Biomass of understory species of Pinus Halepensis Mill, forests in the Kassandra Peninsula - Chalkidiki

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Abstract

This study deals with the biomass estimation of the understory species of Pinus halepensis forests in the Kassandra peninsula, Chalkidiki (North Greece). These species are: *Quercus coccifera, Quercus ilex, Phillyrea media, Pistacia lentiscus, Arbutus unedo, Erica arborea, Erica manipuliflora, Smilax aspera, Cistus incanus, Cistus monspeliensis, Fraxinus ornus.* A sample of 30 shrubs per species was taken and the dry and fresh weights and the moisture content of every component of each species were measured, all of which were processed for aboveground biomass data. Then several regression equations were examined to determine the key words.

Key words: *Biomass, Pinus halepensis, understory species, forest fire, forest management.*

1. Introduction

Pinus halepensis and *Pinus brutia* forests cover 8.72% of our forests (Ministry of Agriculture 1992), which is one of the most inflammable areas of our country. Biomass distribution, both of the upperstory pinus and the understory evergreen broad-leaved species, will help us to take the appropriate measures so that imminent fires can be restricted. The present study aims at determining the biomass of understory in Kassadra's Pinus halepensis forests.

2. Study area

This research took place in the Kassandra peninsula, Chalkidiki, North Greece. The soils in its extreme north belong to brown forests and to rendzinas, in its south to red Mediterranean soils, while a small part in the northwest belong to the alluvial soils. (FAO, 1965).Kassandra has a Mediterranean type climate with dry, hot summers (Flokas, 1991). The dry period lasts 5 months, from mid April to mid September.The vegetation in this area belongs to *Quercetalia illicis* (Dafis, 1973) and three site qualities are found (Tsitsoni, 1991).

3. Methods

The species that have been studied are the most common in this area and are:

1. *Quercus coccifera*
2. *Quercus ilex*
3. *Phillyrea media*
4. *Pistacia lentiscus*
5. *Arbutus unedo*
6. *Erica arborea*
7. *Erica manipuliflora*
8. *Smilax aspera*
9. *Cistus incanus*
10. *Cistus monspeliensis*
11. *Fraxinus ornus*

To study the biomass of the above species a number of 30 trees per species was randomly (Little and Shainsky, 1992) taken; 10 trees from a *Pinus halepensis* stand aged 22 years, 10 trees from a stand aged 48 years and 10 trees from a stand aged 100 years. In this way all the conditions and the whole range of tree biomass were represented.

All the trees were cut just above the ground level and the following characteristics were measured (Young et all, 1964; Alembag, 1980; Matis and Alifragis, 1983-84).

- The total height of the trees
- the diameter outside bark at ground level
- the annual rings at the bottom of the stump (total age).

The total fresh weight and the weight of the following components of every species were immediately weighed in the field :

- Foliage and branches diameter up to 0.5 cm
- branches diameter 0.5 - 2.0 cm
- branches diameter 2.0 - 5.0 cm
- branches diameter > 5.0 cm.

Afterwards, samples of every component of each species were taken and transported to the laboratory; the samples were oven-dried for 24 hours at 105° C and their dry weight was found.

In order to compute the biomass (fresh and dry weight) of each species by their physical dimensions (height and diameter), several regression equations (linear and nonlinear) were examined to determine these relationships.
Finally, equations with the highest determination coefficient (r^2) were selected as the model equations for each species individually, which are (Young, 1976; Little and Shainsky, 1992; Elliott and Clinton, 1993; Kalinganire and Hall, 1993).

$W = ae^{bd}$ $\qquad$ $W = a+b(d^2h)$ $\qquad$ $W = a+b(dh)$

W the weight, d the diameter, h the height and a,b coefficients of regressions.
To define biomass, at this stage, a sample of 30 surfaces 4x4 was used as follows: 20 surfaces for 4 age categories (23,48,70, over 100 years) in the medium site quality, 5 surfaces in fair quality trees up to 70 years old and 5 surfaces in the worst site quality for trees older than 70 years.

On each surface the diameter and the height of all shrubs with diameter larger than 0.5cm were measured. To manage the understory in the medium soil quality for trees greater than 50 years of age, felling was applied for charcoal and firewood.

4. Results

From table 1 and figures 1 and 2 the results of biomass estimated of all the measured species can be seen. As shown in this table the distribution of biomass varies among the species. According to this table the species with the larger relative percentage of foliage are *Smilax aspera* (97.2% of total weight), *Cistus incanus* (67.3%) and *Erica arborea* (51.8%). On the contrary, the smallest relative percentage of foliage was found in *Fraxinus ornus* (19.9% of total weight), *Arbutus unedo* (23.8%) and *Phillyrea media* (24.9%).

Another important element is the low contribution of large branches (> 5 cm) to the whole biomass. Only the species *Quercus ilex*, *Quercus coccifera* and *Arbutus unedo* present a remarkable percentage (>10%).

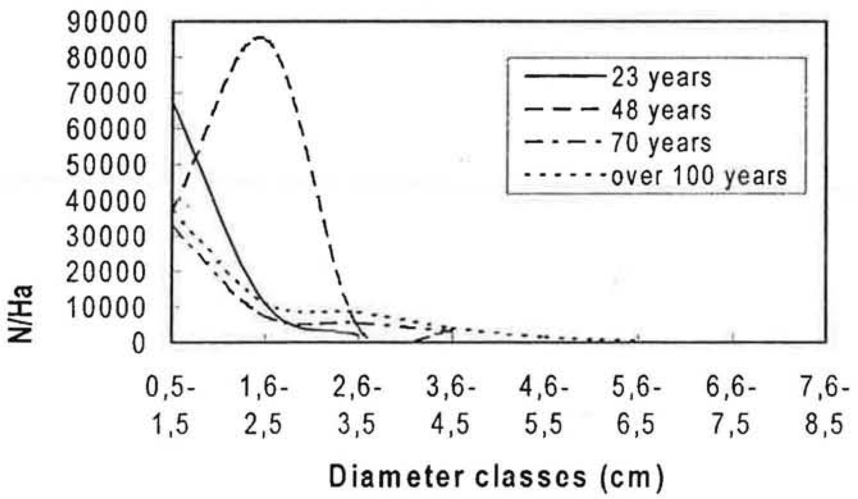

Figure 1. Distribution of understory diameter classes per ha, of 23, 48, 70 and over 100 years quality site Aleppo pine stand

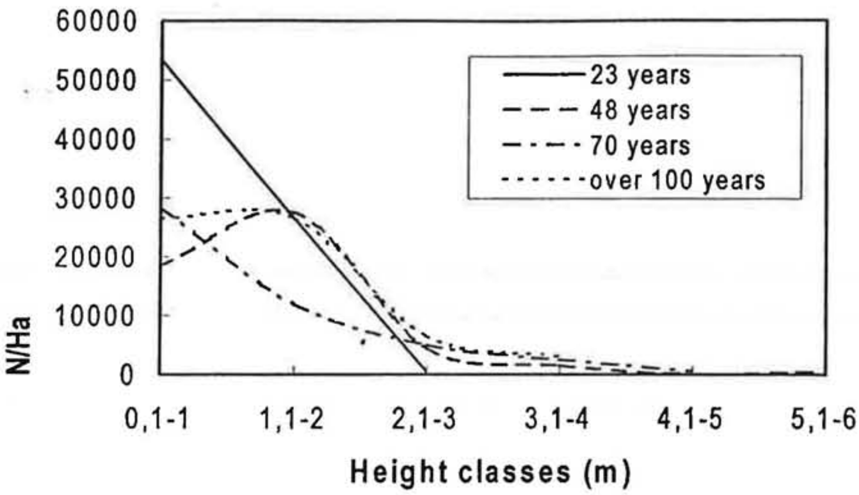

Figure 2. Distribution of understory height classes per ha, of 23, 48, 70 and over 100 years quality site Aleppo pine stand

Table 1. Percentage of each component (%) of total weight

a/a	Species	Foliage	Branches 0,5-2,0 cm	Branches 2,0-5,0 cm	Branches >5 cm	Total
1	Quercus coccifera	33,16	29,15	26,89	10,79	100
2	Pistacia lentiscus	30,40	42,07	27,50	0,00	100
3	Phillyrea media	24,95	31,89	43,47	3,81	100
4	Arbutus unedo	23,76	29,67	35,78	10,79	100
5	Erica arborea	51,77	41,12	7,11	0,00	100
6	Erica manipuliflora	52,63	38,40	8,97	0,00	100
7	Smilax aspera	97,24	2,76	0,00	0,00	100
8	Cistus incanus	67,27	32,44	0,27	0,00	100
9	Cistus monspeliensis	46,63	48,06	5,31	0,00	100
10	Quercus ilex	27,17	20,54	31,03	21,26	100
11	Fraxinus ornus	19,86	31,20	43,39	5,55	100

From table 2 the range of moisture content of each species and every component can also be seen. According to this table, the higher relative amount of moisture content (in total weight) was found in Smilax aspera (122.2% of dry weight), Pistacia lentiscus (75.4%) and Arbutus unedo (72.4%). Instead, the lower relative amount of moisture content was in Erica arborea (42.9% of dry weight), Cistus incanus (47.1%) and Phillyrea media (47.1%).

The moisture content is always higher in foliage in relation to the other components and decreases in foliage in the large branches. The lower relative amount of foliage moisture was found in Erica arborea (42.9% of dry weight), and the species of genus Cistus (47.1%) and the high moisture was found in Smilax aspera (122.2%), Fraxinus ornus (108.3%) and Arbutus unedo (92.3%).

Table 2. Moisture content of each component (% of dry weight)

a/a	Species	Foliage	Branches 0,5-2,0 cm	Branches 2,0-5,0 cm	Branches >5 cm	Total
1	Quercus coccifera	72,41	56,25	51,52	47,06	58,73
2	Pistacia lentiscus	88,68	66,67	53,85		75,44
3	Phillyrea media	51,52	51,52	44,93	35,14	47,06
4	Arbutus unedo	92,31	75,44	56,25	53,85	72,41
5	Erica arborea	42,86	42,86	38,89		42,86
6	Erica manipuliflora	58,73	49,25	44,93		55,04
7	Smilax aspera	122,22	78,57			122,22
8	Cistus incanus	47,06	47,06	42,86		47,06
9	Cistus monspeliensis	47,06	53,85	47,06		49,25
10	Quercus ilex	66,67	63,93	56,25	49,25	56,25
11	Fraxinus ornus	108,33	61,29	56,25	45,99	63,93

Finally, table 3 shows the selected regression equations with the highest determination coefficient (r^2) for each measured species and the sample number, the mean height and the diameter range of the samples.

Table 3. Regression equations of physical dimension of shrubs on total weight

a/a	Species	N	Diameter Range in cm	Mean height in m	Regressions	r^2
1	Quercus coccifera	30	0,5-6,2	2,1	$W=214,0e^{0,56d}$	0,92
2	Pistacia lentiscus	30	0,6-4,5	1,8	$W=111,0+53,4(d^2h)$	0,81
3	Phillyrea media	30	0,9-5,9	2,1	$W=-5,9+62,8(d^2h)$	0,65
4	Arbutus unedo	30	0,9-7,5	2,0	$W=57,2+31,6(d^2h)$	0,87
5	Erica arborea	30	0,5-6,5	1,3	$W=106,3+47,8(d^2h)$	0,75
6	Erica manipuliflora	30	0,7-4,8	1,2	$W=241,3+29,7(d^2h)$	0,78
7	Smilax aspera	30	0,5-2,5	0,8	$W=4,8+55,5(d^2h)$	0,94
8	Cistus incanus	30	0,6-2,8	1,2	$W=-5,5+45,1(d^2h)$	0,84
9	Cistus	30	0,2-0,7	3,9	$W=-20,5+82,5(dh)$	0,53
10	Quercus ilex	30	1,3-8,1	4,0	$W=453,2e^{0,43d}$	0,96
11	Fraxinus ornus	30	0,8-7,2	3,0	$W=256,2e^{0,47d}$	0,93

W the weight, d the diameter and h the height of the tree

The selected equations present good fitness for all species (except the equation for the species Smilax aspera with r^2=0.53). The higher determination coefficient was found in the equations for the species Quercus ilex (0.96), Cistus incanus (0.94) and Fraxinus ornus (0.93).

With the use of equations the biomass of each species was estimated for each species separately and for all of them (Table 4). In the medium site quality the total biomass for trees of 23,48,70 years and older than 100 years covers 21.1 26.7 25.3 and 46.3t/h correspondingly.

Already at the age of 23, trees show a significant biomass accumulation. At the age of 70, the biomass is reduced, due to felling of most robust shrubs charcoal and firewood production.

For trees older than 100 years a high accumulation of biomass has been observed. In this quality site, higher biomass is present in the following species: Quercus coccifera, Pistacia lentiscus, Phillyrea media and Erica arborea. The increases and reductions of biomass in different shrubs is due to the treatment they have received (felling, grazing etc.).

In the best site quality, without timbering, the biomass older than 70 years amounts to 36t/ha. Here, except for the mentioned species of the previous site quality, we also find Quercus ilex and Arbutus unedo. In poorer and drier sites quality, without felling, the biomass in 70 year old trees amount to 28.2t/ha with a strong presence of E. manipulilfora and C. incanus.

Comparing these three sites quality, the increase in the biomass production has been observed, depending on the improvement of the site quality. In fig. 3 and 4 the distribution of diameters and heights for each is given for each site quality.

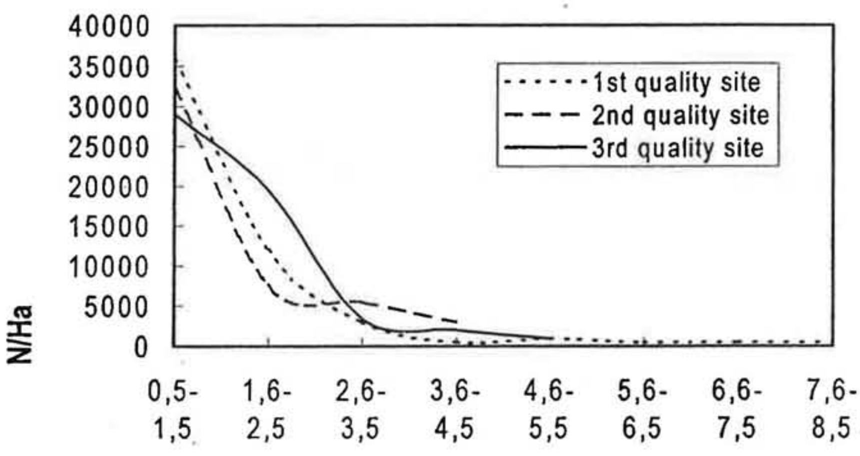

Figure 3. Distribution of understory diameter classes per ha, of a 1st, 2nd and 3rd quality site Aleppo pine stand

Table 4. Understory biomass of Aleppo pine stands in tn/ha

a/a	Species	Stand					
		2nd quality site				1st quality site	3rd quality site
		23 years	48 years	70 years	over 100 years		
1	Phillyrea media	1,5598 (7,4%)	2,355 (8,8%)	5,3398 (21,1%)	12,2578 (26,5%)	3,098 (8,6%)	2,2241 (7,9%)
2	Pistacia lentiscus	6,2183 (29,5%)	3,7465 (14,0%)	3,8467 (15,2%)	13,0904 (28,3%)	4,5029 (12,0%)	2,3649 (8,4%)
3	Fraxinus ornus	0,3162 (1,5%)	0,4817 (1,8%)	0,5061 (2,0%)	1,0176 (2,2%)	1,48 (4,1%)	
4	Quercus illex					8,4654 (23,5%)	
5	Arburus unedo	0,4427 (2,1%)	0,6155 (2,3%)	0,6327 (2,5%)	1,2489 (2,7%)	5,2954 (14,7%)	3,3221 (11,8%)
6	Cistus incanus	0,3162 (1,5%)	0,2141 (0,8%)	0,4555 (1,8%)	0,8789 (1,9%)	0,9366 (2,6%)	2,4775 (8,8%)
7	Quercus coccifera	10,2866 (48,8%)	17,0735 (63,8%)	12,2739 (48,5%)	13,2292 (28,6%)	11,7075 (32,5%)	14,6396 (52,0%)
8	Erica manipuliflora						2,0552 (7,3%)
9	Cistus mospeliensis	0,3794 (1,8%)	0,16057 (0,6%)	0,1012 (0,4%)	0,3701 (0,8%)		0,0563 (0,2%)
10	Erica arborea	1,4545 (6,9%)	1,9 (7,1%)	1,8980 (7,5%)	3,608 (7,8%)		0,7883 (2,8%)
11	Smilax aspera	0,1054 (0,5%)	0,2141 (0,8%)	0,2531 (1,0%)	0,5551 (1,2%)	0,5404 (1,5%)	0,2252 (0,8%)
	Total	**21,079 (100%)**	**26,761 (100%)**	**25,307 (100%)**	**46,256 (100%)**	**36,023 (100%)**	**28,153 (100%)**

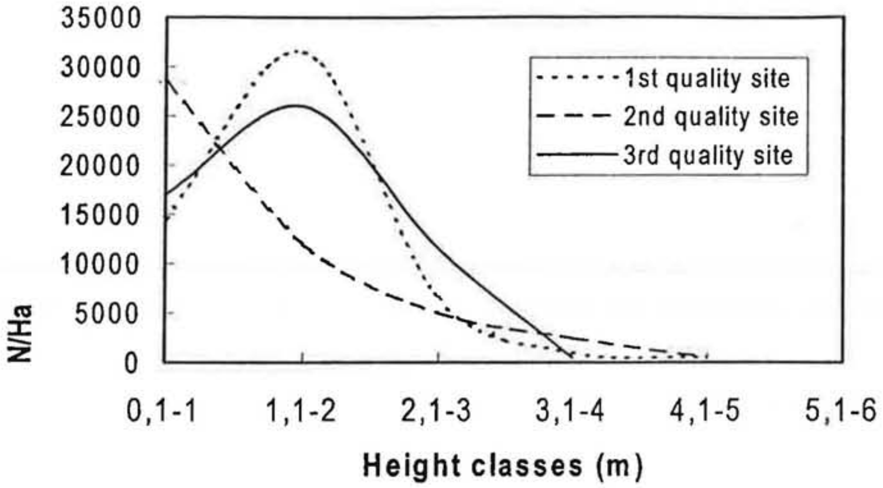

Figure 4. Distribution of understory height classes per ha, of a 1st, 2nd and 3rd quality site Aleppo pine stand

An increase in biomass accumulation of trees with larger dimensions has been observed with the increase of age. However, the most significant factor for the fires is the accumulation of biomass in higher categories with the increase of age, because the canopy of shrubs touches the canopy of Pinus Halepensis. Felling trees older than 50 years influenced both the reduction of biomass and the evolution of the understory height.

5. Conclusions

The most important conclusions of our results are:

- Biomass production depends on the site; the better the site, the better the biomass.
- The increase of age in combination with the site, influence the increase of height and diameter of the understory.
- Fellings in the understory are considered to be necessary for production of firewood and charcoal for trees of 40 to 60 years and 80 to 100 years.

When removing the understory, we should preserve the valuable species, which are less inflammable than pinus (eg. Fraxinus ornus).

-In high-risk positions (eg. along the roads) this removal takes place more often.

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