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Research Article

Phytosociological and Ecological Structure of *Fraxinus Angustifolia* Subsp. *oxycarpa* Forests in the Central Black Sea Region*

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Abstract: *Fraxinus angustifolia* Vahl. subsp. *oxycarpa* (Bieb. ex Willd). Franco & Rocha Afonso forests formed pure stands along the alluvial delta of the Central Black Sea Region. These forests represent hygrophyllous azonal formations. This species usually forms mixed stands with other deciduous species in other regions. In this study the phytosociological structure and soil characteristics of *F. angustifolia* subsp. *oxycarpa* forests were investigated. Nutrient concentrations in the leaves of the dominant species *F. angustifolia* subsp. *oxycarpa* were also studied during mid-growing season and senescence. It was determined that nutrient concentrations tended to decrease during senescence.

Key Words: *Fraximus angustifolia* Vahl. subsp. *oxcarpa* (Bieb. ex Willd) Franco & Afonso, Hydromorphic Alluvial Soils, Phytosociology.

Orta Karadeniz Bölgesindeki *Fraxinus Angustifolia* Subsp. *oxycarpa* Ormanlarının Fitososyolojik ve Ekolojik Yapısı

Özet: *Fraxinus angustifolia* Vahl. subsp. *oxycarpa* (Bieb. ex Willd). Franco & Rocha Afonson ormanları, Orta Karadeniz Bölgesindeki alüvyal deltalar boyunca önemli topluluklar oluştururlar. Bunlar "higrofil azonal formasyonları" temsil ederler. Orta Karadeniz Bölgesi daşında bu tür saf orman oluşturmamakta ve dağınık halde diğer yaprak döken türlerle karışık olarak bulunmaktadır. Bu çalışmada bu ormanların fitososyolojik durumu ile birlikte toprak özellikleri ve hakim tür olan *F. angustifolia* subsp. *oxycarpa*'nın yapraklarındaki besin elementi miktarları gelişme mevsiminin ortası ve senesens döneminde incelenmiştir. Besin elementi konsantrasyonlarının senesens döneminde genellikle azaldığı tesbit edilmiştir.

Anahtar Sözcükler: *Fraxinus angustifolia* Vahl. subsp. *oxycarpa* (Bieb. ex Willd) Franco & Afonso, Hidromorfik alüvyal topraklar, Fitososyoloji.

Introduction

According to the Ramsar Convention, wetlands are defined as marshes, bogs and swamps temporarily or permanently covered by flowing or standing, fresh, brackish or salty water, including tidal zones covered with water not deeper than six meters at low tide. Flooded forests are one of the most important wetland ecosystems in this respect (1, 2).

Hydromorphic alluvial soils cover large areas around the Çarşamba and Bafra plains, located at the Samsun city boundaries. Such soils have serious problems with respect to drainage. At the beginning of spring soil surface usually covered with water. Such areas, usually called flooded forests, tend to be *Fraxinus* L., *Almus* Miller, *Salix* L. and *Populus* L. forests. In our study area, *Fraximus angustifolia* Vahl. subsp. *oxycarpa* (Bieb. ex Willd.) Franco & Rocha Afonso is the most widespread species. Flooded forests constitute the climax phase of hydrosere (3) and they have been protected effectively all over the world.

This study was carried out around Gelemen, Çakırlar Korusu and Balık Gölleri (Figure 1). According to Davis's grid system (4), our study area was located at square A6. Gelemen, Hacı Osman Forest and Galeriç Forest (around Balık Gölleri), which constitute the main part of the study area, are defined as unique and endangered world class alluvial ecosystems (2).

In this study, the phytosociological and ecological properties of *F. angustifolia* subsp. *oxycarpa* forests, which are different from those of other Euxinian forests, were ınvestigated.

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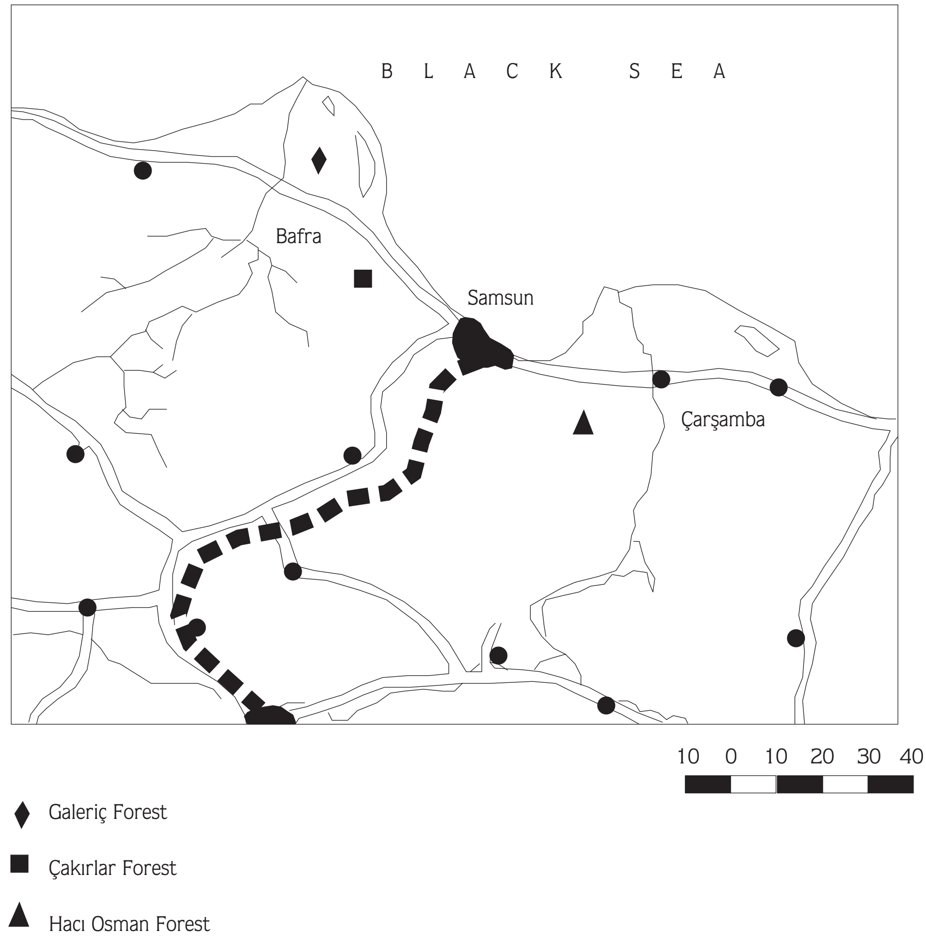

Figure 1. Map of the study area.

Material and Methods

From August, 1994, to July, 1996, the study area was divided into 30 floristically and structurally homogeneous quadrats in accordance with Braun-Blanquet's method (5). The size of quadrats were estimated by means of minimal area method. The vegetation of the study area was classifed according to diferential and characteristic species. Differential and characteristic species were chosen from among species with high occurrences medium constancy values (3). Davis's taxonomic nomenclature (4) and Barkman et al.'s phytosociologicul nomenclature (6) were used in the phytosociological tables.

The percentage of similarity between *Pterocaryo pterocarpae - Fraxinetum angustifoliae* association and the association identified by Quezel et al. (7) and Aydoğdu (8) were compared with Sørensen's similarity index (9).

Soil samples were taken at a depth of between 0 and 30 cm during mid-growing season and senescence. *Fraximus* forests occur on hydromorphic alluvial soils. The effective soil depth was limited because of severe gleyisation in such soils (10). The samples were transported to the laboratory and then passed through a 2 mm sieve.

Soil texture, soil pH, organic matter, concentrations of nitrogen (N), phosphorus (P), potassium (K), soluble cation (Na, Ca, Mg), soluble anion (HCO_3, Cl, SO_4) and $CaCO_3$ were determined according to the methods described in Chapmann & Pratt (11) and Walkley and Black (12).

In addition to soil analysis, concentrations of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and iron (Fe) in the leaves of *F. angustifolia* subsp. *oxycarpa* were also determined. Seven 0.06 ha (600 m^2) plots were sampled in the study area for leaf macroelement analysis. At least seven individual plants from each plot were collected. Plots with closed tree canopies were selected. The trees were selected randomly from each plot. Since

Table 1. Phytosociological structure of F. angustifolia subsp. oxycarpa Forests (Pterocaryo pterocarpae-Fraxinetum angustifoliae ass.)

Quadrat number	1	3	25	10	7	5	11	9	17	6	Presence	
(Area (m^2)	750	700	600	550	650	700	650	600	600	700	%	
Altitude (m.)												
Exposition	NW	N	NE	N	N	N	NE	NE	NE	NE		
Slope	5	5	5	5	5	5	5	5	5	5		
Height of tree layer (m.)	35	30	30	30	30	30	30	25	30	35		
Cover of tree layer(%)	70	75	80	80	80	75	70	75	75	75		
Height of shrub layer (m.)	25	25	3	25	3	35	3	35	3	35		
Cover of shrub layer (%)	35	35	40	35	35	30	40	30	40	35		
Height of herb layer (cm.)	80	80	65	90	85	80	80	75	80	75		
Cover of herb layer (%)	40	40	20	25	40	40	35	35	30	30		
Differential and characteristic species of the association												
Fraxinus angustifolia subsp. oxycarpa	44	44	44	34	44	44	44	44	44	44	100	V
Arum euxinum	+1	11	.	+1	+1	+1	11	12	11	11	90	V
Smilax excelsa	12	23	23	11	11	22	+2	12	12	.	90	IV
Fraxinus excelsior	11	11	22	.	11	22	.	22	.	22	70	IV
Leucojum aestivum	12	22	.	.	12	.	11	11	12	+1	70	III
Periploca graeca	23	12	.	.	.	12	.	.	11	12	50	III
Euonymus europaeus	.	.	12	.	.	.	.	12	12	12	40	III
Pterocarya fraxinifolia	.	22	.	.	12	.	11	.	11	.	40	III
Alnus glutinosa	22	.	.	.	.	12	11	11	.	.	40	III
Characteristic species of POPULETALIA ALBAE												
Iris pseudacorus	.	.	.	12	23	+1	+1	.	11	.	50	III
Rumex conglomeratus	11	.	.	.	11	.	11	11	.	11	50	III
Carex pendula	.	.	.	12	12	22	.	.	.	22	50	III
Cornus sanguinea	12	.	12	.	.	12	11	.	.	.	40	III
Agrostis alba	12	.	.	12	11	12	.	.	.	.	40	III
Solanum dulcamara	11	.	.	.	11	11	.	+1	.	.	40	III
Oenathe silaifolia	12	.	.	11	12	12	.	.	.	.	40	III
Galium palustre	+1	.	.	+1	11	12	.	.	.	.	40	III
Ranunculus repens	11	.	.	.	13	.	.	.	11	.	30	II
Veronica anagallis-aquatica	.	.	12	.	.	.	.	11	.	12	30	II
Characteristic species of QUERCO-CARPINETALIA ORIENTALIS												
Acer campestre subsp. campeste	22	11	.	.	11	12	11	.	11	22	70	IV
Quercus hartwissiana	+1	+1	.	+1	.	+1	.	+1	.	+1	70	IV
Carpinus orientalis subsp. orientalis	11	11	.	.	.	11	12	11	11	11	70	IV
Helleborus orientalis	11	12	.	.	11	.	12	+1	12	11	70	IV
Characteristic species of QUERCO-FAGETEA VE QUERCO-FAGEA												
Hedera helix	22	22	22	22	12	22	12	12	12	12	100	V
Primula vulgaris subsp. sibthorpii	11	11	.	.	.	.	11	11	11	11	60	IV
Crataegus monogyna	+1	11	.	.	.	+1	11	.	.	11	60	IV
Ligustrum vulgare	11	11	.	.	.	.	11	.	12	.	40	III
Cornus mas	11	.	.	.	.	.	11	.	11	.	30	II
Ulmus glabra	11	.	.	.	.	11	.	11	.	.	30	II
Tamus communis subsp. communis	.	.	12	.	11	.	.	.	.	11	30	II
Clematis vitalba	.	.	23	.	.	.	11	.	.	11	30	II
Clinopodium vulgare subsp. vulgare	+1	.	.	.	+1	.	.	.	.	+1	30	II
Characteristic species of QUERCETEA ILICIS												
Ruscus aculeatus var. aculeatus	22	22	22	.	.	22	12	12	12	22	80	V
Laurus nobilis	12	.	.	.	.	11	.	.	.	12	30	II
Companious												
Prunella vulgaris	.	.	12	.	.	12	.	.	.	11	30	II
Pulicaria dysenterica	.	.	11	.	.	12	.	+1	.	.	30	II
Ranunculus constantinopolitonus	.	.	.	+1	11	.	11	.	.	.	30	II
Taraxacum macrolepium	.	.	.	.	+1	.	+1	.	.	.	20	I
Galega officinalis	.	.	.	.	11	.	.	.	.	+1	20	I
Morus alba	.	11	.	.	.	.	11	.	.	.	20	I
Bellis perennis	.	.	.	+1	.	.	.	.	.	+1	20	I
Rubus sanctus	.	.	.	.	.	11	.	.	.	.	10	I
Erodium acule	.	.	.	.	.	+1	.	.	.	.	10	I
Conyza canadensis	.	.	.	.	.	+1	.	.	.	.	10	I
Urtica dioica	+1	.	.	.	.	.	.	.	.	.	10	I
Verbena officinalis	+1	.	.	.	.	.	.	.	.	.	10	I
Avena fatua var. fatua	+1	.	.	.	.	.	.	.	.	.	10	I
Cirsium vulgare	.	.	+1	.	.	.	.	.	.	.	10	I
Poa infirma	.	.	+1	.	.	.	.	.	.	.	10	I
Ajuga reptans	.	.	.	11	.	.	.	.	.	.	10	I
	.	.	.	.	12	.	.	.	.	.	10	I

Table 2. Mean and Range Values of Soil Chemical Properties During Mid-Growing Season and Senescence

Soil Factor	Mid growing season	Senescence	F.value	Probability	Significance
pH	6.35-7.20 (6.92±0.12)°°	6.25-7.45 (7.09±0.16)	.699	.4195	NS
Total salt (%)	0.04-0.14 (0.087-0.028)	0.05-0.07 (0.06±0.01)	.810	.4190	NS
N(%)	0.420-0.840 (0.491±0.064)	0.414-0.924 (0.670±0.147)	2.398	.1474	NS
P (kg/da)	2.244-18.549 (7.78±0.064)	2.483-19.465 (6.91±1.54)	.123	.7435	NS
K (kg/da)	71.55-186.50 (101.26±14.15)	154.83-186.57 (179.46±32.58)	.491	.5220	NS
Organic Matter (%)	5.78-13.50 (10.18±0.95)	0.44-12.17(5.70±1.43)	9.132	0.0106	*
CaCO3 (%)	0.49-8.72 (3.65±1.25)	0.16-6.55 (1.80±0.84)	1.503	.2437	NS
Soluble Na (meq/lt)	1.05-5.00 (2.48±1.26)	1.10-2.50 (1.61±0.44)	.419	.5525	NS
Souble Ca (meq/lt)	3.42-8.95 (6.93±1.76)	2.63-6.32(4.00±1.16)	1.923	.2378	NS
Souble Mg (meq/lt)	1.13-7.21 (3.32±1.94)	0.97-2.67 (1.78±0.49)	.584	.4574	NS
Soluble HCO3 (meq/lt)	5.05-14.95 (9.63±2.88)	4.24-5.86(5.05±1.63)	2.461	.1918	NS
Soluble Cl (meq/lt)	0.99-1.61 (1.31±9.40)	0.62-1.85(1.51±0.36)	.609	.4787	NS
Soluble SO4 (meq/lt)	0.07-4.76 (2.06±1.39)	0.91-2.26 (1.49±0.40)	.155	.7135	NS

*P<.05 °Mean value °°Standard error NS Not significant

sun-exposed and shade-exposed leaves may differ in foliar nutrient concentrations, only outer sun-exposed leaves were collected, and upper-crown samples at the four cardinal points were taken using an extension tree-pruner (13). The plants were sampled during both the mid-growing season and senescence in order to determine the changes in nutrient concentrations. Healthy mature leaf blades were cut off above the petiole and placed immediately in tightly stoppered, previously weighed bottles. The seven samples (about 100 g.) were bulked dried at 70°C, then powdered in a hammer mill and ground in a Wiley mill to pass through a 20-mesh sieve (212.5 µm openings) prior to analysis. Sieved leaf samples were digested in a mixture of nitric and perchloric acids, with the exception of samples for N analysis, which were digested with sulphuric acid and selenium using a Kjeldahl apparatus. Macroelement analysis was carried out by standard methods (14).

Soil properties were explained according to Kaçar (15). The results were evaluated by using one-way ANOVA test on a software programme (16).

Results

The phytosciological properties of *F. angustifolia* subsp. *oxycarpa* forests are shown in Table 1. The differential and characteristic species of *Pterocaryo pterocarpae-Fraxinetum angustifoliae* ass. are *F. angustifolia* subsp. *oxycarpa, Arum euximum* R. Mill, *Smilax excelsa* L., *Fraxinus excelsior* L., *Leucojum aestivum* L., *Periploca graeca* L. var *vestita* Rohlena, *Euonymus europaeus* L. and *Pterocarya fraxinifolia* Poiret. The order Populatalia Albae Pawl. 1928 is represented by a great number of species, such as *Iris pseudocorus* L., *Rumex conglomeratus* Murray and *Carex pendula* Hudson. The order Querco-Carpinetalia Orientalis Quézel, Barbéro, Akman, 1977, is represented by fewer species than the previous order. Some of the characteristic species of the Querco Carpınetalia Orientalis are *Acer campestre* L. subsp. *compestre* and *Quercus hartwisiana* Steven. Querco-Fagetea (Br.-Bl. et Vlieger, 1937). Fuk et Fab. 1968 is characterized by *Hedera helix* L., *Crataegus monogyna* Jacq. subsp *monogyna, Ligustrum vulgare* L., *Cornus mas* L. and *Ulmus glabra.* Quercetea Ilicis Br. Bl. 1942 class is only characterized by *Ruscus aculeatus* L. var *aculeatus* and *Laurus nobilis.* L.

F. angustifolia subsp. *oxycarpa* forests occur on sandy-loamy, sandy clay loamy and loamy soils. Soil pH is slightly acidic or neutral. Soil salinity values range between quite low extremes. Soil N concentrations are within normal ranges. Although P concentrations are quite low, these values can be high also. Potassim concentrations are usually high during both mid-growing season and senescence. Soluble cation and anion concentrations are at mid-level. $CaCO_3$ values are quite low or at mid-level. Organic matter concentrations are usually high. There is only one important difference between mid-growing season and senescence in the organic matter of the soil (Table 2; $p<.05$). However, there are statistically

Table 3. Mean and Range Values of Foliar Nutrient Concentrations of *F. angustifolia* subsp. *oxcarpa* Leaves During Mid-Growing Season and Senescence

Nutrient	Mid growing season	Senescence	F-value	Probability	Significance
N (%)	0.61-2.3 (1.60°±0.27)°°	0.44-0.78 (0.59±0.07)	12.605	7.506x10-3	**
P (%)	0.26-0.28 (0.27±0.04)	0.20-0.39 (0.29±0.03)	.092	.7769	NS
K (%)	0.66-2.30 (1.65±0.55)	0.20-0.55 (0.40±0.34)	9.464	9.603x10-3	**
Ca (%)	2.5-3.02 (2.79±0.11)	0.87-3.73 (2.22±0.50)	1.220	.3015	NS
Mg (%)	0.25-1.23 (0.55±0.18)	0.12-1.03(0.44±0.16)	.202	.6651	NS
Fe (%)	0.039-0.077 (0.049±0.012)	0.019-0.030 (0.027±0.011)	8.378	.0275	**

**P<.01 °Mean values °°Standard error NS Not significant

important differences between the mid-growing season and senescence in leaf N, K and Fe concentrations (Table 3; p<.01).

Discussion

Pterocaryo pterocarpae-Fraxinetum angustifoliae association should be included in the order Populetalia Albae and the class Querco-Fagetea with respect to cover abundance values and the number of taxa belonging to these phytosociological units (Table 1). This association was first described by Quézel et al. (7) and later named according to phytosociological nomenclatural rules (17). Aydoğdu identified the same association in the areas surrounding Adapazarı (8). The percentage of similarity between these associations and the association in our study area was 49.46% and 28.57%, respectively.

Organic matter concentrations in the soil were significantly lower during senescence than during the mid-growing season. This may be due to the rapid degeneration of leaf litter during senescence. However, organic matter concentrations are usually quite high. Flooded forests are recognised as having the most organic matter per unit producing ecosystems (2). Soil K concentrations are quite high as well. Deciduous forests usually occur on soils rich in potasium (18).

The order of abundance in elemental concentrations for leaves of *F. angustifolia* subsp. *oxycarpa* is Ca>K>N>Mg>P>Fe during the mid-growing season and senescence. These values are similiar to those found in previous studies (19, 20). The one noticeable difference is in the ranking of potassium higher than nitrogen. The explanation could be that our study area was influenced by seepage. Yarie (21) has described a similiar situation for the hygric and mesic sites of Hemlock Biogeoclimatic Zone.

There were statistically important differences in the N, K and Fe concentrations in leaves between mid-growing season and senescence (Table 3). Nitrogen concentration in leaves had a positive correlation with the rates of photosynthesis. Thereas also a strong positive correlation between nitrogen concentration in leaves and the amount of Ribulose biphosphate carboxylase/oxygenase enzyme, which is the primary carboxylating enzyme in most plants (22). The iron concentration in leaves is of vital importance for the photosynthetic carbon dioxide fixation process (23).

Because of these factors, N, K and Fe concentrations in leaves decrease during senescence (Table 3). Senescence is interpreted as part of programmed reallocation of resources within the plant. It can also be defined as a complex series of coordinated processes that result in a substanital removal of nutrients from the leaves. The removal of nutrients appears to be responsible for the decline in photosynthetic capacity and other ecological and physiological processes in deciduious species (24). The difference between mid-growing season and senescence in respect to K concentration may also be due to the fact that potassium is a very phloem-mobile ion, while calcium and phosphorus are rather phloem-immobile (25).

The recycling of nutrients during mid-growing season and senescence may occur through a combination of internal and external mechanisms. The importance of these mechanisms depends on the nature of each nutrient. Though nutrient concentrations in plants growing in natural ecosystems may vary around a mean concentration under different environmental conditions, the relative abundances of elements, especially essential nutrients, should remain more or less constant for a given plant species. However, there are major differences between tree species in this respect. More research is needed on the nutrient concentrations in the leaves and soils of wetland tree species during mid-growing season and senescence.

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