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STAND STRUCTURE OF A CALABRIAN PINE OLD-GROWTH FOREST: INDICATIONS FOR FOREST MANAGEMENT AND LANDSCAPE CONSERVATION ([1])

Calabrian pine forests are the peculiar feature of the landscape of many Italian mountain areas: Etna, Aspromonte and, especially, Sila. Sila landscape conservation is important not only for cultural and historical heritage value, but also for environmental and socioeconomic aspects. This is particularly relevant as most Calabrian pine forests are now included in the Sila National Park. The authors analyze the structure of an old growth pine forest. The main structural characters are compared with those of small group selection pine forests. Results show that small group selection felling, a tradidional silvicultural system peculiar to this area for Calabrian pine, is the best silvicultural approach for the conservation of Calabrian pine forests.

Key words: pine forest; old-growth forest; pine management; structure.
Parole chiave: pinete di laricio; boschi vetusti; gestione pineta; struttura.

1. Introduction

The landscape outlines a certain part of the territory, as it is perceived by the populations, whose character depends on the action of natural and/or human factors and their interaction (Council of Europe, 2000).

The forest landscape is the result of millenarian interaction between the

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environment and human activity and its management consists in actions aimed at orienting and harmonizing transformations caused by social, economic and environmental development processes.

Starting from middle XIXth century the abandonment of many forests, due to changes in the socioeconomic context, has given rise to changing processes in forest landscapes, to the disappearance of "traditional knowledge" and of the related culture (CIANCIO *et al.*, 2004).

In Italy Calabrian pine stands represent the peculiar element of the forest landscape, strictly connected with anthropic activities, of large areas where the species is native: Etna, Aspromonte and especially Sila which is the most important and representative area for extension and forest features.

Conservation of this landscape is important by cultural and historical points of view, as well as by environmental and socioeconomic perspectives. Nowadays, it is of particular interest since most of the pine forests are within the Sila National Park territory.

The following outstanding writers witnessed the importance, significance and beauty of the Sila landscape:

"… a region of gentle ondulations, the hilltops covered with forest-growth, the valley partly arable and partly pasture. Were it not for the absence of heather with its peculiar mauve tints, the traveler might well imagine himself in Scotland. There is the same smiling alternation of woodland and meadow, the same huge boulders of gneiss and granite, and the same exuberance of living water" (DOUGLAS, 1992).

"… Perhaps only a few among all the Italian mountains can offer such spectacularly fast changes of nature and scenery as this: maybe none. Suddenly, like a fantastic change of sets on a stage, vast, different lands and vegetation unfold before the traveller's astounded eyes: finally Sila! … On the slope of Montescuro, at the feet of the observer looking towards the upland plain, a magnificent thick sweep of pines, impenetrable to the gaze until the bottom, descends to rise again on the South and East in majestic uniformity up to the first stretch of mountains, beyond which there are others, that are more sublime and less wooded with peaks that are strewn with snow even in the middle of summer" (ISNARDI, 1927).

"… It was a big mistake in the past to consider Calabria some kind of transit area on the way to Sicily, rather than a region where to linger for its varied and unique beauty. It is sufficient to go up the Sila to realize that it was a mistake. This chain of mountains in the middle of the region is unique not only in the South of Italy, but in the entire Southern Mediterranean area. I have already said that the Sila is a paradoxical North rising in the South. This green landscape of forests and pastures is the real mountains in the northern sense: it recalls the Trentino landscapes such as the Alpe di Siusi, or even the

Scandinavian peninsula, … a mysterious outcropping of the far North on the southern tip of the Italian peninsula. … Nonetheless what is left of the Sila forests, too little for the economist, enough for the tourist, surely surpasses the splendour of the Swiss or Trentino forests. The Calabrian pine reigns here, a free tree whose seeds flourish even if carried by the wind. It is a tree that we laymen find very similar to a fir, though taller and more slender. It creates arboreal cathedrals with even, thick trunks, that sometimes stretch for kilometres, embracing the peaks and filling the Sila with secret places. We could say that the South, forced into the forms of a northern landscape, reveals itself in disguise with a surplus of vital lymph. The Sila is a Northern fantasy performed with the exuberance of the South…" (PIOVENE, 1971).

"… Indeed the peculiar morphology of the Sila, together with its main ornament – conifer forests of mainly Calabrian pine – make this massif totally unique in the Mediterranean region" (BEVILACQUA, 1999).

Nowadays, it is necessary to point out cultural and management approaches able to preserve this peculiar landscape. Lacking silvicultural activities, many areas are experiencing a gradual change in structure and composition of Calabrian pine forests (IOVINO e MENGUZZATO, 2000).

Only few areas host pine forest relics with old-growth features. The presence of big and old trees, standing dead trees and snags, woody debris and gaps in canopy cover characterize old-growth forest (SPIES, 2004; DI FILIPPO, 2005).

This paper analyses the structure of an old-growth Calabrian pine forest, one of the few remnants of old growth-forests in the Sila territory. Its main features will be compared to those of uneven aged Calabrian pine forests managed by "small group selection felling" (CIANCIO *et al.*, 2004; 2006).

2. MATERIALS AND METHODS

2.1. Study area

Calabrian pine forests characterize a vast area of the Sila range including the provinces of Cosenza, Crotone and Catanzaro, up to 1600-1650 m altitude, and part of the mountainsides that branch off in the four cardinal directions.

The old-growth pine forest is State property and covers an area of about 12 hectares near Fosso Cecita (39°23'23" Latitude North and 16°33'22" Longitude East) on mountainsides with S-SW exposure at an altitude varying from 1140 to 1200 m.

Climatic data, for the station of Cecita (1180 m a.s.l.), shows an average

yearly rainfall of about 1083 mm, with a minimum of 24 mm in July and a maximum of 163 mm in December. During the winter snow is quite frequent, with monthly average between October and March of over 100 mm (Figure 1). Over 80% of rainfall is concentrated in the same period, and it reduces to only 8% during the Summer.

During the months of June, July and August the average Mitrakos drought stress index was 96 mm, while the average Mitrakos cold stress index of the area was 468. The average yearly temperature is 9.9°C, that of the coldest and of the hottest month, respectively, 1.2°C and 19.2°C. The average of the yearly minumum is 9.4°C, the average of the coldest month -1.8 °C, while the average of the maximum of the hottest month is 24.8°C.

The area lies on igneous and metamorphic rocks; soils are acid, ranging from very shallow to moderately deep, with texture from medium to coarse and moderately coarse.

Soil water reserve varies between high and very low, drainage from good to fast (ARSSA, 2003).

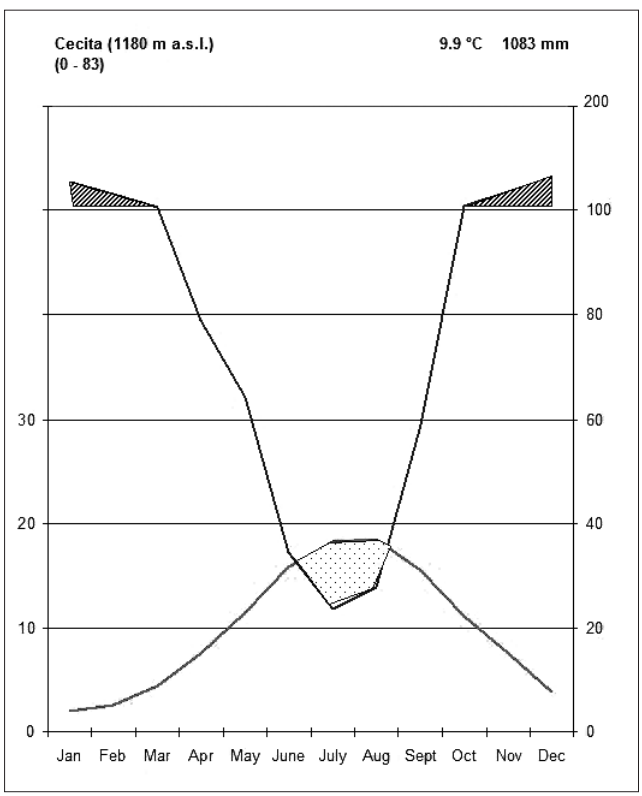

Figure 1 – Climate diagram of Cecita's station.

2.2. Surveys and data processing

Structural analysis was carried out in a transect 20x50 m, in average conditions of the old-growth forest. Inside the transect for each tree the following data was recorded: position; diameter at 1.30 m (DBH), starting from a minimum threshold of cm 3; total height; height of green crown insertion; crown projection in the four cardinal directions.

An increment core at the height of 1.30 m from ground with an increment borer was taken on a sample of about 75% of trees with diameter over cm 3; age was estimated by counting the number of increment rings; their thickness was measured with a binocular stereomicroscope interfaced to a computer for simultaneous data collection. With this data individual dendrochronological curves were obtained.

Graphic representation of stand structure (vertical profile, perspective view and horizontal crown projection) was obtained using SVS software (Standard Visualization System, USDA FOREST SERVICE, 1999). The same software was used for calculating total canopy cover, and canopy cover referred groups of trees of different size. Volume was estimated using the general double-entry tables of the Forest National Inventory (MAF-ISAFA, 1988).

Vertical structure was characterized using the Latham index (LATHAM *et al.*, 1998), while for horizontal structure, the Winkelmass UAI (Uniform Angle Index; Von GADOW *et al.*, 1998; CORONA *et al.*, 2005) was calculated using the NBSI software (Neighbourhood Based Structural Indices) (CALVANI *et al.*, 2005).

3. STRUCTURAL ANALYSIS OF OLD GROWTH FOREST

This Calabrian pine forest is one of the few remaining remnants of old-growth forests in the Sila territory. It has not been managed since the beginning of the last century and the first management plan for the area (AZIENDA DI STATO PER LE FORESTE DEMANIALI, 1966) described it as a "stand with mature individuals and others of various ages (ranging from young to close to maturity)". No intervention was prescribed and it was suggested to treat it as a natural park, due to its aesthetic and soil protection functions.

Therefore, present structure is the result of a natural disturbance regime, at least for the last 100 years, as proved by historical documents and confirmed by dendrochronological analysis.

Some of the oldest trees originated during the last stage of the Aragonese domination ended in 1714, others during the Bourbon domi-

nation (1738-1860). Both periods were characterized by great changes in land use – forest destruction over vast areas – and by deep changes in the landscape.

Four trees have diameters greatly exceeding the rest. These old-growth trees are situated in the central part of the stand. Core extraction was possible only on three of them because the fourth had a cavity in the lower part of the bole.

Conventional age (at 1.30 m above ground) of the three sample trees is 230, 246 and 325 years (Table 1).

Tree age and the analysis of time-related diameter increment variations highlighted some relevant aspects of the structural dynamics of the stand.

Diameter increment analysis shows how the last anthropic disturbance occurred in the second half of the XIXth century. Only the 246-year old tree shows a significant growth starting from 1940, which is not noticeable in the others (Figure 2). This can be due to the fall of a big pine as witnessed by the settlement, in the gap, of a group of Calabrian pines (group D), whose age can be referred to the years in which the diameter growth occurred.

The stand density is 1279 trees per hectare with a basal area of 79.11 m^2; excluding the 4 old-growth trees, the distribution in diameter classes ranges from 5 to 40 cm; starting from class 20 number of trees decreases with increasing diameter (Figure 3).

Vertical distribution is very articulated, as shown by the Latham Index. The profile is composed of seven layers: starting from above, the first four are well spaced (Figure 4), the lower three are less differentiated and are composed of a low number of trees with heights ranging from 2.2 to 4.25 m. In these layers, Beech and Turkey oak individuals are randomly distributed, with ages ranging between 20 and 25 years, with a density of 90 trees per hectare; Turkey oak have diameters from 4 to 7 cm and heights from 4 to 6 m; Beech diameters from 4 to 6 cm with heights from 5 to 7 m.

The first layer comprises 26% of the number of trees and 78% of basal area; it is composed by the 4 old growth trees, which by themselves contribute for 67% of the layer's basal area, and by younger trees with heights over 22 m.

Table 1 – Main features characterizing old growth trees.

ID tree	DBH 1,3 m (cm)	H total (m)	H crown insertion (m)	Crown projection (m^2)	Age
78	143.3	22.9	5.9	208.7	–
80	79.6	25.6	10.7	82.5	325
81	114.6	24.9	8	233.7	230
108	113	35.1	13.2	169.7	246

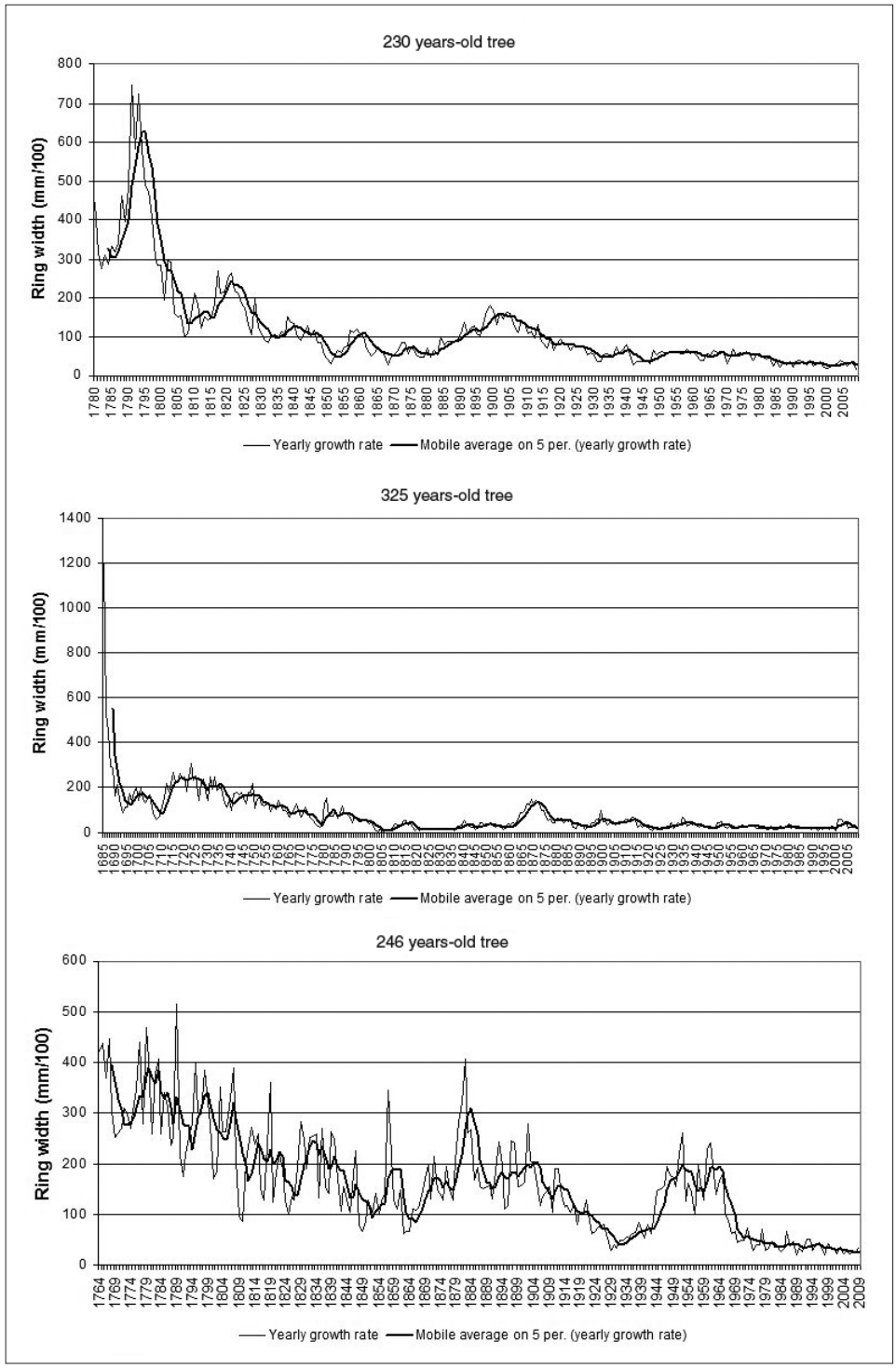

Figure 2 – Variation of yearly growth in old growth trees.

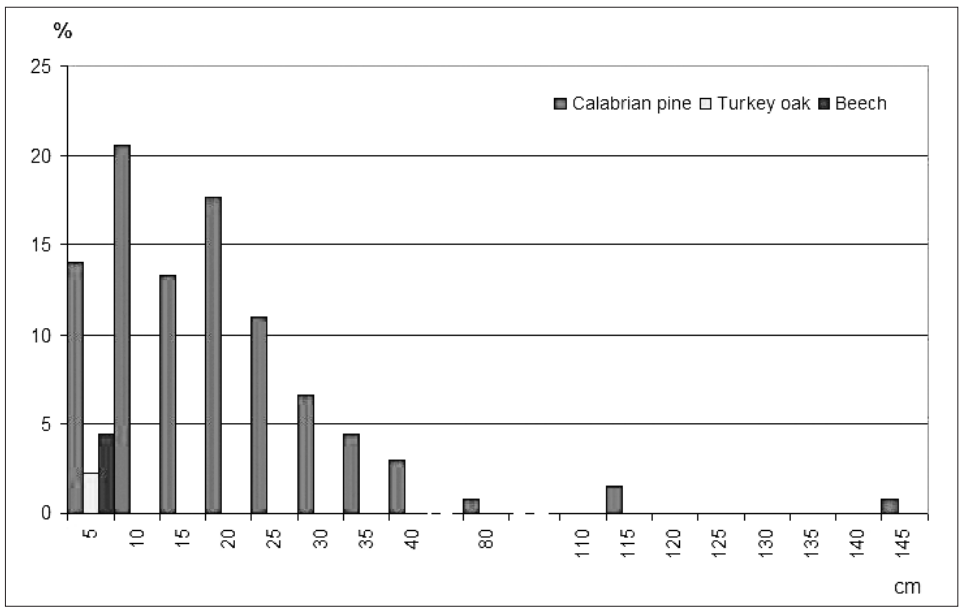

Figure 3 – Distribution of trees in diameter classes.

The second layer hosts 29% in number and only 16% of basal area and is composed of trees having diameters and heights ranging, respectively, from 7 and 39 cm and 13.5 and 22 m.

The third layer with 21% in number and only 4% of basal area is composed of individuals having diameters and heights ranging, respectively, from 4 and 29 cm and 8.9 and 13 m.

The fourth layer, while hosting about 2% of stand basal area, comprises 18% in number of trees with diameters from 4 to 24 cm and heights between 5.6 and 8.7 m.

Stand structure is characterized by the presence of 4 groups of trees (A, B, C, D), partly covered by the old-growth trees. The trees forming these groups have different age and occupy areas of different size in relation to the dynamic of the old growth population (Figure 5).

Group A: covers an area of 350 m^2 and was originated from the fall of two big trees placed at the end of the group, as shown by two stumps still present on the ground with 55 and 65 cm diameters. The group is composed of 52 trees with diameters between 4 and 39 cm and heights reaching in the tallest trees 25-27 m, with insertion of the crowns at 12-15 m; smaller trees (diameters less than cm 12) have heights of 7-10 m, and crowns insertion at 3-5 m. The distribution of trees in diameter classes shows a variation between cm 5 and 40. The crowns projection of the biggest trees is 36-38 m^2, while

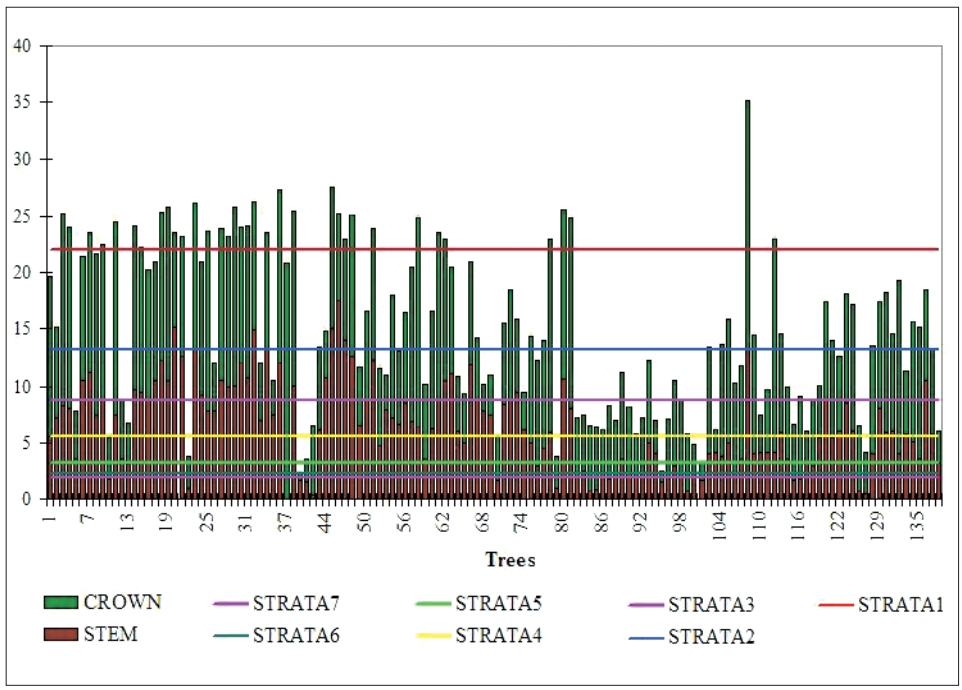

Figure 4 – Vertical profile of crop and strata individualization.

Figure 5 – Structural profile of old growth pine forest.

that of the smallest ones 1-2 m^2. Average age of the trees is 59 ± 5.31 years. Inside the group three subgroups were discriminated relating to the trend of diameter growth rate. The analysis of values of diameter and height of trees belonging to each group demonstrated that the first subgroup contains 25% of the trees with diameter over 30 cm and heights over 25 m; the second one, 30% of trees with diameter from 20 to 30 cm and heights between 20 and 25 m; the third one the remaining 45% of trees having diameter and height inferior to, respectively, cm 25 and m 20.

Group B: covers an area of 170 m^2 and is situated between the lower end of the preceding group and the external limit of the crown projection of an old-growth tree. The group is composed of 19 trees with diameters comprised between 4 and 34 cm and heights that reach, in the biggest specimens, 23-24 m, with crown insertion at 10-11 m; in the smallest ones (diameter less than 12 cm) the height is 10-12 m and insertion 5-6 m. The distribution in diameter classes has a variation field of 5 and 35 cm, with the highest values between 6 and 21 cm. The crown projection of the biggest trees is 22-24 m^2, that of the smallest ones 1-3 m^2. The average age is 50 ± 7.4 years.

Group C: covers an area of 60 m^2 and is situated under canopy of old-growth trees crowns. The group is formed by 12 trees with diameters between 4 and 14 cm and heights between 6 and 12 m and crowns insertion at 2-3 m; crown projection area is 15-17 m^2. Distribution of trees in diameter classes has a variation between cm 5 and 15. Trees have an average age of 37 ± 5.33 years.

Group D: covers an area of 190 m^2 and is situated partly under canopy and partly on the end of the old growth trees crowns. The group is composed of 32 trees, diameters 4-24 cm, heights 3-18 m, crown insertion at 2-8 m and crown projection from 2 to 12 m^2. Distribution in diameter classes shows a variation field between 5 and 30 cm, with highest frequency in the classes of 9 and 18 cm. Average age of group is 66 ± 8.61 years.

As for horizontal structure, the Winkelmass UAI index highlights a distribution of trees mainly random (67%) and into groups (22%) (Figure 6).

The analysis of diameter growth rate highlighted the relevance of differences among the trees belonging to groups discriminated with regard to age. Figure 7 illustrates average values and intervals corresponding to the minimum relevant difference at probabilistic level of 95% of average growth rate in the different groups.

Altogether, the major average growth rates were recorded in group A (Table 2), while the lowest was recorded in group D. The latter, as well as group C, is situated under canopy or at the end of old-growth trees, that limit its development. Group A

Table 2 – Values of average growth rate in single groups.

Groups	Average growth rate (mm)
A	1,865
B	1,407
C	0,946
D	0,858

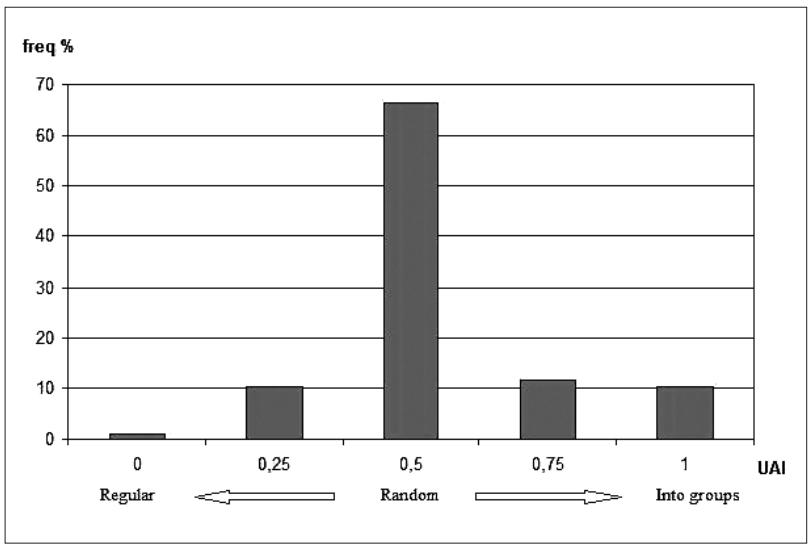

Figure 6 – Distribution of values of Winkelmass index.

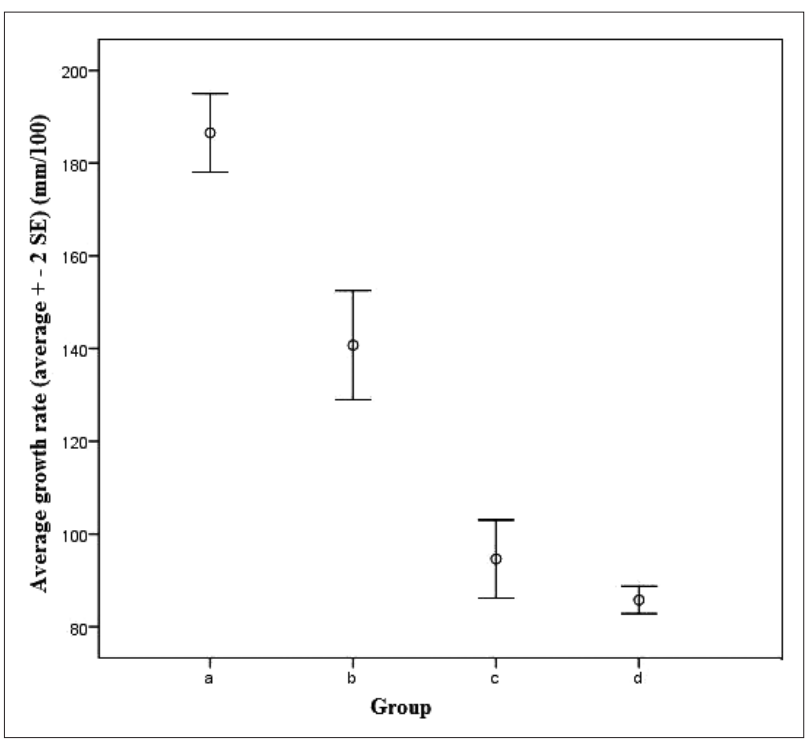

Figure 7 – Variance analysis of yearly growth rate.

and group B are very different from groups C and D, that, instead, are not much differentiated.

Multi-varied analysis inside each of groups A, B, C (the latter comprising group D as well) applied to average growth rates, highlighted the presence, in each group, of two clusters indicating the different increment in comparison to the social position of the trees (Figure 8).

4. Uneven-aged pine forests managed by small group selection felling

The old-growth pine forest here examined has a structure characterized by the presence of groups of trees of different age and dimension. Such a structure is similar to that of the Calabrian pine forests managed by small group selection felling, analyzed in previous works (Ciancio *et al.*, 2006).

This type of management leads to the creation of sporadic gaps, depending on the number and dimensions of felled trees. In these gaps during the following few years there is an abundant and diffused regeneration.

Tree distribution in the space is aggregated and random. Each group has a multiple age one, two, three or four times the interval of time between two subsequent cuts, that is 15-20 years. Individuals of each group are even aged. In the whole the forest is uneven-aged in small groups.

The forest has a multi-layered structural profile with four kinds of groups (Table 3).

Single groups cover an area – estimated on the basis of the external perimeter of the crown projection of the trees in the group – varying between 60 and 100 m^2. The number of groups per hectare is comprised between 67 and 100. Canopy cover varies around 60%.

Dimensions of groups, age and dimensions of pines of these groups are different in comparison with those surveyed in the old-growth Calabrian pine forest. What is noticeable is that processes of regeneration of the forest are similar to those that have taken place in the old-growth pine forest, though with rhythms and on a spatial scale that depends on the age and dimensions of the trees of each stand.

Table 3 – Main features characterizing groups.

Groups	N° trees	Age	Diameters (cm)	Heights (m)
I	2-3	80-90	>40	23-25
II	5-6	60-70	31-40	21-23
III	9-10	40-50	21-30	17-20
IV	14-15	20	<20	Up to 17

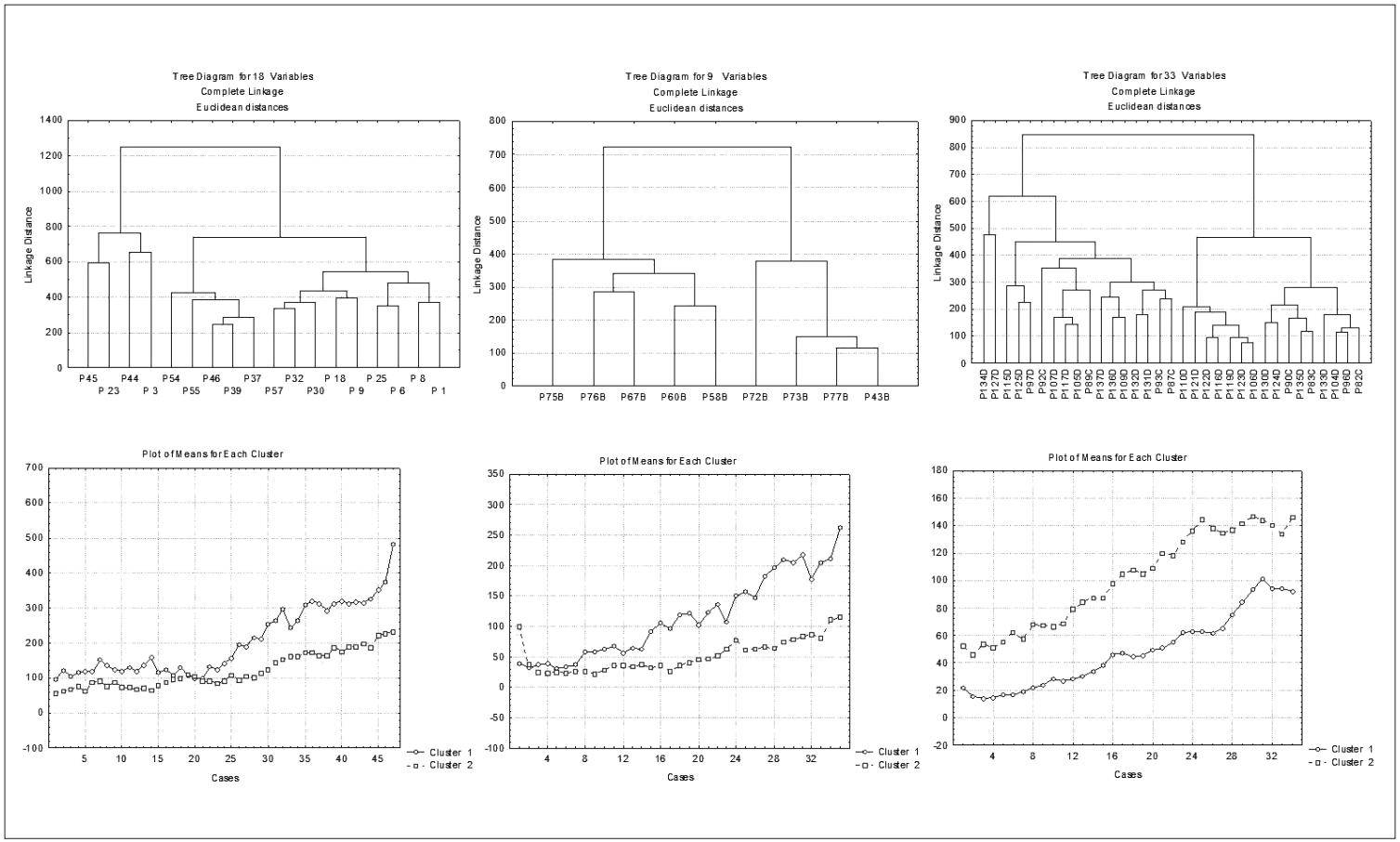

Figure 8 – Multi-varied analysis of the stand with respect to average growth rate.

5. Conclusion

Calabrian pine forests in the Sila territory represent a peculiarity of the local landscape. Preservation of such landscape depends on the maintenance of its most significant and characterizing elements, among them, pure Calabrian pine forests. Their present distribution and structure results from their silvicultural and management history – historical vicissitudes, kind of property and economic conditions – that have characterized the territory.

Management of Calabrian pine forests has applied, over the last forty years, different cultivation techniques such as elimination of small trees, strip or patch clear felling, and small group selection felling. This kind of management has caused the presence on vast areas of stands with different structural features. Pure Calabrian pine forests with even or uneven aged structure alternate with pine forests where there is a diffused and dense regeneration of Beech and other broadleaves, or, in the more advanced stages, young Beech forests under old-growth pines.

Comparison between old-growth Calabrian pine forests and uneven-aged pine forests highlightes how small group selection felling allows the maintenance of pine forests while preserving the typical Sila landscape. On the other hand, from a scientific and technical point of view, this type of management can be considered similar to the structural evolution of an old-growth pine forest.

In the old-growth pine forest, falling of big trees, at different times, led to the creation of gaps, with surface depending on crown width, in which pine regeneration settled in. On the whole, stand structure is layered into groups.

The structure of small group uneven-aged pine forests is instead the consequence of small group selection felling, i.e. elimination of groups of 2 or 3 big trees, together with limited intervention on nearby dense groups, usually felling only few specimens, generally malformed or withered.

Our results contribute to the knowledge of structural dynamics of Calabrian pine forests without anthropic activity. Furthermore, they can provide indications on the silviculture to be applied in Calabrian pine forests. Results confirm how small group uneven aged Calabrian pine forests show a kind of structure that, while linked to anthropic activity, resembles that of Calabrian pine old growth forests. Furthermore, this management system meets the landscape requirements of the Sila territory and, more generally, of those areas characterized by Calabrian pine forests.

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RIASSUNTO

Struttura di un bosco vetusto di pino laricio: indicazioni per la gestione delle pinete e la salvaguardia del paesaggio forestale

Le pinete di laricio costituiscono l'elemento peculiare del paesaggio di ampi territori italiani: Etna, Aspromonte e, soprattutto, Sila. La conservazione del paesaggio silano diventa rilevante non solo in termini culturali e storici, ma anche sotto gli aspetti ambientali e socioeconomici. Oggi, poi, assume maggiore valenza perché gran parte di tali pinete ricadono nel territorio del Parco Nazionale della Sila. Gli Autori analizzano la struttura di una pineta vetusta le cui principali caratteristiche sono messe a confronto con quelle delle pinete disetanee ottenute con il trattamento «taglio a scelta a piccoli gruppi». I risultati ottenuti forniscono utili indicazioni sulla selvicoltura da applicare alle pinete di laricio. Dallo studio emerge come la tipologia strutturale che più si avvicina a quella dei boschi vetusti di pino laricio sia, appunto, la pineta disetanea a piccoli gruppi. Il trattamento a taglio a scelta a piccoli gruppi corrisponde quindi alle esigenze di ordine paesaggistico e culturale.

REFERENCES

ARSSA - SERVIZIO AGROPEDOLOGIA, 2003 – *I suoli della Calabria*. Rubbettino Industrie Grafiche ed Editoriali, Soveria Mannelli (Catanzaro).

AZIENDA DI STATO PER LE FORESTE DEMANIALI, 1966 – *Piano di Assestamento per il decennio 1965-74.* Foresta Demaniale Sila Grande. Distretto Amministrativo di Cava di Melis.

BEVILACQUA F., 1999 – *Il Parco Nazionale della Sila. Guida naturalistica ed escursionistica*. Rubbettino Editore, Soveria Mannelli, 283 p.

CALVANI P., CORONA P., LAMONACA A., 2005 – *Quantificazione della diversità strutturale in soprassuoli forestali.* EM Linea Ecologica, 5: 6-9.

CIANCIO O., IOVINO F., MENGUZZATO A., NICOLACI A., NOCENTINI S., 2006 – *Structure and growth of a small group selection forest of calabrian pine in Southern Italy: A hypothesis for continuous cover forestry based on traditional silviculture*. Forest Ecology and Management, 224: 229-234.

CIANCIO O., IOVINO F., MENGUZZATO G., NICOLACI A., NOCENTINI S., 2004 – *Il taglio a scelta a piccoli gruppi" nelle pinete di laricio in Sila.* L'Italia Forestale e Montana, 2: 81-98.

CORONA P., D'ORAZIO P., LAMONACA A., PORTOGHESI L., 2005 – *L'indice Winkelmass per l'inventariazione a fini assestamentali della diversità strutturale di soprassuoli forestali.* Forest@, 2 (2): 225-232.

COUNCIL OF EUROPE, 2000 – *The European Landscape Convention. Strasbourg.*

DI FILIPPO A., 2005 – *Le foreste vetuste: ecosistemi chiave per la conservazione della biodiversità e lo sviluppo di una selvicoltura a basso impatto ambientale*. Linea Ecologica, 2: 22-25.

DOUGLAS N., 1992 – *Vecchia Calabria*. Introduzione di John Davenport. Giunti Gruppo Editoriale, Firenze, 485 p.

IOVINO F., MENGUZZATO G., 2000 – *La gestione delle Pinete di laricio nelle Aree Protette.* Atti della Tavola Rotonda: Selvicoltura ed Arboricoltura da legno: quale gestione? Palermo 25 marzo 1999. Supplemento alla rivista trimestrale Sicilia Foreste, 7: 25-34.

ISNARDI G., 1927 – *La Sila*. In: Le Vie d'Italia. Rivista mensile del Touring Club Italiano, 5 (7): 771-784.

LATHAM P.A., ZUURING H.R., COBLE D.W., 1998 – *A method for quantifying vertical forest structure.* Forest Ecology and Management, 104: 157-170.

MAF-ISAFA, 1988 – *Inventario Forestale Nazionale 1985. Sintesi metodologica e risultati.* Ministero dell'Agricoltura e delle Foreste, Istituto Sperimentale per l'Assestamento Forestale e per l'Alpicoltura, Trento.

PIOVENE G., 1971 – *La Calabria.* In: Viaggio in Italia. Arnoldo Mondadori Editore, Verona, p. 507-535.

SPIES T.A., 2004 – *Ecological concepts and diversity of old-growth forests.* Journal of Forestry, 102: 14-20.

USDA FOREST SERVICE, 1999 – *Software SVS (Standard Visualizationn System) versione 3.31.* http://www.fs.fed.us

VON GADOW K., HUI G.Y., ALBERT M., 1998 – *Das Winkelmass - ein Strukturparameter zur Beschreibung der Individualverteilung*. In: Waldbestanden. Centralbl. Fur das ges. Forstw., 115: 1-10.