenji Tanaka at Kyoto University and all ICCAP members for their great help and support to our research, and Tottori University students, Mr. Keisuke Kato and Ms. Yuki Kishibe for their data analysis especially on the land-use pattern using a Landsat image and on the potential vegetation patterns in present and future.

5. References

Ando, M., Tamai, S. and Sano, J. (2004) The Effects of Global Warming on the Tree Species Composition in Forests of the Eastern Mediterranean Region in Turkey - The Vertical Distribution of the Vegetation on the Basin of the Seyhan and Ceyhan Rivers -. *The Interim*

Report of ICCAP: 79-82.

Evrendilek, F. and Wali, M. K. 2004. Changing global climate: historical carbon and nitrogen budgets and projected responses of Ohio's Cropland Ecosystems. *Ecosystems* 7: 381-392.

Kilic, S., Evrendilek, F., Berberoglu, A. and Demirkesen, C. 2006. Environmental monitoring of land-use and land-cover changes in a Mediterranean region of Turkey. *Environmental Monitoring and Assessment* 114: 157-168.

Sano, J., Tamai, S. and Ando, M. (2003) A Preliminary Research of the Effects of Global Warming on the Species Composition and Vegetation Productivity in the Eastern Mediterranean Region of Turkey - The Vertical Distribution of the Dominant Tree Species -. *Proceedings of the International Workshop for the Research Project on the Impact of Climate Change on Agricultural Production System in Arid Areas (ICCAP), Kyoto, Japan: 49-52.*

Vera, F. W. M. (2000) Grazing Ecology and Forest History. 506 pp. CABI Publishing, Oxon, UK

Yilmaz, K. T. (1998) Ecological diversity of the Eastern Mediterranean region of Turkey and its conservation. *Biodiversity and Conservation* 7: 87-96.