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HOW CAN SMART ALDER FORESTS *(ALNUS GLUTINOSA (L.) GAERTN.)* FROM THE SOUTHERN CARPATHIANS BE IDENTIFIED AND MANAGED

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Abstract

The concept of smart forest is rather recent, being adapted from the climate smart agriculture concept, which has appeared in 2010. The forest situated in this category should fulfill the following criteria: increased income and productivity, improved resilience and reduces greenhouse gases. In addition, climate-smart forestry in mountain regions tries to situate forests from the mountain area based on their adaptation towards climatic changes, carbon stocks, biodiversity or other synthetic indices. The present article tries for the first time the framing of alder forests from the Southern Carpathian Mountains based on 16 indices regarding their site and stand characteristics. Alder stands from this area are generally located on plain fields, at low altitudes and on average or superior bonity stations. However, only 3.6% of them can be situated in the smart forest category. These stands are indicated on humid and rich soils, while their exploitation should be realized when they reach an age of 60-70 years.

Key words**:** *smart forest, alder stands, station type, altitude, exposition*

INTRODUCTION

In the last decades, an increasing concern was shown worldwide on improving forest management under rapid environmental changes [3, 16, 19, 27, 29]. In this context, an urgent need for new and efficient planning tools that can help cope with these challenges was emphasized [14, 24]. In this regard, the concept of Climate-Smart Forestry (CSF) was suggested as a comprehensive solution for increasing the forest ecosystem's capacity for adapting to climatic changes. The CSF notion represents a complementary option of the Climate-Smart Agriculture (CSA) concept, created and widespread by FAO (2010). Furthermore, it is considered one of the most adequate and rapid method through which the forest sector can contribute to climate change adaptation and mitigation, being sustained by numerous specialists [15, 21, 22, 30].

Compared to conventional approaches, a forest-smart approach to climate generates threefold benefits (triple-win): increased income and productivity, improved resilience and reduced greenhouse gases [17].

Recently, the *Climate-smart forestry in mountain regions* initiative was launched at a European. Its main purpose is to identify, define and develop "smartness" criteria for ensuring a sustainable long-term forest management in regard with global environment changes [6]. Mountain forest ecosystems generally present a high stability, especially due to their high structural diversity [23]. Some of the most important Romanian forest ecosystems can be found in the Southern Carpathian Mountains, this being known as the mountain chain with the largest surface of unfragmented forest [13]. The health state of these forests is good [2], as well as the soils [8, 20, 28]; in addition, the last period of time has recorded a forest altitudinal advancement [9].

Due to its eco-protective and structural importance, alder is one of the species that ensures a higher stand stability. All three indigenous species (*Alnus glutinosa*, *A. incana* and *A. viridis*) display a great climate adaptability and fulfill important soil protection functions.

More importantly, the resources of *Alnus* sp. can provide many opportunities for socio-economic development, especially in the surrounding rural areas. For example, black alder is a fast-growing species, being

appreciated as a source of raw materials, mainly timber and bioenergy [5], but also tannins and natural pigments [25].
Moreover, grey alder proved to have real productive wood biomass potential in short-rotation tree plantation on agricultural lands [7].
Also, the village communities can obtain financial benefits from practicing ecotourism, as the region is renowned for outstanding landscapes with an evident cultural heritage.

MATERIALS AND METHODS

The database present at INCDS Brasov was used as it contains information regarding forest management plans realized between 1992-2018 for the 45 forest districts from the area [1]. From here were extracted data regarding site and stand characteristics for all stands that contain alder (between 10% and 100%), namely 2998 stands. Each parameter has obtained a grade from 1 to 5, where: 1 = very low; 2 = low; 3 = average; 4 = high; 5 = very high (Table 1).

Table 1. Grades obtained based on stand and station characteristics.

Crt. No.	Characteristic	Grade				
		1	2	3	4	5
1	Average diameter (cm)	0-10	12-16	18-20	22-26	28-52
2	Average H (m)	0-9	10-12	13-15	16-17	18-27
3	Production class	5	4	3	2	1
4	Volume (m^3)	0-16	17-30	31-65	66-129	130-313
5	Current growth (m^3/an/ha)	0.1-0.3	0.4-0.6	0.7-1.2	1.3-2,2	2.3-12.2
6	Liter	1	2	3	4	5
7	Flora	35; 45; 53; 68; 74; 75	14; 15; 16; 17; 36; 42; 46; 52; 67	12; 22; 23; 32; 34; 44; 63; 65; 71	13; 33; 43; 51; 61	11; 21; 31; 41
8	Soil type	1703, 2207, 3305, 4102, 9101	1701, 1704, 2205, 2402, 2408, 3107, 3304, 4205, 9601, 9901	201, 401, 2101, 2212, 2214, 2501, 3104, 3105, 3206, 3302, 4101	2407, 3101, 3301, 9505	3102, 3108, 3115, 3306, 6101, 6205, 9501, 9502, 9506, 9511
9	Forest type	1162, 1342, 1521, 2116, 2213, 2214, 5172	1113, 1114, 1141, 1152, 1153, 1241, 1341, 1361, 1362, 4112, 4114, 4173, 7181, 4182, 4191, 4212, 4221, 4261, 4282, 4313, 5121, 5323, 5513, 6132	1121, 1151, 1321, 1331, 1422, 2212, 2221, 2231, 2241, 2251, 2261, 2321, 4131, 4141, 4142, 4151, 4161, 4211, 4231, 4241, 4311, 4322, 4331, 5314	1111, 1112, 1181, 1211, 1311, 1313, 1411, 2111, 2112, 2211, 4111, 5151, 5153, 5211	1171, 9112, 9211, 9712, 9721, 9722, 9811, 9812, 9820, 9821, 9822, 9831, 9912
10	Site type	2120 3120 4120 4210 5112	1510 2311 2321 3210 3311 3331 4311 4321 5131 5231 5241 7520	2322 2331 2510 3312 4220 4322 4324 4420 5132 5141 5152 5212 5221 5253 6142 6252 6263 7530	2333 2540 3333 3640 3720 4430 4720 5142 5153 5232 5243	2630 3730 3740 4520 4530 4540 5233 5254
11	Lopping	0.1; 0.2	0.3; 0.4	0.5	0.6	0.7
12	Vitality	5	4	3	2	1
13	Structure		1	2	3	4
14	Consistency	0.2-0.4	0.5-0.6	0.9	0.7	0.8
15	SUP	O; Q; C	A	J, V	B; G,K	E, M
16	Functional group + functional category	1,3C; 2,1A; 2,1C	1,4B;1,4C; 1,4D; 1,4E; 1,4F;1,4I; 1,4J;1,4K; 1,5L; 2,1B	1,2B; 1,5H; 1,5I	1,2A; 1,2C; 1,2E; 1,2F; 1,2H; 1,2L; 1,5C	1,1A; 1,1B; 1,1C; 1,1D; 1,1E; 1,1G; 1,2D; 1,2I; 1,5A; 1,5B

Source: original.

The meaning of terms present in Table 1 is rendered below:

Vitality: 1= very vigorous; 2= vigorous; 3= normal; 4= weak; 5= very weak

Structure: 1= even-aged stand; 2= relatively even-aged stand; 3= relatively uneven-aged stand; 4= uneven-aged stand

Production/protection subunits (SUP): A= regular forest, common assortments: wood for timber, constructions, cellulose; E= Reservations for integrally protecting nature; J= quasi-selection system forest; M= Forests submitted to exceptional conservation regimes; V= Forests with recreation functions through hunting.

Functional group (GF) and functional category (FCT) (excerpt): 1,1B= Forests on direct accumulation or natural lake slopes, present or approved; 1,1E= Forests situated in the river's superior bed (in the measure in which they don't reduce water leaking sections) or under its necessary limit and forests for protecting river shores, including the ones from the mountain region;

1,2I= Forests situated on fields with permanent swamps from terraces and interior meadows; 1,2L= Forests situated on fields with very vulnerable lithological substratum towards erosion and landslides; 1,4I= Forest strips situated along very important touristic roads;1,5A= National parks; 1,5L= Forests located in reservation protection areas (buffer areas); 2,1B= Forests destined to produce thick trees with superior timber quality.

Litter: 1= missing litter; 2= thin interrupted litter; 3= thin continuous litter; 4= normal continuous litter; 5= thick continuous litter.

Flora (excerpt): 11= Oxalis-Dentaria; 15= Hylocomium; 16= Vaccinium; 21= Asperula-Oxalis; 22= Luzula albida-Hieracium transilvanicum; 31= Asperula-Dentaria; 33= Symphytum cordatum-Ranunculus carpaticus; 35= Luzula-Calamagrostis; 41= Asperula-Asarum; 42= Carex pilosa; 44= Festuca altissima; 46= Vaccinium-Luzula; 51= Asarum-Brachypodium; 53= Luzula albida-Carex montana; 61= Asarum-Stellaria; 67= Poa pratensis-Carex caryophyllae; 71= Erachypodium-Geum-Pulmonaria; 74= Carex brizoides-Agrostis alba; 75= Carex riparia-Iris pseudacorus.

Soil type (excerpt): 201 = histosol; 2201= typical preluvisol; 2209 = stagnic preluvisol; 2401= typical luvisol; 3101= typical eutric cambisol; 3301= typical dystric cambisol; 4101= typical entic podzol; 4102= lytic entic podzol; 4201= typical podzol; 6205= gleysol; 9501= typical fluvisol, 9506= gleic fluvisol.

Forest type (TP), (excerpt): 1171= Norway spruce and white alder stand; 1311= Normal resinous and common beech mixture with mull flora; 1321= Resinous and common beech mixture with Rubus hirtus; 2212= Fir-common beech stand with mull flora of average productivity; 4111= Normal common beech stand with mull flora; 4131= Mountain common beech stand with Rubus hirtus; 4151= Mountain common beech stand with Luzula luzuloides; 4211= Hill common beech stand with mull flora; 4221= Common beech stand with carex pilosa; 4241= Hill common beech stand with acidophil flora; 9712= Alder stand on gleysols of average productivity; 9721= Black alder park; 9722= Pure black alder of superior productivity from the hill area; 9811= Alder stand with Oxalis acetosella; 9821= White alder on sandy and gravel soils; 9831= White alder stand on muddy soil.

Type of station (TS), (excerpt): 2311= Mountain Bi podzolic Norway spruce stands with Vaccinium of raw average and low humus; 3331= Mountain mixtures, Bi low edaphic eutric cambisol with Asperula-Dentaria +- acidophilus; 3332= Mountain mixtures, Bm average edaphic eutric cambisol with Asperula-Dentaria; 3333= Mountain mixtures, Bs high edaphic eutric cambisol with Asperula-Dentaria; 3720= Mountain mixtures, Bi alluvial, weakly humiferous; 3730= Mountain mixtures, Bm moderately alluvial, humiferous; 4321= Mountain-pre-mountain, Bi low edaphic dystric cambisol common beech stands; 4410= Mountain-pre-mountain, Bi low edaphic eutric cambisol common beech stands with Asperula-Dentaria; 4420= Mountain-pre-mountain, Bm average edaphic eutric cambisol common beech stands with Asperula-Dentaria; 4520= Mountain-pre-mountain common beech stands, Bm alluvial, weakly humiferous; 4530= Mountain-pre-mountain common beech stands, Bm alluvial, moderately humiferous; 5253= Hill holm stands, Bm-s alluvial, moderately humiferous in the low meadow; 5254= Hill holm and common beech stands, Bs-m, gleysol in the high meadow.

RESULTS AND DISCUSSIONS

We can consider that the smart forest alder category includes stands that have a grade higher than 59, namely 3.6 % of the total number of alder stands present in this area (Fig. 1).

From a geographic repartition point of view, the majority of smart alder forests are located in the Retezat, Făgăraș, Parâng and Bucegi Mountains (Fig. 2).

As it was expected, the majority of alder stands are located on plain fields without slopes as well as on expositions (especially shadowed) with small inclinations (Table 2).

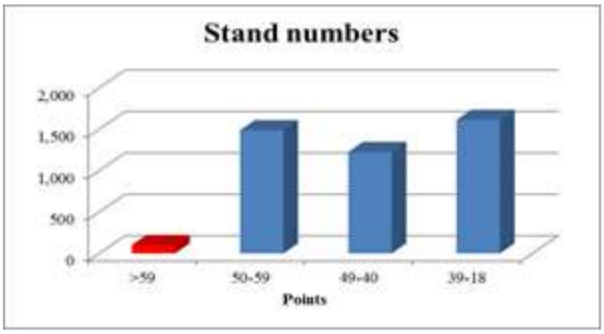

Fig. 1. Framing of alder stands from the Southern Carpathians in the smart forests category
Source: original.

Fig. 2. Distribution of the first 10 smart alder forests from the Southern Carpathians
Source: original.

Table 2. The characteristics of the first 20 smart alder stands from the Southern Carpathians

Crt. No.	Location	Alder percentage (%)	Age (years)	Exposition	Field slope (%)	Altitude (m)	Site type
1	RETEZAT	6	40	0	0	1,250	9506
2	RETEZAT	7	30	0	0	1,250	9506
3	NEHOIASU	10	45	NV	15	590	9501
4	ARPAS	8	50	N	12	445	9501
5	BUMBESTI	10	35	SE	6	730	9501
6	NOVACI	7	40	0	0	570	9501
7	NOVACI	10	40	0	0	560	9501
8	PIETROSITA	7	35	NE	15	800	3108
9	BUMBESTI	10	30	0	0	605	9501
10	ARPAS	4	40	N	10	585	3101
11	ANINOASA	8	70	NE	15	440	9502
12	BUMBESTI	10	35	0	0	380	9501
13	POLOVRAGI	10	60	E	6	520	9501
14	NOVACI	3	60	0	0	570	9501
15	ARPAS	5	70	N	20	595	3101
16	ARPAS	8	80	N	10	575	3101
17	ARPAS	8	70	SE	25	475	9501
18	ARPAS	8	60	SE	15	490	9501
19	TALMACIU	8	55	0	5	570	9505
20	TALMACIU	9	35	0	3	560	9505

Source: original.

Most of the alder stands are located in the following categories: 5253 (Hill holm stands, Bm-s alluvial, moderately humiferous in the low meadow), 5254 (Hill holm and common beech stands, Bs-m gleysol in the high meadow) and 3730 (Mountain mixtures, Bm alluvial, moderately humiferous) (Fig.3).

The stations have a superior bonity in this area due to the increased quantity of humus present in forest soils [10, 12] as well as due to their good water supply [11].

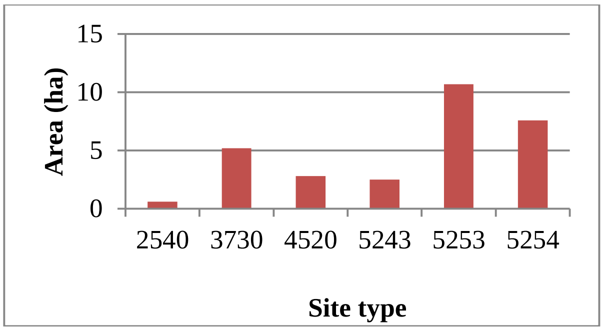

Fig. 3. Distribution of the first 20 smart alder forests from the Southern Carpathians on station types
Source: original.

It can also be observed that alder stands are located in the Southern Carpathians both at reduced altitudes (400-700 m), as well as at average ones (800-1,000 m) (Fig. 4). This fact is caused by the alder's ecologic specific as the species spreads near riverbeds (mountain ones in this case) but does not adapt well at very high altitudes (where it is replaced by Norway spruce, mountain pine or arolla pine).

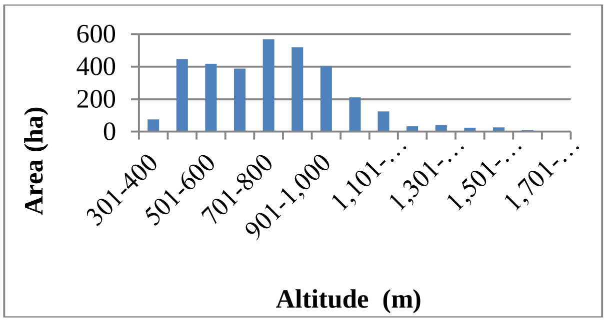

Fig. 4. Distribution of the first 20 smart alder forest from the Southern Carpathians by altitudes.
Source: original.

Management measures concerning alder stands from the Southern Carpathians.

Green alder (*Alnus viridis* (Chaix) D.C.) is scarcely spread in comparison with the black one, being adapted to harsher climates of high altitudes. Present in areas with short periods of vegetation, the species has an extremely important role in consolidating debris and landslide aisle. However, its reduced presence (it does not even form pure stands) does not lead to the establishment and adaptation of specific silvicultural measures.

Black alder (*Alnus glutinosa*, named alder from now on) is the most widespread alder species in our country. The following management measures concern this species.

As alder is a frost-resistant species, its spreading area also covers mountains and does not require special protection measures against this harmful climatic factor.

Alder prefers fertile soils, rich in humus, well drained and profound but it can also adapt on muddy soils, weakly aired. For this reason, fluvisols, gleysols and stagnosols are the soil types indicated for it.

Alder is a species with a light temperament, preferring sunny places. As such, the species will not be introduced in the composition of stands with growths faster than his as it can be eliminated by them.

Alder stands play an extremely important ecologic role, being a food and shelter source for many animal species such as birds, deer, rabbits, or butterflies [4]. The species is associated with over 140 plant-insect species and with 47 mycorrhiza species [31].

Alder trees must be extracted at the age of 60-70 years [5].

The alder wood has recently many usages, much more important than in the past so that attention offered to this species has increased lately. Until recent times, alder was considered more as a natural species that appears in places where other species cannot survive (mountain meadows), being considered more valuable than the birch but more inferior than Norway spruce, fir or common beech. The alder's wood value for the foundation of buildings located under water was well known from the past (being used in Venice or Ravenna). However, recently, this wood is used for producing veneer, furniture, window frames, toys, pencils, as well as for charcoal production.

Adler bark is used in treating swelling, inflammation and rheumatism, pharyngitis and other disease [26], while the seeds can be used against pathogenic bacteria and as anti-MRSA drugs [18].

CONCLUSIONS

Alder stands can be found in the Southern Carpathians especially on plain fields. The species can also be found on reduced slopes (0-10%), being situated especially on shadowy expositions, at reduced or average altitudes, on mountain or hill stations of average towards superior bonity (this bonity is caused by soil humidity and its supply with high humus quantities).

By taking into consideration 16 site and stand characteristics and by organizing hierarchically the obtained results for all alder stands from this area, we can say that only 3.6% of these stands can be situated in the smart forests category.

The mountain areas from the Southern Carpathians with a consistent presence of smart alder forests are: Retezat, Făgăraș, Parâng and Bucegi.

Alder is a tree species with many usages (wood destined for constructions and other usages, bark and seeds with medicinal properties, etc.), as well as with important ecologic consideration (food and shelter source for numerous animals, association with mycorrhiza that enrich the soil, etc.). Alder stands are recommended for humid and fertile soils, without competing with other species that can grow faster, while their exploitation is indicated at the age of 60-70 years old.

Furthermore, alder forests can contribute significantly to maintaining landscapes with natural, cultural and material heritage values, and also for a durable economic development in rural areas.

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