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FOREST AND SUSTAINABLE DEVELOPMENT

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FOREST AND SUSTAINABLE DEVELOPMENT

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PREDICTING TIME CONSUMPTION OF CHIPPING TASKS IN A WILLOW SHORT ROTATION COPPICE FROM GPS AND ACCELERATION DATA

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Abstract: *Biomass procured from willow short rotation coppice has a promising potential to ensure the provision of clean energy. To evaluate and validate the effectiveness of different harvesting techniques and equipment for small-scale willow short rotation coppice applications, time and motion studies are usually implemented in small trials. Nevertheless, the results of such trials may be biased by the exclusion of the variability which could be generated by a long-term data collection approach; therefore, techniques and methods should be developed to sustain the implementation of long-term studies. This study tested the capability of GPS and acceleration data to accurately document chipping tasks in a small-scale willow short rotation coppice. Coupling location and acceleration data, followed by a threshold-setting based on video recorded data and direct surveys in the field, led to the possibility to accurately separate the time spent in moving, chipping and non-chipping tasks. In addition, it was possible to observe, but not to extract, other events such as the transition time between the chipping and non-chipping states of the machine. The approach described in this study could be used to conduct long-term studies being suitable also for monitoring other harvesting equipment such as that chipping the stems during moving, as this could be enabled by a higher response in terms of acceleration induced by the vibration during chipping than by the movement itself.*

Key words: *willow, short rotation coppice, static chipping, time and motion, data collection, automation.*

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1. Introduction

The forecasted changes in climate and the increasing depletion of fossil fuel resources changed the contemporary socio-economic paradigms, with obvious effects in the change of views, policies and regulations, towards the preference in use of renewable energy sources that hold a promising potential to develop a bio-based, circular economy. For instance, to be able to sustain the European energy consumption, a significant effort has been undertaken to develop the willow short-rotation cultures (WSRCs), with major innovations in both, the breeding material [12] and in the practice and technology used to establish, manage and harvest the biomass [14, 16, 29].

Typical procurement operations in WSRCs are those making use of either a cut-and-chip or cut-and-store harvesting system which can be operationally implemented by the use of motor-manual or fully mechanized equipment [9, 13, 23, 30]. Nevertheless, both, motor-manual and mechanized harvesting of WSRCs still account for a significant share of the biomass delivery costs [13, 30]. While such costs can be sustained under the conditions of large-scale industrial WSRC applications [14], they may become a limiting factor under the conditions of small-scale farming, a reason for which self-employed small entrepreneurs often choose to use inexpensive multipurpose equipment [25] such as brush-cutters [28], chainsaws [9, 23, 30] and small chippers powered by agricultural tractors [14]. Obviously, this approach could be also the result of a lack of association [25] or of a limited availability of technology which is known to depend on the economic condition of a country [20, 22].

In Romania, the experience with willow cultivation is rather new [24], holding most of its background in the establishment of some test plots back in 2007-2008. Since then, an important area has been cultivated year-by-year, with many of such cultures being now in the harvesting stage. On the one hand, the Romanian farmers learnt on-the-job about the technology used in harvesting, and some local tacit experience exists about the most suitable equipment to be used in harvesting. Nevertheless, a significant part of the equipment used today in the Romanian WSRCs was purchased based on subjective opinion of farmers, including purpose-built small-sized harvesters.

To evaluate the time consumption and productivity in harvesting operations of the Romanian WSRCs, a series of pilot studies have been carried so far with focus on the motor-manual felling [8, 28], showing that the time consumption per hectare was high and the productivity was low. Nevertheless, the productive performance of such operations may be affected by several factors [28], including the limitations brought by human capability and the size of the harvested stems [28], confining the motor-manual harvesting to very short rotations [27]. This is a reason to test easy-to-use reliable technology for long-term data collection [8] and to elucidate the effects of various factors to be able to design new ways to harvest the willow.

Besides that, there are many reasons why data collected for a long period of time is useful to understand the behavior of a given harvesting system. Long-term collected data can account for variability which cannot be observed in small trials characterized, for instance, by complex tasks [5-6] and particular conditions to be surveyed [4, 7], enabling this way more informed decisions based on conclusive results [1]. Time and motion studies are usually implemented to collect such data but the traditional approaches have a series of limitations related to the accuracy [11], safety [1] and resources committed to the study [2-3, 21]. In contrast, the use of different available technologies which are currently developed to a reliable consumer-grade standard may enable long-term data collection and partial automation of the data processing effort [2, 27]. This is particularly important for that kind of equipment which is not characterized by the integration of measurement and production management systems [5], and which is further characterized by a low integration of mechanization or automation [27], limiting the possibility to extract data on long term and to support the management and decision-making in production. In fact, such limiting features characterize most of the equipment that is currently used in both, WSRC and typical timber harvesting operations from the south-eastern Europe [15, 20].

While there are many equipment options that could be used to harvest the willow by chipping, in our knowledge, chipping the willow at fixed points as a technical alternative which uses regular wood-designed chippers has not been studied so far. Such technical choices are versatile in the sense that they could be easily switched to operate with regular wood or willow, enabling the chipping in the field but, at least in WSRCs, they involve additional operations such as motor-manual stem felling, bunching (collecting) and feeding the chipper.

The aim of this study was to test to what extent is possible to automate data collection and processing in time and motion studies used to evaluate the time consumption and productive performance in fixed-point in-field chipping operations. The study was designed as a combined approach to collect GPS and acceleration data that were used to extract meaningful information about the time consumption on tasks, after data pairing.

2. Material and methods

Chipping operations were carried out on a 1.4-hectare WSRC plot located at approx. 46° 04'20.2" N - 26° 11' 04.2" E, 580 m about sea level, near Poian, Covasna County, Romania (Figure 1). The stems were motor-manually felled, chipped using a small-sized tractor-powered chipper (Figure 2) and the resulted wood chips were transported to a terminal using trailers powered by agricultural tractors (Figure 3). Motor-manual felling operations were carried out as typical to Romania, by a team consisting of two men, of which one used a brush-cutter to fell the stems and the other one assisted the felling using a wooden stick. A description of such work tasks is detailed in Talagai et al. (2017) and Borz et al. (2018). Chipping operations, which were the subject of this study, were carried out using a small chipper powered by a tractor. The work included both manual and mechanized tasks.

A team consisting of 6-7 workers was used to manually bunch, move and feed the willow stems into the chipper (Figure 3). Such tasks were organized on smaller sub-plots having a length less than 15 m and a width up to 10 m (7 twin rows). When finishing a given sub-plot, the chipper was moved ahead on a given strip to start a new sub-plot and when reaching the headland, the chipper was maneuvered to enter a new strip and to operate in the opposite direction. The chipper operated in parallel with a tractor-powered trailer designed to store and transport the wood chips. When the trailer was almost loaded, one of the workers was used to manually arrange the wood chips into it and when fully loaded, the tractor started the transportation to a terminal, being replaced by the other one operating in the area.

Fig. 1. Study location

Chipping operations were monitored using three devices. A Garmin 62 STC GPS unit (Garmin Ltd., Olathe, USA) was placed on the tractor used to power the chipper into a position that enabled a clear sky for the antenna and it was used to collect location data at a 5-second rate (Figure 2). An Extech® VB 300 acceleration datalogger (Extech Instruments, FLIR Commercial Systems Inc., Nashua, USA) was placed on the chipper, on the left side of the inlet, and it was used to collect data at a 1-second rate (Figure 2). The third device consisted of a digital video-camera mounted on a tripod that was used to videotape the operations at random intervals. It was used to collect 10 to 20 minutes in length digital video files that were used at the office to recognize specific events and to assist the decision algorithm used to categorize the time consumption data extraction from the GPS and acceleration datasets.

At the office, GPS data was transferred into a computer using the regular data downloading procedures and it was stored as GPX files. Then, the acceleration data was transferred and paired with GPS data using the dedicated software of the datalogger. The full data transfer, pairing, processing and analysis procedures used in this study are similar to those described in Borz et al. (2018). Resampling of the data collected by the acceleration datalogger was also made according to the procedures described in Borz et al. (2018) and it was necessary to be able to pair it with the GPS-collected data.

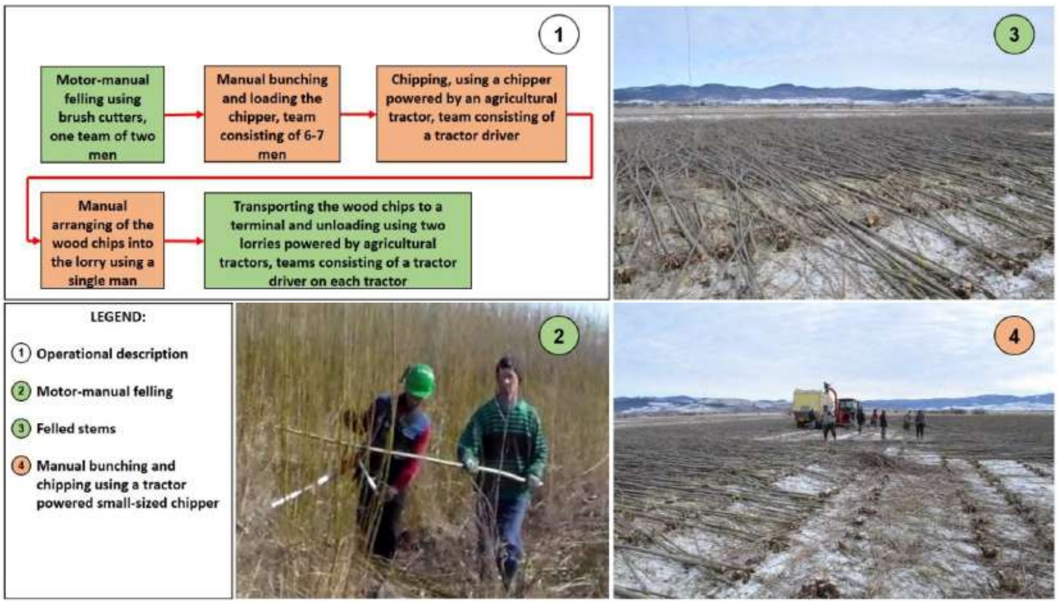


Fig. 2. Work organization: 1) general operational layout and the work teams, 2) procedures used to fell the stems, 3) felled stems to be bunched and 4) manual bunching and chipping

Fig. 3. The Tractor-mounted chipper observed during the field study (a) and the placement of acceleration datalogger (b)

The main differences in this study were those related to the chipping functions that were observed and the thresholds set to separate between specific events. To this end, given the work organization, two chipper movement events were monitored: not moving (*NM*) and moving (*M*). The first one characterized the time in which the chipper was stopped in a given point irrespective of the carried-out operations (chipping - *C* or not chipping - *NC*), while the second one was used to characterize the movements within the plot assuming, on logical reasons, that no chipping events occurred during movement. To document such events a speed threshold of the GPS collected data was set at 0.5 km/h (*S* = 0.5 km/h). Following a video analysis at the office, a threshold set at 5 g for acceleration (*A* = 5 g) was used to characterize the utilization of the machine by chipping and not chipping events. This was necessary as following the video analysis, the chipper was identified to be in three specific states: engine stopped, engine running without chipping and engine running and chipping. The last event was that in which the response of the acceleration datalogger exceeded 5 g. Therefore, this study attempted to separate between three events that characterized the operation of chipper: not moving and chipping - *NM_C*, not moving and not chipping - *NM_NC*, and moving - *M*.

3. Results and Discussion

This study used 6,945 GPS-collected locations and a dataset consisting of 34,715 acceleration samples.

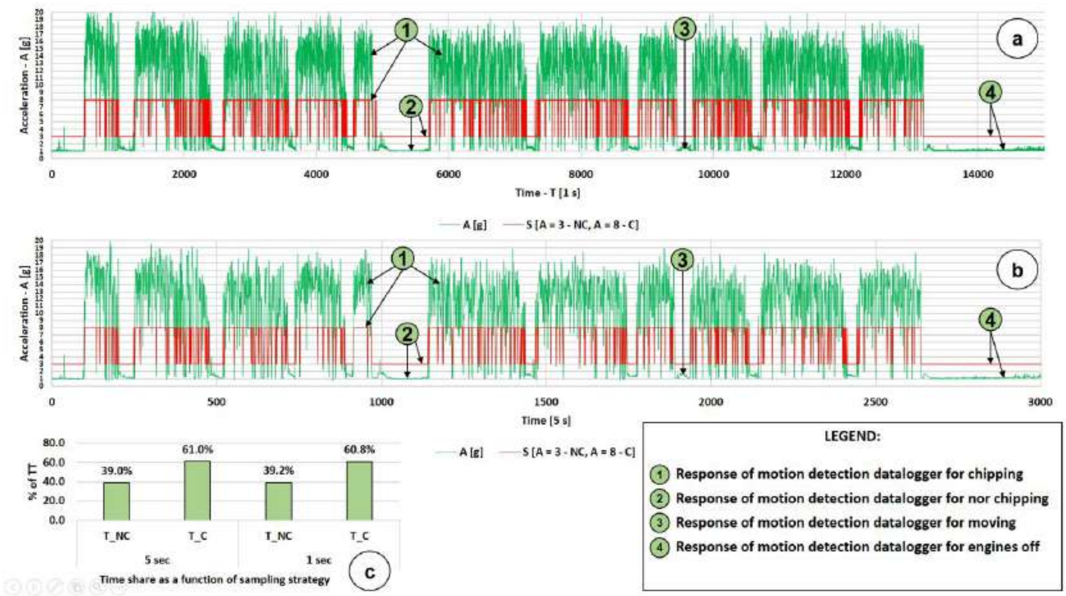


Fig. 4. Resampling accuracy and distinguishable events. Legend: a) accuracy and distinguishable events on the original acceleration data; b) accuracy and distinguishable events after resampling: in red - threshold set for chipping, in green - response in acceleration; c) resampling strategy & accuracy

Each fifth acceleration sample was extracted from the original dataset and paired to the corresponding GPS location. Figure 4 shows a comparison of two subsamples extracted from the original (a) and resampled (b) acceleration data sets. The acceleration threshold set at 5 g was used to differentiate between chipping and not chipping events in both datasets, events that were distinguishable using this threshold. Also, this approach enabled the identification of other kind of events such as operational breaks and chipper movement. Examples of such events are also given in Figure 2.

Data resampling resulted in a similar accuracy of the data set as shown in Figure 4. The differences were less than 0.02% in the case of chipping and non-chipping events. Therefore, chipping time, accounted for almost 61% of the total time, while the non-chipping time and chipper moving time accounted for the rest. Nevertheless, moving time characterizes moving events that were needed to relocate from a chipping point to another; therefore, it was reasonable to separate it from the observed time and particularly from that time category indicating no movement and no chipping which, in turn, may stand for organizational, technological and personal delays. The separation was based on the speed parameter extracted from the GPS files. Figure 5 shows the geospatial prediction of results obtained using three separation algorithms. Figure 5a shows the geospatial prediction of the moving versus non-moving time, Figure 5b shows the geo-spatial prediction of chipping versus non-chipping time while Figure 5c shows the geospatial prediction of the moving, chipping and non-chipping time accounting, therefore, also for possible delays.

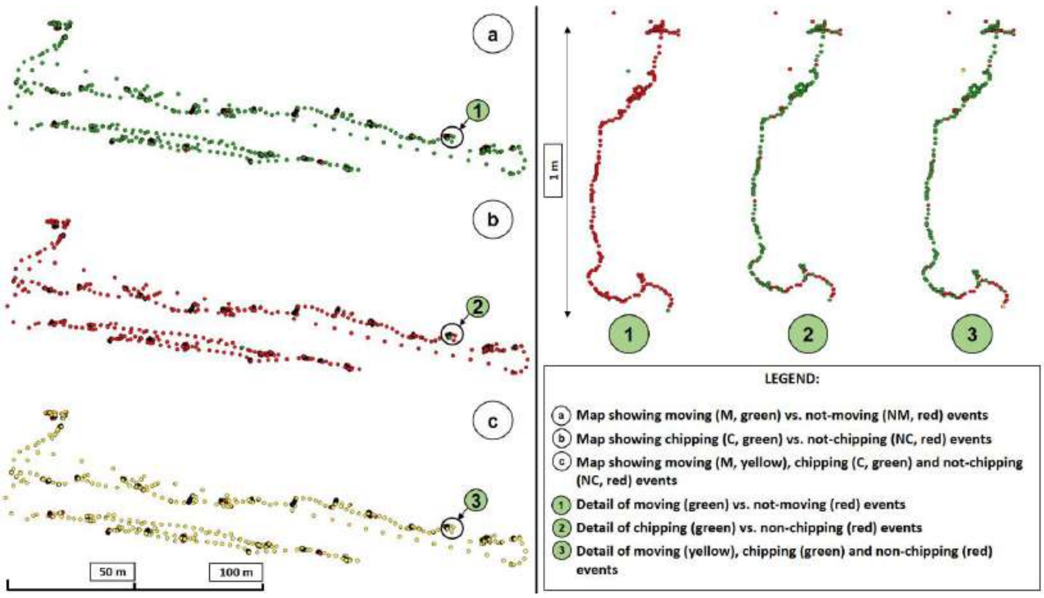
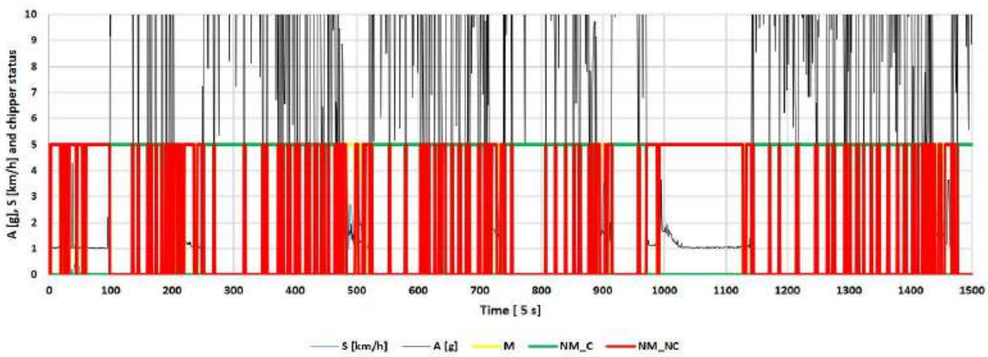


Fig. 5. Geo-spatial prediction of moving, chipping and non-chipping events

Differences shown for chipping versus non-chipping locations in the details shown in Figure 5 are the result of those events in which the chipper engine worked while it was not fed with willow stems. Therefore, the two are not characterizing the engine events such as the engine turned on or off but the effective chipping versus non-chipping. There were events in which acceleration responses were affected by the chipper movement, but not to the extent shown during the effective chipping. Other specific events such as turning off or on the chipper’s engine may also be seen in Figure 4 right before and after those responses characterizing the chipper’s movement.

As separated by the used algorithm, in the total study time - TT (9.64 hours), chipper moving time which included movement between successive subplots, movement to turnaround the chipper and to enter or exit the operated strips accounted for 4.8% (0.46 hours). More than 60% of the total study time was consumed during the effective chipping operations while the rest represented delays of organizational, technical and personal nature. In this category were included also those small parts of time in which the chipper engine worked without chipping between two successive feeds made by the workers. A detailed description of the moving, chipping and non-chipping time is given in Figure 5, which also shows the results of the separation algorithm that succeeded to differentiate between the three studied events.



TOTAL STUDY TIME – TT [h]	9.64
Non-moving, chipping time - NM_C [h]	5.88
Non-moving, non-chipping time - NM_NC [h]	3.30
Moving time – M [h]	0.46

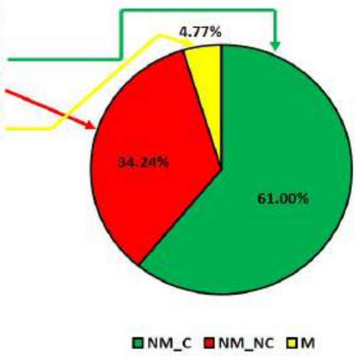


Fig. 5. Statistics of time consumption and results of the separation algorithm

Performance of a given system may be estimated using various metrics. Given the scope of this study, productivity and efficiency were estimated based on the operated area since no production outputs such as chipped volume or mass were measured. Based on estimates of the area operated during the study (cca. 0.5 ha), the gross production rate was evaluated at 0.05 ha/hour. This accounted for 23 points in which the chipper worked and another 3 major stops which were made for other reasons. The net production rate included only the time spent for moving and chipping and it was estimated at cca. 0.08 ha/hour. These figures translated into a gross and net efficiency of 12.68 and 18.92 hours/ha respectively.

The results of this case study indicate that coupling GPS and acceleration dataloggers to collect time and motion data in fixed-point chipping operations proved to yield very accurate results which could sustain the effort of collecting long-term data. As a fact, there are several studies which evaluated the capability of GPS in documenting time consumption of ground-based operations [17-18] including WSRC operations [10, 13, 28] but only few of them paired also the data collected by accelerometers [19, 26] to yield accurate separations of the time categories [8]. Given the experimental approach of this study, that accounted for static chipping operations, it is obvious that other operational layouts may result in different responses in terms of acceleration. Further studies could explore the potential of data collection using the procedures described in this study for those operations in which chipping is undertaken during the machine's movement over the WSRC plots. In such cases, the collection of acceleration data that differentiates between work tasks could be enabled to a greater extent by the amount of vibration generated by chipping devices; one could expect less acceleration generated by movement compared to the acceleration induced by the chipping vibration itself.

4. Conclusions

This study tested the possibility to automate data collection in time and motion studies specific to static chipping operations carried out in WSRCs. The results indicate that the separation of productive and non-productive time was possible and accurate when coupling GPS and acceleration data, followed by their thresholding. Both, chipping and non-chipping time were accurately extracted from the engine running time category. Moving time was also accurately predicted from the speed derived from GPS data. An approach such as that described herein could sustain long-term data collection with less researching effort.

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RESEARCH CARRIED OUT IN ROMANIA ON ECOLOGY AND MANAGEMENT OF THE POPLAR DEFOLIATOR *CLOSTERA (PYGAERA) ANASTOMOSIS* L. (LEPIDOPTERA: NOTODONTIDAE)

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Abstract: *Hybrid poplar cultures have been noticeably expanded in Romania, after the World War II. These artificial cultures provide the conditions for outbreaks of the different poplar specific pests. Among these, defoliator Clostera anastomosis proves to be, lately, very dangerous. First outbreak in Romania was recorded in 1971, in the Prut Floodplain, within Iași County, followed after 4 years of a new outbreak, in the Danube Floodplain, within Giurgiu County. Then, there were no records of severe attacks, but starting with 2003, attacks of high intensity are accounted, mainly in hybrid poplar cultures in the Danube Floodplain, section Oltenița-Brăila, resulting in significant defoliation, on a cumulated area varying from 220 ha, in 2006, to a maximum of 706 ha, in 2010. Poor knowledge on biology and ecology of this species couldn't provide the basis for assessing the critical threshold values, required for developing prognosis of the population and damage trends, from a generation to another. Consequently, decision for control action was taken depending on the intensity of the current attack, and if the economic threshold was exceeded (loss of > 50 % of the foliage), aerial or ground spraying were applied, using chemical and biological insecticides. The largest area (620 ha) was sprayed in 2004. For the future, an intensification of the attacks is predicted, so that further research is required for an in deep insight of the ecology and biology of this species, in order to support the developing of an adequate prognosis, as well as an efficient pest management.*

Key words: *Clostera anastomosis, hybrid poplar, outbreaks, pest management, Romania.*

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1. Introduction

The increasing world timber demand, especially after World War II, led to a massive expansion of hybrid poplar plantations in the Northern Hemisphere (North America, Europe, partially in Asia [5-6, 12, 27], as well in regions at Southern latitudes (Australia, Brazil, Chile, New Zeeland, South Africa) [23]. Romania is not an exception, first experimental plots were installed after 1915 [8]. Subsequently, these plantations were significantly expanded, from an area of approx. 12000 ha in 1960 to a maximum of approx. 80500 ha in 1984 (66000 ha compact areas and 14500 ha alignments) [8]. Recently, in 2015, there were recorded, at national scale, approx. 70000 ha plantations with different species/clones [7].

In the world, a large area of hybrid poplar plantations consists in intensive crops, oriented for varied biomass production (from biofuels to wood for industrial applications). These are even-aged poplar plantations, generally consisting of one clone selected for increased capacity of biomass accumulation [5, 24]. Often, these plantations become the object for specific or polyphagous pest outbreaks, due to the absence or low action of natural control mechanisms [9]. The hybrid poplar crops in Romania are not an exception, a lot of insect species, mainly defoliators, developing severe outbreaks [16, 28, 30, 32-33, 36]. Among poplar defoliators, during the last years, it is noticeable the species *Clostera* (*Pygaera*) *anastomosis* Linaeus, 1758 (Lepidoptera: Notodontidae), which caused important losses especially in Euromerican poplar plantations in the Danube Floodplain or interior river floodplains [38].

2. Geographic Distribution

C. anastomosis is a common lepidopteran species in Palearctic region, native in whole Europe as in Asia (Russia, Mongolia, China, Japan, Turkey, Kazakhstan) [26]. It lives mainly on poplar and willow species, so the local area of the defoliator is restricted to the presence of the host plants.

In Romania, the first faunistic record of this species dates since 1892 in the North-Eastern part of the country, near Rădăuți (47.8463 N; 25.9399 E) [21], and shortly after there were added new records from different locations all over the country [20]. At the moment, *C. anastomosis* is distributed almost in the entire country where species of *Salix* and *Populus* are present, up to elevations of 1400-1500 m a.s.l. [25, 31] (Figure 1).

3. Life History

In Romania, first observations of the activity and development of *C. anastomosis* were carried out at the end of 19th century – the beginning of the 20th century, when it is mentioned that the species has two generations per year in North [20-21], two complete generations and the third incomplete, in Transylvania [20], three complete generations and the fourth incomplete in South [22].

Adults of the overwintering generation start flying on the second half of May until the end of June, earlier in South comparing to Northern region. The flight of the first generation occurs in July – August, and of the second generation in

September [2, 36, 38]. During the warmer years, in South, adults of the third generation might fly to the end of September, the former generations' flight occurring earlier.

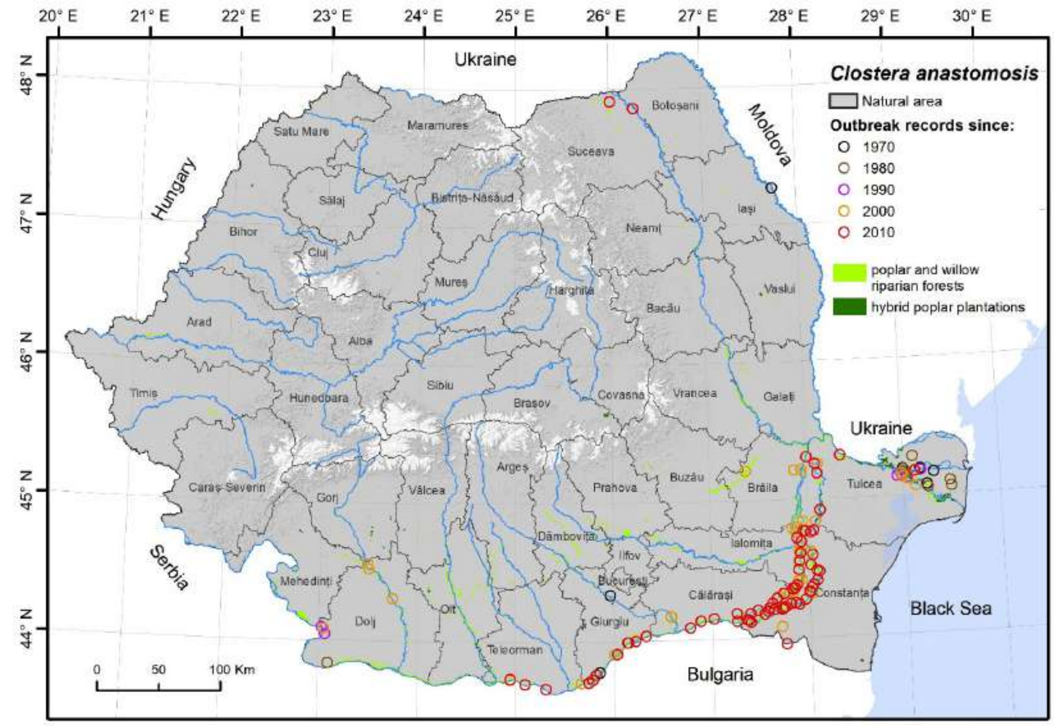


Fig. 1. *Clostera anastomosis* in Romania: distribution area and outbreak records

The flight activity is mainly nocturnal, and during the day the adults are resting on poplar leaves. Females are heavier so, the most part of the time, they shelter on branches or leaves. Males are more active, looking for females in fast and short flights [1, 36]. Adults are able to mate two – three days after emerging [40]. The copulation lasts 8-15 hours, but can be prolonged to 48 hours [1].

In three – four days after mating, females are laying in average 700-800 eggs, on the lower part of the leaves, in batches, on different leaves [36]. The embryonal development lasts for 5-8 days [2], and the eggs are changing the colour from yellow – green to reddish, finally they become grey – blackish, easily pearly [20, 38].

Neonate and second instar larvae feed gregarious, skeletonizing the leaves. Starting with the third instar they spread in the crown, eating the entire leaf, excepting the main vein [2, 20, 36].

The pupation occurs after the larvae go through five instars, and prepare by weaving a white – greyish cocoon, in a rolled leaf. In approximately two weeks, first come up the male butterflies, then the females [2].

The complete development lasts 40 – 45 days for summer generations [36] and up to 5-6 months for overwintering generation [36].

The insect overwinters as larva (second or third instar) most common in small silk nests in crevices of the bark on the lower section of the colonized tree stems [2, 36]. There are accounts of the insect overwintering as egg [21] or pupa [31].

The larvae are resuming their activity in spring when average air temperature during the day exceeds the threshold of 13,5°C [2].

4. Natural Enemies

Like numerous other lepidopterans, *C. anastomosis* has a lot of natural enemies, from viruses causing diseases, to insects and vertebrates. Most often, defoliator outbreak (with specific consequences as overpopulation and larvae starvation) triggers the natural action of specific diseases (cytoplasmic polyhedrosis) caused by *Baculovirus* sp. These diseases may cause mortality to up to 90 % of larval populations [36].

Up to now, there were recorded numerous species of parasitoids which develop in eggs, larvae or pupae of *C. anastomosis*. Eggs are parasitized frequently (approx. 23-33 %) by *Trichogramma* spp. [38]. On larvae and pupae were recorded parasitoid species belonging to Family Tachinidae, as polyphagous species: *Exorista larvarum* (Linnaeus, 1758), *Blondelia nigripes* (Fallén, 1810), *Zenillia libatrix* (Panzer, 1798) [10]. In Family Braconidae was recorded the parasitoid *Apanteles congestus* (Nees 1834) [20].

Larval populations of *C. anastomosis* can be considerably affected by insectivorous bird species. In May 2017, a starling flock (*Sturnus vulgaris* Linnaeus, 1758) has eaten over 95 % of the larvae in an outbreak spot, with severe defoliation, developed in a 4 years old plantation of hybrid poplars, in Zamostea (Suceava County). The birds succeeded to naturally extinguish the outbreak [4].

5. Outbreaks in Romania

Lately, *C. anastomosis* proves to be a dangerous defoliator for artificial cultures of hybrid poplars in Romania. Complete, subsequent defoliations, occurring during outbreaks, can severely affect the stability and productivity of the infested plantations. In the case of a hybrid poplar plantation (clone AF8), age of 4, the volume increment loss during the defoliation year was of 80-90 % at complete successively defoliated trees, comparing to non-defoliated trees, and the mortality recorded in the autumn of the defoliation year among the defoliated trees can reach 28,9 % [4].

First important defoliations in Romania (most of all of heavy intensity) occurred in 1971, on approx. 200 ha, in an 8 years hybrid poplar plantation (clone Robusta), in Golăești Forest, placed in North – Eastern part of Romania, in the Prut river floodplain, within Iași County [19, 32]. Then, in 1975, it was accounted a severe infestation, in South, at hybrid poplar saplings (0.12 ha), in Malu Nursery, Giurgiu County (Danube Floodplain). Large areas with low infestations were recorded in 1976 (1298 ha) and 1977 (215 ha) in poplar plantations in the Danube Delta. Until 1980, were accounted spots with low infestations, cumulating up to 21 ha [32] (Figure 1 and Table 1).

During 1981-1990 and 1991-2000, most of the infestations produced by *C. anastomosis* were of low intensity, summing up between 5 ha (1981-1985) and 600 ha (1987). Most of the infestation spots were placed in the Danube Delta and the Danube Floodplain, in Dolj County.

In 1989, for instance, were recorded 100 ha of poplar plantations moderately infested, at Segarcea Forest District, in Dolj County [30] (Figure 1 and Table 1).

The cumulated area of the infested cultures strongly increased during 2001 – 2010, reaching a maximum of 5452 ha in 2010. Most of the cultures were low infested (from 5 ha in 2001 to 4736 ha in 2010), but there were accounted areas with severe infestation as well (620 ha in 2004, 572 ha in 2005, 220 ha in 2006 and 706 ha in 2010). Moderate infestations were recorded on areas from 4.5 ha in 2003 and 1412 ha in 2006. Affected areas were placed mainly in the Danube Floodplain and Delta, as in floodplains of several interior rivers (Ialomița Floodplain). Severe attacks were accounted mainly in poplar plantations in the Danube Floodplain, on sections Călărași, Fetești, Brăila, where, in this period, were recorded outbreaks of this defoliator for the first time [28, 38] (Figure 1 and Table 1).

Since 2011, a decrease of the infested areas was noted, from 2153 ha (2012) and 1452 ha (2011), to 508 ha in 2016. The extent of the cumulated areas with severe attacks of *C. anastomosis* exceeds the one recorded in the previous decade, for instance in 2013, only, the areas with severe attacks summed up approx. 69 % of the affected areas. In 2011 and 2012 were recorded large areas with moderate attacks: 360 ha, respectively 638 ha. Most of the infestation spots were placed in the Danube Delta and Floodplain. The severe infestations were placed in the Danube Floodplain, on section Oltenița – Brăila (Nețoiu, unpublished data). Since 2013 new infestation spots were recorded in North Eastern Romania, in Rădăuți Depression, Suceava County, where on approx. 50 ha were recorded severe defoliations [2] (Figure 1 and Table 1).

Comparing to period 1971-2002, when the cumulated area of poplar plantations infested by *C. anastomosis* was small, reaching a maximum of approx. 1300 ha in 1976 and the average number of infestation spots didn't exceed 14 yearly, beginning with 2003 a strong increment was recorded both of the infested areas, at over 5400 ha in 2010, and of the number of infestation spots, at over 50 yearly, in 2013 or 2014.

The maximum level recorded in 2006 and 2012, for cumulated infested area as well for their number, is succeeded of much lower levels in the next years. This significant decrease is the result of the control actions conducted in areas with moderate – high infestations, as well of the natural control agents (Figure 2).

6. Management of *Clostera anastomosis*

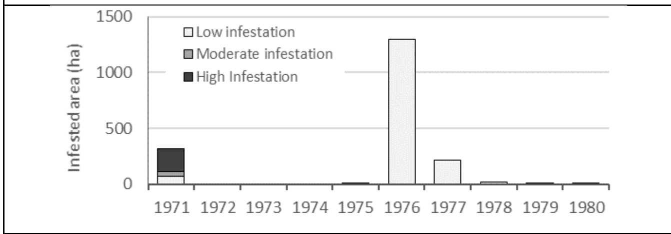
Pest detection is done by observation and ascertainment of the presence of the insect on the poplar leaves, in different development stages (egg masses on the lower side of the leaves, larvae feeding on leaves, pupae in cocoons sheltered between leaves, or resting adults), as by checking the defoliations [2, 36].

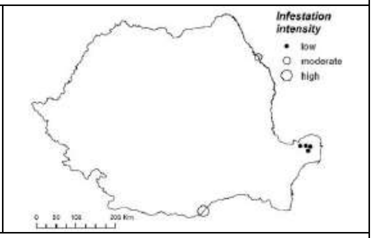
Larvae defoliations are easily noticeable, so a careful check during the vegetation season, and mainly in spring, for the defoliations produced by the overwintering generation, result in a facile mean of establishing a simple and efficient pest management.

Table 1

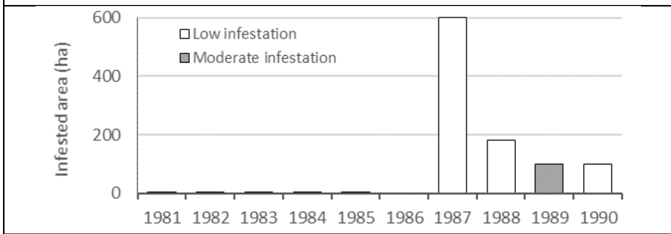
Dynamic of poplar plantation areas attacks of different intensity of *Clostera anastomosis*[3]

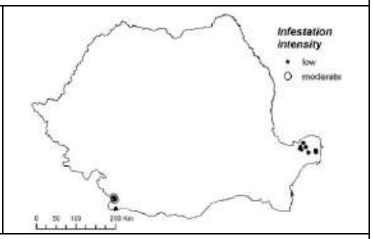
1971-1980



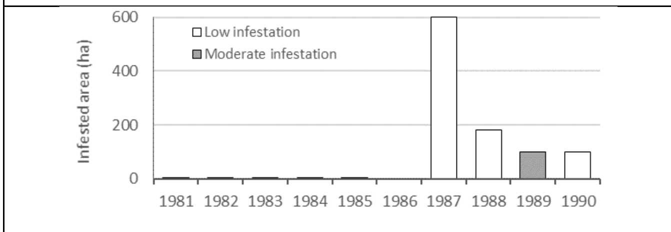


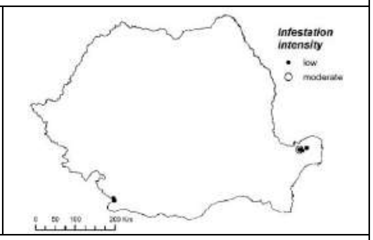
1981-1990



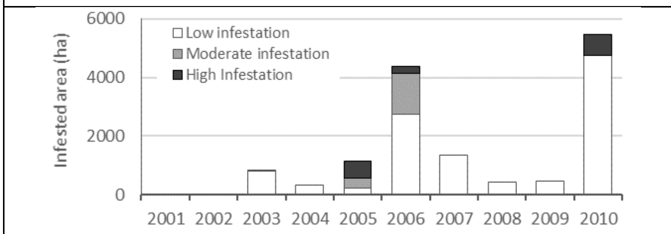


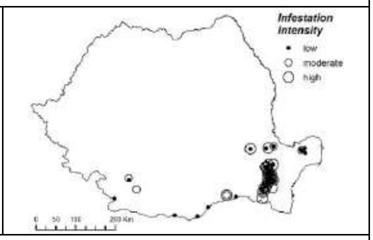
1991-2000



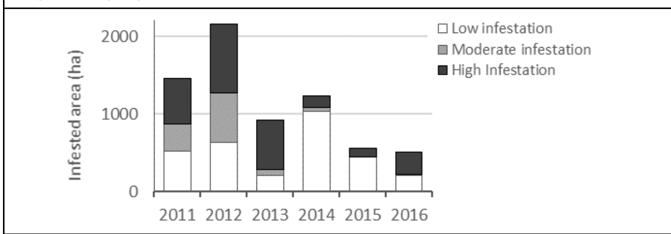


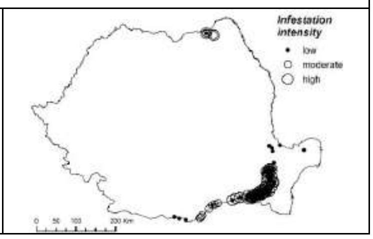
2001-2010





2011-2016





[3]For this summary were used data published in forest pest statistics in Romania [28, 30, 32], as well data from scientific papers [2, 4, 19, 38], or unpublished data (Nețoiu 2018, unpublished data).

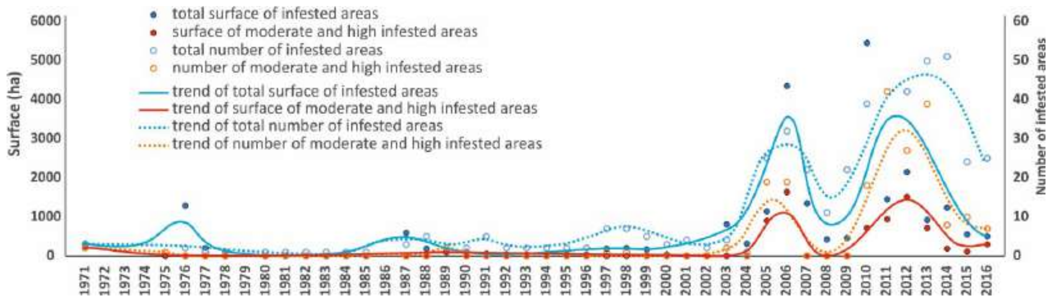


Fig. 2. Trend of cumulated infested areas and number of accounted infestation spots

In the same time, the large number of generations per year, the variations due to the geographical position, as the lack of an articulate method for damage prognosis by a generation to another, determined the introduction of the infested stands in the control area on a basis of the level of defoliation caused by the former larval generation. Thus, if real defoliation done by larval generation *n* exceeded 50%, considered the economic damage threshold [11], for the next generation (*n+1*), the affected stands were included in the control area and the control tactics were initiated only after the check of the larval population density. If it was ascertained the presence of a population large enough to produce a defoliation over 50%, chemical treatments were applied on the ground or even in the air, for mature stands. Population density was assessed by various means, recorded in literature, as control trees method [29], sprayed with chemical insecticides (aerosols) on the ground (in mature stands), or by assessing the larvae on the branches, collected by random from the crown of the young trees, and extrapolating to the whole crown [36].

Due to the large number of generations/year and, in some of the years, to the overlapping of some stages, the control of the pest become relatively difficult, the optimal moment for conducting the treatment requiring a careful monitoring of the insect phenology. Chemical and biological control efficacy depends mostly on the correlation with pest phenology [36, 40].

Starting with the first outbreaks of this insect and with the first severe defoliations recorded, in nurseries, as in poplar plantations, were conducted chemical control actions. Thus, in the case of outbreak in 1971 (Golăești – Iași) [19], were applied on the ground, with good results, chemical treatments with DDT (0.5 kg active substance/ha). Afterwards, in 1975 (Pepiniera Malu – Giurgiu), Detox 25 (active substance DDT) was administrated on approx. 0.12 ha [32]. After these two severe attacks, poplar plantations in Romania cross a calm period regarding the infestations with *C. anastomosis,* since 1975 to 2003 [16, 28, 30].

In 2004, in mature poplar stands of Răcari – Coțofeni Forest (Dolj County), because of the high density of the overwintering larval population, aerial insecticide spraying was given on approx. 620 ha, with Dimilin 48 SC (diflubenzuron), dose 80 g/ha in 3 l water. In the same forest, on approx. 85 ha of young cultures (1-2 years), insecticide ground spraying was applied, using pyrethroids [38]. Chemical spraying was applied at the end of April, when 60 % of the larvae were in third instar, 20 %, in second instar and 10 % in fourth instar, with high efficacy (96 %), even, in some spots, severe defoliations were recorded before the application of the aerial spraying [13].

Control actions were conducted in spots during the next years, only in young plantations, with high attack risk. For that purpose, were applied bacterial insecticide Dipel 8L, so that pyrethroids (Lamdex 5 EC 0.05% (lambda-cyhalothrin) and Faster 10 CE (cypermethrin). Solely in 2014, were applied ground insecticide sprayings with Lamdex or Faster on approx. 270 ha, in Departments Călărași (142 ha) and Constanța (128 ha), and in 2015 on approx. 134 ha (Călărași: 96 ha, Constanța: 32 ha, Ialomița: 6 ha). In 2016 control actions were conducted only in Călărași Department, on 110 ha) [39].

Trials were conducted in order to assess the efficacy of *C. anastomosis* larvae control after overwintering. The insecticide sprayings on the stems of the trees colonized with overwintering larvae led to 100% mortality of the larvae, using the pyrethroid Karate Zeon (lambda-cyhalothrin 50g/l). When insecticide Confidor was applied, the mortality reached 78-90 %. In the same trial, has been shown that after overwintering, the larvae can be caught in sticky band traps placed on the stems in order to prevent from crawling up to the crown [3].

7. Discussion

C. anastomosis is a native component of natural poplar and willow ecosystems. In artificial poplar ecosystems, this insect can produce outbreaks, causing severe defoliations to the colonized trees. In epidemic conditions, this insect is a threat for hybrid poplar cultures.

Many of the biological and ecological features of *C. anastomosis* are relatively well-known in Romanian scientific literature, excepting aspects referring to survival rate of larvae during overwintering, mortality rate in different development stages, quantity and quality of the food ingested by larval individuals, fecundity, etc.

Also, less is known on the natural mortality factors, and on the influence of the climate parameters on the insect development. On the other side, even though the composition of the natural specific pheromone is known [41], the artificial pheromone was not produced up to now.

Outbreaks of this species are more likely triggered by the abundance of the quality food for larvae, available especially in artificial monocultures, consisting in poplar clones selected mainly for their productivity. In Romania, as in many of the European countries, and not only, hybrid poplar cultures expanded after the World War II [1, 8, 19], but C. *anastomosis* acts as a pest just in spots in 1971 [32]. Attack intensity and frequency increased noticeable since 2003 (Figure 2), even the area of the hybrid poplar cultures were slightly decreasing in Romania [5-7].

Outbreaks of *C. anastomosis* recorded lately are not a unique scenario in Romanian silviculture. There are more and more frequent the records of outbreaks produced by insect species that didn’t act as pests in the past: *Pristiphora abietina* (Christ 1791) in spruce stands extended outside the natural area [18], *Cephalcia abietis* (Linnaeus 1758) in spruce stands in Eastern and Southern Carpathians [17], *Stereonychus fraxini* (De Geer, 1775) especially in pure ash tree stands or within forests with high percentage of ash trees [16], Polyphagous species of *Orthosia* [29]. As *C. anastomosis,* some of the mentioned species developed outbreaks mainly in artificial forest monocultures established outside the natural area.

Otherwise, in Romania, during last decades, in the context of the climate changes and of establishing of more and more favourable life conditions to outbreaks, new circumstances were created for common insect pests, showing trends of time and space expansion of outbreaks. An example is the polyphagous defoliator *Lymantria dispar* (Linnaeus, 1758), which, during the last decades, showed an noticeable altitudinal and latitudinal expansion [38], and, during the outbreak in 2004-2006, was able of severe infestations in beech forests in Orșova-Băile Herculane- Moldova Nouă or in South Maramureș [14, 37].

Another example is the defoliator *Dasychira pudibunda* (Linnaeus, 1758), which, during 1992-1994, developed a severe outbreak on approx. 10 thousand ha, in Sovata region, in beech forests, causing complete defoliations on approx. 700 ha [34-35].

Managing the losses caused by *C. anastomosis* is a big challenge for Romanian foresters. In the context of the scarcity in knowledge on biology and ecology of the mentioned species, up to now there weren't assessed the critical threshold values. Therefore, a long term prognosis of the population development isn't possible at the moment. Under these circumstances, there are required researches on the parameters specific for critical thresholds: larvae food demand, natural mortality for different development stages and outbreak phases, sex ratio of adult populations in different outbreak phases, etc.

Referring to the integrated control of the pest, there are required researches in order to design a control scheme considering several strategies: a) mechanical control of larvae by sticky band traps; b) contact insecticide spraying of the stems, on rhytidome, in early spring; c) biological insecticide spraying during the vegetation season; d) favouring insectivorous bird population.

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RECENT OCCURRENCE OF THE AMERICAN MINK (NEOVISON VISON) IN THE CENTRAL ROMANIA

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Abstract: *American Mink (Neovison vison) is one of the most aggressive non-native species of mammals from Europe. In Romania there are only a few data about the American Mink occurrence in the wild. This paper presents 13 new recent records of the species from the central Romania (Brașov County, Transylvania) escaped from a fur farm. Two specimens were caught by traps within the monitoring scheme during 2017 season. To prevent the escaping and to know the potential risk on the native species, three measures should be apply: a permanent monitoring scheme, improving the bio-security measures within the fur farm, the necessity to have official national and EU regulations concerning fur farm bio-security.*

Key words: *American Mink, occurrence, central Romania.*

1. Introduction

American Mink is an alien invasive species introduced in Europe especially through the fur farms [2] and has now feral populations in the central, northern and western European countries, such as: Poland, Spain, France, Great Britain etc. [2, 9].

There are a variety of studies on its status, range, naturalization, biology, ecology, impact and control within Europe and a recent risk assessment was carried out [5].

Its impact on native species was well studied. Thus, the species could have a significant impact especially on vertebrates, such as ground-nesting birds, rodents, amphibians and mustelids [2] but also on crustaceans, such as *Austropotamobius torrentium* (Schrnk.) [6]. Waterfowls and other water birds are the most affected by American Mink predation [1]. Maybe the most important impact from a conservation point of view is on the European Mink (*Mustela lutreola* Linnaeus), a Critically Endangered species. The American Mink affects European Mink by competition, hybridization, abortion

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and blocking the European Mink females to reproduce [8].

Concerning Romania, a few American Mink fur farms were built during communism period but after 1990 many of them collapsed. New farms were established in recent years and maybe their number will increase because of the permissive law in Romania comparing with other European countries. There is no official evidence of wild-living American Mink or about American Mink fur farms within the country. The main problem at the national level is the lack of regulation concerning the livestock of non-native or invasive species. For example, there is no technical normative of fur farm bio-security. Within Romania there are only a few data concerning the species occurrence in the wild habitats. Thus, in a synthesis of the old and recent observations within Romania [7], there are presented the locations or the regions where it was present. The authors mention some published observations from Danube Delta and the eastern side of Romania. They collected all data on this species within their study area (Mureș River, Mureș County) where some fur farms are known. A total of 21 occurrence records from 1986-2009 were presented in that paper.

The highest risk of biodiversity loss in our study area (Brașov County) is mainly within two sensitive protected areas (Dumbrăvița Fishpond Complex Ramsar Site and Dumbrăvița-Rotbav-Măgura Codlei Natura 2000 Site - Special Protection Area). These are located at only 3-6 km from the American Mink fur farm and they hold a very rich bird fauna. Thus, the main breeding species from a conservation point of view (some of them have the highest number of pairs from the central Romania – Transylvania or hold over 1-5% of the minimum national breeding population) are: Pygmy Cormorant (*Microcarbo pygmeus* Pallas), Night Heron (*Nycticorax nycticorax* T. Forster), Squacco Heron (*Ardeola ralloides* Scopoli), Great White Egret (*Ardea alba* Linnaeus), Little Egret (*Egretta garzetta* Linnaeus), Purple Heron (*Ardea purpurea* Linnaeus), Ferruginous Duck (*Aythya nyroca* Guldentadt), Marsh Harrier (*Circus aeruginosus* Linnaeus), Little Crake (*Porzana parva* Scopoli), Whiskered Tern (*Chlidonias hybrid* Pallas). During fall and spring migration these wetlands are very important stop over areas for several bird species, such as: Black Stork (*Ciconia nigra* Linnaeus), Great White Egret (*Ardea alba* Linnaeus), geese, ducks, waders, gulls, terns etc. Some of them form quite large feeding or resting aggregations especially during fish harvesting time when many hectares of mudflat and shallow water are the suitable habitats.

The main aim of the paper is to present the preliminary knowledge of the America Mink occurrence in Brașov County, surrounding the fur farm from Feldioara village. To improve this knowledge, a monitoring scheme was applied within the area to study its spreading, abundance, habitat selection and maybe the presumptive feral population structure by sex and age.

The study area is located within Brașov Depression and its surroundings as part of Brașov County (Figure 1). This is a typically depression in Transylvania, at the internal curvature of the Carpathian Mountains. It is also part of the Olt river basin which has some tributaries, such as: Ghimbășel, Bârsa, Vulcănița, Homorod Ciucaș, Crizbav. We mentioned at the introduction chapter about two important mane-made wetlands (Dumbrăvița and Rotbav wetlands) which are used for aquaculture and angling. The mink farm is located at 1500 m from Feldioara village (Figures 1 and 2) and has more than 40000 minks on an area of 8.5 ha [3].

Fig. 1. The study area (white circle), American Mink fur farm (white dot) and Dumbrăvița-Rotbav-Măgura Codlei Special Protection Area boundaries (red line)

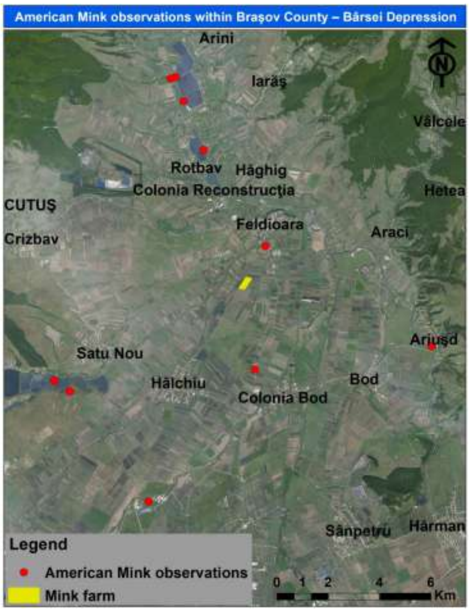

Fig. 2. American Mink records (2015-2017) within Brașov County

2. Materials and Methods

Data about American Mink presence within the study area were collected during 2015-2018, after our first finding of the species within nature (photo captured by trap camera in September 2015). In this period, there were permanent discussions about the American Mink presence in the wild with all representative factors within the study area, such as: fish owners, hunters and hunting associations, field biologists, stakeholders, city halls etc. Only the valid identifications of this species, proofed by photos and movies were taken into account. Some photos and movies were captured using camera Trapping (12 cameras were captured images between September 2015 till now within the Dumbrăvița Ramsar and Natura 2000 Site). A camera model from Bushnell manufactured was used. The main types of wetland habitats, such as: streams, reed beds, channels, marshes were covered by cameras.

For a further monitoring scheme, live-trap method was used within Rotbav and Dumbrăvița wetlands beginning from

2017 (February-April and September-October). A biologist expert was working by this method using classic cage traps for mustelids. All traps were placed in characteristic habitats for American Mink, such as: along dams or channels, river banks, reed beds and were covered with vegetation and debris for a good camouflage. Any trap contains bait (a specific food from the farm, fish can or some attractants - gland lure). The scheme used was 1-1.25 km transects. The cages were placed at 250 m one from each other along transects and were verified every morning [3].

3. Results

All valid identifications of American Mink in the area are presented in the Table 1 and the locations in the Figure 1.

A total of 13 valid occurrence records of American Mink within the area are shown. The majority of occurrences proceed from September 2015 (30% of the total identifications) and between September-December 2015 (more than 60% of the total identifications). Concerning the identified locations there was a widespread of this species within all compass points and in many directions from the fur farm. The maximum linear distance from the fur farm was more than 9 km. More than 60% of the records were located between 7 and 9 km from the fur farm. In point of habitat of occurrence, the majority of locations were in wetlands (channel, rivulet, river, lake shore, gravel pit), but also near human settlements. The identified specimens had different fur colour from white to blackish (Figures 3, 4 and 5).

Fig. 3. American Mink with greyish-brown fur, Rotbav-Vadu Roșu restaurant parking (photo CristianBarbu, 2015)

Table 1

American Mink observations within Brașov County – Bârsei Depression, Transylvania, Romania (2015 - 2017)

No.	Location	Coordinates	Data	Fur color	No. ind.	Photo / Video	Observations / notes	Distance from the fur farm
1	Olt River, near Ariușd village	N 45 46 29.19 E 25 40 28.46	March 2015	White	1	Photos	Within the river bank and water	7400 m
2	Dumbrăvița, fish farm	N 45 45 49.15 E 25 29 07.42	September 2015	Greyish-brown	1	Photo	Photo trap, running	8120 m
3	Dumbrăvița, fish farm	N 45 45 49.15 E 25 29 07.42	September 2015	Brown	1	Video	Photo trap, walking	8120 m
4	Vadu Roșu, Rotbav, parking	N 45 52 09.82 E 25 32 40.70	September 2015	Greyish-brown	1	photos	Near cars, biting a cable	8310 m
5	Vadu Roșu, Rotbav, lake shore	N 45 52 11.83 E 25 32 50.71	September 2015	White	1	Video	Fed by anglers with fish	8300 m
6	Near Feldioara periphery	N 45 48 37.92 E 25 35 30.34	October 2015	White, Grey	2	Photos	Killed by dogs near a house	1390 m
7	Farm near Feldioara village	N 45 46 01.94 E 25 35 09.14	October 30th 2015	Blackish	1	Photos	Killed by a farmer	3000 m
8	Dumbrăvița, fish farm	N 45 45 35.67 E 25 29 35.40	November 2015	Brown blackish	1	Video	Photo trap, running	7750 m
9	Crizbav stream	?	December 2015	White	1	Video	Walking on a stream bank	?
10	Dumbrăvița, fish farm	N 45 45 35.67 E 25 29 35.40	January 2016	Brown	1	Video	Photo trap, walking in snow	7750 m
11	Stupini gravel pit	N 45 43 16.40 E 25 31 55.70	August 2016	Brown	1	Photos, Video	Hunting a Coot, hiding in debris	9400 m
12	Vadu Roșu, Rotbav fish farm	N 45 51 41.31 E 25 33 04.92	April 2017	Grey	1	Photos	Captured by a live-trap, monitoring of SC AG Roneco Farm	7400 m
13	Rotbav Lakes	N 45 50 39.54 E 25 33 40.27	September 2017	Grey	1	Photos	Idem no. 12	5370 m

Fig. 4. American Mink with blackish fur, killed near a farm from Feldioara (photo Dan T. Ionescu, 2015)

Fig. 5. American Mink with grey fur, captured within monitoring scheme in Rotbav-Vadu Roșu (photo Marius Drugă, 2017)

4. Discussion

The fur farm from Feldioara has started the activity in 2014. An accident inside the fur farm with a car which transported Minks in September 2015, could be responsible for a mass escape of the species. Maybe this is the explanation for the number of records during the autumn of 2015. After that the mink farm has improved the bio-security through a double fence and other measures to prevent the animal escape. However, other records of American Mink in the wild were proved during 2016 and 2017. Thus, a living specimen was found in a pit gravel habitat in August 2016 at more than 9 km from the fur farm (the maximum known distance from the fur farm). The most recent records are two specimens captured within monitoring scheme by traps in Rotbav wetland during spring and autumn of 2017. At least the specimens captured in 2017 could suggest that a feral population or only individuals have established in the wild. Another hypothesis is that the farm bio-security is hereinafter improperly to prevent the animal escape. So whatever which hypothesis is real, a few important measures should by apply:

1. To implement a permanent monitoring scheme for American Mink especially inside the protected areas and important wetlands;
2. Improving the bio-security measures within the fur farm, not only concerning the fence but also on animal manipulation, cages security, gates operating etc.;
3. There is strongly necessary to exist official regulations concerning fur farm bio-security, taking into consideration the lack of these rules in Romanian and the EU Regulation no. 1143/2014 on Invasive Alien Species;

Our study was not carried out on the American Mink impact on native fauna. However, based on our observations and monitoring of birds species within the protected areas, no evidence of that species influence on the local avifauna within Brașov Depression was found. However, there is necessary a monitoring and also permanent observations especially on bird aggregations, such as breeding colonies in relation to predators. Thus, within the described Natura 2000 Site and Ramsar Site of the area, there are a few breeding colonies of some water birds. A large Black-headed Gull (*Chroicocephalus ridibundus* Linnaeus) colony and a small one of Whiskered Tern (*Chlidonias hybridus* Pallas) are located on a lake from Rotbav, the gull colony at only 80 m from the nearest American Mink record and the tern colony at 350 m. A mixed colony of Pygmy Cormorant (*Microcarbo pygmeus* Pallas), Herons (*Nycticorax nycticorax* T. Forster*, Ardeola ralloides* Scopoli)*,* and Egrets (*Egretta garzetta* Linnaeus*, Ardea alba* Linnaeus) is located on some fishponds from Dumbrăvița wetland at 350m from the nearest American Mink record point. At the same time, other groups of wild animals (crayfish, some shells, European water vole etc.) as a potential American Mink prey should be taking into consideration (some of them with conservation implications) in the whole Brașov Depression.

5. Conclusions

A number of 13 valid records of American Mink are known until now within Brașov Depression, Transylvania province, Romania. These specimens escaped from a recent large fur farm in the area. Based on our data, American Mink has spread on all compass points from the farm in many wetlands and open habitats, some of the record points at more than 8-9 km from the fur farm. It means a potential real threat for many native species if an American Mink feral population has established in the area. The threats for these species could also exist if only some individuals permanently escaped from the fur farm. Whatever the situation, a permanent monitoring scheme should be applied. At the same time, any fur farm with alien species should create a very good bio-security system to avoid animal escapes.

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EXTRACTION OF RESINOUS ROOT WOODS AS AN ALTERNATIVE SOURCE OF RESIN IN TURKEY

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Abstract: *To meet increasing market demands on resin raw material and its derivatives leads to the search for new alternative sources. The resin, which is generally produced by opening the wounds on the standing trees, can be produced by extracting from the root parts of the trees. Especially after the pine trees are cut, there is a high accumulation of resin in the stump on the soil surface and the root parts under the soil. These parts of the trees that are left under the soil surface are called resinous root wood and in recent years its importance as an alternative source of resin production is increasing in Turkey. In this study, technical information about pine root wood and its extraction was given and methods of producing resinous root wood were presented. The information obtained from forest service was evaluated in terms of marketing of resinous root wood. It is anticipated that the production of resinous pine root wood will be promising alternative source of resin raw material with the arrangements that can be made to provide alternative job opportunities to the local people in rural areas.*

Key words: *root wood extraction, resinous wood, resin production, Black pine, non wood.*

1. Introduction

Among the products obtained from the forests, there are also non-wood products beside the wood raw materials. Turkey has very large variety of non-wood forest products [6] and 60% of the economic vale gained from exported forest products comes from non-wood products [1]. Main non-wood products include resin, fagaceae, gallnut, daphnia leaf, pine nuts, carob, sumac, chestnut, lime flower, anggrek etc. Availability of the non-wood products are important sources of income for the local people living in the vicinity of the forests. In addition, production of various non-wood products in the concept of pharmacy, veterinary medicine as well as food products contribute to economy. According to the data obtained from Forestry Statistics of Turkey covering the period of 1988-2016 [3], non-wood forest products that have been produced

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more than 10 tons annually were listed in Table 1 [6].

Table 1
The forest products produced more than 10 tons annually between 1988 and 2016

Non-wood products and species	Average production [tons/year]
Various underbrush non-wood species	11391
Raw leaves of *Laurus nobilis (daphnia)*	7839
Resinous root woods	5552
Non-resinous root wood	3236
Raw *Thymus spp.*	2245
Cone pine	2005
Leaves of *Folium myrti*	614
Salvia sp.	468
Cistus	453
Carob	311
Chestnut	257
Rosmarinus officinalis	247
Moss	168
Çalba (*Ballota cristata, B. saxatilis*)	129
Resin	120
Ruscus aculeatus	89
Cyclamen cilicium, C. coum, C. hederefolum	76
Erica arborea, ling-root	49
Lavandula officinalis	48
Rhododendron	47
Dryopteris	38
Leucojum aestivum	36
Hedera helix	30
Tilia sp.	30
Galanthus elwasii, G. woronowii	28
Faggot and shoot of *Buxus sempenvirens*	26
Fir faggot	23
Anemone blanda	18

One of the most important non-wood forest products is resin in Turkey. Resin, which is a chemical mixture containing colophony and turpentine, is a valuable product mostly obtained from coniferous trees by various methods. Resin Acid-paste method is generally used to produce the resin in the forest areas designated as resin production areas (Figure 1). Production efficiency in this method is increasing every year. The annual yield per tree in Brutian pine stands is about 1.5 kg in Turkey, while the efficiency is about 3-3.5 kg in the case of major resin producer countries. The most important reason for the difference in productivity is the fact that these countries make resin production in the plantation forests generated for resin production purpose. However, resin is produced in natural forests in Turkey and there are no specific forests generated for resin production purposes [5].

Fig. 1. Resin production using resin acid-paste method

Demand on resin has been reduced with the production of synthetic chemicals, but the resin has recently become a highly demanded product again [1]. The resinous root woods left in the forest without any process during timber extraction have important opportunity to improve the amount of resin and economic gain from the non-wood forest products (Figure 2). These root woods that are under the soil contain large amount of resin. Particularly, the Black pine wood parts are rotting in time, while the resin can stay in the soil for a long time. When the trends of non-wood forest products in the period 1988-2016 are examined, it is seen that production of the root woods are unstable (Figure 3). However, figure shows that there has been a significant increase in the production of resinous root wood in last few years probably due to the increasing market demand to resin.

In the world as well as in Turkey, it is important to have new production resources to meet the increasing demand for resin and its derivatives. The resin can be obtained by opening the wounds on the planted trees, as well as by extraction of resinous root woods, especially in coniferous stands. As a result of extracting resinous pine root woods, the high quality resin containing turpentine, pine-oil and colophony can be produced. Thus, after the production of pine wood roots remaining on the soil surface and in the soil, extra resin are evaluated and contributed to the economy and also new business lines are generated.

Fig. 2. Resinous root woods [1]

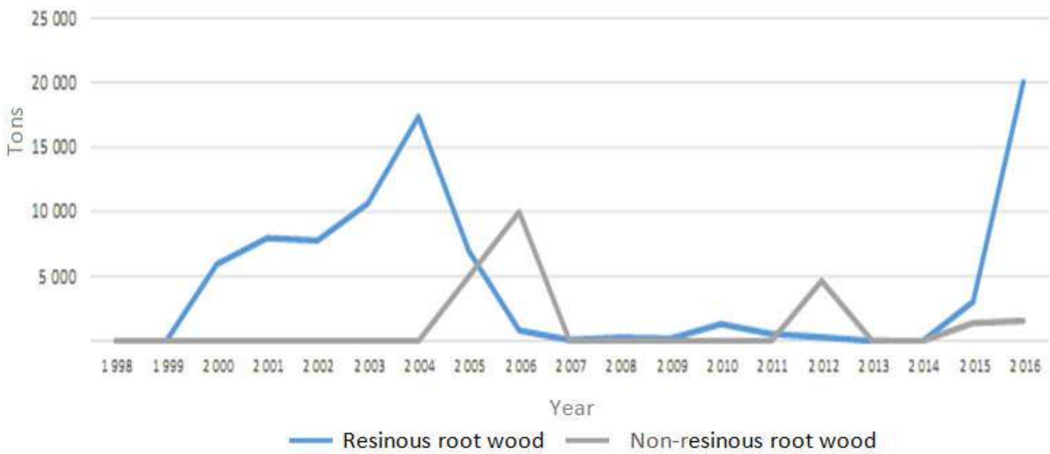

Fig. 3. Trend of root wood production (tons/year) [6]

In this study, it was aimed to present technical information about pine root wood and methods of producing resinous root wood. The extraction of root wood was evaluated under three main stages including preparation, extraction, and storage stage. Besides, marketing of resinous root wood was evaluated based on the information obtained from forest service in the regional.

2. Root Wood Production

2.1. Preparation Stage

Roots remaining under soil and resin stored stumps are removed with the help of human-power based systems, mechanized systems, or other forms of extraction systems (Figure 4). The areas where the pine root woods will be produced should not be selected from regeneration areas, production forests, or from the areas that are subject to erosion hazards. The production sites should be close to the existing forest roads. Production of resinous root wood should not be allowed on areas that are susceptible to forest fires. Surely no production can be done from standing trees.

Fig. 4. Stump removing techniques

Production should be carried out in areas where wood production activities are completed and there is no any other forestry activity. It is possible to produce the existing roots of trees that have been produced in the past years. Depending on the production technique and the quantity to be produced, the production areas can be selected from one or more divisional batches without deteriorating field integrity. With the finalization of the contract, the field will be handed over to the person receiving the business after visiting the production area with forest engineer and the forest ranger, showing the boundaries of the area [2].

2.2. Extraction and Storage Stage

After roots and stumps are removed from the soil by workers or stump removal machinery, extraction should be well planned to prevent damages on residual trees and young seedlings during production. After removing the crushed pine root woods from the soil, they should be cleaned from the pieces of stones and the soil and transported to the designated landing areas (Figure 5). The roots should never be rolled during extraction and the roads should not be blocked during operation [2].

The start and completion dates of extraction activities should be determined according to seasonal conditions, other forestry activities and capacity and conditions of work to be done. If the work cannot be completed within the given periods, additional time may be granted if there is a valid reason in the administration [4].

After transporting root woods at the landing areas, they should be loaded into the logging trucks and then trucks should be weighed by tons. Since there are difficulties in stacking and storing root wood since the root woods are not in a regular structure, the quantity can be determined and sold before moving to the sales depot (Figure 6). Since root woods do not have regular structure, there is a difficulty in stacking and storing, therefore, it is very important to determine the buyers before production [2].

Fig. 5. Transporting root woods

Fig. 6. Resinous root woods

3. Sales of Root Wood

The unit sale prices of resinous root wood are determined by the purchase and sale commission of Forestry Enterprise Directorate and then approved by the Forestry Regional Directorate. Since periods of storage entrance and exit are very long, there are losses on quantity. Besides, loading and unloading time in storage increase which then increases the total costs. For these reasons, it is preferable to make sales through the alive-auction, which guarantees the sales [4].

In recent years, there are factories which produce resin from the pine root wood as also request the root woods from the forest services [1]. Forestry Enterprise Directorates in the regions dominated by Black pine stands make harvest plans for root woods and the pine trees that are subject to sale are evaluated and sold to these factories. Root woods that are brought to the factory with trucks are first shredded by the shredder and further divided into smaller pieces. Then, products are transferred to the extraction unit for hexagonal treatment and the raw resin is separated from the sawdust. The resin containing turpentine and colophony is exported to foreign countries and therefore provide higher income to economy (Figure 7). One of these factories located in Edremit province of Balıkesir in Turkey annually exports about 600-700 tons of resin produced from pine root woods [7].

Fig. 7. Resinous root woods (up) and resin production process (dpwn) [1]

4. Conclusions

Non-wood forest products are used for various purposes such as pharmacy, veterinary medicine, and food products. The non-wood products are important sources of income for the rural people. Turkey has very large variety of non-wood forest products and one of the most important non-wood forest products is resin. To meet the increasing demand for resin and its derivatives, it is important to have new production resources. The resinous root woods containing important amount of resin can be alternative source of resin production.

General Directorate of Forestry (GDF) has increased the amount of production and income of non-wood forest products in Turkey. In this context, OGM's goal is to produce 350 thousand tons of non-wood forest products in general each year. Thus, it is necessary to plan the production of the resin obtained from the pine root wood, which has a high proportion in this potential production. Besides, it is very important to determine the buyers before production because it is difficult to store root woods for long time.

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HOME RANGE, DAILY AND SEASONAL ACTIVITY OF BROWN BEAR (*URSUS ARCTOS*) IN SOUTH-EASTERN CARPATHIANS – A GPS/GSM TELEMETRY STUDY

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Abstract: *Approximately 35% of the European population of brown bears (Ursus arctos) is located in Romania, thus representing the largest stable population. Here, we analyzed 11 brown bears in the Romanian Carpathians for determining a series of eco-ethological characteristics of the species, such as: i) the size of territories; ii) daily routes and iii) an average value of intensity of bear activity for day/night/seasons and periods, information that can be used for conservation planning. The dataset was collected across eighteen months, thus the individuals were captured, tranquilized and set up with GPS Collars. The total number of monitoring days was 2.235, thereby hourly locations (24 locations per day) for each monitored individual obtaining a total of 30,004 valid locations.The longest distance registered was 1,912 kilometers in 391 days, with highest daily average at 4.9 km/day for ID 2271 Predeal (male, 2 years). The largest home range was 127,358 ha (MCP Method) / 38.165 ha (Kernel Bivariate Method 95%) by ID 2271 Predeal (male, 2 years). Moreover, for determining daily and seasonal activity, two individuals whose activity was at least one cycle of four seasons were chosen: a dominant adult male (ID 2278, male, 9 years) and an adult female with a cub in second year (ID 2274, female, 7 years). While autumn seasonal movement is correlated with both northern and southern aspect and is influenced by the fructification of forest species and food availability in orchards, the occurrence of significant agglomerations of individuals results in damages and human - bear conflicts. Our results may contribute to a better knowledge of brown bear eco – ethology and territories characteristics.*

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Key words: *Ursus arctos*, brown bear, home range, GPS Telemetry, activity sensors, GPS/GSM collars, Carpathians.

1. Introduction

Large carnivores, including brown bears (*Ursus arctos*), are top of the food chain species and are considered key species in regulating herbivores populations and consequently in maintaining ecological communities’ equilibrium [3].

Romanian Carpathians, although represent less than 2% of Europe's surface, sustain viable and stable populations of large carnivores, moreover about 35% of the entire European population of brown bears is located in Romania, representing largest stable population. This population has an important role in the ecosystem by "top-down" controlling the huge territories on prey populations [3].

There is a permanent concern for knowledge of wildlife populations ecology existing in a certain area [1], for determining the habitat where they can be found at different times of year or day and as well as finding methods for maintaining a large number of animals and places for movement (wildlife corridors), with applicability on ecological management of populations [7].

In Romania there are few scientific datasets regarding the influence of infrastructure development on eco-ethological characteristics of large carnivores and interconnectivity of habitats across time. Brasov area which represents a major transport junction will be crossed by some important highways that are currently planned to be executed. Consideration for creating a wildlife database correlated with ecological network was recommended prior to infrastructure development [2]. A harmonious development of infrastructure should consider the basic principles of conservation and protection of natural environment and biodiversity [6].

Regarding other studies across Europe, low densities of brown bears are registered in Northern Europe (approx. 5 bears/100 km^2) [8] comparing with very high densities in Romania (approx. 20 bears/ 100 km^2). These high densities are highly correlated with home ranges and territories overlapping, which can vary depending on food availability and population density [5].

However, to determine more precisely density intervals requires a better understanding of the size of the territory species, which can be determined using GPS/GSM Telemetry [4].

One of the specific objectives of this research was to monitor brown bears individuals in relevant population segments, using advanced systems Radio/GPS/GSM. Further we decided to determine for monitored bears a series of eco-ethological characteristics such as: the size of territories, daily route, average value of intensity of bear activity for day/night/seasons periods.

We consider that this study is particularly important for determining the above described parameters with very good accuracy (using GPS/GSM technology), a novelty in the last decade implemented in studies regarding brown bear movement in Romania.

2. Material and methods

The study was conducted on 11 brown bear individuals, which were captured and tranquilized. For those bears we set up GPS 8000 Collars, purchased from Lotek Wireless (Canada). These collars are suitable for midsize and large mammals and are using two remote communication options – a high speed UHF modem and a GSM modem, to provide users with more convenience when downloading the collar's data records.

The collars provide the following information: GPS location (GPS fix), temperature and activity status of subjects (activity/inactivity/mortality). One of the important characteristics is "on demand" - two ways communications that provide user the possibility of upload and download data. Also "on demand" the drop-down system is included, in order to recover the collar.

In addition to radio transmitter, the collar is equipped with a GSM modem which can send information in SMS format. In there isn't GSM coverage, data is stored and will be sent when the bear enters in the GSM coverage area. The sensors that equip the collar are: temperature sensor for monitoring the ambient temperature with 1^{o}C precision, the activity sensor that measure the animal acceleration of movement 6-8 times/second, inactivity/mortality sensor (can store up to 132 events) and hibernation sensor which can determine the collar to switch on stand-by mode when the individual has low activity. When the activity rate increases the collar starts to function normally.

The data acquired by collars can be downloaded using GPS Total Host (Lotek Wireless) software, in this interface data can be easily managed, in order to view or export information (Appendix A3).

The GPS fixes were analyzed using GIS software ArcGIS v.10.2.1 (ESRI) and we generate the maps regarding the home ranges in the study period (Appendix A1).

The home range mapping was done using two methods: Minimum Convex Polygons (MCP) and Kernel with bivariate density estimation (Hawths Tools for ArcGIS extension v.3.27).

Statistical analyses of activity data was processed with Activity Pattern v.1.2.3 (Lotek Wireless) software.

3. Results

The monitoring period of the 11 bear individuals bear totalized 18 months (539 days). The whole period was covered by the bear with ID 2274 (female, 7 years), the smallest monitoring period was for ID 2276 (female, 17 years), which was captured before entering at denning winter sleep. We have managed to recover the collar after leaving the den, meanwhile the female gave birth.

The total number of monitoring days was 2235, in this period we collected hourly locations (24 per day) for each monitored individual, in total 30004 valid locations were obtained (Appendix A4).

The longest distance traveled per unit of time was 1912 kilometers in 391 days and represents the highest daily average, at 4.9 km/day, probably due to the fact that this bear was is dispersion movement for ID 2271 Predeal (male, 2 years). The shortest distance traveled per unit of time was 10 km in 33 days, with daily average of 0.3 km/day that might be due to the fact that the female was captured a few days before going to winter for the ID 2276 Lăptici (female, 17 years). Average daily distances traveled by the monitored individuals was 4.3 km for adult males, 4.1 km for young males and 1.6 km for females (Table 1).

Table 1

The resulted home ranges of monitored bears

No	Bear ID	Home Ranges							
		MCP Method		KDE Method					
		P [km]	S [ha]	95%		50%		5%	
				P [km]	S [ha]	P [km]	S [ha]	P [km]	S [ha]
1	2270	89.7	43617.8	128.9	21167.3	63.5	3585.4	4.2	139.2
2	2271	147.7	127358.2	238.9	38165.6	66.4	4872.0	5.7	258.7
3	2272	39.5	7757.2	51.0	7572.5	19.2	1519.6	4.7	173.3
4	2273	91.3	28548.3	72.6	10308.5	25.1	1904.0	4.7	175.4
5	2274	36.3	6860.4	23.2	3879.2	19.0	1128.3	5.4	155.0
6	22751	28.7	5362.2	37.6	5045.1	12.0	763.5	3.1	78.1
7	22752	17.5	1904.6	20.7	2948.7	10.4	737.2	3.8	107.5
8	2276	8.5	265.5	14.9	1607.1	7.3	376.5	2.7	54.1
9	2277	53.9	10112.4	58.5	6790.1	15.6	1064.8	3.9	118.1
10	2278	59.4	15804.0	67.5	10428.1	37.1	2320.8	5.3	225.4
11	2279	41.6	9096.3	46.6	7206.8	26.4	1498.1	6.9	184.2

The largest home range was 127358 ha (MCP) / 38.165 ha (Kernel 95%), registered by ID 2271 Predeal (male, 2 years), this might occur due to the fact that this young male was monitored shortly after its mother left him and searched for establishing a territory. The average values of home ranges for studied bears can be consulted in Table 2.

The detailed maps for studied bear individuals are presented in Appendix A1.

Table 2

The home range of studied bears (average)

Males	Method	Home range [ha]
< 2 years	Minimum Convex Polygon method (MCP)	85.488
	Kernel Bivariate Method	29.667
> 2 years	Minimum Convex Polygon method (MCP)	9.505
	Kernel Density Estimation Model Method (KDE)	7.563
Females	Minimum Convex Polygon method (MCP)	9.538
	Kernel Density Estimation Model Method (KDE)	5.107

4. Statistics - Daily and Seasonal Activities

GPS monitoring system from collars contains activity and temperature sensors, these sensors provides information about daily and seasonal activity. Thus, we chose two bear individuals whose activity were at least one cycle of four seasons: a dominant adult male (ID 2278, male, 9 years) and an adult female with a cub in second year (ID 2274, female, 7 years).

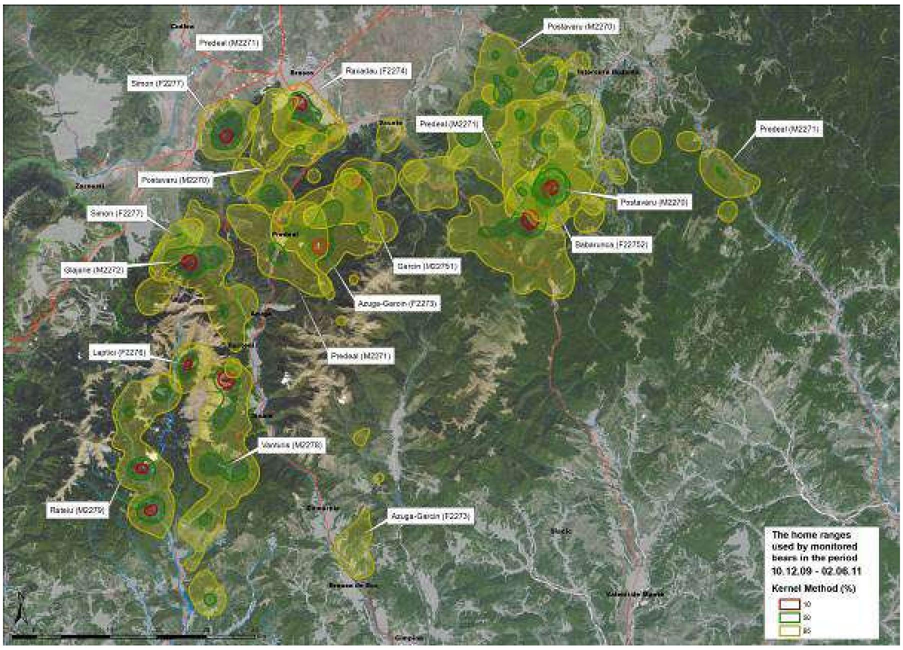

Fig. 3. The home ranges of monitored bears (KDE)

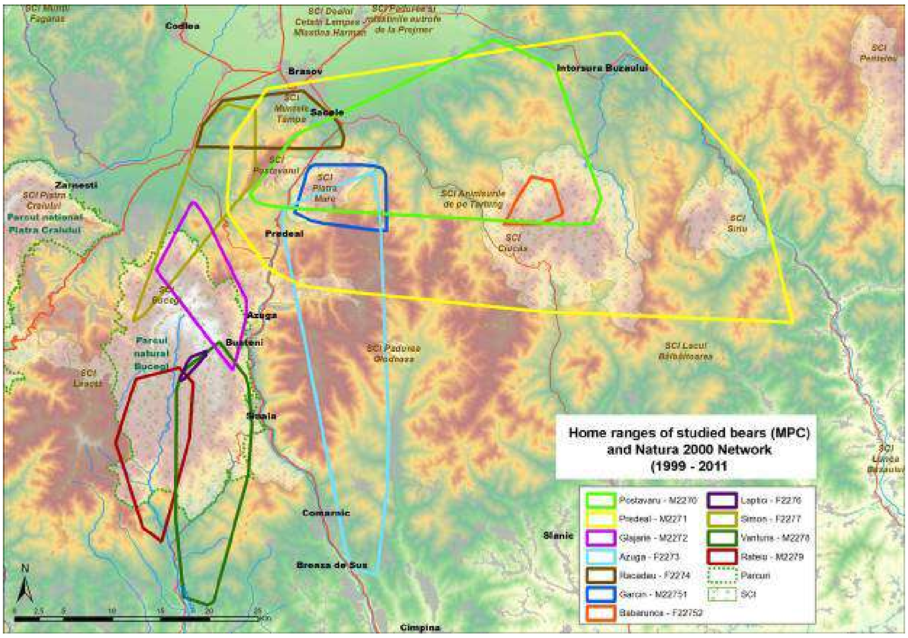

Fig. 4. The home ranges of monitored bears (MCP)

To access and download activity data, the operator should identify the individual in the field using a UHF radio receiver. The range of data connection is quite small

(100-500 m), so it requires physical effort to follow the animal in the field and to get close to him.

For generating the charts below, we have used a number of 90.000 activity information from bear ID 2278 and 160.000 activity information from bear ID 2274.

These analyzes were performed based on the activity diagrams that are presented in Annex A2.

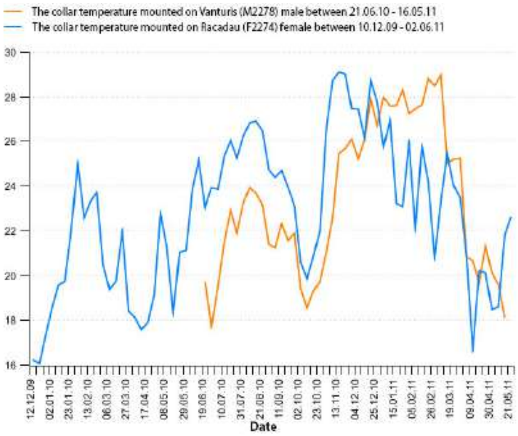

Fig. 5. Seasonal statistical variation of collars temperatures

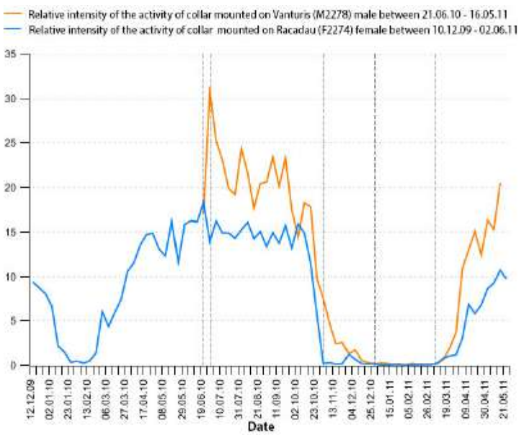

Fig. 6. Seasonal statistical variation of bears relative intensity of activity

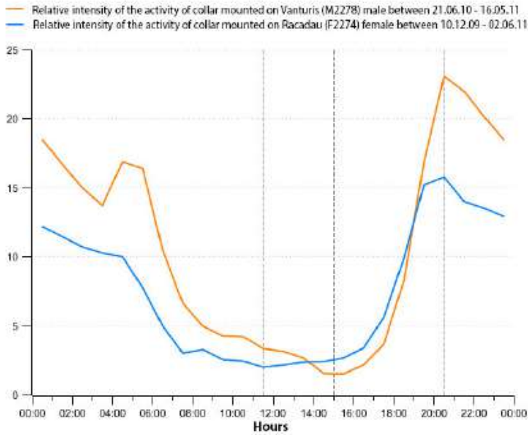

Fig. 7. Statistical variation of bears relative intensity of activity per periods of the day

5. Discussion

Using **satellite radio-telemetry**, we collected very high information quantitatively and qualitatively. We consider that satellite radio-telemetry compared with classic telemetry provide better results regarding the home ranges used by studied individuals.

The total area resulted from 11 monitored home ranges with GPS/GSM system is 256686 ha, some young males individual’s territories overlaps. In home ranges of the three dominant males doesn't exist overlapping areas.

Analysis of the maps resulted, indicated that bears spring movements are correlated with the grass species availability, while in the summer period individuals are moving in the areas where berries are available. In the autumn brown bears are using as main source of food trees fructification or/and fruit trees.

Autumn seasonal movement is correlated with both northern and southern expositions, being influenced by the fructification of forest species and availability of food from fruit tree orchards. The existence of orchards can determine the occurrence of significant agglomerations of individuals and will result in damages and conflicts with human communities.

Given the expected development of the transport system in Romania it is foreseeable that restrictions of species movement to be increasingly higher. High-capacity transport infrastructure will cross large areas of important habitat of the brown bear. This can result in fragmentation and connectivity loss of species favorable habitat. Moreover, in a 10 km buffer area from highway significant noise occurs with a negative impact on the existence of individuals, if not proper mitigation measures are implemented.

Regarding **activity analysis** based on obtained data, we consider that according to statistical variations of activity and collar temperature the seasonal temperature is higher for female specimens, as determined by differences in altitude home range. The male has predominant activity at altitudes of 900-1900 m and the female has activity at an altitude of 600-1400 m. Temperature variations are about the same, except the period of winter sleep, when the male variation is reducing. On the seasonal periods there is a similar activity in terms of variations of both.

We found an interesting fact that on the same day (06.09.2010), both bear individuals had an abnormal increase in activity variation and then returned to normal.

Another observed fact is the female who went denning earlier and went out later than the male bear individual.

Statistical variance of bear activity during a day peaks between the hours 20-21 and then reaches the minimum value between the hours 11-15.

Also, analyzes of activity diagrams reveals that daily activity is closely related to sunrise and sunset, so it begins 1-2 hours before sunset and ends at 2-3 hours after the sunrise. The exception is during the fall, immediately before entering denning and in spring immediately after exit denning, when activity time is longer during the day. During winter sleep occasionally bears are still active, but brief, which proves that the bear is not idle throughout the winter.

The female with ID 2274 which was found in the second year of study have had 2 young cubs of 3-5 months. The first 2 months after winter sleep end she has the predominant activity during the day, up to 2-3 hours after sunset.

6. Conclusions

Our data suggest that the bear monitoring method based on GPS/GSM Telemetry is more convenient than radio telemetry classical method in terms of economic aspect but particularly in terms of quantity and quality of information obtained. We consider that the downsides of the method based by GPS collars is a relative limited duration of collar batteries of 12-18 months (depending on the environmental temperature and activity of individual which the equipment was set up) and of course a larger acquisition price. Moreover, the batteries in “classical” collars without GPS/GSM/UHF technology implemented can last tree times longer.

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Appendix list

A1. Maps of home rages and tracks for studied bears: MCP and KDE Methods

Figure 1: Home Range of F2274 - Minimum Convex Polygon Method (MCP)
Figure 2: Home Range of F2274 - Kernel Density Estimation Model Method (KDE)
Figure 3: Home Range of M2278 - Minimum Convex Polygon Method (MCP)
Figure 4: Home Range of M2278 - Kernel Density Estimation Model Method (KDE)

A2. Activity patterns chart

Figure 5: Activity patterns chart for M2278 (21.06.2010–16.05.2011)
Figure 6: Collar Temperature Variation chart for M2278 (21.06.2010–16.05.2011)
Figure 7: Activity patterns chart for F2274 (10.12.2009–02.06.2011)
Figure 8: Collar Temperature Variation chart for F2274 (10.12.2009–02.06.2011)

A3. Database structure

Table 1: Database structure

A4. The monitoring – bears information and resulted routes

Table 2: The monitoring – bears information and resulted tracks

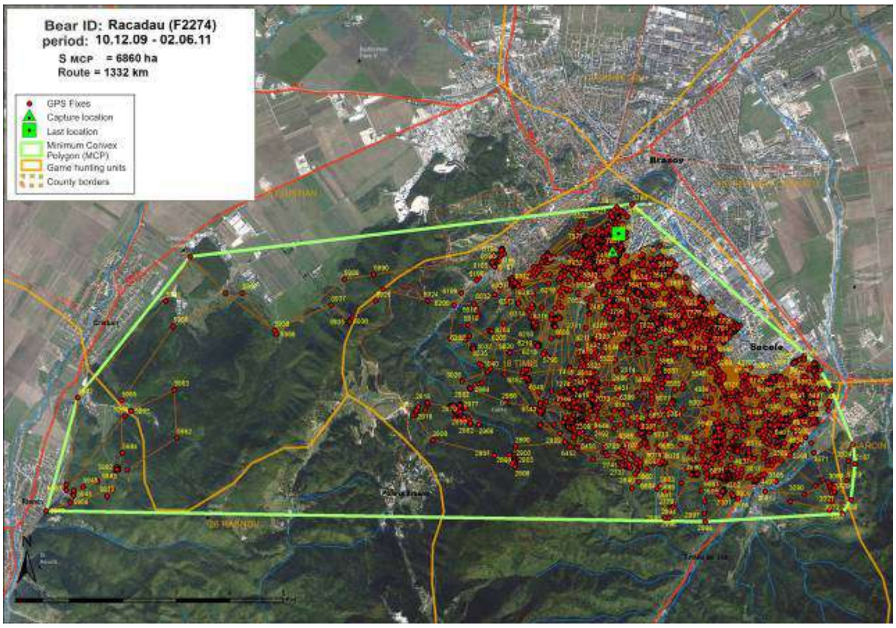

Fig. 1.Home Range of F2274 - Minimum Convex Polygon Method (MCP)

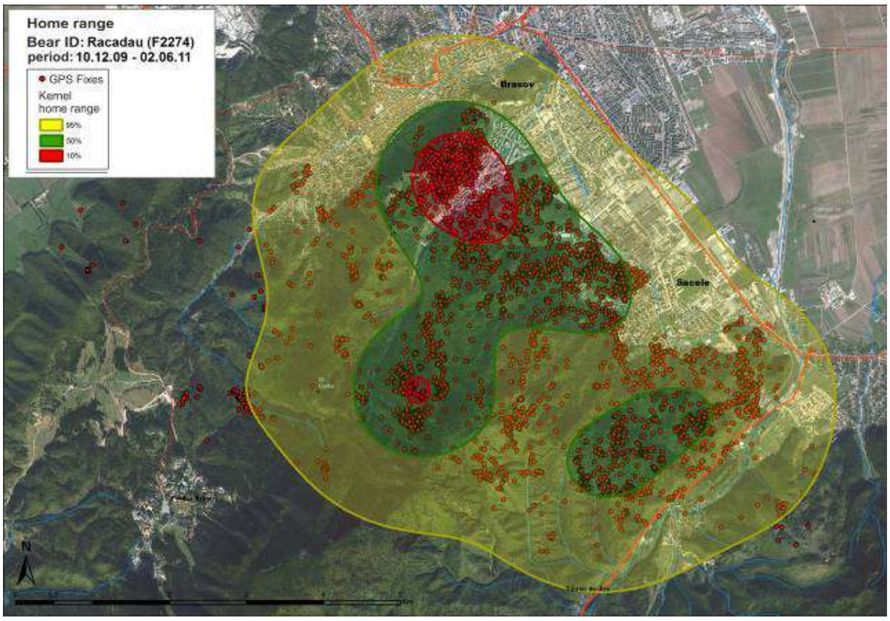

Fig. 2. Home Range of F2274 - Kernel Density Estimation Model Method (KDE)

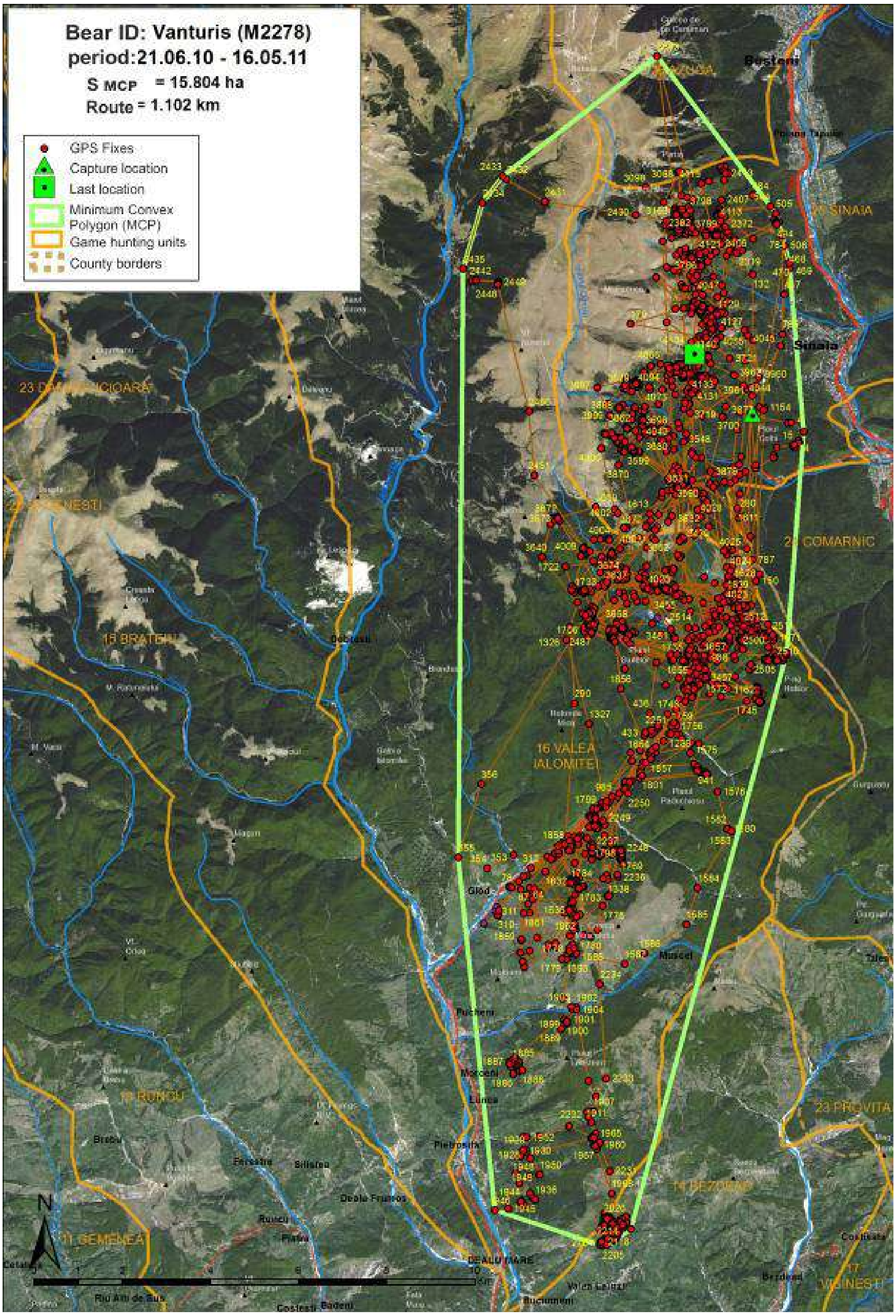

Fig. 3. Home Range of M2278 - Minimum Convex Polygon Method (MCP)

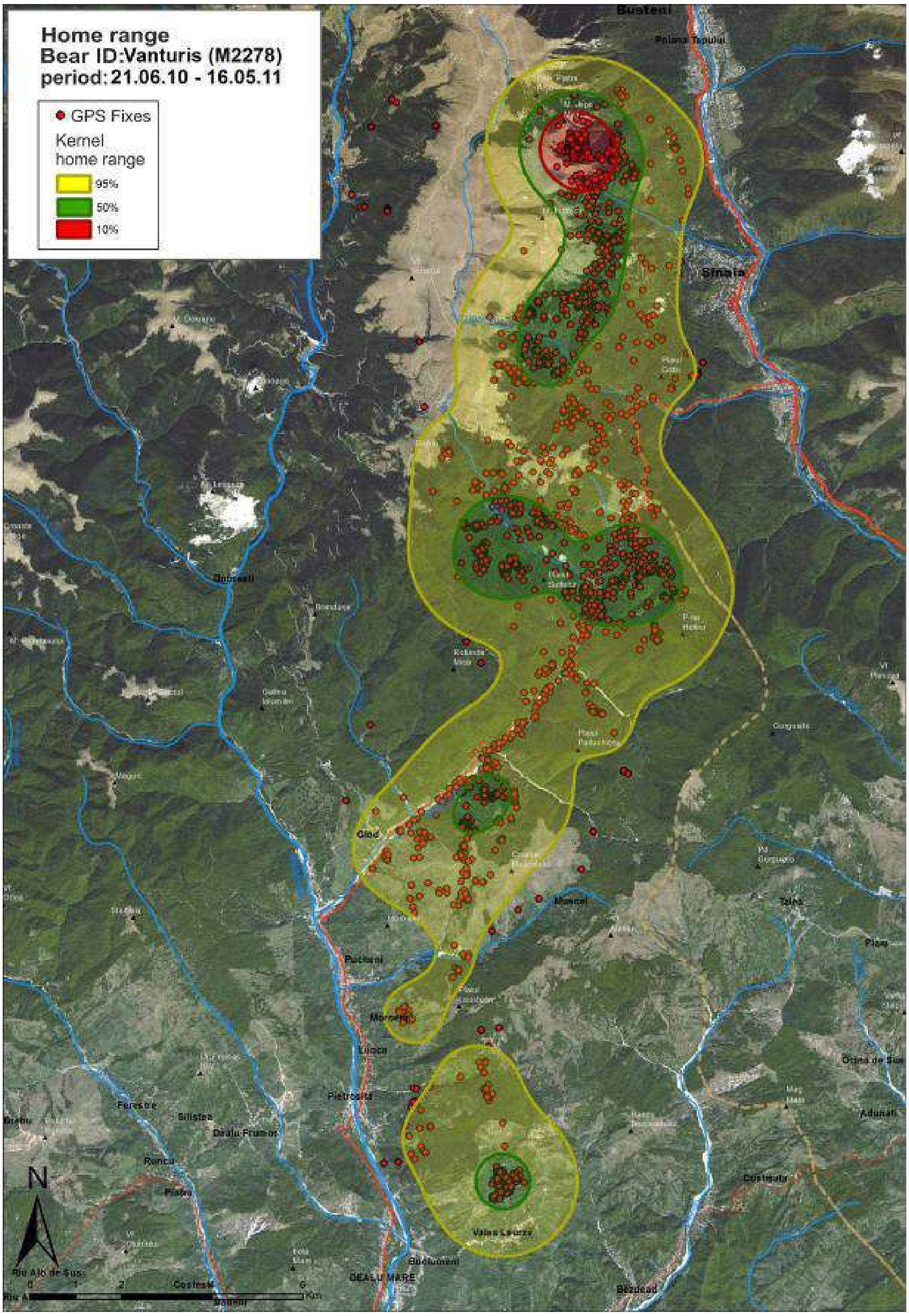

Fig. 4. Home Range of M2278 - Kernel Density Estimation Model Method (KDE)

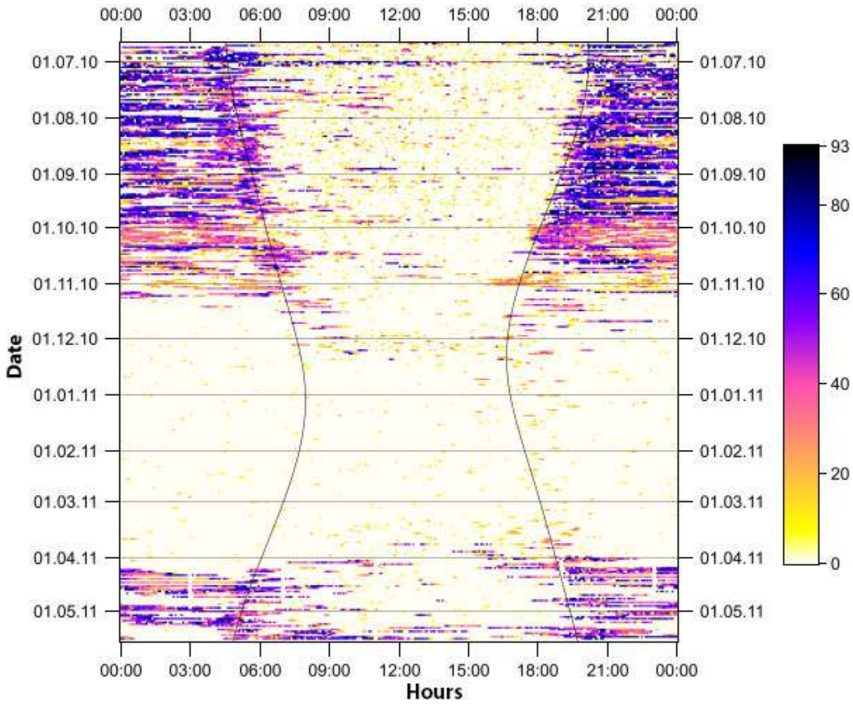

Fig. 5. Activity patterns chart for M2278 (21.06.2010–16.05.2011)

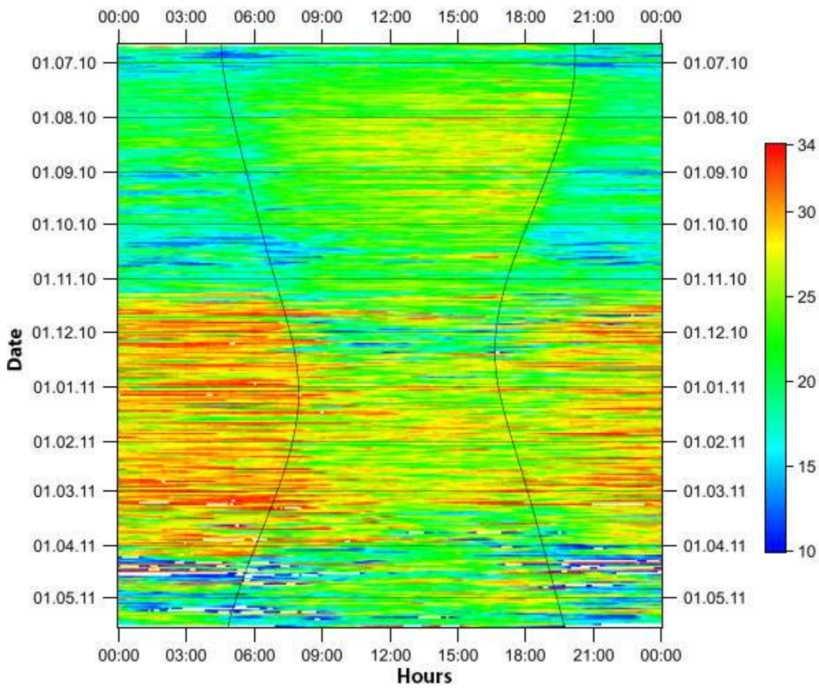

Fig. 6. Collar Temperature Variation chart for M2278 (21.06.2010–16.05.2011)

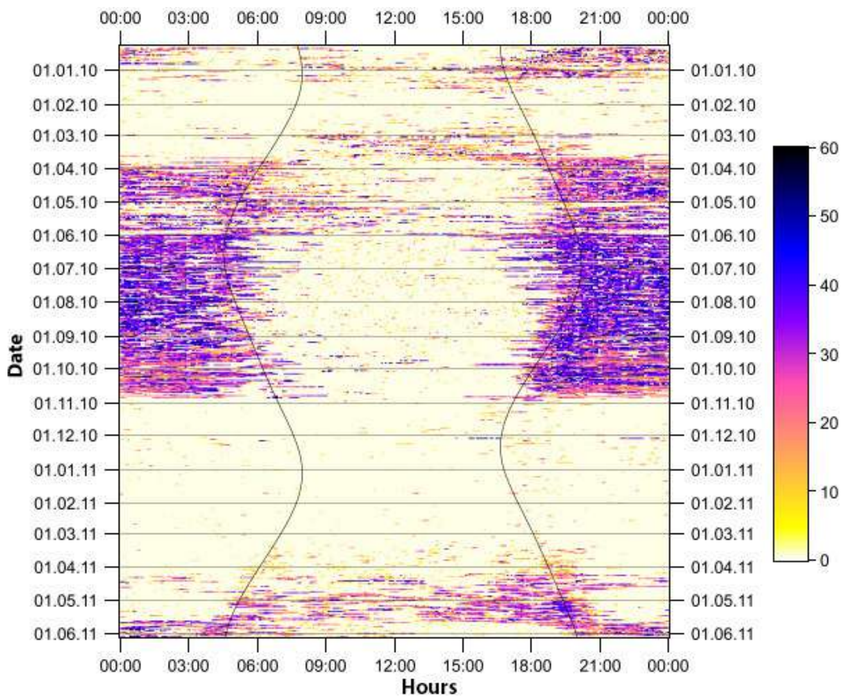

Fig. 7. Activity patterns chart for F2274 (10.12.2009–02.06.2011)

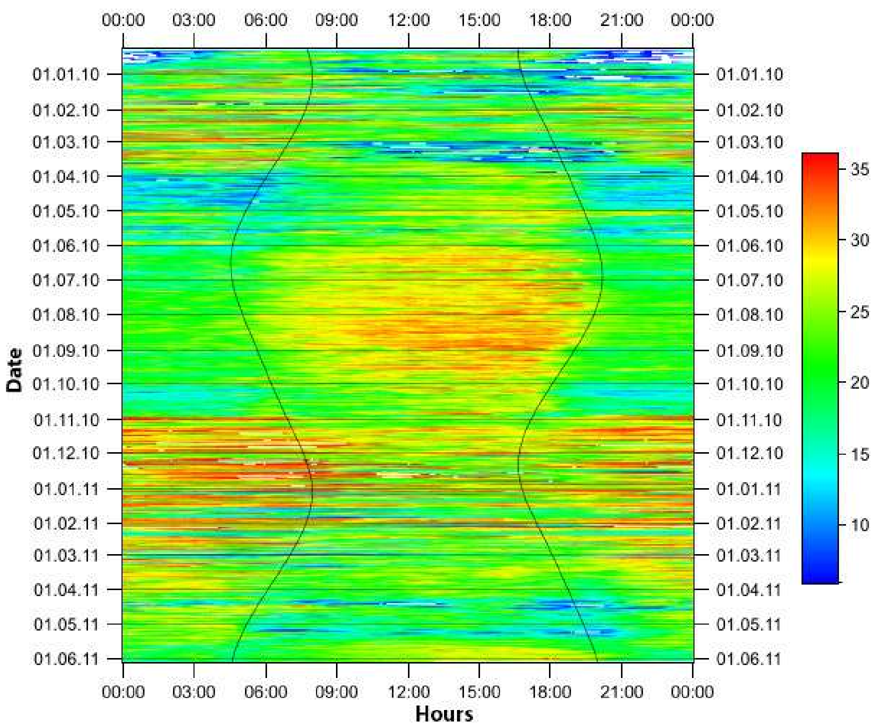

Fig. 8. Collar Temperature Variation chart for F2274 (10.12.2009–02.06.2011)

Database structure Table 1

No	Date	Time	Latitude	Longitude	Altitude [m]	Dilution of precision (DOP)	Navigation	No of satellites used	Temp [Celsius]
1	10.07. 2012	17:30:20	52.43075	13.52548	89.12	1.4	3D	8	28
…	…	…	…	…	…	…	…	…	…

The monitoring – bears information and resulted tracks Table 2

No	Bear ID	Sex	Name	Esti-mated age	Capture date	Last location date	Days of moni-toring	Loca-tion	Total track [km]	Average length of tracks [km/day]
1	2270	M	Postavaru	2	19.04.2010	16.09.2010	150	2.390	557	3.7
2	2271	M	Predeal	2	07.05.2010	02.06.2011	391	7.823	1.912	4.9
3	2272	M	Glajarie	21	22.04.2010	28.05.2010	36	548	169	4.7
4	2273	F	Azuga-Garcin	8	27.05.2010	02.05.2011	340	3.184	1.168	3.4
5	2274	F	Racadau	7	10.12.2009	02.06.2011	539	7.860	1.332	2.5
6	22751	M	Garcin	6	22.03.2010	07.05.2010	46	1.061	149	3.2
7	22752	F	Babarunca	11	13.06.2010	14.11.2010	154	538	91	0.6
8	2276	F	Laptici	17	13.10.2010	15.11.2010	33	160	10	0.3
9	2277	F	Simon	6	11.12.2010	02.06.2011	173	1.548	237	1.4
10	2278	M	Vanturis	9	21.06.2010	16.05.2011	329	4.140	1.102	3.3
11	2279	M	Rateiu	10	08.07.2010	21.08.2010	44	752	226	5.1

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TOWER YARDER WORK TIME AND PRODUCTIVITY STUDY IN RHODOPE MOUNTAINS

Stanimir STOILOV[1]

Abstract: *Ground-based vehicle logging systems require a dense network of skid roads as the terrain gets steeper. In terrains where the slope is 40% and greater, cable yarding systems are expected to be most efficient and environmentally-sound than ground vehicle systems. Nowadays small cable yarding systems are used mainly for uphill yarding. The main reason is that uphill yarding systems are much easier and faster to rig. The most common timber harvest unit layouts are parallel or fan-shaped [17]. In Bulgaria approximately 60% of the forests are situated in mountainous areas with steep slopes and complex terrain shapes. The logging sites in Rhodope Mountains, South-Central Bulgaria are between 400 and 1200 meters above sea level. Typically, in Rhodopes Mountains the sloppy and smooth terrain predominate, which give an opportunity to uphill yarding. In Rhodope Mountains forests consist mostly of Norway spruce (Picea abies L.) and Scots pine (Pinus sylvestris L.). The aim of the present study is to improve the use and operational efficiency of the tractor-mounted cable yarder in coniferous stands and to determine the time and volume of logs transported per unit of the yarder. Knowledge of these parameters is useful for defining the operational efficiency of cable logging and improvement of cable yarder performance. The main results indicate that the productive time for the studied cable yarder was about 87% and operational and mechanical delays accounted respectively for 5.5% and 7.5% of the scheduled machine hour. The mean yarding productivity, excluding and including delays, estimates at 38.82* m^3 *per shift and 36.27* m^3 *per shift, respectively, i.e. close to the maximum for that type of cable yarders under given condition.*

Key words: *cable yarder, work cycle time, yarding productivity, delays.*

1. Introduction

Ground-based logging systems require a dense network of skid roads as the terrain gets steeper. In terrains where the slope is 40% or greater, cable yarding systems are expected to be more efficient and environmentally-sound compared to ground based systems. Cable-based technologies have been a backbone for harvesting on steep slopes [1].

Cable yarding is taking logs from the stump area to a landing using an overhead system of winch-driven cables to which

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logs are attached with chokers [22]. Standing line is fixed cable that does not move during logging operations; for example, a skyline anchored at both ends. Mobile cable yarders have tower – steel mast used instead of a spar tree at the landing for cable yarding.

On steep terrain, cable yarding is the cost-effective alternative to building an extensive network of skidding trails and results in a much lower site impact compared to ground-based logging [19].

Yarding causes the least stand and soil damage, suggesting that silvicultural prescriptions should favour the application of cable logging, if possible [19]. Cable yarding also has the advantage of minimizing the impact in environmental sensitive areas and can be integrated into biodiversity goals and ecosystem management plans [6, 13]. In general, cable yarding is more complex and expensive than ground-based logging, which places the steep terrain cable yarding operations at a general disadvantage in terms of pure harvesting cost. However, modern cable yarding technology can fill this gap, and productivity models can assist users in refining their work technique, so as to maximize the productive potential of their machines [20].

Nowadays small cable yarding systems are used mainly for uphill yarding. The main reason is that uphill yarding systems are much easier and faster to rig. The most common timber harvest unit layouts are parallel or fan-shaped [17].

In Bulgaria approximately 60% of the forests are located in mountainous areas with steep slopes and complex terrain configurations. The logging sites in Rhodope Mountains, South-Central Bulgaria, are located between 400 and 1200 meters above sea level. Typically, in Rhodope Mountains the sloppy and smooth terrain predominate, which give an opportunity for uphill yarding, and the forests consist mostly of Norway spruce (*Picea abies* L.) and Scots pine (*Pinus sylvestris* L.). Tractor-mounted tower yarders have been widely used in Bulgaria since 1980 in primary timber transportation.

Lateral yarding consists of moving the logs (load) to a bunching point from where the load is partly or entirely lifted off the ground by the cable (mainline) and moved to the landing. Therefore, a yarder is a system of power-operated winches used to haul logs from a stump to a landing. Tractor-mounted tower cable yarders are driven by power take-off shafts (Table 1). Both single- and multi-span layouts are used for tower yarders. For single-span layouts, a crew of 2-, 3-, and 4-members can be used when using solely a yarder and a 3- and 4-member crew when using both a yarder and skidder [8-9].

According to Huyler and Ledoux (1997b) the yarding delays for operational, mechanical, and non-productive time accounted for approximately 35% of the total cycle time on steep slopes in the US Northeast. The authors also proposed that delays should be factored to separate the delay-free time to be able to give an estimate of the total cycle time. The average delay-free-cycle time was 5,72 minutes [6]. The relevant variables used in the time prediction equation were the yarding distance, lateral yarding distance, volume per turn and stem volume.

In conditions of Italian Alps, productivity ranged between 8.5 and 10 m^3h^{-1}, including all delays, but excluding set-up and dismantle time. Machine utilization was about 60%, which was consistent with previous studies [20].

According to Dimitrov (2012), to increase the productivity of tractor-mounted tower yarder operated in beech (*Fagus sylvatica* L.) stands located in Ograzhden Mountains in Southwest Bulgaria, operational times for lateral outhaul (28%), inhaul (21%), nonworking time covering spare and delays of workers (16%) and unhook (13%) should be minimized. He also estimated that the mean productivity of the studied yarder of 3.22 m^3h^{-1} for 33-m lateral yarding and 230-m outhaul could be defined as moderate. The results are comparable with those of studies carried out in coniferous stands of Northeast Turkey – 6.6 m^3h^{-1}, 5.5 m^3h^{-1} and 4.9 m^3h^{-1} respectively for inhaul distances of 100, 200 and 250 m [18].

Table 1

Technical data of studied Koller K300T cable yarder

Parameter	Value
Skyline capacity 500 m, ø14 mm swaged or 450 m, ø15 mm	44 kN (tension section)
Mainline 550 m, ø8,5 mm swaged or 450 m, ø9,5 mm	18 kN (average drum)
Guyline	3x30 m, ø16 mm / 2x10 m (extension)
Line speed	Up to 3.6 ms^{-1}
Tower height	7.2m
Tower height (with tower extension)	8.4 m
Operating range	on the left side of the yarder
Power station	PTO of the tractor (mechanically driven)
Engine power of the tractor: 49 HP (36 kW)	minimum 36 kW (49 hp)
Clutch	Hydraulically operated single dry disk on both drums
Brakes	
Skyline	manually actuated band brake
Mainline	hydraulically actuated band brake
Operation	Hydro-mechanical / electro-hydraulic single lever operation with dead-man´s control
Carriage	Koller SKA-1 /SKA 1-Z
Weight	
without lines	1550 kg
including lines (non-compressed/compressed)	2050/2250 kg

Production rates observed by Zimbalatti and Proto (2009) during fuel wood yarding operations in two Turkey oak (*Quercus cerris* L.) stands in Calabria, Italy, were lower – mean load volume of 0.75 and 0.54m^3, and productivity of 2.38 and

$3.21 m^3 h^{-1}$, respectively for coppice and high forest. According to Melemez et al. (2014) the extraction by skyline was determined to be the most efficient extraction method, but the slope of the terrain needs to be greater than 50% to use this method.

As most of tractor-mounted tower yarders in Bulgaria operate in Rhodope Mountains in coniferous forests, time and productivity studies are of great interest because the data obtained in such studies could be used to develop simulations in order to give loggers and forest managers an effective tool for operational planning in similar terrain conditions. Most operations will be economical when taking place in a high-yield stand and when all factors affecting costs of operations have been considered carefully [10].

The aim of the present study was to improve the use and operational efficiency of the tractor-mounted cable yarders in coniferous stands and to determining the time, and volume of logs transported per unit of the yarder. Knowledge of these parameters is useful to integrate the work of the cable yarders in order to achieve economic and environmental efficiency of timber extraction.

2. Material and Methods

The study focused on a Koller K300T tractor-mounted tower yarders, which is among the most widespread in Bulgaria.

The work team consisted of three people, of which one was the winch operator and unhooks the logs, and the rest were choker-setters at the loading site. The work team had at least 5 years of experience with cable yarding and they were all 35-45 years old. The study was carried out in the Rhodope Mountains at the Kormisosh State Hunting Range and Borika Forest Owner Cooperative. Trees removed consisted of 100 years-old, Scots pine (*Pinus sylvestris* L.), with mean height of 26.0 m and mean diameter at breast height of 34 cm, and of Norway spruce (*Picea abies* L.), with mean height of 24.0 m and mean diameter at breast height 30 cm. To minimize residual stand damages during the lateral yarding the logs were extracted in lengths of 3, 4, 5 and 6 m. In most cases only one log was yarded.

Three skyline corridors were opened on terrain slopes of about 25° (47%), 30° (58%) and 35° (70%). Field observations were carried out on 30 work cycles (turns) at each corridor. Extraction direction was uphill. A double-span using double-tree intermediate supports (also known as M-support) layout was implemented each time. A detailed time and motion study was conducted to estimate the duration of work elements and productivity of the cable yarders in the given conditions. A yarding work cycle was assumed to be composed of repetitive elements [15-16, 20]. In this study the yarding work cycle was composed of following repetitive elements [16]: descending of empty hook, outhaul, lateral outhaul, hook, lateral inhaul, inhaul, unhook and delays.

The time-motion study was designed to evaluate duration of work elements and yarder productivity and to identify those variables that are most likely to affect it. Each yarding cycle was stop watched individually. Productive time was separated from delay time [11].

Yarding distances were measured with a laser range-finder, the terrain slope – with professional clinometer. Load volume was determined by measuring the length and the diameter at mid-length of all logs in each load.

Regression analysis was performed on the experimental data in order to develop prediction equations for estimating the work cycle time and productivity. Variables used in the modelling approach included lateral yarding distance *l*, yarding distance *L*, load volume per cycle *Q*, and terrain slope angle *s*.

Statistical analysis consisted of identification and exclusion of outliers, correlation analysis for independent variables with a correlation coefficient set at $R \le 0.75$ as an acceptable threshold to exclude the independent variables from regression analysis for reasons such as the inflation of determination coefficients. The descriptive statistics of the variables were computed and a stepwise backward regression procedure was used to model the variability of yarding cycle time and productivity as a function of independent variables.

Since factors have different dimensions (m, m^3, degree), it is difficult to determine their impact. Factor coding is particularly effective and simplifies the computation of the regression model parameters [14, 24].

The confidence level used for regression analysis was α=0.05 and the assumed probability $p<0.05$. Independent variables are significant at $p<0.05$, i.e. very strong presumption against neutral hypothesis.

To process the experimental data the Statistica 8 (StatSoft Inc., Tulsa, OK, USA) software was used.

3. Results and Discussion

The summary of experimental data from 90 cycles for each of the selected variables used in the cycle time and production equations is shown in Table 2.

3.1. Duration of Work Cycle Elements

The greatest portion of cycle time (Figure 1) was specific to the inhaul (54% and 47% respectively, excluding and including delays) and it was most probably related to the low inhaul velocity of carriage with load; descending of empty hook accounted for the smallest share (1%). Hooking accounted for the second highest share (16% and 14% respectively, excluding and including delays). Operational and mechanical delays accounted respectively for 5.5% and 7.5% of the total cycle time of the studied cable yarder (Figure 1c).

The characteristics of independent variables in really values and code values are shown in Table 3.

The regression analysis was performed on the time-study data in order to develop a prediction equation for estimating the yarding cycle time by excluding and including delays. Significant variables were the lateral yarding distance *l* (m), yarding distance *L* (m), and terrain slope *s*, deg (Table 2). The delay-free cycle time T_{net} regression equation obtained with significant variables (R^2=0.774, $F(14.75)$=18.311, $p<0.05$) is as follows:

$$T_{net}=7.491+0.411x_1+1.065x_2+0.307x_4-0.809x_1x_2+0.727x_2^2-0.440x_4^2 \text{[min]} \quad (1)$$

In Eq. (1) minimum values of delay-free cycle time T_{net} may attain in case of low level of lateral yarding distance *l* (i.e. x_1=-1), and slope yarding distance *L* (i.e. x_2=-1), but high level of terrain slope angle *s* (i.e. x_4=+1). The variable load volume per cycle *Q* with code value x_3 is insignificant, probably due to the load consists mainly from one log.

The following regression equation for cycle time including delays T under the given forest conditions one obtained:

$$T=4.099+7,505x_2-2.893x_4-2.554x_1.x_4+12.290x_2x_3-4.668x_3x_4+3.767x_1^2+4.824x_3^2 \text{ [min]} \quad (2)$$

Regression summary of Eq. (2): $R^2=0.54$, $F(14,75)=6.29$, $p<0.05$, Std. Error of estimate: 4.174.

Consequently, the minimum duration of cycle time including delays achieves when $x_1=-1$, $x_2=-1$, $x_3=1$, and $x_4=1$, and respective natural symbols and values of factors.

Table 2

Mean experimental data

Yarding variables	Cycle time [min]			Distance [m]		
	Mean value ± St. dev	min	max	Mean value ± St. dev	min	max
Descending of empty hook	0.12±0.02	0.08	0.15			
Outhaul	0.58±0.06	0.42	0.67	202±35.36	180	230
Lateral outhaul	0.37±0.09	0.20	0.54	17.5±4.50		
Hook	1.38±0.35	0.90	2.13			
Lateral inhaul	0.80±0.12	0.56	1.08	17.5±4.50	10	25
Inhaul	4.56±0.60	3.26	5.36	202±35.36	180	230
Unhook	0.64±0.15	0.26	0.90			
Delay	1.30±5.72	0	30.00			
Total cycle time	9.82±5.99	6.40	38.74			
Delay-free cycle time	8.32±0.94	6.40	9.63			
Load volume per cycle (turn), m^3	0.66±0.21	0.37	1.23			
Productivity, m^3/PMH*	5.08±1.69	2.68	10.41			
Productivity, m^3/SMH*	4.73±1.73	1.47	8.59			
Number of cycles per SMH*	6.27	5.42	8.16			

*St. dev. – standard deviation, PMH – productive machine hour, SMH – scheduled machine hour.

Table 3

Characteristics of independent variables

Characteristics	Really values				Code values			
	l [m]	L [m]	Q [m^3]	s [deg]	x_1	x_2	x_3	x_4
Low level	10	145	0.37	25	-1	-1	-1	-1
High level	25	230	1.23	35	+1	+1	+1	+1
Basic level	17.5	187.5	0.8	30	0	0	0	0

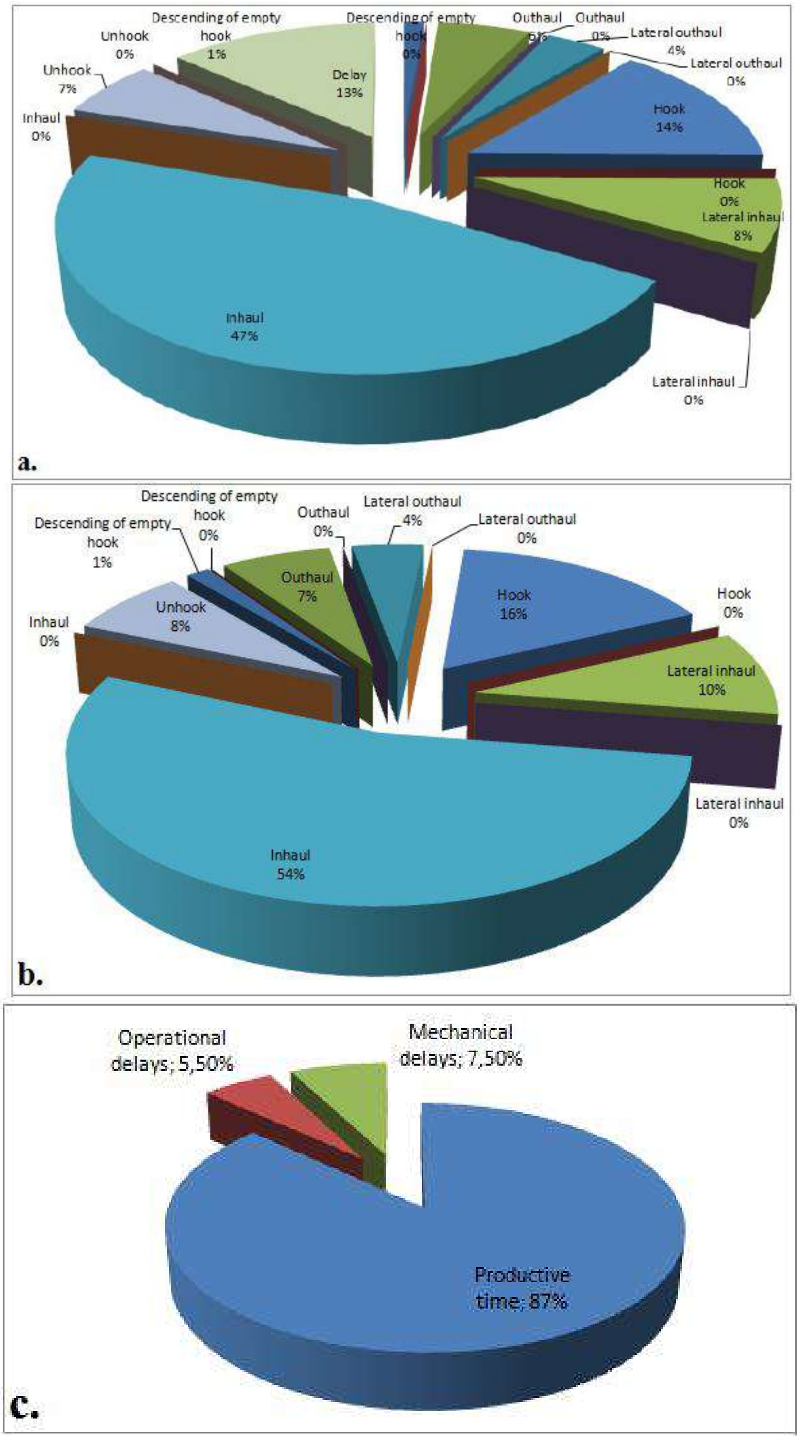

Fig. 1. Percentage of cycle time work elements including and excluding of delays: a. percentage of cycle time work elements including of delays; b. percentage of cycle time work elements excluding delays; c. productive time vs. delay time

3.2. Productivity of Tower Yarders

Delay-free yarding productivity is defined by the following regression equation:

$$P_{PMH}=6.372-0.339x_1-0.820x_2+3.498x_3-0.338x_4+0.543x_1x_2-0.343x_3x_4+0.302x_4^2 \quad [m^3h^{-1}] \quad (3)$$

Regression Summary for Dependent Variable: $R^2=0.95$, $F(14,75)=101.76$, $p<0.05$, Std. Error of estimate: 0.413.

Therefore, to increase delay-free yarding productivity lateral yarding distance *l*, slope yarding distance *L*, and terrain slope *s* should be at low level (i.e. $x_1=-1$, $x_2=-1$ and $x_4=-1$), whereas the load volume per cycle *Q* will be at high level ($x_3=1$).

The yarding productivity including delays is expressed as:

$$P_{SMH}=7,064-2.544x_2+3.095x_3+0.622x_4-3.455x_2x_3+1.160x_3x_4-0.775x_1^2-1.496x_3^2 \quad [m^3h^{-1}] \quad (4)$$

Regression Summary for Dependent Variable: $R^2=0.74$, $F(14,75)=15.99$, $p<0,05$, Std. Error of estimate: 0.957.

From equations (3) and (4), reducing at low level the lateral yarding distance *l* (i.e. $x_1=-1$), yarding (inhaul) distance ($x_2=-1$) and increasing to high level the volume of load to the maximum allowed (i.e. $x_3=1$) it could expect that the yarding productivity will rise in this case to 9 m^3 per scheduled machine hour. The mean yarding productivity at shift level (duration of work day of 8 h), excluding and including delays, estimates at 38.82 m^3 per shift and 36.27 m^3 per shift, respectively. Generally, the mean yarding productivity of studied machine per hour and shift level is close to the maximum for that type of cable yarders under given conditions, compare to the rates quoted by Dimitrov (2012), Senturk et al. (2007), Melemez et al. (2014) and Zimbalatti and Proto (2009).

On the other hand, in order to improve the yarder productivity and to use the full load capacity of the carriage, is advisable at least to double the mean load volume per turn (0.67 m^3). This could be achieved, for example, by yarding stems or whole trees instead logs or several logs per turn. In this way, delimbing and bucking operations may be moved from stump to the landing at roadside or machinery equipped with processors may be used. Nevertheless, in this study there was no enough space at the landing to process stems and ~~piles~~ the logs using the motor-manual techniques.

The use of Processor Tower Yarder (PTY) technology is recommended in steep terrain given the improved productivity, which ranges from 90 to 120 m^3 per 8-h day [3]. Such technology enables tree processing, sorting and piling after releasing the load consisting of whole trees [2, 4, 21, 23].

4. Conclusions

The greatest part of cycle time holds inhaul (54% and 47% respectively, excluding and including delays), whereas descending of empty hook is the shortest cycle element (1%). Hook is second by heaviness cycle element (16% and 14% respectively, excluding and including delays). As the tree load mostly drags on the ground during lateral inhaul with mean ground distance of 17.5 m the share of this cycle element is also significant – 10% and 8% respectively, excluding and including delays. The duration of unhook is 8% and 7% respectively, excluding and including delays, due to insufficient landing area.

The productive time for the studied cable yarder was about 87% and operational and mechanical delays accounted respectively for 5.5% and 7.5% of the scheduled machine hour. The mean productivity of tractor-mounted tower cable yarder at shift level is close to the maximum for that type In order to improve the yarder productivity and the full load capacity of the carriage is advisable at least to double the mean load volume per turn by yarding stems or whole trees instead logs. The use of Processor Tower Yarder (PTY) technology in coniferous stands under given terrain conditions is recommended to significantly increase productivity.

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SHORT HISTORY OF FOREST MECHANIZATION AND ITS PERSPECTIVES IN JAPAN

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Abstract: *This study aimed to obtain future perspectives of forestry mechanization by analyzing the statistic of forest machinery in Japan. The mechanization was proceeded by introducing processors, harvesters, and forwarders with the historical background where the Japanese forest conditions for harvesting were not always suitable for cut-to-length systems. Swing yarders were introduced as a cable system although they required high-dense road network than tower yarders. It was also verified that the machineries were introduced for their renovation of operation systems and the increase in the number of machines shown in statistic could not be directly regarded as the increase in the domestic timber production at the national level. Forestry mechanization process should be reviewed for realizing high productivity and safety works. The development and expansion of tower yarders for downhill yarding would be the issue to move Japanese forestry forward.*

Key words: *forestry mechanization, harvesting system, productivity, safety, downhill yarding.*

1. Introduction

As a renewable material, the demand for wood has boosted the development of forest machinery. Forest machinery has always required reasonable development from the viewpoint of not only the economic advantages but also the ergonomics, safety, and ecological functions. They introduced the most advanced technologies at that time such as engines, hydraulic systems, electronic devices, sensors, and Information Communication Technology (ICT). The development in forest machinery will change not only the harvesting systems but also the management of supply chain. This study aims to obtain future perspectives of forestry mechanization by analyzing the history of forest machineries in Japan by referring the domestic timber production and by reviewing the national policies.

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1.1. The Dawn of Forest Mechanization in Japan

The conditions surrounding the forest industry made differences in the progress of forest mechanization among countries. From the aspect of forest engineering, steep terrain and the ownership of planted forests characterized the harvesting systems in Japan. Forest area occupied two-thirds of Japanese land. The 58 %, 12 %, and 31 % of it were owned by private, local-publicly, and the national government, respectively [3]. The quarter of Japanese land is the coniferous forest which has been planted mainly after the clear cut of natural forest since ‘50s. The 65 % of them are privately owned and there are 0.6 million of small-scale forest owners who have less than 5 ha of forest [3].

In the middle of ‘80s, thinning operations in private forests inspired the need for mechanization instead of manual logging and horse skidding which was the main method especially in the northern part of Japan. Small forwarders were invented [5], and they equipped a hydraulic grapple loader imported from Scandinavian countries after a while. The introduction of grapple loaders apparently improved the efficiency of log loading operation [6]. National forest had introduced tractors for whole-tree skidding and yarders for clear cuts on steep terrain in the middle of ‘50s.

1.2. Short Review of Policies Related to Forestry Mechanization

As the planted forests matured and needed thinning, “the Forest Act” was renewed in 2001, and the aim of Japanese forestry shifted to the promotion of large-scale industrial forestry to utilize the matured planted forests effectively by modernized forestry machinery. “Fundamental Plan of Forest and Forestry” was announced in 2009 and the Forest Act was revised again in 2011. The aim of the original plan was to improve the self-sufficiency rate of timber production up to 50 % from 30 % in ten years. From 2011, the national government started to subsidize the forest road construction and the thinning operation in the forest where the management plan was established, and the forestry machines such as farm tractors with remote controlled winches [8], wheel-based harvesters and tower yarders were imported from oversea countries for the forestry enterprises who had motivation and operation skills. The annual volume of timber production hit the bottom at 16 mills. m^3 in 2002. It reached to 20 mills. m^3 in 2012 and produced a similar amount till 2015.

2. Materials and Method

The Japanese statistic had made public the number of forestry machinery introduced and the annual production amount [2]. The numbers of feller bunchers, harvesters, processors, skidders, forwarders, tower yarders, swing yarders and the others were recorded from 1988 to 2015. The characteristic of machinery was that almost of machinery was excavator-based or crawler-equipped in Japan. Swing yarders were the excavators with two-drum winches for short distance cable logging. The others indicated mainly the lately-developed excavators with the felling-bucket [5] which used for earth works and tree-felling and suited to road construction. In the statistic, the data of tower yarders included the number of swing yarders until 1999 and the record of the others started from 2000. The trend of mechanization was overviewed at first. Since the subsidy started in 2011 would influence on the number of machinery, the increase in the number of machinery was compared before and after 2011 in this study.

We supposed that the introduction of new machines would be recognized as the direct increase of the production amount at the beginning of mechanization. For example, we experienced the increase of timber production by introducing chainsaws and tractors which were imported to deal with the damaged forest attacked by the typhoon in Hokkaido Island in 1954. Therefore, the ratio of increased production to the previous year was analysed in the increasing of timber production started in 2003 as defined in Table 1.

Table 1

The unit increased production each year

Operation	Machinery	Formula	Definition
Harvesting	Harvesters Feller bunchers Processors	$\frac{p_i - p_{i-1}}{n_i - n_{i-1}}$	p_i: the production amount in the year of i (10 thousands m^3) n_i: the number of harvesters, feller bunchers, and processors in the year of i
Prehauling	Skidders Forwarders Tower yarders Swing yarders	$\frac{p_i - p_{i-1}}{m_i - m_{i-1}}$	m_i: the number of skidders, forwarders, tower yarders, and swing yarders in the year of i

3. Results

Figures 1 and 2 showed the changes in the numbers of introduced forestry machinery in every year from 1988 to 2015. The total number of forestry machines was 7,686 in 2015 and about half of them was achieved by forwarders and processors.

According to Figure 1, forwarders and processors were the modern-machines which were introduced at the very beginning and mostly spread. The number of forwarders increased especially in 1999 and 2010. The processors expanded the share in 1993 and 2014 while its spread was relatively stagnant between ca. 2000 and 2004. The small number of feller bunchers could be explained by the steep terrain condition in Japan. They were used dominantly in Hokkaido Island. The number of harvesters increased in 2010 and kept increasing like forwarders. Tower yarders were expected to be suitable for the Japanese steep terrain conditions [7] and were introduced in 1990. They were, however, not expanded. Swing yarders were not popular at first. They were introduced instead of tower yarders in 1999 and constantly increased the number until 2015. The number in the "others" category was rapidly increased in 2012 and kept increasing.

According to Figure 2, the numbers of harvesters, forwarders and the others were increased after 2011. It indicated that the year of 2011 was a turning point of forestry mechanization. On the other hand, the numbers of feller bunchers, skidders, tower yarders, and swing yarders were slightly increased or not increased. The introduction of the others from 2012 made the variance wider. The reduction in the number of tower yarders was because the statistic excluded the number of swing yarders in 1999.

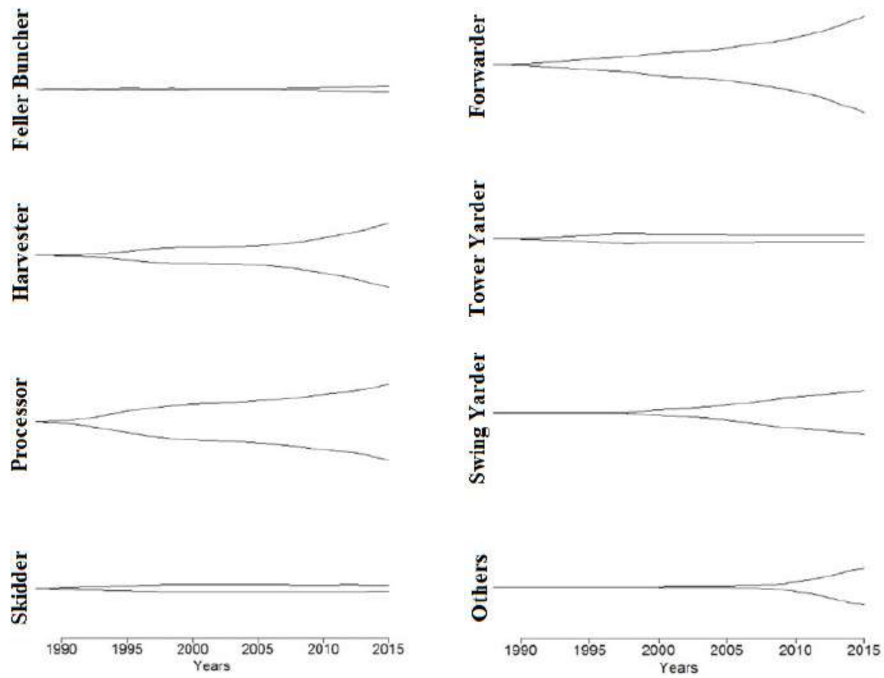

Fig. 1. The introduction of each forest machinery from 1988 to 2015

Figure 3 showed the unit increased production to the previous year. It did not show any trend. It was 3,600 m^3 per a harvesting unit and 2,300 m^3 per a prehauling/skidding unit on average.

4. Discussion

The forestry mechanization was driven by introducing processors, harvesters, and forwarders in Japan which were used in the cut-to-length system (CTL system). CTL system was established in Scandinavian countries and we compared Japanese history of forestry mechanization with that of Finnish history [1]. The shape of the harvester in Figure 1 was similar to that of Finland [1], but harvesters had already been introduced approximately in 1975 and rapidly spread in ca. 1990 in Finland. Forwarders had used in the mid of '60s prior to harvesters in Finland. In 1990, about half of timbers were produced by harvesters and almost timbers were transported by forwarders in Finland [4].

In Japan, the introduction of processors preceded earlier than that of harvesters because of steep terrain and soft soil conditions which were not suitable for harvesters to move in the forest and the insufficient forest road network which was still an issue in Japanese forestry. At first, they were imported after the Plaza agreement in 1985 and a domestic processor was developed in 1997.

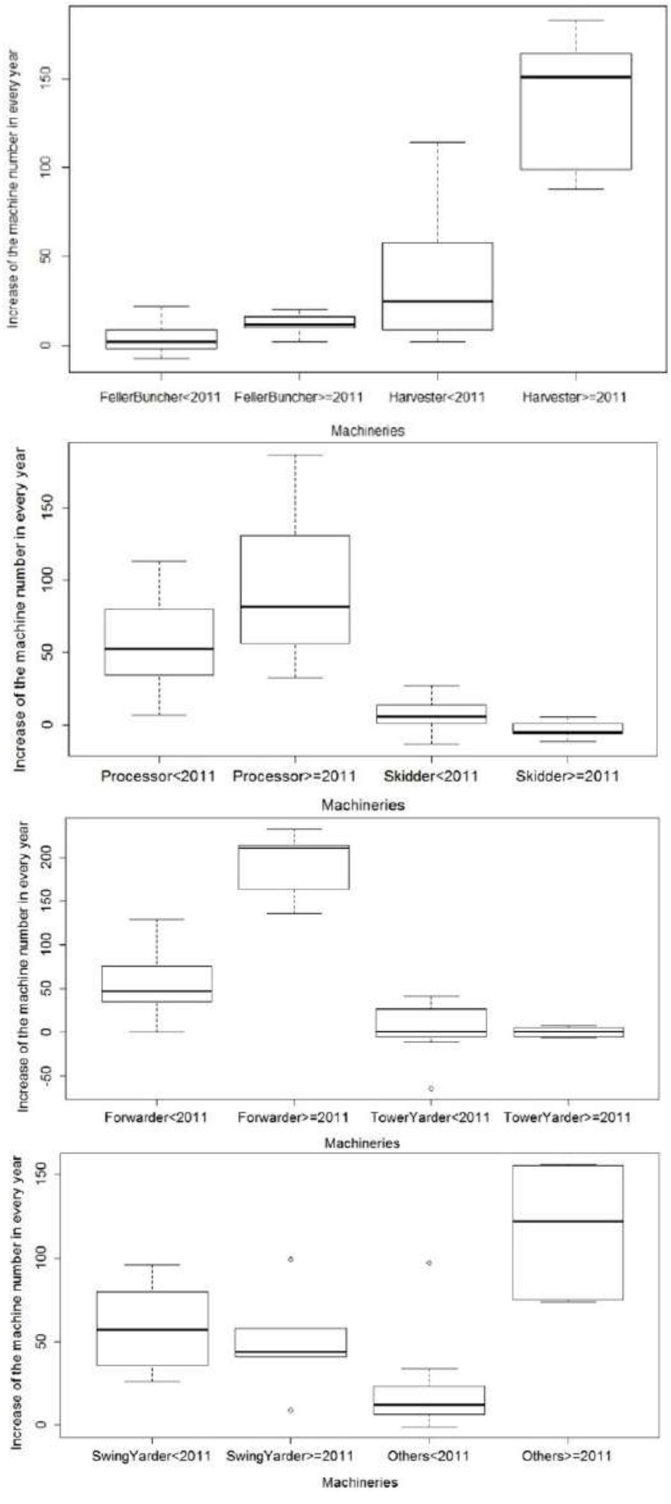

Fig. 2. Comparison of machine numbers introduced before and after 2011

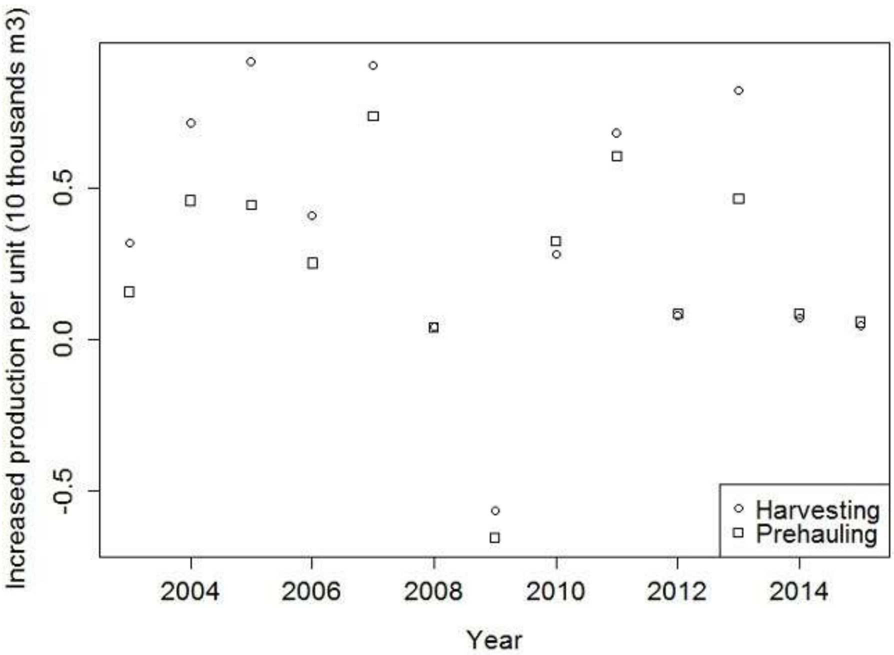

Fig. 3. Increased production per one harvesting or skidding unit every year

The development of a domestic processor did not seem to accelerate its spread although processors were constantly introduced. Since the harvesters were used at roadside, they equipped with a small winch for prehauling (Figure 4) and forwarders transport bucked logs from roadside to the landing. This point was different from the Scandinavian CTL system. The introduction of harvesters was 15-years later in Japan compared to Finland. Although forwarders also required the high-dense forest road network, the introduction was supposed to have proceeded because they were familiar to operators who usually drove vehicles on forest roads and transported timbers by domestic small forwarders [5].

According to Figure 3, the unit increased production was small and the minus growth in 2009 might be affected by Lehman shock in 2008. This small amount of the unit increased production indicated that some of the machineries were introduced mainly for its renovation from the behind mechanization. Therefore, the increase of machinery would not be directly regarded as the increase of the production.

Fig. 4. A typical harvester mounted on excavator at roadside equipped with a small winch for prehauling (Photo: Hideo Sakai)

The increase in the number of the harvesters and forwarders in 2010 and the others in 2012 indicated that the change of policy in 2011 and the subsidy for forest road construction possibly contributed the introduction of those machines among private forests.

The implementation of cable harvesting systems was preceded by introducing swing yarders. The preparation of swing yarders was easier than that of tower yarders because they did not require guy-lines. It could be also used for loading operations as a grapple loader. Operators preferred the simplicity of its operation and its bi-functionality. However, the disadvantage of swing yarders was the shorter skidding distance requiring high-dense forest road networks consequently. As the harvesting operation moved to the more difficult terrain condition, the introduction of swing yarders slightly decreased after 2011 as shown in Figure 2, and the tower yarders would be necessary. Since it is challenging to construct the roads in Japan [5], tower yarders should be suited for downhill yarding in the forest with insufficient forest road density. Additionally, education and training were essential to spread the use of tower yarders on the operational level. In practice, there were the operators who trained the tower yarding operation in oversea countries and the importance of guy-lines was recognized for safety.

The increase in the price of machinery could be expected because of emission regulation of engine. It would require the increase in the productivity of machinery to reduce the harvesting cost. Another solution for cost reduction would be the use of the forest machinery with the base which was mass-produced such as excavators or farm tractors because of their widespread use and its relatively lower purchase price.

The data did not include the mobile chippers for wood chip production for energy. The steep terrain condition sometimes prevented mobile chippers and larger trucks to drive into forest so that the landing for chip production should be planned between a harvesting site and a demand [9]. Since the wood demand for energy was enlarging, the number of mobile chippers should be recorded, and the better location of intermediate landings should be considered into the plan of forest road network.

5. Conclusion

The mechanization in forestry was basically preceded by introducing harvesters, processors, and forwarders. The increase in the number of machinery did not directly indicate the increase in production. We supposed that they were basically introduced for renovation. Forestry mechanization process should be reviewed for realizing high productivity and safety works. The introduction of cable systems was not preceded compared to the machines for CTL ground-based systems although the cable systems were necessary in terms of terrain condition. The development and expansion of tower yarders suitable for downhill yarding would be the issue to move Japanese forestry forward because the slopes is steep to construct forest roads.

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GENETIC VARIATION AND INHERITANCE OF BUD FLUSHING IN A NORWAY SPRUCE SEED ORCHARD ESTABLISHED IN ROMANIA

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Abstract: *Genetic variation and parameters for bud flushing were estimated in a seed orchard of Norway spruce established in Romania. The experiment contained 28 clones originated from 7 forest districts located in the Eastern Carpathians. Bud flushing was assessed in two consecutive growing seasons (2017 and 2018) by examining 168 trees. Results revealed high genetic differences both at the clone level, at the population and within population level. Bud flushing of the Norway spruce clones exhibited strong clinal variation with the altitude of origin of the plus trees. The clones from lower altitude started earlier their growing in spring compared with those from higher altitude. The clone heritability estimates ranged from 0.85 to 0.94, which means strong genetic control and implies that it can be effectively selected during breeding. The knowledge of the genetic variation of this adaptive trait is extremely important in breeding, but also for management and conservation of forest under climate changes.*

Key words: *Norway spruce, bud flushing, genetic variation, heritability, correlations.*

1. Introduction

Norway spruce is one of the most important forest species in Romania, both for economic and ecological purposes. It covers about 22% of the national forest area and 77 % of the coniferous forest area (approximately 1,450,000 ha) [20]. Since the middle of the 19th century, Norway spruce was the most cultivated species outside its natural range. Thus, the artificial stands of Norway spruce created outside the natural area reached currently 360,000 ha [24]. Also, 41% of the artificially regenerated area is still planted with Norway spruce (about 17 million seedlings).

In Romania, the tree breeding programme was started in the 1960s, and the Norway spruce was one of the

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prioritized species. Selection of the seed stands followed by the plus trees selection and establishing of seed orchards were the first steps in the breeding programme [5]. Over 1400 plus trees were selected in natural and artificial stands. There have been installed 13 seed orchards (96 ha) of which only 9 seed orchards (72.9 ha) remained by now. They are currently the main sources for producing genetically improved seeds in Romania.

Breeding activities have focused on improving growth, wood quality and resistance to biotic and abiotic factors. Among abiotic factors, late spring frosts often cause injuries to young shoots of Norway spruce if the forest reproductive material is poorly adapted to the climate of the planting site. The frosts spring produce stem forking by killing the terminal shoot, which are considered one of the main shape defect because reduces the timber use value.

Phenological studies have shown that the trees growing season in Europe increased on average by 11 days during 1960 – 1990, and climate change is expected to advance the spring in the future [14]. One of the consequences will be increasing the frost damages due to earlier bud burst. Thus, bud flushing is one the most important traits in breeding but also for successful of regenerations. The phenology of bud flushing is fundamental for survival and growth of the forest species.

At the European level, the first results regarding the geographic variability of bud flushing in Norway spruce come from IUFRO experiments [7, 12]. The climate control and the timing of bud flushing in Norway spruce were studied by Beuker 1994, Leinonen and Hanninen 2002, Sogaard et al. 2007, Vitasse et al. 2009, Malyshev et al.2018. However, despite the economic importance of Norway spruce, studies regarding the genetic control of bud flushing are limited as compared with those for growth or wood quality [4, 6, 9-11, 17].

Therefore, knowing the genetic variation and inheritance of the important adaptive traits is extremely important both from a theoretical and practical point of view. Information is essential in the species breeding programme for selection of the genotypes or populations with high adaptability or plasticity. Also, they are useful for the delineation of the provenance regions and the transfer of forest reproductive material, in order to maximize adaptability and wood yield.

To address these problems, the objectives of this study were: 1) to investigate the genetic variation of bud flushing in a seed orchard of Norway spruce; 2) to determine the genetic parameters; 3) to assess the relationships among variation of bud flushing and geographic parameters of the location of parents’ origin; and 5) to evaluate the implications for the breeding programme.

2. Material and Methods

2.1. Genetic Material and Assessments

Within 1979 - 1981, 197 plus trees were selected from 7 forest districts, both from natural and artificial seed stands located in the Eastern Carpathians. Further, a clonal seed orchard was established at Fantanele Forest District (Eastern Carpathians) on a surface of 15 ha. The seed orchard is situated far away from other spruce stands, in the oak zone at $46^0 36'$ N latitude, $26^0 50'$ E longitude at an elevation of 300 m above sea level (a.s.l.)

and currently comprises the vegetative copies of 168 plus trees belonging to 2 provenance regions [22]. In this study, we chose 28 clones originated from all 7 forest districts. The location of the plus trees tested in this experiment is presented in Table 1 and Figure 1.

The assessment of bud flushing (BB) was made in two consecutive growing seasons (2017 and 2018) by examining 168 trees (6 ramets per clone in three replications). Because the trees heights are ranging between 7 to 10 meters, it was not possible to assess the terminal bud of the annual shoot.

Table 1

Location of the plus trees studied in this experiment.
Provenance region by Parnuta et al. (2010)

Crt. no.	Clone number	Altitude [m]	Lat. N	Long. E	Forest district	Provenance region
1	1-2	1000	$46^0$89′	$26^0$14′	Tarcau	A2
2	3-7	650	$46^0$47′	$26^0$43′	Moinesti	A2
3	8-12	650	$46^0$14′	$26^0$68′	Manastirea Casin	A2
4	13-14, 16-18	1100-1200	$46^0$49′	$26^0$22′	Agas	A2
5	15	900	$46^0$95′	$25^0$94′	Ceahlau	A2
6	19-25	860-1180	$46^0$42′	$26^0$40′	Comanesti	A2
7	26-28	420	$47^0$25′	$26^0$71′	Pascani	G1

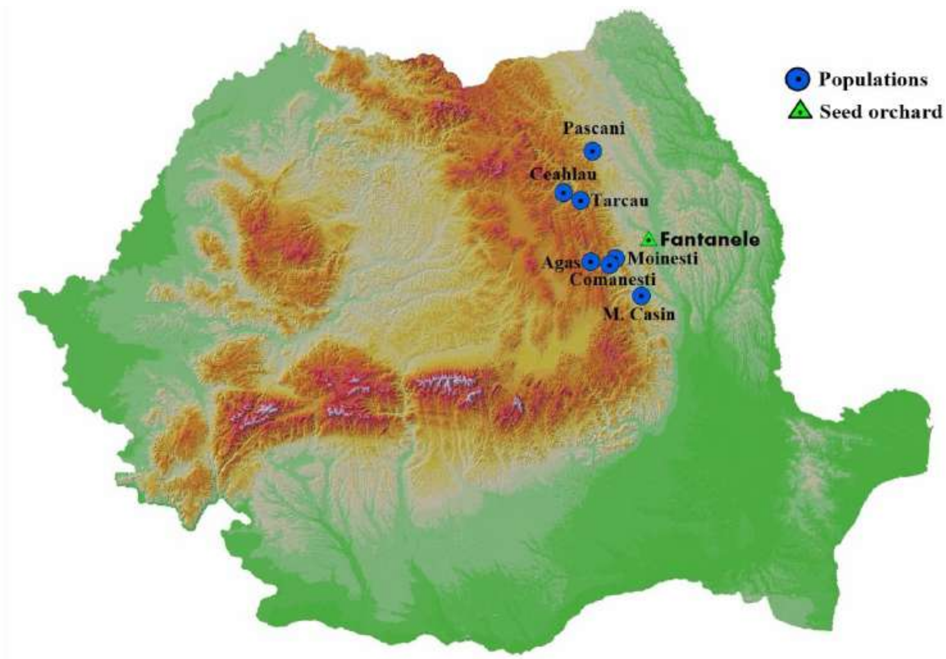

Fig. 1. Location of Norway spruce plus trees and the seed orchard

The bud flushing survey involved recording the terminal bud of a lateral branch situated at the 2 m height and always on the eastern part of the tree crown. Accordingly with Ducci et al. 2012, we have used a 5-point scale starting from 1 = unbroken bud to 5 = needles completely open and fully elongated. This has simplified the interpretation of the data by ranking the clones to a scale of 1 = late to 5 = early. The observations were made in a single day with a periodicity of five days. Thus, three evaluations were performed in each year starting at 26 April in 2017 and 2018 too.

2.2. Statistical Analysis

Individual tree data were analyzed separately using appropriate mathematical model [19] (eqn. 1):

$$Y_{ijlk} = \mu + B_i + P_j + C_l + CB_{li} + e_{ijlk} \qquad (1)$$

where:

- Y_{ijlk} is the performance of the k^{th} tree in the i^{th} repetition in the l^{th} clone in the j^{th} population;
- μ - the overall mean;
- B_i - the effect of the i^{th} repetition;
- P_j - the effect of the j^{th} population;
- C_l - the effect of the l^{th} clone;
- CB_{li} - the interaction of the l^{th} clone and i^{th} repetition; and
- e_{ijlk} - the random error associated with $ijlk^{th}$ trees.

The analyses and variance components were performed using the SPSS software program version 19 (Univariate GLM & VARCOMP). The assumptions of the model were checked by the Shapiro & Wilk test for normality and by Levene’s test for homogeneity.

The genotype heritability (h^2_G) and individual heritability (h^2_i) were calculated by the following formulas [19] (eqn. 2):

$$h^2_G = \sigma^2_C / (\sigma^2_C + \sigma^2_E / r) \qquad (2)$$

$$h^2_i = \sigma^2_C / (\sigma^2_C + \sigma^2_E) \qquad (3)$$

where:

σ^2_C is the variances among clones;
σ^2_E - the error variance;
r - number of repetitions.

Pearson’s correlations based on clone means were also calculated to examine relationships between bud flushing and geographic coordinates of the parents’ origin (LAT = latitude; LONG = longitude; ALT = elevation, in metres a.s.l.).

3. Results

3.1. Genetic Variation and Variance Components

The analyses of variance for bud flushing in the two years are presented in Tables 2 and 3. Very significant differences among clones were found for all evaluations ($p < 0.001$). The differences among populations were also significant. The differences among the clone within a population were significant only for three populations: Moinesti, Comanesti and Pascani (Table 4).

Table 2

Analysis of variance for bud flushing of Norway spruce in 2017

Source of variation	D.F.	BB-I-2017		BB-II-2017		BB-III-2017	
		s^2	F	s^2	F	s^2	F
Population	6	4.157	28.319***	16.919	24.621***	6.505	14.618***
Clone	27	1.364	17.627***	5.325	11.470***	2.283	7.103***
Repetition	2	0.077	1.000	0.613	1.321	0.363	1.130
Error	126	0.077		0.464		0.321	

The level of significance is represented as follows: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

BB-I-2017 = the first evaluation in the year 2017, BB-II-2017 = the second evaluation in the year 2017, etc.

Table 3

Analysis of variance for bud flushing of Norway spruce in 2018

Source of variation	D.F.	BB-I-2018		BB-II-2018		BB-III-2018	
		s^2	F	s^2	F	s^2	F
Population	6	7.431	21.965***	11.174	24.608***	8.353	23.602***
Clone	27	2.268	9.526***	3.086	7.854***	2.569	8.461***
Repetition	2	0.024	0.100	0.113	0.288	0.310	1.020
Error	126	0.238		0.393		0.304	

The level of significance is represented as follows: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

BB-I-2018 = the first evaluation in the year 2018, BB-II-2018 = the second evaluation in the year 2018, etc.

Table 4

Analysis of variance for bud flushing within Norway spruce populations in 2017

Population	BB-I-2017		BB-II-2017		BB-III-2017	
	s^2	F	s^2	F	s^2	F
Tarcau	0.333	2.000	1.333	2.667	0.083	1.000
Moinesti	1.583	11.875***	2.700	9.000***	1.117	11.167***
M. Casin	0.050	0.750	1.050	1.016	0.200	0.207
Agas	0.000	0.000	1.217	2.147	0.883	2.944
Comanesti	0.040	0.833	2.937	15.417***	2.214	7.750***
Pascani	2.389	14.333**	1.722	6.200*	0.222	0.205

In 2017, the bud flushing evaluation was started on 26 April when 78 % of trees had their buds unbroken and 22% in the stages 2 and 3. In 2018, evaluation was started on the same date but 38 % of buds were already burst and only 62% were unbroken. The average index has varied between 1.26 (at first evaluation, BB-I-2017) to 3.99 (at the third evaluation, BB-III-2017) in 2017, and between 1.52 (BB-I-2018) to 4.10 (BB-III-2018) in 2018. The bud flushing was closely related with the air mean temperature of the April month, which was 9.1^{o}C in 2017 and 14.4^{o}C in 2018. The earliest clones were from Pascani (28, 27, 26) and Moinesti (7, 6, 5, 3) forest districts, which already had almost all buds in stage 2 and 3. The latest clones were from Comanesti (20, 21), Agas (17) and Tarcau (1, 2) forest districts, which had the smallest indices at the end of the evaluations (Figures 2 and 3). It can be observed a stability in the behavior of clones related to bud flushing. In the two years, the same clones started the growing earlier and the same clones were tardive.

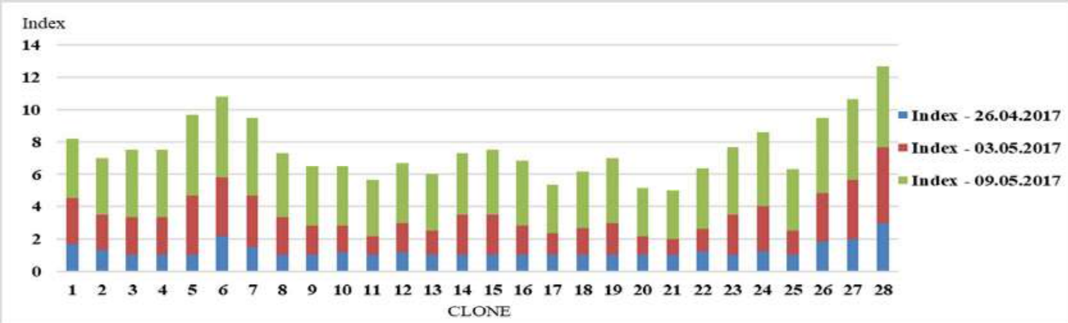

Fig. 2. Variation of Norway spruce bud flushing in the spring of 2017

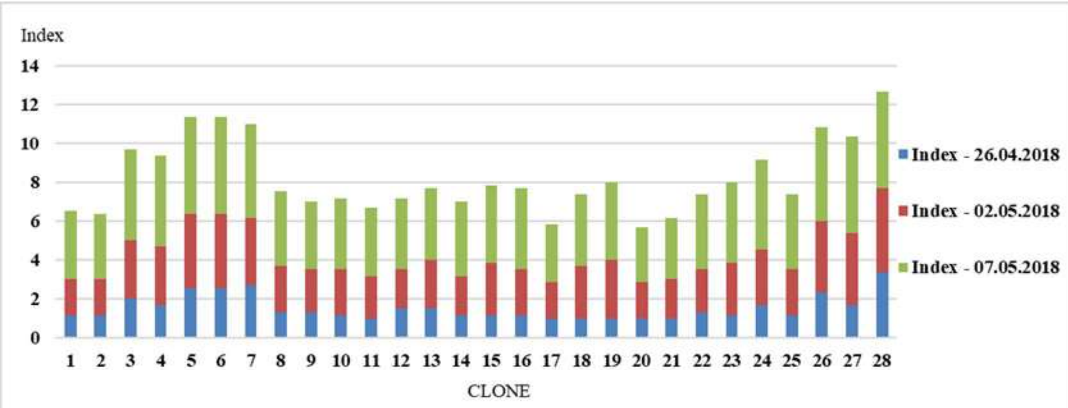

Fig. 3. Variation of Norway spruce bud flushing in the spring of 2018

3.2. Heritability

The values of the heritability coefficients are listed in Table 5. We calculated both the genotype heritability, at the clone level, and the individual heritability, ramets within clone. The clone heritability estimates ranged from 0.85 to 0.94 and was higher than individual heritability. The individual heritability takes into account the microsite variation within the seed orchards but is not so important since we will select clones and not ramets. The highest values of heritabilities were obtained for first evaluation of each year, which corresponds to beginning of the growing season.

Table 5

Estimates of averages, phenotypic variances and heritability

Evaluation	Mean	σ^2_{Ph}	h^2_i	h^2_G
BB-I-2017	1.26	0.455	0.848	0.944
BB-II-2017	2.29	1.725	0.772	0.910
BB-III-2017	3.99	0.747	0.666	0.857
BB-I-2018	1.52	0.827	0.759	0.904
BB-II-2018	2.65	1.222	0.716	0.883
BB-III-2018	4.03	0.854	0.712	0.881

Where σ^2_{Ph} = the phenotypic variances, h^2_G = the genotypic heritability

3.3. Phenotypic correlations

Correlations between BB evaluations in 2017 and 2018 are shown in Table 6. Very significant correlations were obtained between evaluations from each year and among years too. Correlations among BB and geographical coordinates of the location of origin of the plus trees were found for altitude only. The bud flushing was negatively and very significant correlated with altitude of the parents 'origin (r between -0.542** to -0.691***). Correlation with latitude and longitude of the plus tree origin were not significant.

Table 6

Trait - trait phenotypic correlations and correlations with altitude of origin of the plus trees

Evaluation	BB-II-2017	BB-III-2017	BB-I-2018	BB-II-2018	BB-III-2018	Altitude
BB-I-2017	0.764***	0.608**	0.723***	0.645***	0.533**	-0.542**
BB-II-2017	-	0.898***	0.821***	0.824***	0.828***	-0.607***
BB-III-2017		-	0.815***	0.902***	0.968***	-0.691***
BB-I-2018			-	0.857***	0.807***	-0.675***
BB-II-2018				-	0.913***	-0.637***
BB-III-2018					-	-0.666***

4. Discussion

Generally, wind-pollinated tree species exhibit high genetic variability within populations and low differentiation among them [8]. Also, moderate to steep genetic clines along climatic gradients for phenology and growth traits are specific in these species [1, 18, 21]. Results of the present study showed that there is high genetic variation among populations and clones for bud flushing in Norway spruce. At the same time, in three out of seven studied populations we found statistically significant within population variability.

Seed orchard is located far outside of the natural range of species, in different climatic conditions from those of the origin stands, but bud phenology shows well-developed adaptive divergence. Thus, bud flushing of the Norway spruce clones exhibited strong clinal variation with the altitude of origin of the plus trees. In the two years, clones from lower altitude started earlier their growing in spring compared with those from higher altitude.

The earliest clones were from an artificial stand situated at 400 m altitude in Pascani Forest District. The phytoclimatic zone where are situated this stand are specific to oak forests and in no way to spruce forests. It is well known that the natural distribution of Norway spruce in Eastern Carpathians is between 600 – 1200 m altitude [24]. But the clones from this stand started earliest their growing season which means that plus trees were already adapted to this warmer climate condition when the grafts were harvested. This mechanism of adaptation is called epigenetics and is well-known in Norway spruce [23]. The epigenetic way of adaptation implies that the phenotype may change drastically from one generation to the next. Compared with selection, which acts slowly, epigenetic adaptation is a quick process that does not involve any changes in the DNA sequences.

Bud flushing is a trait under strong genetic control, as evidenced the values of heritability coefficients. This implies that it can be effectively selected during breeding. Thus, to increase the survival of the planting stock the plant material with late growth onset or with high level of phenotypic plasticity should be used.

In addition to genetic determinism, air temperature was an important factor which determined the timing of budburst and results are in agreement with many other study [15].

5. Conclusions

The experiment reveals a large genetic variability within species level for bud flushing which can be used in breeding programme and forest regeneration. Results highlight high genetic control for this trait at the clone level, and certainly large genetic gain can be obtained in future breeding generations. The climatic condition of both planting site and origin location have influenced the starting of growth in Norway spruce. Also, the study revealed an adaptive differentiation, indicating the involvement of epigenetic processes in adaptation of Norway spruce to different environments. The knowledge of the genetic variation of the adaptive traits is extremely important in breeding, but also for management and conservation of forest under climate changes.

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ESTIMATING THE VOLUME OF LOWER STEM-WOOD ON STANDING BEECH TREES USING TELEMETRY AND DENDROMETRIC TABLES: A COMPARISON

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Abstract: *Quite often the forest operators look for practical solutions to some of the current problems as specific to the wood supply chain, particularly those resting in the volume differences that occur between the volume estimates of standing trees and the volume estimates of felled trees. For this study three non-destructive methods were applied in order to estimate the volume of lower stem-wood on 32 standing trees from beech stands located between 600 and 1000 m above sea level, near Braşov, Romania. The results showed various total volumes of the lower stem-wood defined as the under-bark volume of wood contained in the stem, from the ground up to that height where the over-bark diameter of the stem decreased to 41 cm. We found an overestimation of volume by 53.95% when using the laser dendrometer compared to the tables developed by Giurgiu et al. in 2004 and an underestimation of volume by 14.16% compared to the tables developed by Popescu-Zeletin et al. in 1957. Based on the results of this study we recommend a careful use of Criterion RD 1000 to measure the stem diameter at considerable heights (more than 15 m) to avoid volume inaccuracy.*

Key words: *Upper stem diameters, standing trees, lower stem-wood, volume.*

1. Introduction

Nowadays, the volume of standing trees can be estimated using many non-destructive methods. For instance, a detailed reconstruction of the tree shape can be produced using LiDAR data as Heinzel and Huber (2017) showed for mature trees. In addition, low-resolution data captured by terrestrial laser scanning equipment can be effectively used for stem reconstruction as a novel technique [8]. Recently, Rodríguez-García et al. (2014) developed a tree measurement method based on stereoscopic hemispherical images. Other methods for

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the measurement of standing trees characteristics based on high-resolution photos have been used too [2-3]. At the same time, laser dendrometers are being increasingly used to collect the biometric data needed to estimate the volume of standing trees, in a non-destructive manner. As an example, Criterion RD 1000 (Laser Technology Inc.) is currently being used for various purposes such as producing taper models for buttressed trees [4], assessing the wood quality by measuring the knotty core taper and the form of standing trees [7], developing allometric equations that enable the estimation of the aboveground volume of trees [9, 23] or developing equations needed in prediction of biomass and carbon storage in urban forests [13]. Such a device was also used by Rutten et al. (2015) in forest inventory applications to analyze the stand structure of selectively harvested and non-harvested forests. When estimating the volume of standing trees, however, these methods are sometimes combined or used together to provide the means for data validation. To this end, laser dendrometers were used to check the accuracy of synthetic aperture radar data when estimating the above-ground biomass and other biophysical parameters of boreal forests [19] or to compare the results provided by space borne bistatic synthetic aperture radar data [10]. Non-destructive methods such as those using a laser dendrometer were also used in conjunction with terrestrial photogrammetry to model irregularly shaped tree trunks using as a predictor of biomass estimates the diameter at 13 m in height [1].

Taking into consideration the use of the laser dendrometers not only as a single non-destructive method to estimate the volume of standing trees but also as a tool to check the accuracy of data provided by satellites, terrestrial laser scanning or high-resolution images, this study aimed to test the accuracy of data collected by Criterion RD 1000 when used to measure diameters located on the lower stem. Therefore, the objectives of this study were set to: (i) produce estimates of the volume of lower stem-wood using three methods namely: based on laser technology (LT), tables developed by Giurgiu et al. in 2004 (T2004) and tables developed by Popescu-Zeletin et al. in 1957 (T1957); (ii) check the accuracy of results obtained by laser telemetry by comparing them to tables. Such research could provide practical solutions to some of the current problems as specific to the wood supply chain, particularly those resting in the volume differences that occur between the volume estimates of standing trees and the volume estimates of felled trees.

2. Material and Methods

Beech is one of the dominant species in Romanian forests [20]. In this study large-breast diameter individuals of beech (*Fagus sylvatica* L.) trees showing no visible stem defects (Figure 1) were chosen from a forest located between 600 and 1000 m above sea level, near Brasov, Romania. An important criterion when selecting each tree, consisted of a visual evaluation of the quality class, which was done according to the Romanian qualitative classification of the trees [5], resulting in the selection of those trees included in the first quality class, meaning that in broad-leaved trees, at least 50% of the stem height could be used by wood processing industry. The sample used in this study consisted of 32 beech trees with breast height diameter ranging between 40.8 and 69.75 cm and total tree height ranging between 25 and 34 m.

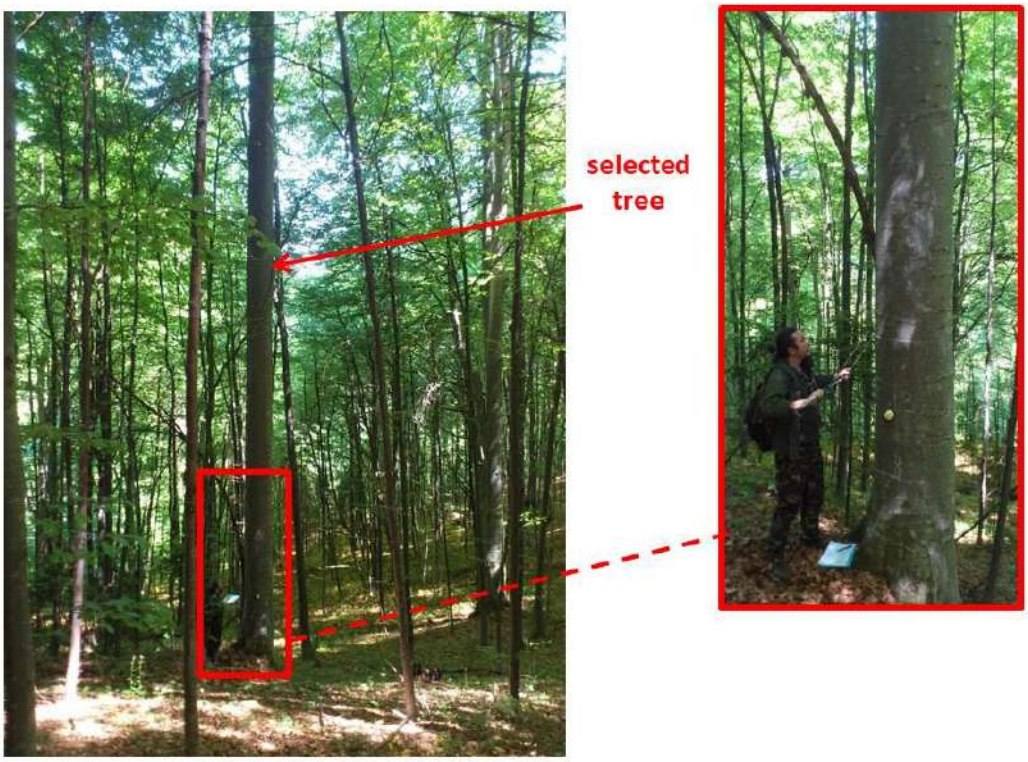

Fig. 1. An example of selected tree

In this study, the volume of lower stem-wood (hereafter V_{LSW}) was defined as the under-bark volume of wood contained in the stem, from the ground up to that height where the over-bark diameter of the stem decreased to 41 cm.

To estimate the volume of the stem in the near-ground segment, the over-bark diameter was measured on the standing trees at 2-m intervals using Criterion RD 1000 instrument (Laser Technology Inc., USA). The diameters were measured up to reaching 41 cm and the over-bark volume was estimated using the Huber's formula. Then, the under-bark volume of each segment was estimated by subtracting 5% from the over-bark volume, using the tables developed to estimate the bark proportion [5]. To improve the estimation by minimizing the effect caused by the shape irregularities on the cross-sectional area, the first section of 2 m in length located near the ground was further divided into two subsections of 1 m in length each. In this study, the selected trees exhibited the V_{LSW} on above-ground heights ranging from 1.8 m to 26.6 m, averaging 14.04 m. Distances needed to measure the diameters on the upper stem and total tree height were measured using an ultrasonic range finder (Haglöf Vertex IV Hypsometer, Langsele, Sweden). These distances ranged between 8 and 18.2 m (13.1 m on average) as they were adapted to the local visibility conditions. In many cases, the branches and smaller trees restricted the position of measurement.

An accuracy check was carried out by measuring two opposite diameters at several heights along each stem (0.8, 1.3 and 1.8 m from the ground level), using a caliper. These diameters were used as the “ground truth” in computing the method’s bias which was defined and computed as the difference between the diameter measured by Criterion RD 1000 instrument and the diameter measured by caliper.

The V_{LSW} for the studied trees was also estimated using the estimation tables developed by Giurgiu et al. (2004) and the tables for estimating the upper stem diameters developed by Popescu-Zeletin et al. (1957).

3. Results

The studied beech trees were best characterized by the relationship between the total tree height (hereafter H), stem height up to that point at which the under-bark diameter is more than 40 cm(hereafter H_{LSW}) and the breast height diameter (hereafter DBH) (Figure 2).

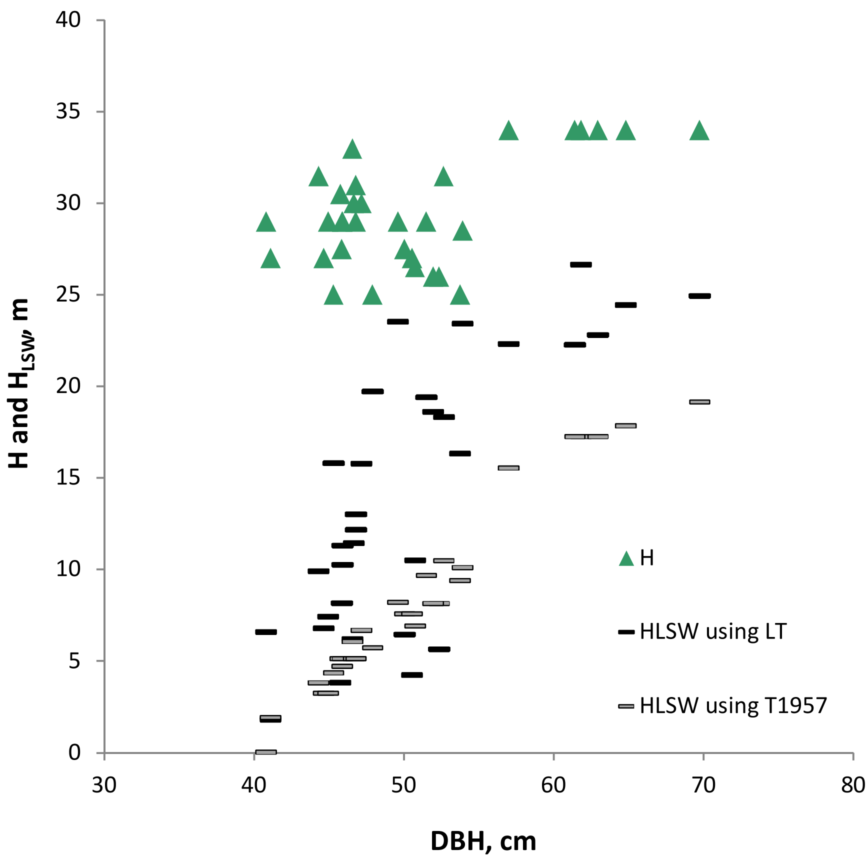

Fig. 2. Variation of the total tree height (H) and stem height up to that point at which the under-bark diameter is more than 40 cm(H_{LSW}) related to breast height diameter (DBH)

Based on the measurements carried out on the same direction at 0.8, 1.3 and 1.8 m aboveground, both, traditionally and by laser technology, the errors of the stem's diameter measured by Criterion RD 1000 were, in average, 0.95, 0.91 and 1.03 cm respectively. For individual trees, however, the errors were higher (Figure 3) depending on different factors. For instance, the eleventh tree was measured with a deviation of 25^0 from the standard direction of the study due to the field obstacles and to the cross-sectional area of this tree which was elliptical. After excluding the outliers, the bias was decreased at 0.73, 0.89 and 1.00 cm respectively.

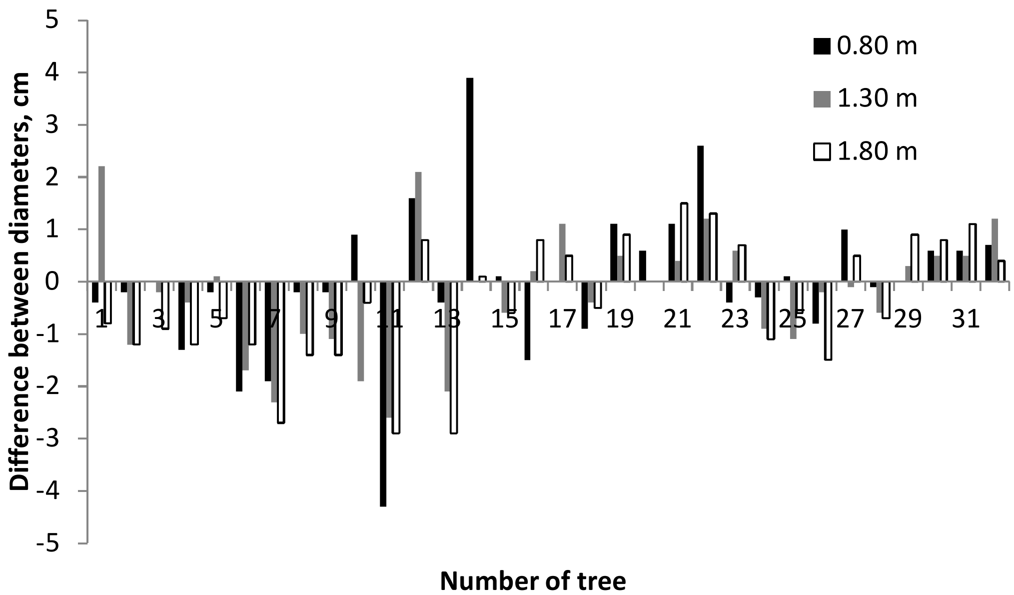

Fig. 3. Individual differences between diameters estimated with laser dendrometer and caliper

The errors of diameter measurement are actually higher when the tree ovality is taken into consideration, therefore when the diameter measured by Criterion is compared with the mean of the opposite diameters measured by caliper. In this case the mean error of the diameter measured by the laser dendrometer was of up to 1.61 cm, with the mean differences computed using the absolute values. If the differences are considered to be both positive and negative, the mean values of the bias were of -0.01, -0.23and -0.39 cm respectively.

The errors of the upper stem diameters affect directly the estimation of individual and total V_{LSW}. For instance, the total volume of wood contained in the segment of up to 40 cm under-bark was estimated at 79.236 m^3using the laser dendrometer measurements. The same variable accounted for 51.466 m^3 when using the estimation tables described by Giurgiu et al. (2004), and for 44.177 m^3 when using the tables developed by Popescu-Zeletin et al. (1957). This resulted in an overestimation of volume by 53.95% when using the Criterion compared to the tables developed by Giurgiu et al. (2004) and in an underestimation of volume by 14.16% compared to the tables developed by Popescu-Zeletin et al. (1957). Obviously, these differences require credible explanations. It is worth mentioning here that the differences in estimation at tree-level are to be expected (Figure 4) taking into account the concept behind the tables which were developed for estimations made at the scale of tree samples.

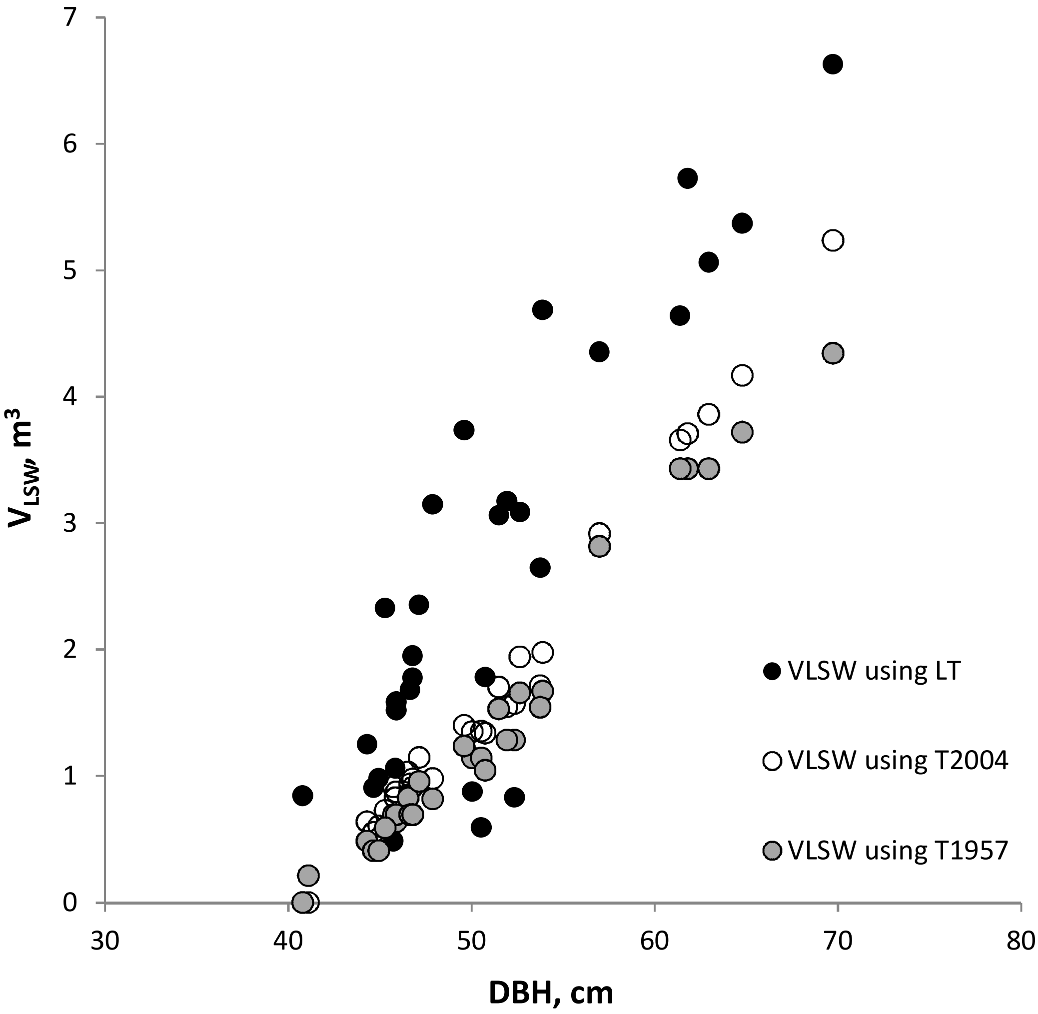

Fig. 4. Variation of the volume of lower stem-wood (V_{LSW}) on standing trees depending on breast height diameter (DBH)

4. Discussion

Can we really explain the differences between the total V_{LSW} resulted from using all of the three methods? On the one hand, the upper stem diameters measured with the laser dendrometer are affected by errors which result in volume differences. Based on the diameter controls, at 0.8, 1.3 and 1.8 m above ground, our study shows that the root mean square error of diameter was of 1.27 cm compared to the diameter values measured by caliper when keeping the direction of measurement, and of 1.79 cm when data was compared to the average of two opposite diameters. In the latter case, the error was higher because it included the deviation of the cross-sectional area from the circular shape when a single diameter was measured. Similar results were obtained by Nicoletti et al. (2015) who have shown that Criterion RD 1000 produced underestimated errors averaging approximately 1 cm, based on measurements of the stem diameters up to 8 m in height. Also, Cushman et al. (2014) mentioned an accuracy of approximately 1 cm when using the same laser dendrometer to measure upper stem diameters and to produce taper models. Compared to other tools, McCaffery et al. (2015) showed that Impulse Laser Rangefinder equipped with fixed scope and the True Pulse 360 R Laser Rangefinderequipped with adapted graduated scope obtained much better results compared to the Impulse Laser Rangefinder and Criterion RD 1000 dendrometer equipped with adjustable scope for diameter measurements on two lower and upper points.

On the one hand, the diameter errors are caused by other factors such as the height of measurement along the stem and the distance to the tree. For instance, Williams et al. (2017) found that Criterion 400 produced unbiased estimates of diameter and biased estimates of height measurements. Also, by using Criterion RD 1000 in their study, Westfall et al. (2016) suspected that the uncertainty of the diameter estimate would greatly increase as the height of the measurement level increases. Moreover, McCaffery et al. (2015) found that in the case of height measurement, the accuracy decreases at upper points when using Criterion RD 1000 instruments. According to Rodrigues et al. (2009), the distance is the most important factor controlling the accuracy when Criterion is used to measure diameters. As far as the distance to the tree is concerned, the accuracy of Criterion RD 1000 was evaluated by Rodriguez-Puerta et al. (2014). Measurements taken from the nearest distance (approximately equal to half of the tree height) showed a significant bias and a variance similar to that obtained from the furthest position (approximately equal to the tree height). In their study the latter was considered to describe an accurate position for estimating the standing tree volume as well as useful for developing more precise taper equations.

Therefore, the total V_{LSW} estimated on standing trees using Criterion RD 1000 might not be real in this study. An argument which could explain the overestimation of the total volume might rest in the H_{LSW}. These heights were higher in almost all the cases compared to the H_{LSW} provided by the used tables. Hence, an overestimation of the HLSW could be one of the causes contributing to the estimates of V_{LSW} shown in this study, when using Criterion.

On the other hand, the T1957 and T2004 based estimations produced as values much lower compared to the LT. However, these tables were developed based on field measurements carried on felled trees more than 6-7 decades ago, therefore it would be reasonable to question their actuality.

Last but not least, all of the methods are less accurate compared to destructive methods, but they are very useful when estimating V_{LSW} on standing trees and whole volume by assortments when there are restrictions for tree felling. The results of the methods tested in this study could be significantly improved in such circumstances in which sample trees would be available for measurement on the ground, after felling.

5. Conclusions

Our study demonstrated that when trees cannot be felled for volume estimation, the accurate estimation of the lower stem-wood on standing trees is still an issue that requires research in the field. Based on the results of this study we recommend a careful use of Criterion RD 1000 to measure the stem diameter at considerable heights (more than 15 m) to avoid volume inaccuracy. To solve the disputes between the harvesting operators when the standing tree volume estimation is different compared to the felled tree volume estimation, the method tested herein still needs improvements.

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STRUCTURE MODELS FOR BEECH-CONIFERS STANDS WITH PROTECTIVE FUNCTIONS

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Abstract: *To manage forest stands in order to achieve management goals it is necessary to develop functional structural models. This study aimed at developing structural models for mixed stands considering natural forest types and site conditions. These models have been defined by the species' structural parameters such as: target diameter, number of trees and volume per diameter, basal area and volume per hectare. The target diameter determines the structure and the size of the growing stock and it has been determined as the diameter of the largest healthy, actively growing tree per hectare. The analysis of radial growth of very thick trees has led to lower target diameters and lower growing stock than recommended by the Romanian technical norms for forest management. For modeling the real structures, the intensity of the silvicultural interventions was determined. The effect of silvicultural interventions should be observed periodically, through successive inventories, to know the dynamics of the structure and the size of the real growing stock. Since the aim is to achieve a functional structure of the stands, the developed model is a flexible one. Depending on the dynamics of the stand structure, the parameters of the model may vary, but stands should retain their vitality, productivity, regeneration capacity and protective function.*

Key words: *structural model, target diameter, stand structure, selection system, management measures, silver fir.*

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1. Introduction

Concerns about setting up optimal stand structures in relation to the assigned functions have always been a research focus. The importance of establishing optimal structures also arises from the fact that many stands have structures that do not perform their functions effectively due to:

- Composition-wise the proportion of species is far different from those corresponding to natural-type ecosystems (defined by the composition of the forest type);
- Low densities;
- Transformation cuttings that led to dimensional class structures, very different from those specific to the uneven-type structures.

Research done in Romania highlighted the effectiveness of uneven-type structures in exercising the assigned protection functions that mountain forests must possess as well as have laid the groundwork for the application of selection cutting [1, 4, 6, 14-16, 20]. Subsequently, this treatment was introduced into the practice of forest planning through technical instructions [19].

Although initially the problem of selection was placed within the forests with hydrological and anti-erosion functions, the effectiveness of the selection structures was also emphasized in the case of the forests of social interest located near big urban and tourist areas [17-18].

The experience of applying selection in other countries [3] and its experimentation in Romania led to the development of type distributions that represent the main structural parameters on functional subgroups for pure spruce, fir and beech stands [7]. These distributions are based on Liocourt and Meyer's relationships [12, 18]. In relevant literature [2, 5], these functions are known as patterns that convey tree diameters decrease in uneven-aged stands.

In the last decade due to climate change, the coniferous plants located on the edge of their area have become much more sensitive, suffering premature drying. There is a growing emphasis on the need to promote mixed stands, as being capable to respond to climate challenges. Future structures, as stable as possible to the action of climatic factors are also necessary in the case of beech wood mixtures. Such structures are to ensure the permanence of the forest in order to continuously exercise the functions it performs.

Through these researches, such models have been attempted for the Silver fir-European-beech stands and for the mixed European beech-Norway spruce-silver fir from the Postavarul Massif. This is the goal we have set ourselves. In this respect, the following objectives were considered:

- Understanding the structural particularities of the mixed beech-conifers and their spreading in the area;
- Determining biometric features of stands;
- Defining structure conditions that the stands must fulfil in order to exercise their assigned protection functions;
- Elaborating models to guide current stand structures.

2. Material and Methods

2.1. Material

Research was carried out in the production unit IV Braşov from the Postavărul Massif, Oriental Curvature Carpathian Group. Within the production unit, observations and measurements were made in mixed beech-conifers stands in order to determine the real characteristics of the structure of the stands. A representative tree was selected from the surveyed stands where a one-hectare sample area (100m x 100m) was placed and the biometric features of the trees were measured (Figure 1).

Fig. 1. Research location

For each tree we measured: breast height diameter - dbh (cm), total height (m), pruning height, crown diameter. The coordinates of each tree were determined, wood cores were extracted from very thick trees, and tree quality, vitality and health were assessed. An Excel database has been elaborated to develop structural models.

2.2. Structural Models

In order to establish the structural models of the future, the objectives established through the forest facilities, respectively the functions of the stands in the area, were taken into account, as they determine the future structures and the management measures to be applied, according to the relationship:

- Multiple protection targets;
- Protective functions assigned to the stands;
- Structures to be carried out (structural models);
- Management measures.

Structures of the future were drawn from the relations established between the characteristics of the trees, namely: diameter, height, quality, crown dimensions.

The elaborated models were defined by: the structure in the vertical plane; the structure viewed from the perspective of tree design and the degree of proximity of their crowns; the structure by species, respectively the composition of the stands, the proportion of the species being important in the case of mixed stands.

For the definition of structural models, the multiple objectives were pursued such as forest management, mainly recreational purposes, as well as the static conditions specific to the forest formations, in which the silver fir (BR), Norway spruce (MO) and European beech (FA) are the main base or mixed. Along with these species, he is also participating conifers species (DR) Norway spruce (MO), European larch (LA) and other hardwood species (DT): Norway maple (PA), sycamore (PAM) and ash (FR). The following target compositions were adopted (in tenths): 4 BR 4 FA 1 DT 1 DR for the silver fir-European beech stands; 4 MO 2 BR 3 FA 1 DT, 3 MO 3 BR 3 FA 1 DT, 2 MO 4 BR 3 FA 1 DT, 5 MO 2 BR 2 FA 1 DT, 6 MO 2 BR 1FA 1 DT for mixed European beech-Norway spruce-silver fir.

Within each formation the main parameters that a model should contain were analyzed, namely:

- Structure by species (target composition);
- A normal fund size different according to the stand production class;
- The target diameter adopted for each species in relation to the static conditions (Table 1);
- Distribution of the number of trees by diameters.

The results show the parameters for silver fir-European beech forest formation.

Table 1

Target diameters [cm]

Species	Relative yield class				
	I	II	III	IV	V
Norway spruce (MO)	72	68	60	56	52
Silver-fir (BR)	84	80	72	64	52
European-beech (FA)	68	64	56	52	48

3. Results

3.1. Real Stand Structures Characterization

The stands surveyed have different structures that differ in relation to the management measures that have been applied, but also due to the development of the stands in time. An example illustrating the structure of the stands in the production unit under investigation is the structure of the stand in the compartment 543 shown in Figure 2.

3.2. Defining Structural Models

Structural models give the parameters of the structures to be achieved through forest management. The structure of the production fund in relation to the thickness of the trees is analyzed by their distribution by categories and classes of diameters. The structure of the stands is normal when the number of trees decreases in diameters following a geometric progression.

Structural models were defined by the following parameters: the size of the production fund, expressed by volume per hectare, V (m^3); a basal area per hectare, G (m^2); a limit diameter, Dl (cm); number of trees per hectare, N; the number of trees expressed (percentage) by classes of diameters; volume (percentage) by diameter class.

These parameters differ in relation with the composition of the stands and the static conditions. Taking into account observations made, the target diameters for spruce, fir and beech species can be adopted as in Table 1.

Tracing the volume curve was necessary for modelling (Figure 3). It is of practical importance for the determination of the volume of trees for the area surveyed, only by diameter.

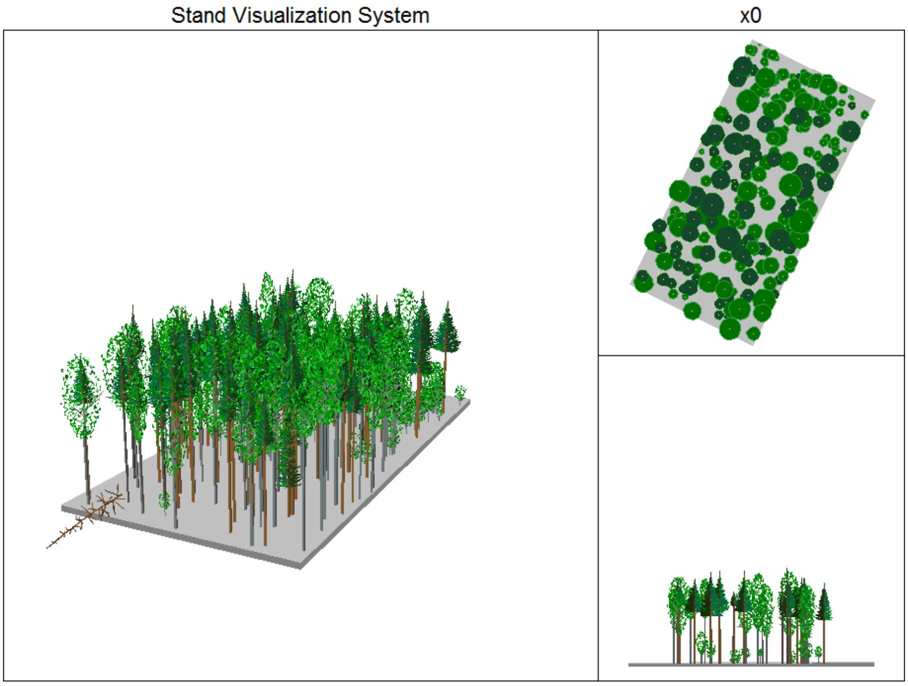

Fig. 2. Vertical profile (compartment 543)

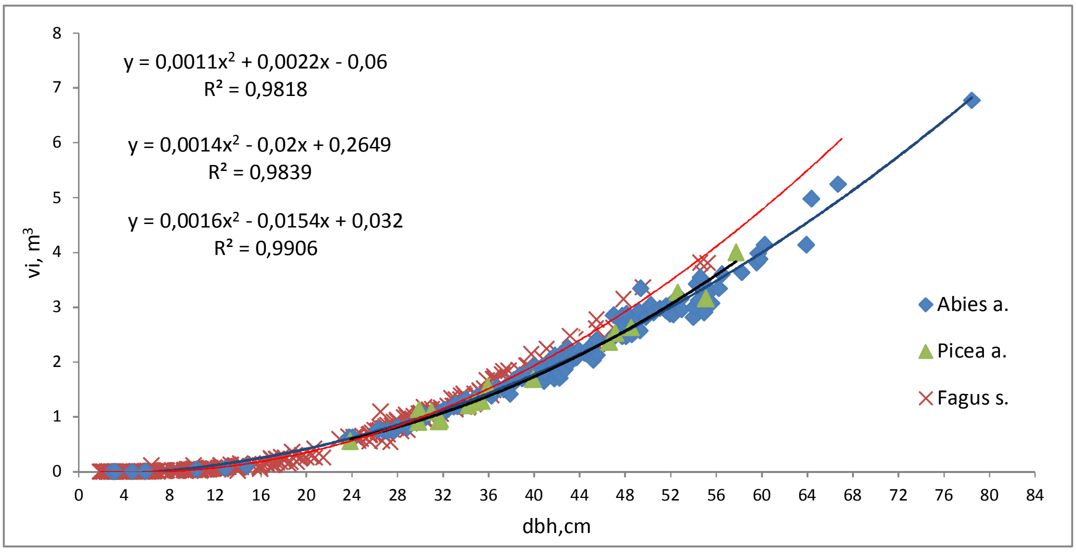

Fig. 3. Relationship between tree volume and their diameter

3.3. Characteristics of Structural Models

For defining the structural models, the following conditions were considered: altitude: 700 – 950 m; formation: silver fir-European beech; composition: 4BR 4FA 1DR 1DT.

The size of the normal growth stock ranges from 210 to 540 m^3 (Table 2).

The structure of the normal production fund shows the decrease of trees by diameter class (Figure 4).

The normal distribution of trees by diameters (Table 3) was determined for the target diameters set out in Table 1.

Table 2

Normal growing stock

Relative yield class	Silver fir-European beech stands (4BR 4FA 1DR 1DT), $m^3 \cdot ha^{-1}$				
	Total	BR	FA	DR(MO,LA)	DT(PA,PAM,FR)
I	540	230	210	60	40
II	440	180	170	50	40
III	360	150	140	40	30
IV	280	110	115	25	30
V	210	80	85	20	25

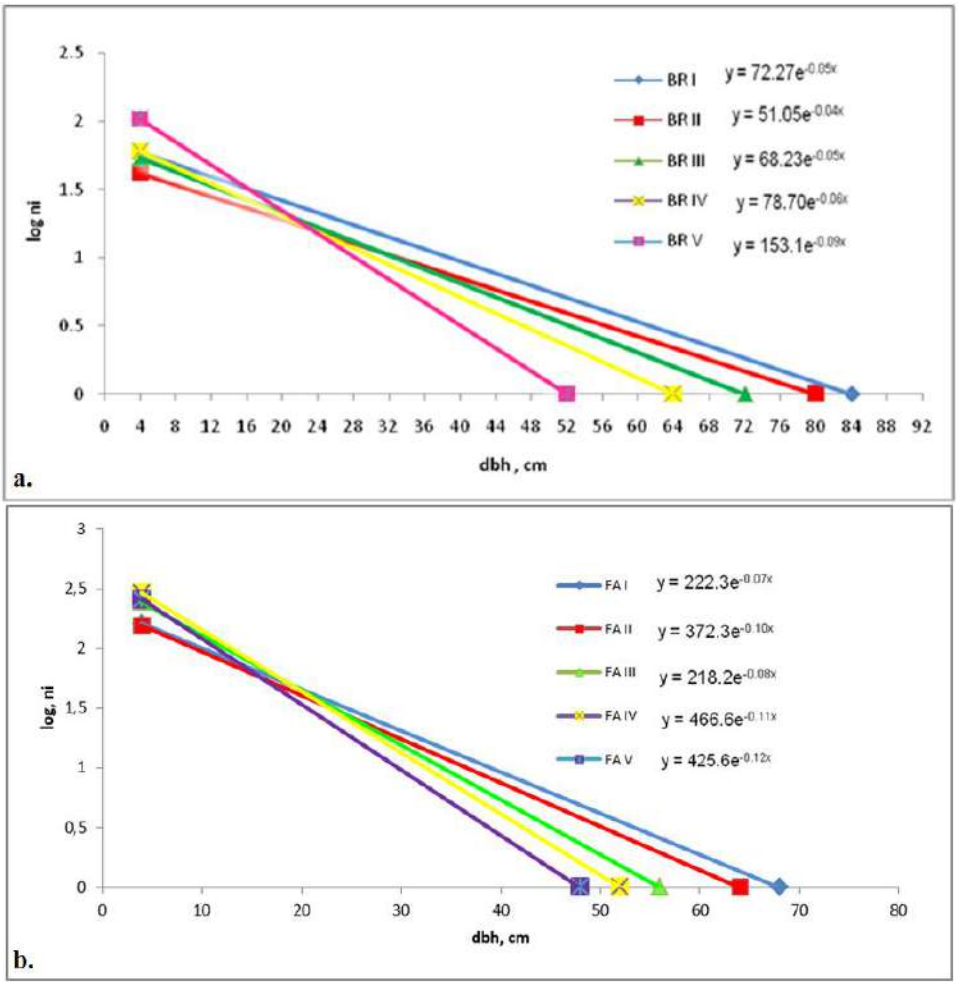

Fig. 4. Logarithmic representation of the number of trees for established target diameter for: a) silver-fir (BR) and b) European-beech (FA)

Table 3

Structural parameters for normal growing stock (per hectare)

Species	N/ha	Vn [$m^3 \cdot ha^{-1}$]	Gn [$m^2 \cdot ha^{-1}$]	q	Dl [cm]	N to Dl
4 BR	315	230	18	1.22	84	1
	264	180	14.2	1.22	80	1
	276	150	11.4	1.27	72	1
	263	110	8.51	1.32	64	1
	341	80	6.3	1.47	52	1
4 FA	602	210	16.6	1.37	68	1
	553	170	13.7	1.39	64	1
	724	140	12.3	1.51	56	1
	777	115	10.8	1.6	52	1
	659	85	8.23	1.64	48	1
1 Mo (LA)	32	60	5.56	1.03	84	1
	28	50	4.3	1	80	1
	26	40	3.34	1.04	72	1
	23	25	2.25	1.05	64	1
	25	20	1.5	1.09	52	1
1 DT (PAM, PA, FR)	25	40	2.91	1.04	68	1
	35	40	2.77	1.1	64	1
	40	30	2.13	1.15	56	1
	61	30	2.3	1.22	52	1
	67	25	2.02	1.27	48	1

(N = tree number; Vn = normal volume; Gn = normal basal area; 1/q = ration; Dl = target diameter; N to Dl = tree number from the target diameter class).

4. Discussion

4.1. Relationship between Biometric Features

The investigated stands are part of forest formations beech-fir and mixtures of beech-conifers [21-22] of different yield classes [9].

In the area researched are stands whose structures tend to uneven structures, where the process of transforming structures began 6 decades ago. In other stands, there is a tendency for trees to be overlapped, with two or three generations being distinguishable, the structures being that of irregular shelter wood cuttings. There are also stands in which the structures resemble the regular ones or stands in which, trees are arranged in close proportions by diameters class, without clearly delimiting the respective structures as regular or uneven, but only as irregular structures. An example is the structure of the stand in the compartment 543 (Figure 5).

The basal area has a higher share in large diameters, although the number of trees in these categories is lower compared to thin and medium trees in categories below the average diameter of the stands. The field observations and the results of the determinations show that in all cases, the lower average diameter is grouped with a lower basal area compared to the other categories (Figure

5). In some cases, the presence of a maximum of this surface in the central, categories shows that respective structures belong to those specific to the regular forest. The transformation of these structures involves the reduction of the basal area in the central categories and, implicitly, of the number of trees in these categories, in order to further create conditions for the seedbed and for the development of young trees.

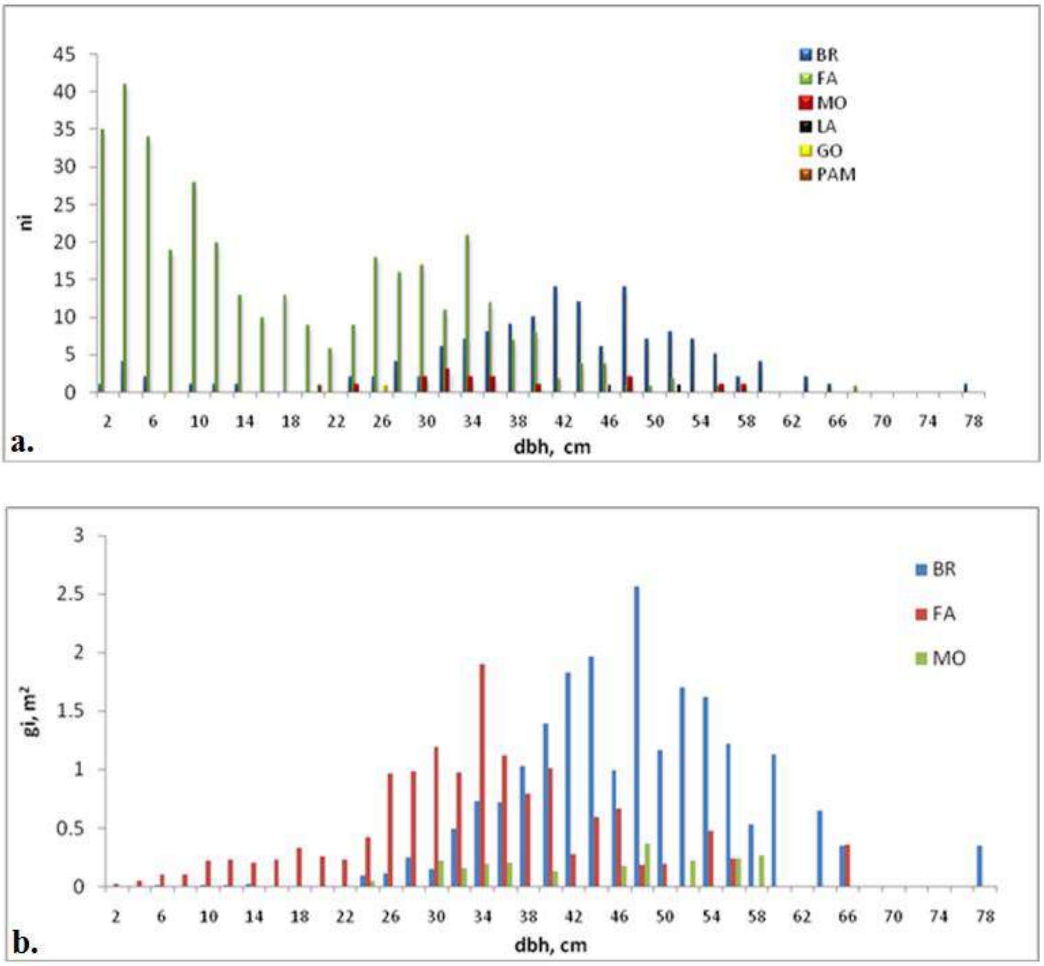

Fig. 5. Tree distribution by diameter class in compartment 543: a) number trees (BR - *Abies alba*; FA - *Fagus sylvatica*; MO - *Picea abies*; LA - *Larix decidua*; GO - *Quercus petraea*; PAM - *Acer pseudoplatanus*) and b) basal area

4.2. Target Diameter, Basic Element for Defining the Structural Model

The target diameter determines the structure and size of the growing stock. It marks the upper limit of the diameters categories and is established in relation to the categories of land quality and productivity assessment characterizing the forest resorts in the stands subject to modelling.

To establish target diameters, research has been done to determine the health of the very thick trees, their quality and the variation of their radial growth. Particularly useful in this respect were the samples extracted with the increment borer.

Analyzing the radial growths on the extracted cores it can be concluded that the trees have undergone several periods in their development (Table 4).

Table 4

Mean radial increment (ir) over periods of tree development

Species	Age	Dbh, cm	Mean radial increment, ir (mm), over period ...			
			until 1908	1909 – 1942	1943 – 2002	2002 – 2017
BR	150	80.9	2.4	4.4	2.2	1.4

Growth reduction at 1.4 mm at this age was also followed by drying, especially after the 2012 drought, which indicates that after a period of growth regress, drying phenomena may occur in the area, at this level.

The target diameter is proposed in the Romanian current Technical norms on silvicultural systems (2000) depending on the tree species and stand functions (Table 5).

The normal growing stock is proposed in the Romanian current Technical norms (2000) depending on the tree species and site conditions (relative yield classes) (Table 6).

Through these researches, the target diameter is computed based on the vigour and tree quality (Table 1), and normal growing stock is much smaller (Table 2).

Table 5

Target (limit) diameter in selection forests in Romania [23]

Stand function	Species	Target (limit) diameter in yield class ... [cm]				
Stands performing special protection functions (functional group I)						
Stands with water protection functions	Silver fir – Norway spruce	76	72	64	60	56
	European beech	68	64	60	56	52
Stands with soil protection functions Stands withclimate protection functions. scientific reserves and nature monuments	Silver fir – Norway spruce	68	64	60	56	52
	European beech	64	60	56	52	48
Stands with social, hunting and leisure functions	Silver fir – Norway spruce	100	90	80	70	60
	European beech	84	76	68	60	52
Stands performing special wood production functions (functional group II)						
–	Silver fir – Norway spruce	92	84	76	68	60
	European beech	84	76	68	60	52

Table 6

Indicative values of normal growing stock in selection forests in Romania [$m^3 \cdot ha^{-1}$]

Species	Relative yield class				
	I	II	III	IV	V
Norway spruce	847	697	548	405	268
Silver fir	729	609	494	385	285
European beech	598	478	372	279	197

4.3. Management Measures for Tending Stands to Optimal Structures

In uneven stands the main feature of the structure is the continuous decrease of the number of trees by diameters. Guiding the stands to the optimal structures defined by the model in relation to the functions assigned to the stands is a long-term process and depends on many factors. Of these, the actual structure of the stands is very important, then the size of the real growing stock, ie the existing volume [8-11] compared to the normal volume established by the model.

Knowing that uneven structures best meet the requirements imposed by the protection functions, stands that have such structures are much easier to be guided to structures established by the model. For uneven-aged stands, in Romanian forest management planning, annual allowable cut is calculated with check method, by current volume increment ($m^3 \cdot ha^{-1} \cdot year^{-1}$). In contrast, it is more difficult to optimize even-aged stands, which require a long-lasting transformation process to selection forests.

The cuttings of transformation to selection forests aims to bring the real structure, as close as possible, to the normal one [13].

In the studied stands, the actual structures are very varied as a result of applied cuttings. Trees of medium (28 – 36) and thick (40 – 48) diameter class are particularly well represented. Very thin (4 – 12) and thin (16 – 24) trees, as well as very thick (> 52cm) trees, are generally less represented and in varied proportions depending on the species. There are also stands where trees are very young, either beech or fir, and in others, there are thicker trees in fir than beech stands. However, silvicultural system can create favourable conditions for the installation of young trees, as well as conditions for the development of already existing young trees, in order to pass into higher classes of diameters, by covering the stands with moderate intensities.

The Romanian current Technical norms (2000) recommend that wood volume to extract during a 10-year cutting cycle should be maximum 17% of real growing stock.

In order to guide the stands, whose structure was presented in Figures 2 and 5, towards the model structure, in the decade of application of the forest management planning, it is expected to cover it at a 16% pace, and subsequently 69,6 m^3 will be extracted (Table 7).

Harvested trees were selected according to two important criteria:

- according to their state of health, with priority being given to the extraction of the trees with broken tops, the poorly conformed, the sick, the bent and those not viable in the future;

- according to the normal number of trees by diameter, aiming at extracting the trees from the excedentary categories as they prevent the seed tree from installing and developing.

Following interventions should take into account these criteria so, as the number of real trees approaches the normal one, favourable conditions for the continuous regeneration of the stands are created (Figure 6).

Table 7

Initial volume and extraction volume by species

Species	Real growing stock, Fr			Normal growing stock, Fn			Trees for harvesting					
							by state			healthy		
	N	G [m^2]	V [m^3]	N	G [m^2]	V [m^3]	N	G [m^2]	V [m^3]	N	G [m^2]	V [m^3]
BR	143	21.19	290.1	317	14.2	180	20	2.15	21.8	7	1.11	34
FA	363	14.24	186.9	522	13.7	170	58	1.38	12.7	–	–	–
DT	2	0.06	1.5	29	1.1	50	–	–	–	–	–	–
DR	17	2.18	30.5	35	4.3	40	1	0.07	1.1	–	–	–
Total	525	37.67	509	903	33.3	440	79	3.6	35.6	7	1.11	34

5. Conclusions

The Postavarul Massifs stands perform multiple functions and in order for these functions to be performed in optimum conditions it is necessary for the respective stands to meet certain structural conditions. As a result of the applied management measures, the stands in the researched area show different structures in relation to their share of the component species and a great variation of tree thicknesses. Given the multiple protection functions assigned to the area stands (hydrological, anti-erosion and social), the most favourable structures in terms of exercising these functions are the uneven type.

Mixed stand structures are very diverse, exhibit large variations of stand density, sometimes with abundant young trees, as well as a wide-ranging dimensional structure. The elaboration of the structural models requires a thorough knowledge of the actual structures of the stands, their growth and development laws, as well as the relations between the trees.

The models elaborated are applicable to conifers-beech stands, situated at altitudes between 700 and 950 m, with recreational main functions. They defined by the following structural parameters: normal volume, differentiated in relation to the tree productivity class from 210 m^3 (5th yield class) to 540 m^3 (1st yield class); target diameters by species ranging from 48 to 68 cm in beech and 52 – 84 cm in fir) basal area of the trees between 18,1 and 43,1 m^2 and the number of trees is variable on the diameter class (on average by production classes, 60% thin trees, 23% medium-sized trees, 10% thick trees, 7% very thick trees).

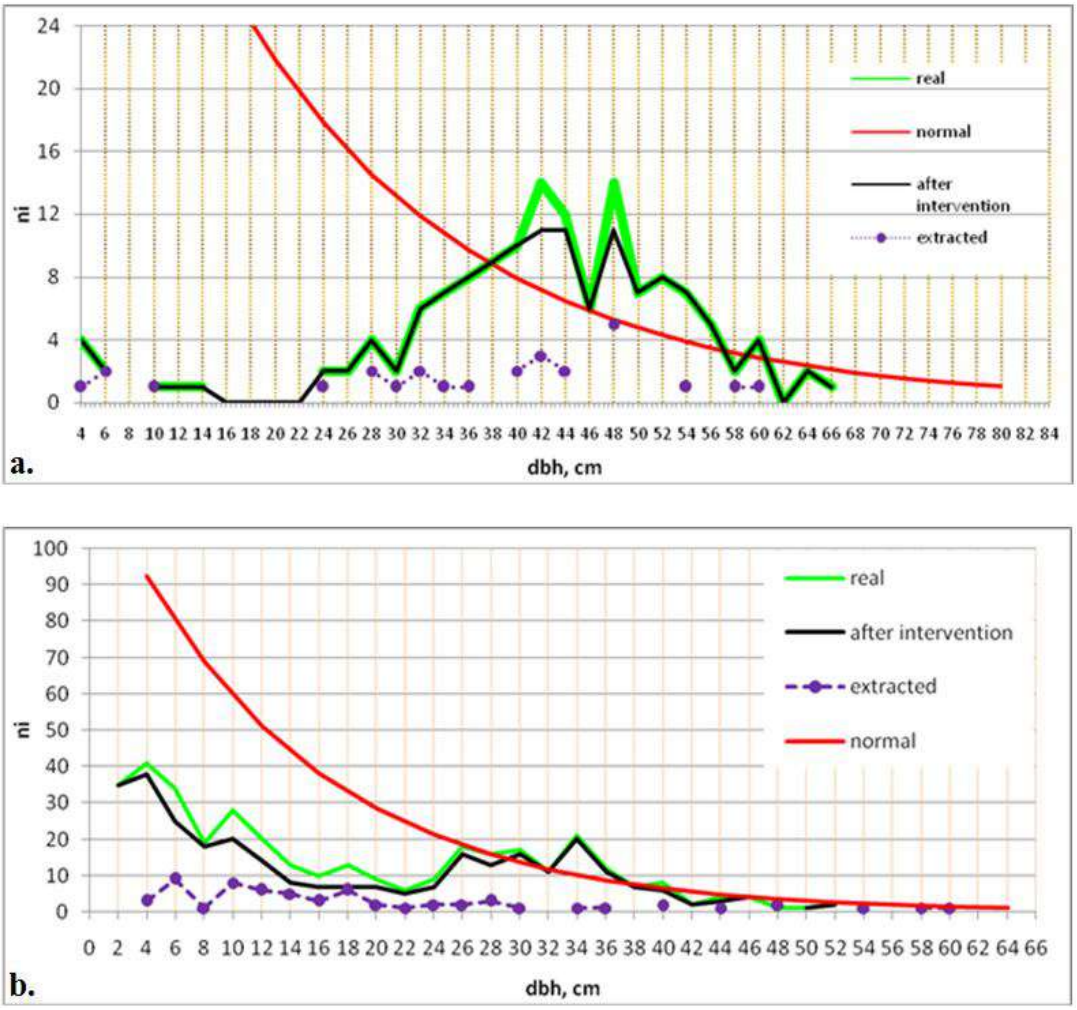

Fig. 6. Number of trees per diameter – real, before and after intervention for: a) fir (BR) and b) beech (FA)

In the target diameter class, thickest, with active increases, healthiest trees are included, that can develop in specific stationary conditions. A valuable indicator in setting the target diameter is the dynamic of the diameter and current volume increment. In order to guide the actual structures of the stands towards the structures envisaged by the models, the intensity of the interventions is variable, in relation to the actual structure of the stands. To maintain the structure of a viable, functional position there are recommended moderate intensities of 16% (17%) from and a permanent control of the number of trees categories based on diameters, through principally inventories. Applying into the practice of forest management, structural models require experience in knowledge of stand structure and proficiency in applying silvicultural system.

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AN ANALYSIS OF VERY DRY AND WET MONTHS OCCURRENCE PROBABILITY IN THE GROWING SEASON FOR BRASOV AREA

Victor Dan PĂCURAR[1]

Abstract: *The paper presents an analysis of the monthly aridity indices variability, for the growing season period in Brasov area, determining the probabilities for the occurrence of individual monthly values indicating very dry or wet months (from extremely dry to excessively wet). The average values of the aridity indexes indicate a climate with enough humidity, but by analysing the monthly charts, with the probabilities for different values in individual years, it occurs that dry months are quite frequent. In the study area, one should expect a month with water deficit once every three years and even very dry or extremely dry months could occur. Very wet or excessively humid months have also considerable chances to be recorded. The aridity indices calculated using data downscaled for Brasov region for the A2 and B2 climate change scenarios show important differences: considerable water deficit in March, April, May and September, and excessively wet June and August. Using the probabilities associated to certain aridity index values one could estimate the risk of damages in a forest plantation or the possible requirements of irrigations in a nursery, consequently having a better support in the decision making process.*

Key words: *aridity index, dry-wet months, probabilities, climate change.*

1. Introduction

Climate plays an important role in our lives and affects almost all sectors of human activity. Examples could be extremely diverse, the type of clothes we wear in a certain period of the year, the need of electric power for heating and cooling, the development strategies for certain regions all depend on the climate conditions [1, 15].

For the sustainable management of natural resources generally and particularly of forest resources a detailed study of climate parameters is a prerequisite. Forest ecosystems are influenced by climate conditions in a continuous manner, thus for an accurate analysis of this interaction one should consider along with the averages at least the standard deviations and ideally the frequencies of certain values. The solely use of averages in characterising the

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climate could be confusing, because at one moment in time the climate parameters could have considerably different values, given their intrinsic variability.

Water deficit or aridity often occurs in some climate regions [14], but it could be also recorded for shorter intervals in areas where the average parameters indicate enough humidity. Climate changes would probably determine the extension of arid regions and longer dry intervals, which could also appear in mountain regions [5], particularly enhanced on steep southern slopes, where local forest ecosystems and especially sensitive tree species could be affected [17].

This paper presents an analysis of the monthly aridity indices variability for the growing season period in a normally wet region (as indicated by climate averages), determining the probabilities for the occurrence of individual monthly values indicating various water supplies (from extremely dry to excessively wet).

2. Material and Methods

The region taken into consideration in this study is that of Brasov, located in central Romania, south-eastern Transilvania. This area is situated at an altitude about 600 meters at the bottom of the Postavaru Mountains.

The climate data used in this study were measured at the former weather station Brasov Prund, for a period of twenty years, spanning from 1985 to 2004, available from the database of the Forest Climatology Laboratory of the Silviculture and Forest Engineering Faculty, Transilvania University of Brasov. An important observation refers to the position of this weather station located in a valley where wind is less frequent and consequently the rainfall amounts collected by the rain gauge are higher than those measured in a wind exposed position.

In this study there were considered seven spring, summer and early autumn months: March, April, May, June, July, August and September. For determining the dry and wet months the monthly de Martonne aridity index was used [7]. This was calculated, using the simple and widely known formula, by dividing the monthly rainfall amount (in mm) multiplied by 12 to the mean temperature (in ^{o}C) plus 10. Values under 30 signal a water deficit, while very dry and extremely dry conditions are indicated by values below 20 and 10 respectively. An aridity index over 30 indicates a climate with enough humidity for forests and higher values indicate moderately humid (up to 40), very humid (50-60) or excessively humid (over 60) conditions. These thresholds were considered for the study region, based on the climate classification limits [14, 17], the bioclimatic sectors and the de Martonne aridity index values distribution over Romania [10]. The average values (1985-2004) of the de Martonne aridity index values for the study months are presented in Table 1.

For analysing the probability of dry or wet month occurrence, as indicated by the de Martonne index values, the quantile plot or the empirical distribution chart method was used, which is a simple empirical procedure, much more easily to apply than the rigorous statistical methods. According to this method, the cumulative probabilities (or plotting positions) are calculated as simple functions of the value rank in the sorted series and the total number of observations [9, 16]. In this study, the empirical probabilities were calculated by dividing the rank index (in the descending sorted data set) by the number of observations supplemented by one [11, 13] and the results were multiplied by 100 for obtaining percent values (chances of exceeding the threshold in a century) and finally were plotted against the corresponding aridity indices values. In all these charts included in the paper, on the horizontal axes are marked cumulative probabilities (expressed in %) for values equal or greater than the aridity indices marked on the vertical axis.

Table 1

Average values of the de Martonne aridity index for the study months

	Months						
	March	April	May	June	July	August	September
Mean index values	47.9	42.2	46.2	47.1	45.24	37.5	39.9

For comparing the present situation with possible changes in the climate, there were taken into account the monthly de Martonne indices calculated for the data statistically downscaled for Brasov area (using the Statistical Downscaling Model –SDSM) for 2020-2050, considering two climate change scenarios A2 and B2 [12, 18].

3. Results

At Brasov, March is a wet month as indicated by the mean value of the aridity index for the twenty years interval that equals 47.9, but the analysis of the quantile plot chart (Figure 1a) reveals that dry or even very dry months could occur. The probability to have a March with sufficient precipitation (an aridity index over 30) is about 62%. It means that there are more than a third chances to have water deficit in March, in other words one should expect such a situation every 3 years. As observable in the chart, the probability to have a de Martonne index with a value under 20 equals 20%, that means a return period of 5 years.

The probability of an excessively humid March (with the aridity index over 60) is 33%, one in three years.

The data downscaled for this region by using SDSM for the A2 and B2 climate change scenarios show that March would be a month with a dramatic decrease in the rainfall amount and consequently the average values of the aridity index, for 2020-2050, are very low, 7.9 and 7.5 respectively, which have less than 5% chances to occur in particular years in the current conditions. Such a change would have a high negative impact on the afforestation works that are presently concentrated in this period.

In April the average value of the aridity index is 42.2, also indicating a humid period but the inter-annual variability is lower than in March as indicated by the standard deviation of 18.9 as compared with 30 for the previous month. On the chart with the estimated cumulative probabilities, presented in Figure 1b, one could note that the chance to have a month with an aridity index over 30 is about 57% but it increases to 87% for a slightly lower value of 28, meaning that a dry April is very unlikely. The probability of an excessively humid month is 20%, lower than in March. For the A2 and B2 scenarios the index values of 15 and 16.5 fall outside the present range.

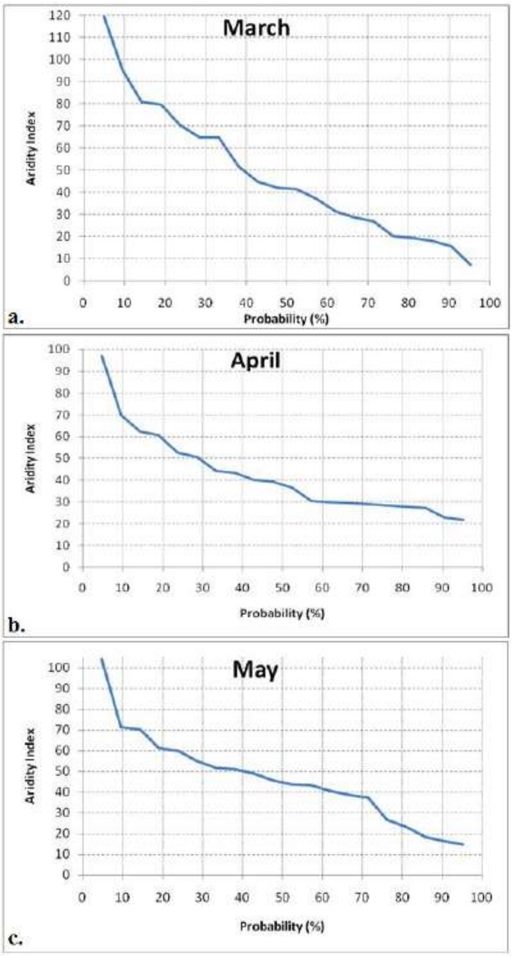

Fig. 1. Cumulative probabilities for aridity indices values in March (a), April (b) and May (c)

In May the average values are indicating enough precipitations (average de Martonne index 46.2) but, as shown in Figure 1c, there are more than 25% chances to have a moderate water deficit (an index below 30) and every 6 years one could expect to have a very dry May (an index below 20). There are good chances (70%) to have a wet May, with an aridity index greater than 39, while values over 50 are expected in four years of each decade (40%). Values between 15 and 16, as determined for the A2 and B2 scenarios, have presently less than 10% chances to occur.

In this climate region, June is the month with the highest rainfall amounts but an important inter annual variability of the aridity index could be observed in Figure 2a. In this normally wet month, a water deficit could be more frequent than one would expect, the chances to have an aridity index below 30 are about 33% (one in three years) and even values under 20 could be expected twice in a decade. There are over 50% chances to have a very humid June (with an index greater than 49) while an excessively wet month (over 60) could occur once every three years.

For June, the downscaled data for the A2 and B2 show a rainfall increase and the mean aridity indexes (for 2020-2050) are 68 and 72, indicating excessive humidity, and in the present situation the chances to have values greater than those are reduced to 15% and 8% respectively.

July is also a wet month in the study region, the average rainfall amount (104.4 mm) is slightly lower than in June (106.9 mm) and the chart in Figure 2b indicates a reduced variability as compared with the previous month. The probability of a July with enough water (aridity index over 30) is more than 70% and the chances for a very dry month are less than 5%.

For determining more accurately the chances of a very humid month (index over 50), taking into account the nearby “plateau” (at 52) a polynomial adjusted curve was added to the graph (dashed line) and using this one could infer a 40% probability for a very wet July.

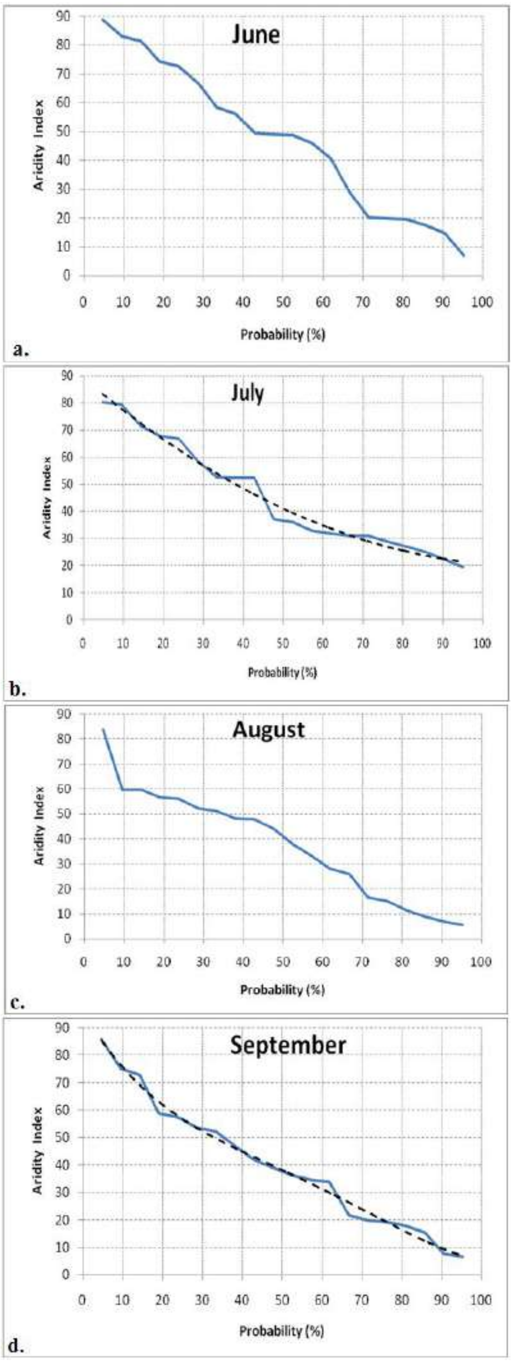

Fig. 2. Quantile plots of aridity indices for June (a), July (b), August (c) and September (d)

The values calculated for the A2 and B2 scenarios are 38.6 and 30.9, which correspond to exceeding probabilities between 50% and 60%, thus July would be quite similar.

August is drier, in Brasov, than the previous two months, with a mean aridity index of 37.5 and a higher variability from one year to another as could be observed in Figure 2c. The chances of having a water deficit are about 40% (60% probability for an aridity index greater than 30), in three years of a decade the aridity index could drop below 20 and extremely dry months (values under 10) could also occur. On the other side the chances of a very wet August (an aridity index over 50) are of approximately 35%. For August the aridity indices calculated with the data downscaled for the A2 and B2 scenarios (indicating a considerable increase in the rainfall amounts) have very high values, 82.4 and 70.4, with extremely low chances (under 7%) of being attained in the present climate conditions. This situation appears to be similar with the one forecasted for June, but most probably in August (given the high rainfall variability) the increased total amount would be produced by several very intense storms.

At Brasov, September is in average slightly wetter than August (as indicated by the mean aridity index of 39.9) but the chances of a water deficit are similar (Figure 2d), about 37% (or 40% if considering the polynomially adjusted curve marked with dashed line). Extremely dry Septembers (with aridity indices below 10) could be expected once every ten years, while the probability of values under 20 could be estimated to 22%. The probability of a very wet month (over 50) could be predicted at 35% and that of an excessively wet September(over 60) at about 20%. In September, the data for the

A2 and B2 scenarios show an increased aridity , similar with that in the spring months, the values of the aridity index being 16.9 and 17.8. In present conditions the probability of values lower than those is reduced to about 15%.

4. Discussion

The study of the de Martonne aridity index values, for each month, show a pronounced inter-annual variability. This is most probable caused by the climate variability (fluctuations) than by a climate change trend. There are several studies of the de Martonne index time series for other regions, in this part of the continent, that have not identified significant trends. In southern and eastern part of Romania the majority of the trends of the aridity indices datasets “are not statistically significant” [6] and in Vojvodina (Serbia) “there are no aridity trends” [8]. Certainly this is an area for further comparative investigations, by taking into consideration more remote and recent time intervals.

August is characterized by the lowest mean value of the aridity index. This result is common to other studies focusing dryer areas, such as the Romanian extra-Carpathian regions. While the monthly average value for Brasov is 37.5, more than 30% of the extra-Carpathian area is characterized by mean values under 20 [6]. Despite the difference in the averages it is noteworthy that in Brasov, in the twenty years study period, there were six years with aridity indices values lower than 20. In particular years the values could be very low indicating very dry conditions. In the study period, the minimum values for August were 5.5, 7.1 and 8.8. Such values are typical of much more arid regions. For instance, in northern Greece [4] the values of the de Martonne index In August (averages for thirty years) are spanning from 2 to 14, with most of the region characterized by values between 5 and 8.

For analyzing the effects of climate fluctuations on local forests, the water requirements or aridity sensitivity of particular tree species has to be considered. Norway spruce (*Picea abies* L., H. Karts.) is an important tree species in the mountain forests near Brasov and for its growth the weather in June plays a very important role [2]. Thus in the years with a drier June (it resulted that aridity index values under 30 and 20 could occur once every three and five years respectively) the spruce stands are probably affected. Another local tree species, European fir (*Abies alba* Mill.), is very sensitive to water stress and its survival is related to de Martonne index average values over 45 [3]. Over the study period there were very numerous dryer months, when the fir stands were affected and this could be related to the high rate of mortality recently observed.

The data downscaled for Brasov region for the A2 and B2 climate change scenarios [12] show that the average annual rainfall amount would be quite similar (779.9 mm for A2 and 733.2 mm for B2, as compared with 787 mm for 1985-2004) but the monthly values would be considerably different and this induces high differences in the aridity conditions. In March, April, May and September the average values of the aridity index indicate considerable water deficit, June and August resulted to be excessively wet and July similar to the present.

5. Conclusions

Climates are often characterised by using long period averages but an appropriate understanding of the climate conditions requires the analysis of the inter-annual variability, especially in the context of the possible climate changes.

As expected for this region, the average values of the aridity indexes indicate a climate with enough humidity, but by analysing the monthly charts, with the probabilities for different values in individual years, it occurs that dry months are quite frequent. In the study area, one should expect a month with water deficit (an aridity index below 30) once every three years and even very dry or extremely dry months could occur. Very wet or excessively humid months (with aridity indices over 50 respectively 60) have considerable chances to be recorded (with probabilities variable from one month to another, as previously discussed).

Particular monthly values, considerably different from the averages, are not always related to climate change, but induced by regular climate variability. Certainly the effects of extreme weather, very dry or with heavy rainfall, even typical of the normal climate are associated with specific damages, which could induce the subjective perception of an abnormal situation.

The analysis of the monthly aridity variability is very useful in identifying real climate trends. Using the probabilities associated to certain aridity index values one could estimate the risk of damages in a spring forest plantation or the possible requirements of irrigations in a nursery, consequently having a better support in the decision making process.

It is said that climate is what we expect and weather is what we get, however one should not expect the averages but take into consideration the probabilities associated to certain values.

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LONG WAY FROM GOVERNMENT TO GOVERNANCE: META-ANALYSIS OF UKRAINIAN FORESTRY REFORMATION

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Abstract: *This study presents findings of meta-analysis on forest governance in Ukraine, based on a rigorous database of 26 academic studies published from 2011 to 2018. We focus on key factors of low effectiveness and slow reformation process of the forest governance, as well as major challenges it faces for future development. Nine key challenges have been identified and classified into three groups: institutional, economic and political/legal. The most critical challenges include distribution of governance functions between different authorities, development of public-private partnerships and improvement of the finance mechanisms. Historical, socio-cultural and professional factors have been identified as major ones in slowing down forest governance reformation process, while 40% of publications do not explicitly state any factor at all. Our major finding is that most studies focus on a narrow range of challenges and factors, ignoring the complexity of forest governance reformation process, which reveals an urgent need for a better scientific discussion on the topic.*

Key words: *forest policy, forest governance, Ukraine, meta-analysis, institutional reform.*

1. Introduction

Reforming of forest governance in Ukraine is an issue that has been thoroughly discussed by scientists in recent years [25-26], requiring rigorous decisions-making that takes into consideration national development priorities and the need to comply with international obligations. Within its European integration process, Ukraine has obliged itself to comply with the non-discriminatory timber trade principle [8] and actively participates in the Ministerial Conferences on the Protection of Forests in Europe [30], recognizing important linkages between forest governance and sustainable development.

Ukraine ranks 9th in Europe in terms of forest area and 6th in terms of total wood stock. The total area of forest lands in Ukraine is 10.4 million ha, with 9.6 million

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ha covered by forest vegetation [16]. The peculiar features of Ukrainian forests include: (1) low level of forest cover (15,9%); (2) growth of forests in different natural zones, manifesting diversity of forest cover types, management approaches and forest uses; (3) primarily ecological functions of forests and high share of protected areas (16,1%); (4) distribution of forest use rights among multiple public agencies; (5) large areas of forests either requiring special management regime or occupying radioactively contaminated areas [30].

Forest governance in Ukraine has been constantly changing since 1991, mostly characterized as ineffective and non-transparent [31]. Deficiencies within the governance system are often considered as major obstacle to the development of forestry and adjacent sectors of economy, thus exploring peculiar features of state forest regulation and governance in Ukraine has been under focus of scientists [26]. Deliberation on the topic has been supported by the Forest Law Enforcement and Governance second program that has finished in 2017 and provided important contributions on improving forest policy and management, with special emphasis on combating illegal logging. It is also currently supported by the Deliberation on the topic is also supported by the “Facilitating forest sector reform in Ukraine” project implemented by the World Bank. At this point, a wide variety of opinions exists among scientists on how forest governance reform should be approached, and which direction it should head, without any single agreed vision or set of provisions shared among researchers. The article responds to this gap through meta-analysis of current research on topic, focusing on key factors contributing to slow forest governance reformation process and challenges it faces.

2. Methodology

Meta-analysis was applied in this study through a comprehensive review of scientific literature based on strict selection criteria and use of relevant statistical tools to reveal patterns across a large body of research. Meta-analysis allows to aggregate and systematize previous findings, as well as to observe general knowledge gaps within research on development and reformation of forest governance in Ukraine. We further describe the selection criteria and process used for this article.

2.1. Criteria for Including Studies

A primary search on articles for meta-analysis on forest policy and governance reform in Ukraine has been conducted using *Web of Science*, *Scopus* and *Google Scholar* databases using following selection criteria:

1. The article search (by title and keywords) featured following keyword combinations and variations based on them (search was conducted in both in Ukrainian and English languages): forest governance, forest governance reform, forest sector development, forest policy, forest regulation, also “Ukraine” was added to each search for a proper focus. A broad keyword search was applied considering the need for a complex approach to forest governance reform and an interdisciplinary scientific effort, involving researchers on economy, environment, law, policy and others. A peculiar feature identified at this stage

was prevalence of focus on state governance within scientific articles, and on forest governance reform / institutional reform in public discourse.

2. The articles were published from 2011 to 2018. The reason for provided timeframe was a change in subordination structure within central forest governance executive authority: State Forest Resource Agency become subordinated to the Ministry of Agrarian Policy and Food of Ukraine (it has previously been subordinated to the Ministry of Ecology and Natural Resources of Ukraine) [31].

3. The articles were published as full-length articles in a peer-reviewed journal, and for articles in Ukrainian scientific journals the criterion was inclusion into a list of specialized journals approved by the Ministry of Education and Science of Ukraine. Reports published by World Bank and PROFOR were not included into analysis, since they are a different type of publication, involving large number of authors and opinions, and are not comparable to scientific articles per se.

2.2. Constructing the Database

Based on the literature search and application of the criteria we selected 54 articles. The next step was to exclude articles that did not correspond to the aim of this study. Five article were excluded because of focusing solemnly on terminological issues, 7 articles were purely focused on statistical analysis of the forest resources use and provided no relevant contribution to the discussion, 9 more articles were excluded for focusing solemnly on single problematic issue (e.g. forest protection), without reference to the governance system in general. If a certain author had several publications on the relevant topics, we chose the publication that best suited the aim of the analysis and provided the most comprehensive presentation of author's opinions. Inclusion of few publications by a single author into the analyses may have led to imbalanced representation of opinions. This eliminated 7 articles. Thus, the final list of articles selected for meta-analysis included 26 entries, including 8 articles on forest governance as such, 7 on forest policy, 7 on development of forest governance, 2 on reforming forest governance and 2 on regulation within forest governance.

3. Results

3.1. Forest Governance Reform Challenges

3.1.1. Institutional Challenges

A. Distribution of governance functions

The key challenges in reforming forest governance in Ukraine (Table 1) belong to the group of institutional challenges – 68% of researchers emphasize the need for organizational and functional transformation of the forest governance and forest management, 32% of publications emphasize the need for better distribution of governance functions between different authorities. Most crucial is the need better distribution of management and control governance functions [11, 17-18, 20, 32-33, 37], currently concentrated within one executive authority. State Forest Resources Agency, its regional subdivisions and state forest management enterprises combine functions of forest protection, safety, control of state of forest resources, performed by representatives of the state forest guard, awarded with the status of law enforcement body. This leads to internal conflict of interests, since one body combines management and control function [26]. Institutional transformations in Ukraine's forestry have started, but the rules of the game and the arrangements have not changed substantially so far, neither administrative nor financial decentralization has been achieved [29].

Table 1

Challenges in reforming forest governance system in Ukraine, results of meta-analysis

Challenges	Number of publications, mentioning the challenge,%*
Institutional	68
Distribution of governance functions between different authorities	32
Change in the system of forest ownership	16
Decentralization of forest governance	8
Integration of environmental considerations (e.g. climate change)	12
Political/legal	12
Development of national forest policy	12
Absence of clear legislative definitions	8
Economic	64
Improvement of the finance mechanism	28
Development of public-private partnerships	32
Development of payment for ecosystem services mechanism	4

*31% of publications discuss two or more challenges

B. Change in the system of forest ownership

The Forest Code of Ukraine defines three forms of forest ownership – state, private and communal [34]. Unlike in most neighbouring Central European countries, property restitution was not considered in Ukraine during the process of reforming forestry in the years following the gaining independence. This was due to specific historical circumstances in the different regions of Ukraine and the public's fear that forest management would be unsustainable in privatized forests. However, some authors support priority for state forest ownership in Ukraine, especially on strategically important forestlands [34], emphasizing their social and ecological functions [32] and almost completely lost skills of landowners in private forest management [33].

C. Decentralization

Decentralization of forest governance in Ukraine, emphasized by 8% of publications, is considered in the context of administrative decentralization reform in Ukraine in general [36], that started in

2014 and concerns primarily development of communal forest ownership, leaving incomes from wood and non-wood forest resources to newly created territorial communities [33], providing them with better control over forest management activities [26].

D. Integration of environmental considerations

The major focus of publications mentioning integration of environmental considerations (12%) is on recognizing their impact on forest management [19, 38] and development of national policy for counteracting global environmental threats [32], however no detailed measures in this regards are suggested by the scientists. Ukrainian and international environmental NGOs (WWF, IUCN, Earthsight, Green Cross Society and others) are increasingly involved in investigations on environmental and social impacts of forestry activities, especially biodiversity degradation, illegal logging and corruption. But still one of the main challenges for environmental and social aspect of forest governance is to create effective institutional mechanisms for the involvement of all stakeholders in the forest management planning and decision-making.

3.1.2. Legal/Political Challenges

A. Development of national forest policy

At this point there is no single document that would provide long term vision and goals for the development of forest policy in Ukraine [32], while a comprehensive system of forest legislation is in place. Some authors do not different between forest policy and strategy, ignoring their relationships with forest legislation [15], while others emphasize the necessity for improving legislation without considering the need for developing a national forest policy [13].

B. Legal provisions

Absence of clear legal provisions and terminology in the field of forest management, including the problematic definition of the term "forest" and complexity of differentiation between forest governance and state forest governance [6] is another legal challenge to reforming forest governance in Ukraine (8% of publications). The definition of "forest" in Ukraine significantly differs by its substance from the term widely used in EU, since there no single agreed understanding of what is the object of forest policy – forest or land [2]. According to FAO definition forest is "land with tree crown cover (or equivalent stocking level) of more than 10 percent and area of more than 0.5 hectares (ha)" [9]. According to the Forest Code of Ukraine [34] forest is a "type of natural complexes (ecosystem), combining mainly forest and bush vegetation with appropriate soils, grass vegetation, animal world, microorganisms and other natural components, interdependent in their development and influencing each other and natural living environment". As we can see Ukrainian definition ignores connected between land, forest and forest resources, as well as identification of forest as property. Ukrainian legislation also utilizes the term "forest users" (usually state enterprises, having the right to own harvested wood and income from its distribution) and not "forest owners". Forests, as well as other natural resources is the property of Ukrainian nation.

3.1.3. Economic Challenges

A. Finance mechanism

Among economic challenges for reforming forest governance in Ukraine finance mechanism is the most widely mentioned (28% of publications). Two key aspects of the mechanism are considered as crucial: 1) creation of a specialized forest fund, which would be financed from income from of wood and non-wood forest products [7, 33], as well as contributions from wood processing enterprises to support forest management activities [3-4], and 2) improvement of financial instruments of forest policy – introduction of innovations into forest management through tax exemptions [3], increasing deductions from fee for special use of forest resources to local authorities budgets to stimulate projects aimed at afforestation and forest resource regeneration on a regional level [14]. Development of the payments for ecosystem services mechanism has not achieved much attention from the scientists, with only one publication mentioning the issue [27].

B. Public-private partnerships

Active development of public-private partnerships within forest governance in Ukraine has been investigate by the 32% of the analyzed articles. Scientists emphasize the need for developing small entrepreneurship and involvement of private entities to forest management operations, which already takes place in certain parts of western Ukraine [7, 22]. Forest concession is considered by some authors as a prospective direction for public-private partnerships, facing legal limitations, since Ukrainian legislation forest management is not clearly defined as separate sphere of economic activity, objects of which may be provided into concession [23]. It is also worth considering that Ukraine has lower forest cover compared to other countries who have successfully implemented forest concessions.

Forest clusters are actively considered in scientific articles on issues of institutional reform of forest governance in Ukraine [12, 21, 26]. A clear benefit of using them is deepening of collaboration between woodworking industry and forest management, as well as increase in volumes of production from wood forest resources. A critical limitation in this a case is availability of wood within the region of cluster formation, which may increase economic inequality between better (Carpathians, Polissia) and less (Steppe, Forest steppe) forested regions of Ukraine.

3.2. Factors Slowing Down Forest Governance Reform

Institutional reforms within forest governance have been happening in Ukraine since it gained its independence. This period has witnessed several important organizational changes within the forest governance (Table 2), however a complex of problems persists, signifying a need for further reform: high level of societal dissatisfaction with the system of the forest governance, absence of state finance of forest management operations, lagging of the current governance system behind key trajectories – decentralization, marketization, stakeholder participation. Thus, our second question for the meta-analysis was "what are the main factors, slowing down reformation of forest governance in Ukraine?".

Table 2

Organizational transformation with forest governance authorities in Ukraine: major events since 1991 till now ([31] with changes)

Year	Event
1991	Ministry of Forestry of Ukraine is established as the result of Ukraine becoming an independent country
1997	Ministry of Forestry of Ukraine gets eliminated The State Committee on Forestry directly subordinated to the Cabinet of Ministers of Ukraine becomes a new authority
2005	State Committee of Forest Resources of Ukraine becomes subordinated to the Ministry of Environmental Protection of Ukraine
2010	State Agency of Forest Resource of Ukraine, a previous authority reframed, becomes subordinated to the Ministry of Agrarian Policy and Food of Ukraine

On the bases of the conducted meta-analysis we have identified that most publications (60%) only implicitly mention – authors do not consider them as their major research objectives, meanwhile other 40% of publications do not provide any analysis of factors. Within the publications, where those factors where mentioned we identified their three major groups: *historical* – such as absence of a proper legal framework for reform and market regulation in this sphere due to the heritage of the old command economic system and centralized forest governance model, *socio-cultural* – insufficient awareness of society about social and environmental functions of forests, benefits of multiple use forestry, and finally, *professional* – low level of application of modern technologies in production, IT support skills within training of young generation of professionals, absence of statistical data and analytical assessments on effectiveness of realization of previous forest governance strategies and programs (Figure 1).

4. Discussion

Based on the meta-analysis, we have identified that current scientific research on reforming forest governance system in Ukraine may be characterized by following features:

1. Absence of holistic (systemic) approach to reforming the forest governance

The contemporary stage of forest governance reformation is influenced by a series of key drivers, which may be classified into political/legal (inconsequent reforming process, weak political will, absence of interest from political leaders of the country in realization of international forest governance initiatives etc.), economic (state finance of forest management, marketization, financial compensations aimed at slowing down deforestation rates, absence of transparent rules for trading forest products etc.), social (the level of social concern over state of forest ecosystems, societal opinions on forest ownership models, potential for including wider public into forest governance process etc.) and biophysical (climate change, forest fires, forest pests and diseases etc.) groups. Meanwhile, analyzed articles mostly do not apply this or any other comprehensive and systematic approach (Figure 2) to reforming forest governance system in Ukraine and mainly focus on one or few aspects of reform.

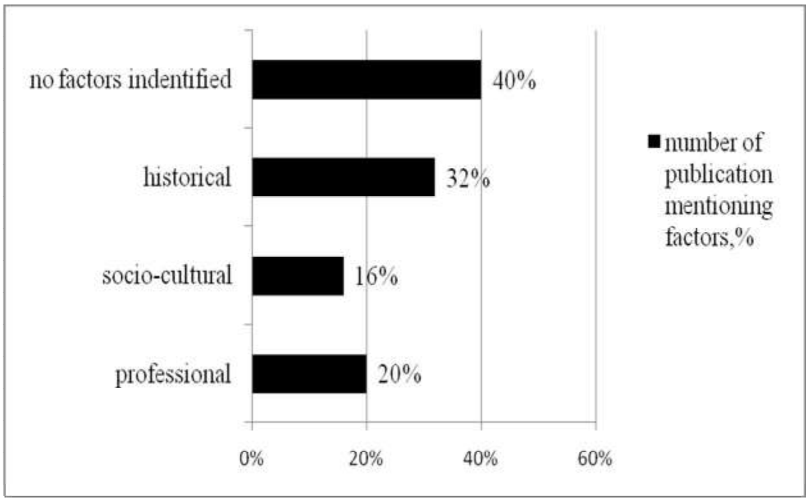

Fig. 1. Factors slowing down forest governance reform in Ukraine, results of meta-analysis

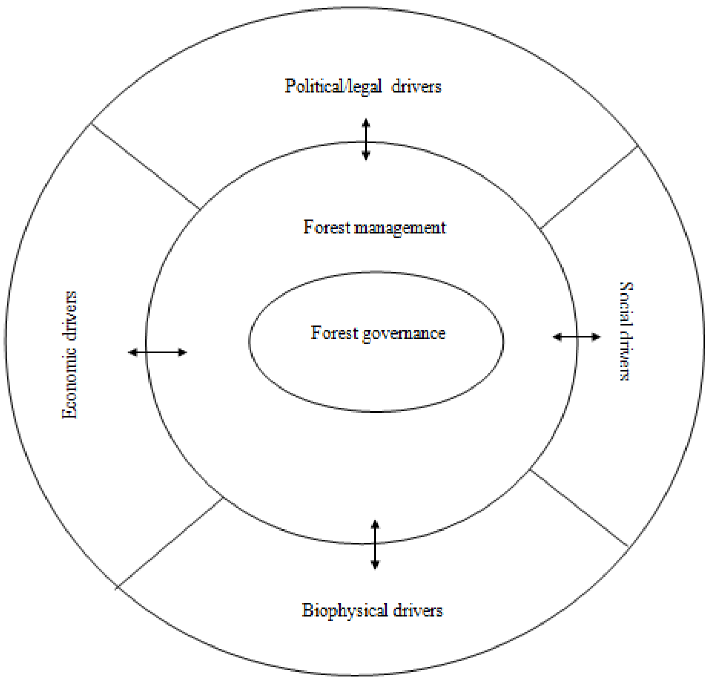

Fig. 2. Complex (systematic) approach to forest governance reformation in Ukraine considering different types of drivers

2. Recommendations on reforming forest governance provide little or no detail on relevant actions that need to be implemented.

Articles from the meta-analysis provide very limited insight into actual activities and measures that need to be taken, rather focusing on narrow theoretical fragments of the broader picture and not providing clear reference points for the necessary reform in the context of the challenges they describe. In most CEE countries, reforms more radically changed the institutional environment. These changes strengthened the role of the forest sector, opened new markets, and increased effectiveness of forest management, but forest resources in some countries at the beginnings of this transition found themselves in a risk [28].

3. Ignorance towards general trends within forest governances

Bas Arts (2014) identify decentralization, marketization and participation as key trends within improving of forest governance. Stakeholder participation within forest governance in Ukraine is partly realized, however it is usually limited to passive forms of participation (informing and consultation). Decentralization is studied mostly within the context of administrative reform, while marketization concerns with a limited number of activities – such as forest certification and payments for ecosystem services, with former achieving more attention than the latter, while scientific exploration of ecosystem services in Ukraine has been very marginal. It is worth noting, that The Law of Ukraine "On the Foundations (Strategy) of National Environmental Policy of Ukraine Until 2020" [35] has mentioned the need for implementing an informational campaign on the value of ecosystem services taking Ukrainian ecosystems as an example, as well as establishment and further application of ecosystem services valuation mechanisms until 2015, however no analysis on implementation of these measures has been conducted.

4. Fragmented analysis of the current forest governance. The last decade has witnessed two prevailing systematic approaches to assessing forest governance: Analytical Framework for Assessing and Monitoring Forest Governance developed by World Bank and UN Food and Agriculture Organization (2011), and Forest Governance Initiative by the World Resource Institute and its partners [5]. Abovementioned methodologies to assessing forest governances comprise all necessary elements and using them for analysis may be a key starting point for analysis aimed to provide comprehensive recommendations on reforming forest governance. Good governance (stakeholder participation; cooperation and knowledge generation; cross-sectoral policy coordination; better policy coordination inside the forest sector, institutional arrangements, participatory policy, transparency), fair rent distribution that support local socioeconomic development, and SFM which takes into account the multifunctional value of forest landscape, potential of ecosystem services and defines the scale of forestry activities are core tools for forest resource decision making [29].

5. Conclusion

Forest governance reform has started more than 25 years ago and still continues. The period witnessed several key institutional and organizational changes in the system, however complexity of present challenges reveals necessity for further reformation.

The meta-analysis revealed that key challenges lie in the economic and institutional realms. As in regards to factors slowing down the reformation process – 40% of reviewed articles do not touch on the topic at all, 32% emphasize absence of appropriate legal basis and market regulations *(historical factors)*, 16% - low social awareness about importance of forests *(socio-cultural factors),* while 20% focus on low level of professional development and insufficient information support within the field *(professional factors).* Meta-analysis also revealed low support towards certain principal measures, such as privatization of forests, meanwhile scientists emphasize positive potential of market regulation in regards to forest governance as well as development of public-private partnerships. More systematic and comprehensive studies on the issue of forest governance are required, as well as more focused studies on issues that have received only marginal attention – most of all integration of environmental considerations and payments for ecosystem services into the forest governance system.

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PROPOSAL OF A THREE-STEP WATER MANAGEMENT PARADIGM FOR MULTI-PURPOSE FORESTRY: THE CASE OF MOUNTAINOUS HALKIDIKI - GREECE

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Abstract: *This paper presents the results of canopy reduction contribution, due to tree harvest, to water yield and soil. It focuses on the relationships and interactions between the ecosystems integrated parts water-soil-trees, as a result of different silvicultural treatments. In addition, it gives a combined solution regarding the water shortage problems during the dry summer seasons. The interactions and relationships as well as sustainability are of major importance in forest ecosystems, which are governed by the law of the unified field. The suggested solution is comprised of the common by the Forest Service thinning treatments (10-15% of total basal area) and the creation of small and large scale multi-purpose water collectors.*

Key words: *water management, silvicultural treatments, oak ecosystems.*

1. Introduction

In nature, the law of the unified filed is predominant. According to this law, everything is interconnected and the slightest change to one part of nature, can influence the whole. Ecosystems are not the sum of their parts but more than this and are functioning united.

Oak ecosystems can play a significant role in a multi-purpose forestry, as they comprise the largest part of the forested area in Greece. The optimization and management of water resources in the region has become a more challenging task in recent years. Future implications on fresh water availability, will have a profound impact on Mediterranean countries like Greece. In these areas, important economic sectors such as agriculture and tourism, are strongly dependent on water. Proper management in order to increase the available water becomes a priority, taking into consideration that half of the country's forested area is covered by oak ecosystems. These also comprise the most important water producing areas [18]. In Mediterranean areas facing severe time and space problems of water deficit,

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whilst having dense forest cover (e.x. Halkidiki, North Greece), it is possible to increase water yield, benefiting both the ecosystems and humans. This can be achieved through rational and controlled reduction of tree canopy.

2. Materials and Methods

The experimental plots are located in the Taxiarhis University Forest (TUF) (40^{o}N, 23^{o}E) which is managed by the Aristotle University of Thessaloniki in Greece for educational, research and demonstration purposes (Figure 1). TUF has an area 3,895 ha, is located in central Halkidiki and is dominated by hardwoods. The dominating tree species is *Quercus frainetto (confertta)*.

Long-term mean annual precipitation is 756 mm, which mainly falls from October to March. The climatic data were collected at the TUF weather station (altitude 860m), that was 150m from the first study plot (exposure SE).

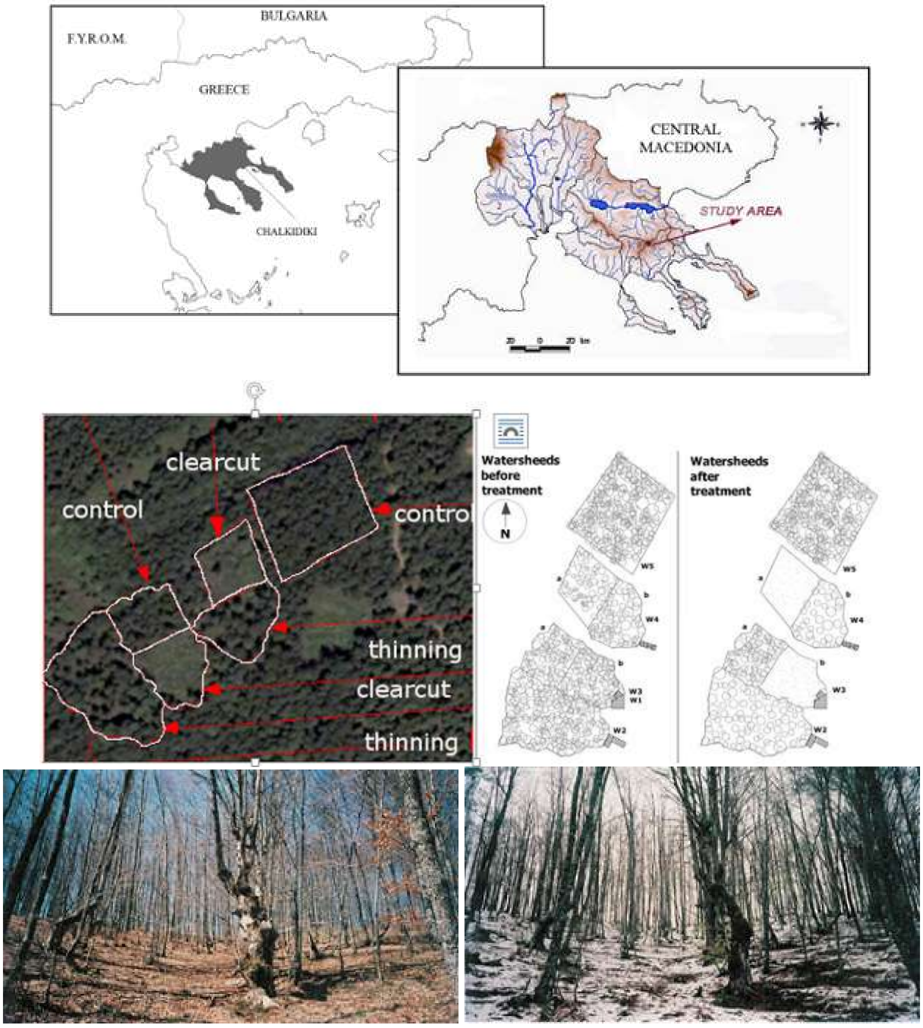

Fig. 1. The study area

Canopy closure is 100% in the summer. Soil is covered by forest floor with average depth of 2-3cm, which increases infiltration and decreases overland flow and erosion. The decomposition rate is high due to favourable temperature and moisture conditions [1]. Today the soils at TUF are well protected by the existing vegetation and forest floor and they are fertile with limited surface erosion. Soil depth is fairly deep (53cm) in the upper part of the study plots and deep (110cm) at their lower part.

Experimental watersheds have been established for the study of the impacts of thinning and clear cutting on water yield and soil. Watersheds were used as control, while others were under thinning (removal 50% of basal area) and clear cutting treatments [8].

The first and the last one (W1 and W5) were the controls with no vegetation removed. In W2 the basal area was decreased by 50%. In the upper part of W3 (W3a) no treatment was applied, whereas its lower half (W3b) was clear cut. The upper half of W4 (plot W4a) was clear cut and in its lower half (W4b) 50% of the standing trees were removed during the period from September - October 2001. The experimental design and data about each watershed can be viewed in Figure1.

All harvesting works in the TUF are conducted according to the harvesting schedule, which is included in the management plan (Figure 2). Forest operations are practiced by the forest workers' cooperative of the adjacent community of Taxiarhis under the supervision of the Greek Forest Service. According to the management plan, thinning operations aim at the conversion of the existing coppice forest into high quality forest [11].

Fig. 2. The three study treatments: a) control; b) thinning 50%; and c) clearcut [8-9]

Through fall at the study watersheds was measured for a continuous period of 24 months, starting from November 1st 2001 until October 31st 2003. Three fixed and three roving collectors (Figure 3c) were used for each treatment.

Surface flow was measured with the help of four water collectors, located at the lower limit of W1, W2, W3, W4 with a depth of 1m and an area of 40 m^2, 42 m^2, 30 m^2 and 50 m^2 respectively (Figures 3a, 3b, 4 and 6). No ditch was dug for W5 because of its zero slope. All ditches were carefully coated with plastic material in order to inhibit water infiltration and provide more accurate measurements. Otherwise, plastic cover is of no use because the main purpose of constructing ditches in a large scale is to minimize surface runoff and maximize infiltration. The amount of water gathered in the ditches was measured once per week, from November 1st 2001 until October 31st 2003, as well as after each occurrence of heavy rain events during the entire study period. The collected water was pumped into two plastic barrels (120 lt and 80 lt respectively) with the help of an oil pump.

Fig. 3. Construction of the ditches, the pumping of surface runoff from the collectors and a collector of through fall (c, left) [8]

Fig. 4. Watershed collectors: a) thinned-W2 (left); b) clearcut-W3 (lower part); c) thinned- W4 (lower part) [8]

The birth place of water production is the mountainous forests that also play an important regulatory role. Due to the bedrock type of the study area, within an area of thousands of hectares, only few springs (five in total as far as we know-one located in the selected area) flow throughout the year (Figures 5a and 5b). Natural water reservoirs are missing from the area. Therefore, the study suggests a simple but effective system of constructing ditches, to increase infiltration rates. Similar ditches were used in our study as surface runoff collectors and made its measurement easy and simple.

Approximately 2 Km far from the study watersheds, on behalf of and in collaboration with the Forest Service Department, Ganatsios with the support of Professor Pavlidis, planed, designed, studied (2011) [11] and supervised (2013, 2014) the construction of four multi-purpose (hydrological, aesthetic, recreational, ecological) dams. At the selected location, runoff (both surface and subsurface) appeared periodically, and was minimized or eliminated during the dry season. The water shortages on mountain Holomondas were a major motivation to create these dams for aesthetic, recreational, ecological and fire protection reasons. Above all, it is an effort to create a water storage input, both at surface and subsurface level, to enrich the underground horizons and hopefully re-initiate springs that once used to flow. It is important to balance inputs with outputs. Four dams were constructed at the lower end of the basin of the local torrent (the origins of Olynthios torrent.), as part of integral water management plan which is comprised of 3 parts: a) silvicultural treatments to increase through fall (precipitation inputs), b) small scale water collectors, c) bigger water reservoirs.

Fig. 5. Two of the few springs of Holomontas Mt.

3. Results

3.1. Impacts of Treatments on Soil

In control plots, the rhythm of accumulation of organic matter and the amount and weight of forest litter, were found high. The volume of the Ao horizon was much higher than Aoo horizon, which is an indication of relatively good decomposition conditions of organic matter. Decomposition in thinned plots was found much higher in comparison to the clear cut plots. There was significant reduction of organic matter at Ao horizon in clearcut and thinning plots. This reduction is attributed to the lower production of organic matter (falling leaves etc) which is enriching the soil. Although, theoretically, the logging creates better decomposition conditions, data showed that clear decomposition in plots under treatment (very high thinning degree and clear cutting) has been reduced, mainly due to the drier conditions compared to the control plots [8].

3.2. Impacts of Treatments on Water Yield

Canopy annual interception amounted for 9.0%, 6.7% and 1.8% of the total precipitation in the untreated, thinned and clear cut plots respectively. Surface flow was found very low even during large rainfall events. On 21.09.2001 (before any treatments took place) a rainfall event of 49.4 mm in three hours was recorded. Such a large amount of water was not expected for this specific time of the year. Based on the water balance method [14], no water surplus was expected, still in the collector there was 0.4 m^3 of water.

Table 1

Major precipitation incidents during 2 years period and measured surface runoff in the collectors (direct rainfall excluded)

Major precipitation incidents during 2 years period				Measured surface runoff in collectors excluding direct rainfall				
Percipitation Incidents	Percipitation [mm]	Duration [hours/day]	Months Total [mm]	Pumped cubic meters [pcm]	Watershed			
					Control (W1)	thinned (W2)	control+ clearcut (W3)	clearcut + thinned (W4)
				Water shed area [ha]	0,193	0,195	0,1633	0,156
				Ditch area [m^2]	0,04	0,042	0,03	0,05
21/9/2001	49,4	3h	49,8	pumped [m^3]	0,5	0,5	0,4	0,4
September 2001				**Calibration before treatments September 2001**	**0,5**	**0,5**	**0,4**	**0,4**
9-12/3/2002	44,1	4 days					0,2	0,2
22-24/3/02	30	3 days						
March 2002			**87,5**	**March 2002**	**0**	**0**	**0,2**	**0,2**
1/12/02	70	13h				0,1	1,5	1,5
7/12/02	50,1	24h						
1-9/12/02	192,7	9 days			0,1	1,0	4,7	2,4
13-19/12/02	53,7	6 days				0	0,4	0,3
December 2002			**259,7**	**December 2002**	**0,1**	**1,1**	**6,6**	**4,2**
January 2003			**91,3**	**January 2003**	**0**	**0**	**0,1**	**0,1**
Total collected surface runoff in ditches [m^3]					**0,1**	**1,1**	**6,9***	**4,5***
Total potentially collected surface runoff in ditches [m^3/ha]						**5,6**	**42,2**	**28,8**
Total potentially collected surface runoff in ditches [m^3/Km^2]						**560**	**4200**	**2880**
Total potentially collected surface runoff in ditches m^3/5.4Km^2						**3.024**	**22.680**	**15.552**

***** In W3 collector, surface runoff appeared higher than that in W2, because clear cut treatment applied in the lower part of W3. In the field water collector only 0.4 m^3 of water was observed (Table 1).

According to the results presented in Table 1, the observed surface runoff comprises a small portion of the expected total surplus including surface and subsurface runoff and infiltration. (On December 1st and 7th 2002) after two rainfall events of 70 mm (duration 14 hours) and 50 mm (duration 24 hours) no surface flow was measured in the control plot compared to 6.2 m^3/ha and 39.0 m^3/ha measured for the thinned and the clear cut plots, respectively. Only for March 2002, December 2002 and January 2003 when 87.5 mm, 259.7 mm and 91.3 mm of total precipitation have been recorded, respectively, there was water from runoff measured in the ditches. Mean average interception loss was reduced by 107 mm and 209 mm for the thinned and clearcut plots respectively.

Table 2

Expected total runoff and observed surface flow for the study watersheds for the peak period of March 2002, December 2002, January 2003. The expected amount of runoff was based on the water balance method, while the observed was from field water collectors [8]

Watershed	Expected total runoff (surplus) [m^3/(m^3/ha)]	Expected total water surplus [(m^3/5.4 Km^2]	Observed surface flow [m^3/ (m^3/ha)]
W1 (0,1932 ha)	415 / 2.148	1.159.920	0 /0
W2 (0.1950 ha)	465 / 2.385	1.287.900	1.1 /5.6
W3 (0.1633 ha)	413 / 2.529	1.365.660	6.9 /42.2
W4 (0.1560 ha)	384 / 2.461	1.328.940	4.5 /28.8

Sustainable management of forests through thinning operations, has increased water yield and gave an additional 13,2 mm/year (1mm of rain in a watershed of 1Km^2 is equivalent of 1000m^3 of water, 13.200 m^3/year/Km^2). Clearcutting increased the available amount of water by a mean annual average of 42.8 mm (and decreased water surplus for both treatments by 4.6% and 14.7% respectively). This decreased interception (from 185.8mm/2-year study period in control plots to 137.1mm/2years in thinned plots) represented a gain of 24.3mm/year, compared to the control watersheds. The total water surplus represented 29.5%, 30.9% and 33.9% of the average annual precipitation for the control, thinned and clearcut plots, respectively. This increase of 1.4% of total water surplus in thinned plots (compared to control plots), equals to 13.2mm/year (total water surplus).

Thinning at the a rate of 50% of basal area provides 127.980$m^3$of total water surplus during the peak months of March 2002, December 2002 and January 2003 in a watershed of 5.4 Km^2, similar to those where the dams were constructed. A water quantity of a quarter of this amount, approximately 30.000m^3/year, is the estimated total water surplus, and gained by the common thinning practice (10-15% of the basal area). A portion of this winter surplus can be stored in water reservoirs for multi-purpose services (Figures 6 and 7).

The height of the main dam at the crest level is 10.5m, the lake area is 4.170 m^2 and its volume is 13.430 m^3. Under flood conditions this volume can be raised up to 17.859 m^3. The height of the three smaller dams varies between 2,2 to 3m at the crest level. Since 2014, the dams are fully functional.

Fig. 6 . Smaller and bigger scale water management in Mountainous Halkidiki

4. Discussion

Vegetation cover has an important influence on the hydrological cycle. A proportion of rainfall in forest ecosystems is intercepted, collected and stored by the plant foliage while some of it is subsequently lost by evaporation, resulting sometimes in intensified loss of water affecting the hydrological balance. Understanding the relationships between canopy characteristics and interception is thus essential for quantitative prediction on the effects of deforestation [10] and changes in land use and vegetation [3] on water yield.

Forest treatments can increase water yield while reforestation can decrease it. Studies have shown a definite response of water yield to cover alteration [4]. The hydrological cycle of watersheds is affected by canopy interception, which in some cases amounts 10-30% of the rainfall, and can even amount to 50% of the rainfall in some areas [5-6]. Interception varies greatly among species, as a result of differences in leaf area and shape, forest density and structure, and climatic conditions [6]. The investigation of various forest harvesting treatments on the hydrology cycle has been conducted with the help of paired watershed studies in many parts of the world [19].

The results regarding interception agree with previous studies that found interception reduction was not proportional to the amount of biomass removed. In our case, removal of 50% of basal area led to an annual average decline of interception by 34.3% (reduced from 9% to 6.7% of the total precipitation). In other studies with other species 50% removal of basal area led to 18.5% [18], 30.2% [2] and 41.6% [7] decline of interception loss.

Fig. 7. The 4 multipurpose dams (Ganatsios 2014-2017)

The observed surface flow represents a small part of the total runoff. This could be attributed to various soil factors that increases the subsurface flow and the water holding capacity. Springs are areas of discharging this subsurface and infiltrate flow. Silvicultural treatments can play an important role in modifying the hydrological cycle of forested areas for the benefit of human needs. Thinning treatments could increase the available water especially in areas with low precipitation, given the fact that many areas already face water problems in Greece. Serengil et al. (2007a, 2007b) suggest that any thinning over 11% could be described as baseline for water yield increase in a deciduous ecosystem. According to Brown et al. (2005), changes in water yield can be detected after thinning intensities of more than 20%.

However, management priorities should be clearly defined taking into consideration the complexity of environmental factors of the respective area. The role of soil in ecosystems is of primary importance as a life-supporting system. It is a source of: a) nutrients, b) water supply, c) tree support and growth. Soil also determines the infiltration rates and the water yield. The limiting factor of forest growth in these soils is their depth and the seasonal change of soil moisture. It is of primal importance, to maintain forest litter, which regulates temperature and moisture conditions and feeds the precious soil. Wood harvest affects its properties therefore the improvement of these properties is the best investment for a prosperous future. Thinning treatments, can be used to improve soil characteristics e.g. the decomposition rate. Nevertheless, there is a limit over which the deterioration is taking place. So, despite the increased water yield through intense thinning (50% of basal area) [8-9], less thinning and no clear cutting are suggested.

Thinning should be much less for soil protection and creation purposes, which is in common practice of the Forest Service (thinning rate of 10% up to 15%, with upper level implemented in limited cases). Even with this thinning degree, the estimated gain of 5mm/year (5.000m^3/year/Km^2), is very important. The measurement of this gain is a project under study as a means to contribute to the need for further investigation of the hydrological processes in this mountainous area. In order to optimize the thinning degree, we have to keep balance between the needs of increasing water yield and improving the soil’s characteristics while also increasing its depth. Although clear cut treatments increased water yield significantly (42,8mm/year, 42.800 m^3/year/Km^2), they still should be avoided at all cost (flood risk, valuable soil loss). Regarding this statement, some recent, extensive unsustainable forest management practices in Romania and elsewhere, reminded us of the value of sustainability.

5. Conclusions

Holistic knowledge of forest ecosystem services, provided by sustainably managed areas, could facilitate the increase of awareness on the importance of these ecosystems and on their interactions and interconnections with human life. This paper aspires to contribute to our knowledge on the effects of different silvicultural treatments in oak forests related to water yield. Areas like Halkidiki have to cope with heavy pressure on water resources, especially during the summer months, as they represent major touristic attractions for the inhabitants of Greece and the neighbouring countries. Reserving a small portion of annual precipitation, like 5mm/year- winters surplus in particular- is considerable to the benefit of ecosystems and humans.

The plan suggested for integral water management, also aiming at the improvement of soil properties, is comprised of three parts (two of these already applied-a & c): a) silvicultural treatments(thinning-10-15% of basal area) used to change the structure, the composition and the density of forest stands and in this manner increase through fall (precipitation inputs) and water yield, b) small-scale water collectors, c) bigger water reservoirs.

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NEMORAL DECIDUOUS FORESTS UNDER CLIMATIC EXTREMES – PHYTOSOCIOLOGICAL STUDIES ALONG CLIMATIC GRADIENTS IN SW ROMANIA

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Abstract: *Based on studies on stand structure, plant community composition and tree ecology across a climate gradient in western Romania from beech-dominated to oak-dominated forests, we are investigating how climate warming in 50-60 years would affect forest ecosystem structure, the vitality of important tree species, and the provision of energy wood from nemoral broad-leaved forests. The aim is to identify and characterize the tipping-points from mesic-hygrophilous, dark shady deciduous forests of Fagetalia sylvaticae to thermophilous, light deciduous forests of Quercetalia pubescenti-petraeae forests by using data from the Romanian Forests Vegetation Database. We applied non-metric multidimensional scaling, and indicator species analysis to evaluate ecologically three groups of relevés: (1) beech dominated forests, (2) mixed oak-hornbeam forests and (3) thermophilous oak dominated forests. We analysed spatial distribution of high order syntaxa, degree of warm thin terms of mean Ellenberg indicator values and number of thermophilous species, site differentiation in terms of altitude, aspect, temperature and precipitation. Our findings indicate that the gradient analysis could be performed on transects starting from 600 m downhill to 200 m, representing gradients of decreasing mean annual precipitation (from 800 to 600 mm), increasing temperature (+2-3°C) and increasing risk of drought stress as a proxy for climate warming. We proposed the following selection criteria: (i) near-natural deciduous forests; (ii) coherent and widely undisturbed woodland areas; (iii) sufficient elevational sequences; (iv) intermediate level of hygrotope (soil moisture*

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regime) and trophotope (soil nutrient regime); (v) same slope aspect (south-eastern direction); and (vi) sufficient distance (50-60 km) to each other.

Key words: *species niche, nemoral forests, climatic gradients, multiplicative regression, indicator species.*

1. Introduction

In the context of predicted climate warming, planning strategies in forestry need evidences for the capabilities of species to react to environmental changes, as climate or species competition. One approach is to substitute space for time, i.e. to analyse the relation of species to environment along gradients of temperature and/or species composition. Studies on species or habitat niche models [1, 6, 17, 22] indicate the opportunity and offer tools to explore such complex relationships. Due to the site influence on water availability for plants, the climate favourability has to be checked on so-called euclimatopes – gentle slopes or flat terrain with no influence of flooding or groundwater, with non-carbonated soils [23].

In Romania, as in all countries of temperate Europe, the forests are dominated by deciduous broadleaved species, among which beech (31% of forested area) and oaks prevail (16%)(NFI 2006). The oaks are represented by 5 (9) native taxa – *Quercus petraea* (incl. *Q. dalechampii*, *Q. polycarpa*), *Q. robur* (incl. *Q. pedunculiflora*), *Q. cerris*, *Q. frainetto*, *Q. pubescens* (incl. *Q. virgiliana*) [18-19]. Mixed deciduous forests in western Romania are particularly very complex in terms of composition of the tree layer [2-3]. Beside oaks, three lime species (*Tilia tomentosa, T. cordata, T. platyphyllos*), European hornbeam (*Carpinus betulus*), seldom Oriental hornbeam (*C. orientalis*), maples (*Acer platanoides, A. campestre, A. pseudoplatanus, A. tataricum*), European ash (*Fraxinus excelsior*), and elms (*Ulmus glabra, U. minor*) can occur in the species rich mixed forests.

The NEMKLIM project focuses on deepening the understanding of the effects through increasing summer heat and drought on forests in the nemoral zone. Background of the project is the presumption that dominant tree species of the Central European (sub) mesophytic beech and oak - hornbeam forests (so-called "competitor" species) reach their dry climatic limits in western Romania [5, 24]. At the margins (rear edges) of their occurrence these competitor species develop drought-adapted ecotypes, which have advantages in a summer-drier and warmer climate. In transition zones (ecotones) they are frequently associated and subsequently replaced by more drought-tolerant (“stress-resistant”) species of the Pannonian-Balkan oak mixed forests [7, 21]. Based on the modelling project "Margins" (margins.ecoclimatology.com) decisive bioclimatic variables in western Romania were identified as analogous to a future climate predicted in about 50 years for large parts of central Germany [14-16]. The region exhibits an altitudinal climatic gradient simulating the increasing summer heat and drought, as predicted in the climatic scenarios for large parts of the hilly and mountainous regions of Germany [7].

The aim of this study is to identify and characterize the tipping-points from mesic-hygrophilous, dark shady deciduous forests of *Fagetalia sylvaticae* to thermophilous, light deciduous forests of *Quercetalia pubescenti-petraeae* by using data from the Romanian Forests Vegetation Database. Information on the response of forests in western Romania to climate and weather events will be used to adapt forest management decisions for German woodland in the future.

2. Material and Methods

The research area was chosen in western Romania on 110x210 km, following ETRS-LAEA grid with cell size of 10 km^2. Phytosociological data was extracted from the Romanian forest vegetation database [9]. As selection criteria we used: (1) tree layer dominated by one or several nemoral species of *Fagus sylvatica*, *C. betulus*, *Tilia spp.*, *Quercus spp.* (2) quantitative records of species abundances (excluding relevés with presence-absence values), (3) non-flooded vegetation (excluding units of Alnion), (4) near natural vegetation (excluding stands dominated by exotic tree species), (5) relevés in mature stage (excluding relevés without tree layer). The resulting matrix contains 1111 relevés x 634 species (Figure 1). Available information for each releve are: species composition, vertical structure (tree, shrub, herb, regeneration layers), layers cover, site parameters (altitude, exposition, slope angle), geographic coordinates (with accuracy between 10 m -30 km), syntaxa [2]. Database preparation was processed in JUICE software [20].

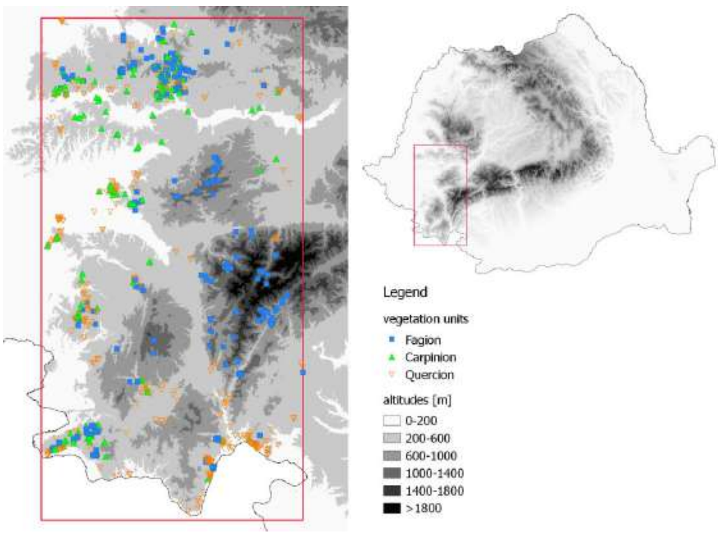

Fig. 1. Forest relevés distribution in south-western Romania

Indicator values of species were extracted from Sârbu et al. (2013), and unweighted averages were calculated for relevés. Climatic parameters were extracted from the WorldClim database [8]. Species ecological niches were drawn by non-parametric multiplicative regression (NPMR), which has the premises that: "the response variable has a physiologically-determined maximum, species respond simultaneously to multiple ecological factors, the response to any one factor is conditioned by the values of other factors, and that if any of the factors is intolerable then the response is zero” [11]. The analysis was performed using HyperNiche software [13], with the settings of Gaussian local mean and quantitative data.

Gradients in species composition and homogeneity of main vegetation units (alliances) were explored by non-metric multidimensional scaling (NMDS) [10], in PC-ORD software [12]. To reduce the variability induced by surveyors, data was transformed as follow: square root of abundance values, deletion of juveniles' records, deletion of species with frequency lower than 3, merging of tree layers.

Indicator species analysis [4] was applied to evaluate the fidelity of species to multi-factorial environment, expressed by vegetation alliances. We consider three major vegetation units that define a multidimensional ecological space: (1) mesic and cold forests, dominated by beech (*F. sylvaticas*) (*Symphyto cordati-Fagion*), (2) mesic and warm forests composed of oaks, hornbeam, limes (*Lathyro hallersteinii-Carpinion*, *Tilio-Acerion*), (3) dry and warm forests dominated by oaks (*Quercion frainetto, Quercion petraeae*). In this study *Carpino-Fagetum* was assigned to *Fagion*, despite its conventional assignment to *Carpinion*.

3. Results

NMDS ordination of forest communities shows a good delineation of major vegetation units (Figure 2).

Coefficients of determination for the correlations between ordination distances and distances in the original n-dimensional space (Bray-Curtis) are: R^2=0.517 for Axis 1, R^2=0.182 for Axis 2.

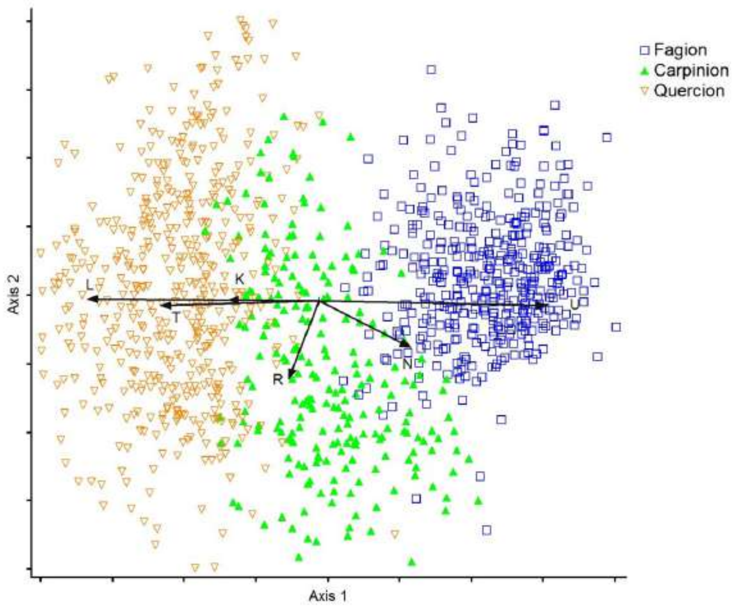

Fig. 2. NMDS ordination of forest communities in western Romania, in relation to mean Ellenberg values (L – light, T – temperature, K – continentality, U – soil water, R – soil reaction, N – nutrients)

The variation in species composition and syntaxa differentiation are best explained by light (R^2=0.805 with axis 1), humidity (R^2=0.792 with axis 1), temperature (R^2=0.550with axis 1), soil reaction (R^2=0.271with axis 2).

Best indicator species for these units are listed in Table 1. Their number increases from beech (18 species) to oak forests (34 species).

Analysis of species niche (Figures 3 and 4) reveals that beech and Hungarian oak are confined to two opposite biomes.

Table 1

Indicator values of species towards vegetation units, as resulted from database analysis. Only species with Ind. Val. > 10.0 are shown. Thermophilous species are in bold. The number of indicator species and thermophilous species increase from beech to oak forests

Vegetation unit	Indicator species
Symphyto-Fagion (401 relevés)	*Fagus sylvatica (87.5), Galium odoratum (36.7), Dryopteris filix-mas (30), Lamiastrum galeobdolon (25.5), Oxalis acetosella (24.8), Dentaria bulbifera (23.7), Festuca drymeia (22.9), Athyrium filix-femina (20.2), Rubus hirtus (17.3), Mycelis muralis (17.1), Luzula luzuloides (16.3), Polystichum aculeatum (15.8), Mercurialis perennis (14.8), Asarum europaeum (14.2), Dentaria glandulosa (11.8),Phyllitis scolopendrium (11.3), Epilobium montanum (10.8), Acer pseudoplatanus (10.7)*
Lathyro-Carpinion (225 relevés)	*Carpinus betulus (66.1), Viola reichenbachiana (29.9), Prunus avium (24.9),* ***Cornus mas*** *(23.2), Acer campestre (20.2), Melica uniflora (20), Stellaria holostea (19.5), Pulmonaria officinalis (19.2), Euphorbia amygdaloides (17.6), Lathyrus vernus (17.1), Galium schultesii (17.1), Glechoma hederacea (16.9),* ***Tilia tomentosa (15.5),*** *Carex pilosa (14.2), Geranium robertianum (14), Primula vulgaris (13.7),* ***Tamus communis (13.6),*** *Tilia platyphyllos (13.3), Hedera helix (13.1), Ranunculus auricomus (12.7), Sanicula europaea (12.2), Carex sylvatica (11.9), Cornus sanguinea (11.8), Ajuga reptans (10.6), Symphytum tuberosum (10.5), Polygonatum multiflorum (10.5)*
Quercetalia pubescentis (485 relevés)	***Quercus cerris (51.6),*** *Poa nemoralis (40.2), Dactylis glomerata (39),* ***Fraxinus ornus (37.8)****,* ***Quercus frainetto (36.5),*** *Quercus petraea (34.7), Crataegus monogyna (30.7),* ***Carpinus orientalis (27.3),*** *Veronica chamaedrys (26.9), Brachypodium sylvaticum (26.5),* ***Lychnis coronaria (25.6),*** *Vincetoxicum hirundinaria (25.5), Lathyrus niger (25), Clinopodium vulgare (24.5), Trifolium medium (23.3), Festuca heterophylla (22.9), Tanacetum corymbosum (21.9), Genista tinctoria (21.2), Campanula persicifolia (20.3),* ***Potentilla micrantha (19.8),*** *Fragaria vesca (19.1), Ligustrum vulgare (18.7), Euphorbia cyparissias (18.5), Buglossoides purpurocaerulea (18), Sedum maximum (16.8), Lembotropis nigricans (16.6), Pyrus pyraster (16.4), Rosa canina (16.4), Veronica officinalis (15.2), Silene viridiflora (15.1), Cruciata glabra (14.8), Geum urbanum (14.6), Chamaecytisus hirsutus (13.7), Rubus canescens (12)*

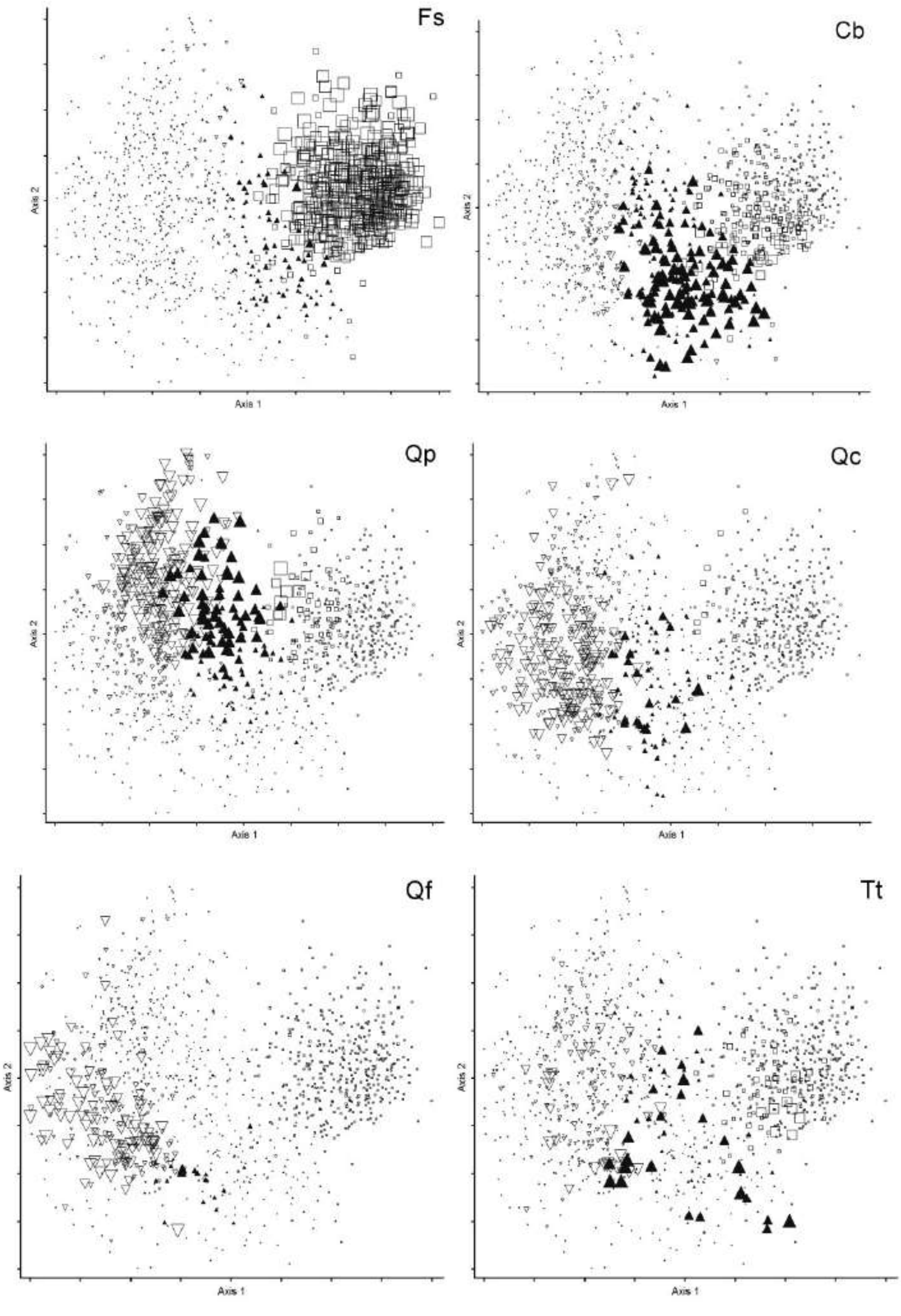

Fig. 3. Abundance domains of beech (Fs), hornbeam (Cb), sessile oak (Qp),Turkey oak (Qc), Hungarian oak (Qf) and silver lime (Tt) on NMDS ordination. Symbol size is proportional with species abundance, and symbol codes correspond to alliances as in Figure 2

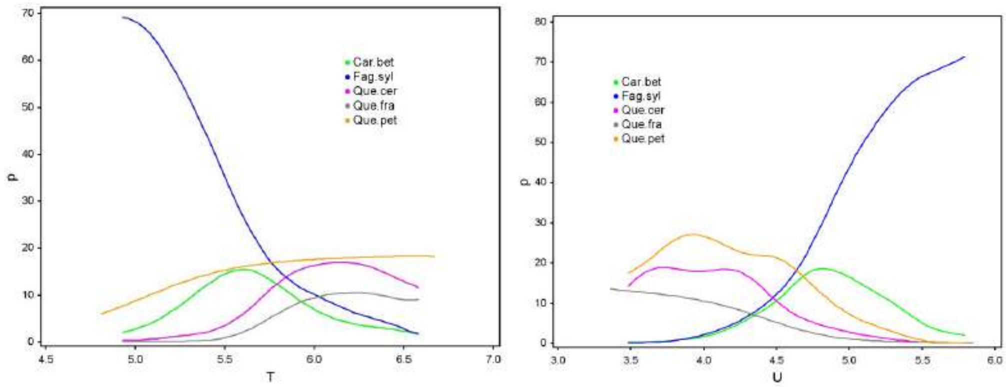

Fig. 4. Response curves of main tree species in western Romania in relation to mean indicator valuesfor temperature (T) and soil humidity(U)

Due to higher negative correlation between humidity and light or temperature, the thermo-hydric gradient may be expressed with the sequence of tree species: beech, hornbeam, silver lime, sessile oak, Turkey oak, Hungarian oak. Ecotonal transition from beech or *Fagion* impression to mesic oak forests of *Lathyro hallersteinii-Carpinion* starts with admixture of hornbeam, wild-cherry, silver lime and other thermophilous herb and shrub species (Table 1).

In terms of site determinants, there is a reciprocal influence of altitude and exposition, which is visible, both to warm demanding species and beech (Figure 5).

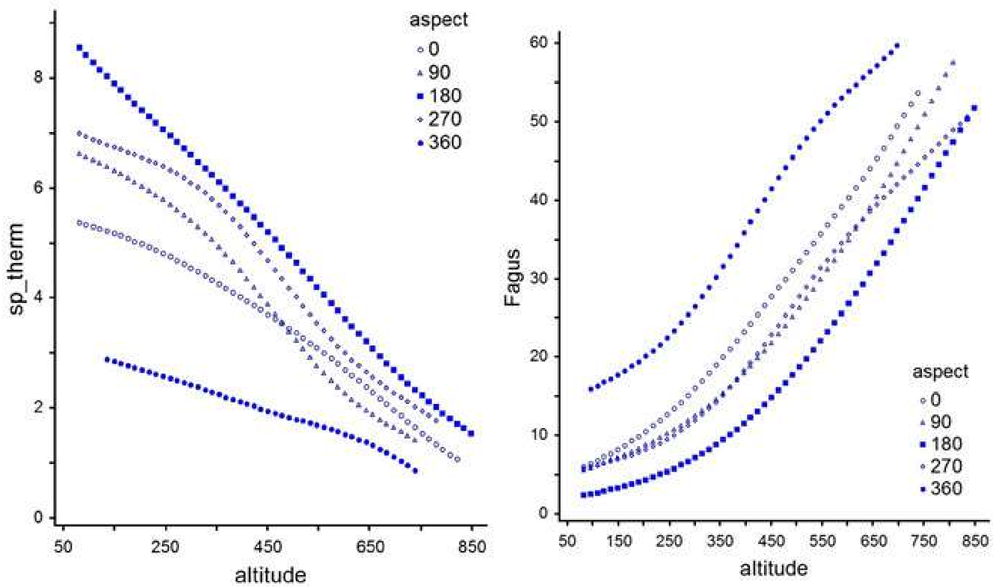

Fig. 5. The effect of altitude and aspect (degrees from N) on the number of thermophilous species (sp_therm) and beech dominance

At altitudes below 500(550) m beech could not become dominant on southern or south-western slopes, whereas at higher altitudes, as the water availability increases, the effect of solar radiation cease to be a limiting factor for beech. As the phytosociological data is expressed in terms of Braun-Blanquet scale, with coarse abundance amplitude, we decided that the score 3 (=cover between 26 and 50%) could express a high competition of beech that leads to *Fagion* forests. Thus, modelled niche of beech in Figure 5 indicates that on sunny slopes beech may exceed 25% cover at altitudes higher than 600 m. For thermophilous taxa, this is a known pattern – decreasing of their number with altitude, but it worth attention that the aspect plays a key role even at lower altitudes (150-100 m). This suggests a significantly distinct microclimate, potentially favourable for mesic species.

4. Discussion

Due to poor data on spatial position of relevés in the existing database, the use of climatic data derived from releve’s location and WorldClim grids may induce considerable bias in the analysis. Thus, indirect estimate of environmental gradients, based on indicator values of species became a safer alternative for an overview for vegetation-climate interaction.

Gradients on water availability can be explored on relatively short altitudinal sequence, due to changes in slope and aspect. The zonal beech forest biomes (euclimatopes) start at approx. 550 m a.s.l., though such forests may occur on shady slopes down to 150 m. The above findings indicate that the ecotonal transition between beech and oak-hornbeam forests should be studied in south-western Romania on gentle slopes near 550 m. The gradient analysis could be performed on transects starting from 600 m downhill to 200 m, representing gradients of decreasing mean annual precipitation (from 800 to 600 mm), increasing temperature (+2-3°C) and increasing risk of drought stress as a proxy for climate warming. We proposed the selection criteria: (i) near-natural deciduous forests; (ii) coherent and widely undisturbed woodland areas; (iii) sufficient elevational sequences; (iv) intermediate level of hygrotope (soil moisture regime) and trophotope (soil nutrient regime); (v) same slope aspect (south-eastern direction); and (vi) sufficient distance (50-60 km) to each other. After applying the stratification criteria we selected (1) Munții Zarandului, (2) Munții Poiana Ruscă, and (3) Munții Almăjului.

Ecotonal transition from the *Fagion* to the *Carpinion*is associated with increasing drought stress, as indicated by mean U-values.

In contrast to the NFI survey the phytosociological database also provides the species composition of the forest field layer. Nevertheless, its preferential sampling does not guarantee to reveal the real climatic gradients on a local scale but for analysis on regional scales this effect diminishes. Other issues that may affect results accuracy are differences of sampling skills between surveyors, some inaccurate records of species cover and uneven records on tree seedlings.

5. Conclusions

Analysis of forest communities in western Romania indicates a close relation between tree and herb layer composition. The gradient of temperature is not strictly bound to latitude, since other factors like orography and relief openness may interfere. The use of mean Ellenberg values allowed to explore thermo-hydric gradients and to define the range of euclimatopes for beech forests and transition drivers to mesic-dry communities. The best predictor for tipping points is the soil water availability, which is better reflected by the mean indicator value for soil humidity (Ellenberg's U), and consequently by stress tolerant species. Comparing with the annual mean precipitation derived from DEM, this parameter incorporates the amount of precipitation but also soil water capacity and evapotranspiration.

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SEASONAL VARIABILITY OF GAS EXCHANGE RESPONSES AND HYDRAULIC TRAITS OF THREE PROVENANCES OF *PINUS HALEPENSIS* MILL.

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Abstract: *The now regenerating forests will have to adapt to overcome novels climatic conditions in order to sustain for several decades, even more than a century. These terrestrial ecosystems play an important role against the increase of greenhouses gas emissions in the atmosphere and so in the prevention from climate change that significantly modify ecophysiological responses of trees and deeply affects ecosystems. The aim of this study was to compare the water status of three Aleppo pine sites from different bioclimatic stages: Djebel Zaghouan (DZ), Djebel Mansour (DM) and Djebel Sarj (DS), based on soil-plant-atmosphere continuity. The experimental approach was based on monitoring soil water behavior, gas exchange and hydraulic conductivity with climatic variability. Our results showed that DZ was both tolerable water status and physiology compared to the others sources DM and DS. It also showed the best performance in terms of adaptation with a low average of* ET_0 *(3.2 mm/d); while DM and DS recorded 5.3 and 5.5 mm/d, respectively. In addition, DZ showed a significant relative humidity in the soil reaching 26% and a xylemic conductivity with 16.3% of embolism compared to DM and DS, which have the highest percentages related to the increase in drying up. In conclusion, our data showed a significant difference in physiological behavior between the three provenances.*

Key words: *Aleppo pine, climate change, gas exchange, conductivity, water status.*

1. Introduction

The forest sector is a vital natural resource in the world. It is closely related to the water sector, being capable of modifying its quality and availability. The forest, through its biological functions, plays an indispensable role by reducing surface runoff and improves water storage. It is as an essential filter of pollutants for the conservation of biodiversity. In Tunisia, forests, maquis and garrigue trees reach 686.459 ha and almost half of the surface is occupied by

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Aleppo pine, which remains an important plant in terms of productivity at national level [6]. One third of Aleppo pine plantations (115045 ha) are located in northeast Tunisia in the regions of Zaghouan and Siliana. These regions were affected by the adverse effects of climate change which had been caused the destruction of quite 6158 ha in the last decade [6]. These effects are mainly explained by the increase of greenhouse gas (GHG) emissions due to the anthropogenic activity.

The manifestations of climate change such as the arising temperatures, the decrease in rainfall, the appearance of extreme events, fires were affected our country more deeply from south to north, which is proven by an increase in aridity from which the forestry sector, like other sectors, is actually increasingly threatened.

Climatic disturbances are also causing the decrease of summer soil humidity [4, 6], the increase of evaporation in all Mediterranean regions and the accentuation of extreme events such as droughts ; they become more intense and more severe, leading to water deficits and decreasing availability of water resources.

Tunisia was therefore facing a situation of water scarcity, which could be intensified further with the potential different scenarios of the future climate changes; bearing in mind that the volume of available water would be only around 360 m^3/year/inhabitant by 2030 [13]. Furthermore, ground water resources at the ground water level will decrease by 28% in 2030, while, the decrease in surface water will be around 5% at the same horizon [12].

The forests service in providing water was the objective of several studies that have a key role hence the reforestation projects around the world are increasing [9]. In Tunisia forestry studies, about adaptation and their productivity in relation to present and future climatic disturbances remain unsatisfactory. The aim of the present study was to create a model of hydrological, climatic and physiological study of the Aleppo pine trees to improve the knowledge of their general status and their spatiotemporal variability in three different geographical zones from Tunisia namely Jebel Zaghouan (DZ), Jebel Mansour (DM) and Jebel el Sarj (DS).

2. Materials and Methods

2.1. Plant Material

The experimental Sites were located in Northeast of Tunisia (Figure 1). Geographical characteristics of sites are illustrated in Table 1.

Table 1

Geographical characteristics of study areas

Forest	Location	Latitude	Longitude	Altitude [m]
Djebel Zaghouan	Zaghouan	36° 22.0' N	010° 07.0' E	320 - 330
Djebel Mansour	El Fahs	36° 15.0' N	009° 47.0’E	397 - 405
Djebel el Sarj	Siliana	35° 57.0' N	009° 33.0' E	793-798

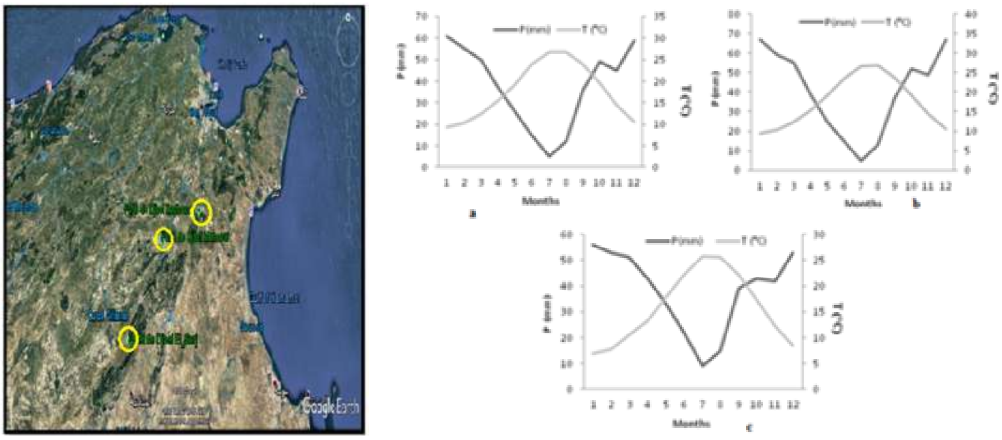

Fig. 1. Location of sites and climatic diagrams of studied sites for the period 1982 – 2012 [23]

2.2. Relative Sol Humidity

Soil water content was monitored weekly by time domain refractometry (TDR, Trase system I, Soil moisture Equipment Corp., USA).

2.3. Leaf Water Potential

Leaf water potential (LWP) was determined using the pressure chamber technique. Small twigs were cut and put in a pressure chamber (Arimad 2®, A.R.I, Kfar Charuv, Israel) fed by a Nitrogen gas cylinder and equipped with a lamp-carrying magnifying glass.

2.4. Evapotranspiration

Evapotranspiration was determined using The 'MABIA-ET0' software according to the FAO-PENMAN-MONTHEITH method [1]:

$$ET_0 = \frac{0{,}408 \cdot \Delta \cdot (R_n - G) + \gamma \cdot \frac{900}{T+273} \cdot u_2 \cdot (e_s - e_a)}{\Delta + \gamma \cdot (1 + 0{,}34 \cdot u_2)} \tag{1}$$

where:

- ET_o is reference evapotranspiration [mm/day];
- R_n - net radiation on the culture surface [MJ/m^2/day];
- G - soil heat flux density [MJ/m^2/day] negligible (G = 0);
- $T_{moyenne}$ - average air temperature [°C];
- u_2 - wind speed measured at 2 m height [m/s];
- e_s - saturation vapour pressure [kPa];
- e_a - actual vapour pressure [kPa];
- e_s - e_a - saturation vapour pressure deficit [kPa];
- D - slope vapour pressure curve [kPa/°C];
- g - psychrometric constant [kPa/°C].

2.5. Climatic Parameters of Studied Sites

The climatic parameters characteristics of the studied sites are summarized in Tables 2, 3 and 4.

2.6. Gas Exchange Measurement

Gas exchanges were measured with a Li-Cor Li-6400XT Portable Photosynthesis

System (Li-Cor, Li-6400XT Lincoln, NE, USA) based on the IRGA principle (Infra RedGas Analysis). The leaf stomata conductance (g, in mol H_2O $m^{-2}s^{-1}$), net carbon assimilation (A, in µmol CO_2 $m^{-2}s^{-1}$), and transpiration (T, in mmol H_2O $m^{-2}s^{-1}$), were measured on the *Pinus halepensis* needles of each studied sites. Twelve branches were used from each site. They were cut and placed in tubes with their bases under water. The experiments were carried at a leaf temperature of 25°C and humidity of 50-60%. The needles of each branch were placed under the clamp of the chamber assimilation (6 cm²) and they were acclimatized for 35 minutes. A program was then set to make a variation of the CO_2 concentration. These measurements were used for the calculation of intrinsic water-use efficiency (WUE, in mmol CO_2 $mol^{-1}H_2O$) according to: WUE = A / g.

Table 1

Climatic characteristics (November 2016 – October 2017) for DZ

Months	T_{max} [°C]	T_{min} [°C]	HR_{max} [%]	HR_{min} [%]	N [h]	U_z [m/s]	ET_o [mm/j]	Precipitation [mm/j]
1	13.8	5.8	72.5	72.5	8.7	5.3	1.7	1.6
2	17.8	8.4	71.5	71.5	12.1	4.8	1.9	1.4
3	20.5	9.6	65.9	65.9	17.7	5.0	2.4	0.3
4	22.4	11.4	61.7	61.7	20.5	4.7	2.9	0.5
5	27.7	15.4	56.9	56.9	25.0	4.4	3.6	0.0
6	32.5	20.1	50.8	50.8	26.6	4.0	4.3	0.6
7	35.1	22.7	45.3	45.3	27.6	5.4	6.1	0.0
8	36.0	23.8	45.0	45.0	25.0	3.8	4.9	0.1
9	30.4	19.7	56.8	56.8	19.0	4.4	3.9	0.2
10	24.8	15.7	68.2	68.2	13.8	4.3	2.5	1.5
11	21.8	13.3	68.0	68.0	9.0	4.2	2.3	0.7
12	17.0	10.5	77.9	77.9	7.0	4.3	1.4	4.5

Table 3

Climatic characteristics (November 2016 – October 2017) for DM

Months	T_{max} [°C]	T_{min} [°C]	HR_{max} [%]	HR_{min} [%]	N [h]	U_z [m/s]	ET_o [mm/j]	Precipitation [mm/j]
1	11.6	2.0	6.3	6.3	8.2	4.8	4.3	1.1
2	17.0	5.3	10.2	10.2	11.5	4.7	4.9	1.0
3	20.0	6.7	12.5	12.5	17.1	4.6	5.3	0.8
4	22.1	8.4	14.7	14.7	19.9	4.2	5.5	0.8
5	28.9	12.7	20.3	20.3	24.3	4.0	6.1	0.0
6	33.6	17.6	25.2	25.2	26.0	3.4	5.9	0.7
7	36.5	20.3	28.1	28.1	26.6	4.8	7.5	0.0
8	37.4	21.5	29.0	29.0	24.7	3.7	6.4	0.0
9	30.1	16.2	22.6	22.6	18.3	3.7	5.9	0.3
10	23.7	12.0	17.0	17.0	13.7	3.8	5.3	1.3
11	20.2	9.2	13.7	13.7	9.7	3.8	5.0	0.5
12	15.0	6.9	10.3	10.3	7.0	3.7	4.3	2.5

Table 4

Climatic characteristics (November 2016 – October 2017) for DS

Months	T_{max} [°C]	T_{min} [°C]	HR_{max} [%]	HR_{min} [%]	N [h]	U_z [m/s]	ET_o [mm/j]	Precipitation [mm/j]
1	12.1	1.2	5.9	5.9	10.2	4.5	4.2	1.0
2	17.6	5.2	10.5	10.5	13.5	4.3	4.8	0.6
3	20.9	7.2	13.2	13.2	18.5	4.7	5.4	0.7
4	22.8	8.7	15.3	15.3	20.4	4.2	5.4	0.7
5	28.9	13.8	21.0	21.0	25.1	3.6	5.7	0.1
6	34.0	18.5	26.0	26.0	27.1	3.4	5.8	0.7
7	36.9	20.7	28.5	28.5	27.6	4.0	6.6	0.0
8	37.2	22.0	29.2	29.2	25.2	3.1	5.6	0.0
9	30.5	16.9	23.1	23.1	20.2	3.7	5.8	0.2
10	24.1	12.1	17.4	17.4	15.2	3.6	5.1	0.4
11	20.5	9.5	14.1	14.1	10.6	3.7	4.9	0.5
12	14.9	6.4	10.0	10.0	8.2	3.7	4.2	2.0

2.7. Hydraulic Conductivity

Measurements of xylem hydraulic conductivity were performed using the HPFM method (high pressure flow meter) as described by Sack et al (2002) and Tyree et al. (2005). The technique consists in perfusing degassed water under positive pressure +P (MPa) in the segment and to measure the flow at the entry. The measured flow values (F, mmol s^{-1}) are automatically recorded in a computer connected to the machine HPFM. The relevant parameter is the extent to which the maximum hydraulic capacity has been reduced by cavitations: Per cent loss conductivity:

$$PLC = \frac{K_{S\,max} - K_S}{K_{S\,max}} \cdot 100 \tag{2}$$

where: K_{min} is the initial conductivity and K_{max} is the maximum conductivity measured after gas trapped within the conduits has been removed, using a high-pressure flush with partially degassed water or holding the measured segment in solution under a partial vacuum [10, 15, 19].

2.8. Statistical Analyses

Data were the object of an analysis of the variance to two factors (Provenance and water stress), significance levels were established at P<0.05. It was completed by a multiple comparison of the averages by the test of Newman-Keuls test (P<0.05) accordingly. The differences between populations for the investigated variables were tested with a Principal Component Analysis (PCA) using R software.

3. Results

3.1. Leaf Water Potential

We observed that in DZ, water potential values (Figure 2a) varied between 4.5 and 5.9 Bar. This variability is highly significant between seasons one can note that there was low variability between measurements on the same trees in different seasons. This variability reflects, as a first approximation, differences in water consumption, due to the low inputs they receive, especially during the summer.

While, it was observed for DM (Figure 2b), water potential were higher than those obtained in the DZ site. They were between 7 and 5.5 Bar in both spring and summer but increase more for the DS site (Figure 2c) but no significant differences were recorded between sites.

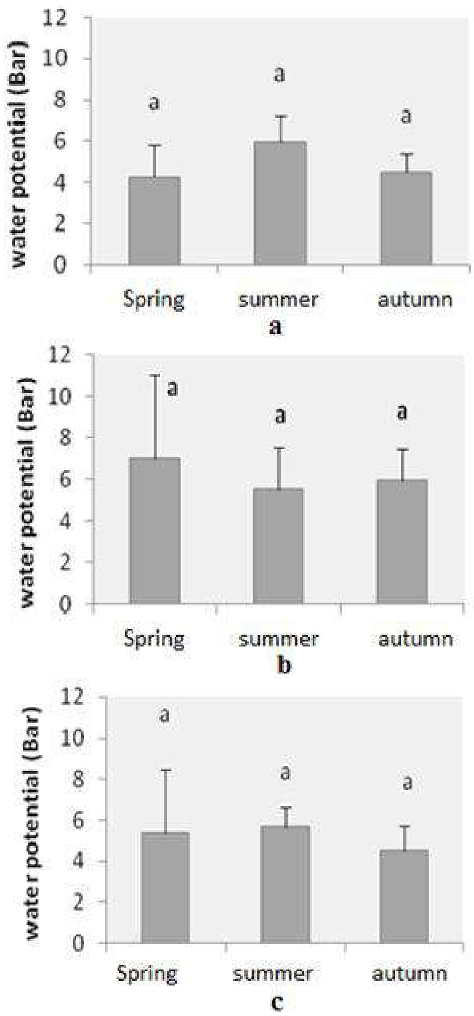

Fig. 2. Leaf water potential in: a. Djbel Zaghouan: b. Djbel Mansour; c. Djbel Sarj

3.2. Seasonal Variation of Net Photosynthesis

For DZ site, the Transpiration (Tr) and Photosynthesis (An) decreased from spring to autumn (Figure 3a) Photosynthesis varies from 8 µmol m^2s^{-1} in spring to 1.5 8 µmol m^2s^{-1} in autumn. The measured values were positively correlated with trees conductivity variation of the trees (Figure 3a).

The two sites DM and DS showed the same trend of variation as recorded in DZ site, but with lower averages (Figures 3b and 3c). This parameter does not have a significant difference between seasons.

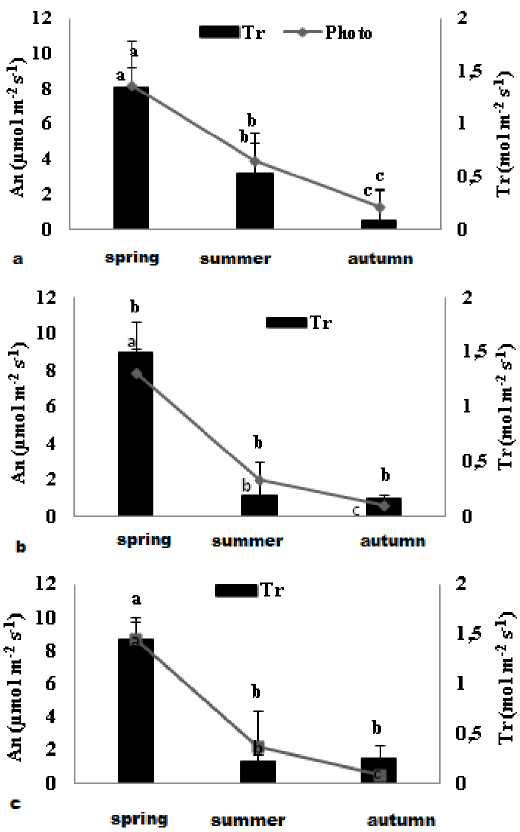

Fig. 3. Seasonal variability net photosynthesis and transpiration of three provenances

For Tr, a significant variability was observed especially in summer and autumn (Figures 3a, 3b and 3c) when the climatic factors are severe. It was recorded between July and August 0 mm office plurality of rain with an increase in temperature about 16 C compared to spring (Figure 4).

The variability of gas exchange was strongly correlated positively with the change in relation to the humidity of the air.

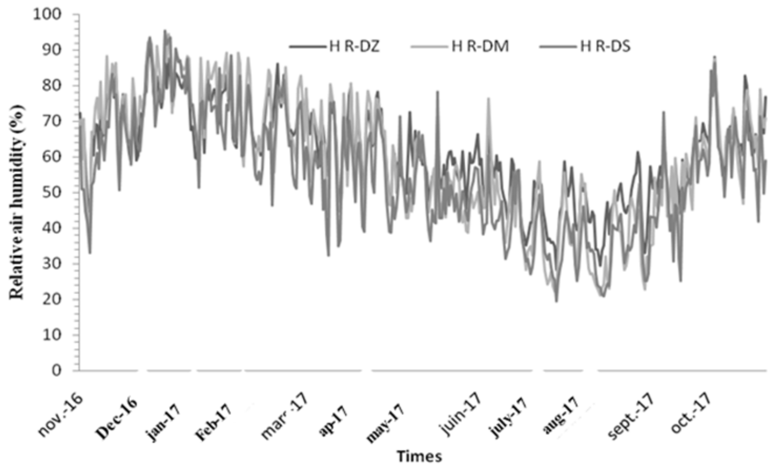

Fig. 4. Evolution of the percentage of relative air humidity in three sites

3.3. Hydraulic Conductivity and Stomata Conductance

In the DZ site, the results obtained from statistical analysis showed that K_{min} had significant inter-seasonal differences.

The obtained averages ranged from 1.4 x 10^{-5} during the autumn to 4.87 x 10^{-4} mmol s^{-1} m^{-2} MPa^{-1} in the spring (Figure 5a) with an intermediate of 1.2 x 10^{-5} mmol s^{-1} m^{-2} MPa^{-1}during the summer season.

We also observed that K_{max}, values were positively correlated with K_{min}. The measurement of embolism showed only 16.3%, which can prove that the drought does not necessarily affect the conductivity in this site (Figure 6).

For the DM site, a significant difference in initial hydraulic conductivity values between the three seasons were recorded. They were almost non-existent during the summer and autumn, compared to spring time (Figure 5b).

Furthermore, low spring temperatures may explain this inter-seasonal variability.

The averages of changes in conductivity at this site ranged from a low level of $5.92.10^{-6}$ in the fall to a higher level of $2.17.10^{-4}$ mmol s^{-1} m^{-2} MPa^{-1}in the spring, which had significant differences with K_{max} values following 63.20% increase in embolism.

Similarly at DS site (Figure 5c) the conductivity increased during the spring compared to the two other seasons but it remains very low and has a significant difference between K_{min} and K_{max}.

We observed that K_{in} and K_{max} xylem conductivity in this site were lower than the two other sites, DZ and DM showing a 70.6% increase in PLC percentage (Figure 6).

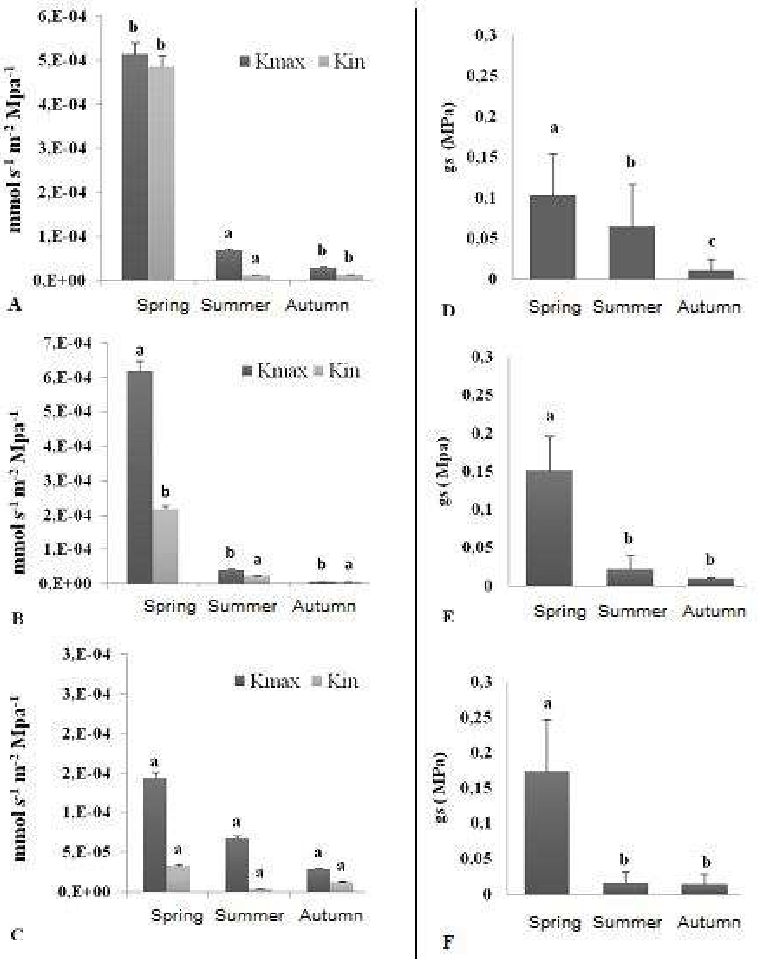

Fig. 5. Seasonal variability of xylem conductivity (Kin and K_{max}) and stomatal conductance (gs) of three provenances

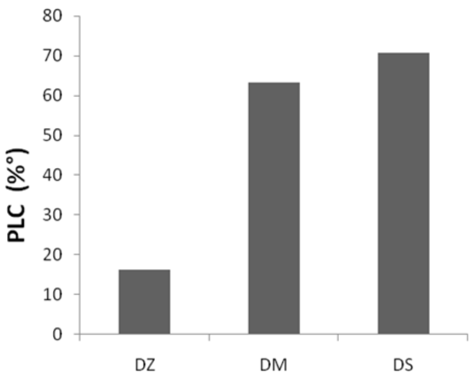

Fig. 6. Percentage of loss conductivity of three provenances

In spring, it was shown an increases in K_{in} and K_{max} values while they also appear to be non-existent during the fall and summer.

These variations are positively correlated with climatic factors such as the rainfall decrease in summer and the increase of the daylight period.

We showed a significant correlation between net photosynthesis, stomatal conductance, and transpiration. While, not significant correlation was observed with K_{in} an K_{max} (Table 5).

Table 5

Correlation matrix of the different parameters measured

	WP	K_{max}	K_{in}	g_s	Photo	WUE	Tr
WP	1						
K_{max}	-0,178	1					
K_{in}	-0,389	0,453	1				
Cond	0,312	-0,446	-0,390	1			
Photo	0,191	-0,497	-0,375	**0,959**	1		
WUE	-0,175	0,020	-0,413	-0,298	-0,400	1	
Tr	0,228	-0,449	-0,449	**0,969**	**0,977**	-0,241	1

In bold, significant values (off diagonal) at the alpha threshold = 0.050 (two-sided test).

Principal components analysis showed that the interactions between the sites and the parameters studied are close. Depending on these parameters, two distinct groups can be distinguished (Figure 7):

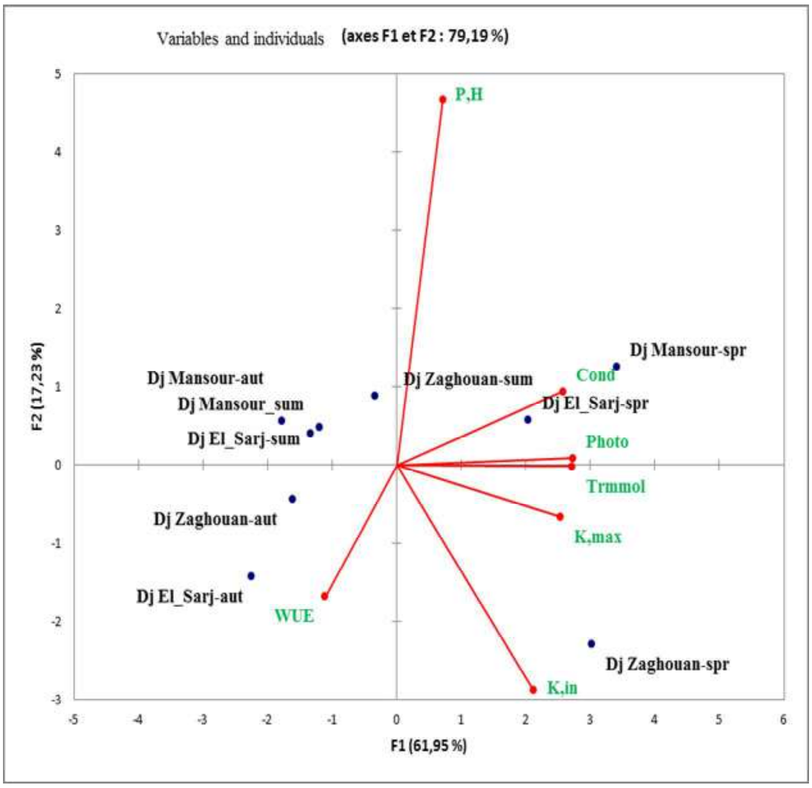

Fig. 7. Distribution of physiological parameters according to provenances and seasons

Zone A: includes the two sites Jebel Zaghouan and Jebel Mansour where most of the studied parameters have positive correlations, which can probably confirm that the physiological state of the Aleppo pine trees in these two provenances, which are probably more resilient towards the climatic disturbances and that they are then more resistant.

Zone B: concerns Djebel El Sarj where the existence of the increase of water potential was observed which is a factor describing the state of stress with climatic factors not very suitable to the growth of this species.

4. Discussions

Drought tolerance is a known characteristic of Aleppo pine trees compared to other species, and is probably due to efficacy stomatal control. The closure and opening of stomata are strongly related mainly to water availability [2]. In the studied sites, DZ presented the site with the lowest stomatal conductance when compared to the other two sites. It gathers then the character of the most tolerant source of climate variability. The increase in pH was considered as a drought alert state of the studied species because the more it increases the more water tends to leave this compartment the lower the humidity on the ground [11]. This increase was more observed in DS than DM and DZ in relation to the increase in stomata conductance in the same site.

It was found that the level of embolism in DZ is lower than the other two sites studied. This low rate can be an index of the adaptation of this site to the drought, which increased more and more when considering the other two sites. These results are in agreement with those of Sperry et al. (2005) and Salleo et al. (2001) who showed that xylemian hydraulic conductance was controlled by physical processes such as vessel dimensions, wall structure that can be disturbed by the creation of embolism or bubbles of air and water vapour that chase the liquid phase. The vessel is then called cavity or embolized [20]. It was also reported that cavitation occurs particularly in case of soil drought [8, 22].

It can also be seen that the stomatal conductance followed the same aspect of variation in the xylem conductance [3]. These results are in agreement with those described by Cruiziat et al. (2001) who found that the variation of the stomatal conductance was positively correlated with the opening and closing of the stomata.

The variation of photosynthesis is dependent on temperature. By causing stomata closure, the water deficit prevents gas exchange and thus a reduction in photosynthesis [14] as the case studied in the three sites during the summer season.

Leaf transpiration is a parameter of the water status of the plant. Its variation is related to that of photosynthesis, at the same stages. The reduction of transpiration was observed mainly in the DS site with increasing temperatures.

The analysis of these parameters shows that the water status of DZ despite increasing temperatures and lowering precipitation is the most resilient site in terms of adaptation to climate change.

5. Conclusion

The adaptability of the Aleppo pine species to climatic factors, such as the variability of temperatures and the reduction of cumulative rainfall, which consider themselves as inhibiting factors of its resilience, does not prevent it from to be more productive and tolerant in more sites than others.

The comparison of the three provenances DZ, DM and DS requires a good knowledge of the soil-plant-atmosphere system during the same periods of study (March-October, 2017).

Principal component analyzes (PCA) after experimental analyzes at the three provenances indicated positive correlations between tree gas exchange, conductivity, and water profile during seasonal variability with maximum spring averages.

Modeling of ET0 using the Penman-Montheith method (FAO-56) by MABIA-ET0 revealed that the DZ site is the most tolerant, with the lowest average (3.2 mm/d).

Using the statistical study of physiological data (stomatal, xylemian conductance) of Aleppo pine trees, a positive correlation was confirmed. These are related to the seasonal variability that affects stomatal status in all sites.

DZ has a lower conductivity than DM and DS which gives it the character of the source having more stomatal control.

In the same context, the decrease in the values of the physiological parameters due to the summer drought is accompanied by an increase in the water potential in the three provenances.

According to all this results, Jebel Zaghouan has the most favourable characteristics for the development of Aleppo pine and the lowest vulnerability to the climatic disturbances that Jebel Mansour and Djebel El Sarj.

No other conflict of interest between my work and that of the authors.

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ESTABLISHING CRITERIA FOR CALCULATING THE TAX/ROAD TOLLING FOR VEHICLES USED FOR TIMBER TRANSPORT ON FOREST ROADS

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Abstract: *The article presents four principles for calculating the toll for vehicles running on forest roads, whether they transport timber or other materials. Based on the discussions with the representatives of the National Forest Administration ROMSILVA RA, the ideas that formed the basis of establishing the calculation principles were outlined. Thus, the first principle involves the establishment of a charge at toll based on the volume of timber harvested and transported on the road, length of the forest roads network and investments on these roads. Taking these aspects into consideration for a period of four years, and the specific weight of the transported material, it reaches a value that will be applied to each cubic meter, under the conditions that does not exceed the maximum permissible total weight. If maximum permissible total weight exceeded, it is recommended to double the value. The second principle involves the establishment of a tool based on the method of calculating the fund for accessing the forest fund. The third principle aims presume to introduce a "Forest Vignette ", similar to the one on national roads, and imposing sanctions under the conditions of exceeding the maximum permissible total weight. Principle four involves differential application of the road tolling according to the type of vehicle, taking into account the wheel-road contact, axle number and axle load. After analyzing the four principles, it is considered that the most viable principle to be applied at national level for forest roads under administration of ROMSILVA RA is the second one.*

Key words: *forest roads, road tolling, wood transportation, vehicles for transport.*

1. Introduction

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Investments in transport infrastructure involve a number of costs relating both to its extension and to the maintenance of the transport network under optimum operating conditions. In Norway, for example [5], revenue from tolls are directed more than 50% for investment in roads and the remaining for investment in public transport, the amounts being considered a joint contribution of users, state and local authorities, representing a consistent source of incomes for the state budget. The problem toll for transport infrastructure is approached differently, in some cases having a fairly long history [5] and can be applied both for highways [7], national roads [5, 10], bridges [8, 10], ring networks around cities [5] or private roads managed by local municipalities [5] or other owners. In case of Romania [10], a usage tariff called vignette, is applied on national roads for both Romanian and foreign users using the national transport network. It is set according to the journey and stationary time, the class of pollutant emissions (EURO), the maximum authorized mass and the number of axles.

In addition to this usage charge, the legislation in force [10] also provides tax that involves the payment of a sum of money for a vehicle crossing a road sector, a bridge, a tunnel or a mountain pass part of the national road network, electronic registration of the tariff crossing representing the toll paid before crossing.

The importance of collecting tolls for transport network lies in the impact that cars have on transport routes, which why there are many studies that highlight the effect of traffic on the structure of the road [2-3], degradations arising from traffic [2, 4], the interaction between vehicles and bridges [8] and even influence electronic automatic charges on the level of emissions in air [7].

The forest roads are designed to meet their own road transport requirements in forest activity, for the purpose of forest management and timber transport, being classified as transport roads in the group of construction for transport [1].

On the forest roads are transported both timber (round wood, split wood, shredder wood, charcoal), as well forest products (fruit, resin, shell), goods needed for supply and maintenance, workers and administrative staff, all leading to wear the forest transport infrastructure.

In order to finance the investment works in forest roads, it is intended to apply a tool tariff which will concentrate the income in a separate account which shall be used only for the maintenance and repair of forest roads [13]. Even if a tariff for use of the transport network can not lead to cost efficiency [5], it has beneficial effects on the investment fund.

Based on these considerations, the paper presents four principles that can be taken into account when calculating the tool for vehicles travelling on forestry roads, especially since the financing of the forest roads construction and maintenance is provided from three sources [11], respectively from the forest accessibility fund, from the state budget or from other sources, according to the law.

2. Principles for Establishing Road Tolling

Based on the discussions with the representatives of the pilot forest county, respectively Bacău, Piatra Neamț and Suceava and the studying of the specialized literature, there are 4 principles that were considered viable and can be applied for a unitary collection of the toll for vehicles running on the forest roads administered by the ROMSILVA RA National Forestry Administration, whether they transport wood or other materials.

2.1. First Principle

For establishing the first principle, the data provided by Forest County Suceava were taken into account.

The calculation method mainly refers to report of the cost corresponding to the current maintenance and repairs, and possibly also the capital repairs, where applicable, for the last 4 years, to the volumes transported on forest roads. Thus, in addition to the volume of the transported mass and the maintenance and repair costs, the length of the entire transport network, the number of roads and the specific weight of the transported material are taken into consideration, finally resulting a tariff expressed in lei/tons*km.

It is worth mentioning that this tariff it is applies if the transported mass does not exceed the total admissible maximum value of 38 tons mentioned in the Normative Document for Design the Forest roads [12], for trucks with trailers. The quantity transported above the maximum total allowable weight shall be taxed by double the tax determined by the previous calculation, applied for each cubic meter of timber transported over the accepted limit. The toll for overtaking the allowable tonnage can also be applied to economic agents transporting wood from the state forest fund or any other material.

2.2. Second Principle

The second principle has the main argument Law no. 56/2010 regarding the accessibility of the national forestry fund, which follow a sustainable management of this, carried out both by road construction works and through interventions on the existing roads in order to maintain the integrity and functionality of them.

Thus, it is proposed that the calculation of the rate of toll on using forest roads to be like the calculation of forest fund accessibility, respectivelly 10% of one cubic meter of standing timber [11], approved by the central public authority responsible for forestry, and the National Forestry Administration which will establish annually the value of the percentage of application.

If the wood mass of a harvested stand crosses forestry roads belonging to several owners, the tariff of toll due to the use of the transport network will be paid to them in proportion to the length of the throughput.

The payment of this charge will be made prior to the issue of the harvesting authorization, by transferring by the forest district that made the stand registration into SUMAL of an amount owed to the Forest County or to the Territorial Administrative Unit that manages the forest road.

The fund will be set up for the entire amount of wood that is harvested, regardless of the nature of the product or the owner.

The same amount (calculated in lei/ tonne) will also be due for the economic operators carrying out works to extract mineral aggregates, for the volume authorized by the National Authority for Mineral Resources.

2.3. Third Principle (Forest Vignette)

This principle is based on the toll tariff use for national roads, with a new form of tolling called " Forest vignette ", which can be purchased for a day, 7 days, 30 days and 12 months.

Although these time intervals are similar to those vignette applied for national roads [10], there some differences that take into account that take into account the specifics of the forest roads, where traffic on the intermittent.

Establishing a toll must take into account the average travel speed (15 km / h), the average length of the country's forestry roads (considered twice for full drive and empty drive, approximately 7 km), the time of the wood loading operation in the loading area (1,5 hours) and the time of the unloading operation. Including the driver's rest times, according to the tachograph diagram finally results 4 hours for each transport. Thus, the type of "Forest Vignette" is proposed with the following alternatives (Table 1): daily, weekly (4.5 actual days), monthly (18 effective days) or yearly (216 real working days).

Table 1

Parameters took into account for establishing the Forest Vignette

Type of “Forest Vignette”	Average mass for one drive [t]	Tonaj maxim admis [t]	Maximum allowable tonnage [m^3]	Number of drive per day	Number of drive days
Daily	18	38	20	2	1
Weekly					4,5
Mothly					18
Yearly					216

It is worth mentioning that the one-day toll corresponds to the value determined by one of the above principles but is multiplied with the average transport distance, and the value is finally expressed in Euro. For the other types of Forest Vignette, the daily toll is multiplied by the real number of transport days.

In addition, it points out that the Forest Vignette calculated in this variant, it could be applied to all vehicles complying with the maximum allowed tonnage [12].

For over tonnage, the legislative framework specific to national roads [9], referring to the maximum masses and dimensions admitted in Romania (Table 2) is applied, compensations taking into account the additional volume transported and the average distance for transport.

2.4. Fourth Principle

Fourth principle is more laborious, but more accurate and leads to differentiated application of the toll based on the characteristics of the vehicle used to transport, taking into account the wheel-road (p * D) characteristic, but also the number of axles and the load on each axis, elements closely related to the magnitude of recorded degradations [2-4, 8].

At the basis of this principle is the very large variety of vehicles traveling on forest roads (truck, semi-trailer tractor, trailer truck) in which the number of axles and maximum permissible load on each axle are different.

Table 2

Establishment the forest tax / road tolling for forest roads in accordance with national road legislation [9]

Application interval	Computing Unit	The compensation fee applied per m^3 of additional transport, with VAT (Euro)
40,01 – 45,00	Tax/road tolling x average transport distance	0,56
45,01 – 50,00		0,62
50,01 – 55,00		1,37
55,01 – 60,00		1,49
60,01 – 65,00		1,62
65,01 – 70,00		1,74
70,01 – 75,00		1,86
75,01 – 80,00		1,99
80,01 – 85,00		2,11
85,01 – 90,00		2,24
90,01 – 95,00		2,36
95,01 – 100,00		2,48

The analysis of the influence of the wheel-road contact characteristic is particularly important when assessing the impact of traffic on the roadside, and has been studied in numerous papers [3-4, 6, 8]. The wheel-road characteristic, hereafter denoted as p * D, is influenced by the load applied to the tire and its size, since the dimensions determine both the pressure to be inflated and the pressure on the ground.

Analyzing the most used vehicles forest transport, it has been found that they have a maximum authorized mass on the rear axle of 21 tones, and the traction type is 6x4. For these types of vehicles, a value of p * D (loaded) of about 190 results (double deck whit twin wheels).

Thus, there is obtained a ratio between the ordinate values corresponding to the values of the abscissa 170 and 190, between 1.05 and 1.2, depending on the type of road structure.

These ratios increase for p * D = 210 with about 0.1 (the increase is linear). In conclusion, the approximate increase, which could be adopted for any of the types of road structure, is 10% for 20 units of the p * D characteristic, as in the example in Table 3.

Table 3

Increasing the ratio E_{nec}/E_{ech}, according to p * D (170 beeing the reference value)

type/p*D	170	190	210	230
1.5	1.00	1.11	1.21	1.32
1.6	1.00	1.12	1.22	1.32

It is important to note that these values are for a deck of the forest truck.In determining the degree of damage to the road structure by a truck or trailer (and hence the toll) must take into account the total number of loaded decks.

Thus, it can be considered as a reference a vehicle for which all axles have the characteristic p * D = 170, with a number of two decks (front simple axle andrear axle twin-wheeled). This means that all vehicles used will relate to the reference vehicle as the number of axles and value p * D for each axle.

For each axle a weighting factor (cp) is applied and for the whole vehicle the effects of all decks will be added:

$$C_p = 1+0.1*(p_iD_i-170)/20 \qquad (1)$$

For example, when considering a Mercedes ACTROS 2646 truck (Figure 1) with 6x4 traction, unloaded at full capacity, then each deck falls to the standard deck (p * D = 170).

Adding the effects of all decks, a multiplication factor is obtained for the entire truck (Table 4):

Fig. 1. Mercedes ACTROS 2646 [14]

Table 4

Example of decks loading for 6x4 trucks

	Mass [kg]	Number of axle	Load on deck [kN]	Pressure [kPa]	Equivalent diametre [mm]	p*D	c_p
Rear deck	2x 8500	2	85	900	173	156	0.93
Front deck	6000	1	60	750	226	170	1.00

Adding effects to all decks provide a multiplier for the entire truck:

$$c_v = 2*0.93 + 1.00 = 2.86 \quad (2)$$

For wood transport often is used trucks with trailers. An example is the one in Figure 2, a 6x4 truck with a 2-axle trailer.

In the study it was considerate that this type of vehicle is loaded at maximum capacity, that means almost 16 tonnes on the truck and 16 tonnes on trailer. The truck has a proper load of approximate 15 tones, and the trailer almost 4 tones. Taking into account all this information, it resulting the data from Table 5, respectively the load on the axles and the multiplication coefficients.

Gathering the effects of all the axles, it can be obtained a multiplication coefficient for the entire vehicle:

$$c_v = 2*1.10 + 1*1.00 + 2*1.35 = 5.90 \quad (3)$$

Fig. 2. Truck with trailer for logs transport [14]

Table 5

Example of decks loading for a truck with trailer

	Mass [kg]	Number of axle	Load on deck [kN]	Pressure [kPa]	Equivalent diametre [mm]	p*D	c_p
Rear axle truck	2x 12500	2	125	900	210	189	1.10
Front axle truck	6000	1	60	900	226	170	1.00
Trailer axle	2x 10000	2	100	750	266	239	1.35

For different types of trucks / trailer, with loads between 0 and 70 t, the diagram from Figure 3 was determined. For each of the vehicle types from the chart, a typical mass (for example about 15 tons for a semi-trailer truck, 4-5 tons for a trailer) was considered, and the charge was added gradually by 5 tonnes to

5 tonnes, distributed on decks proportional to the load capacity of each axle. The horizontal axis of the chart represents the payload, in tones. This means that the total weight for curves 1 and 2 exceeds 80 tones.

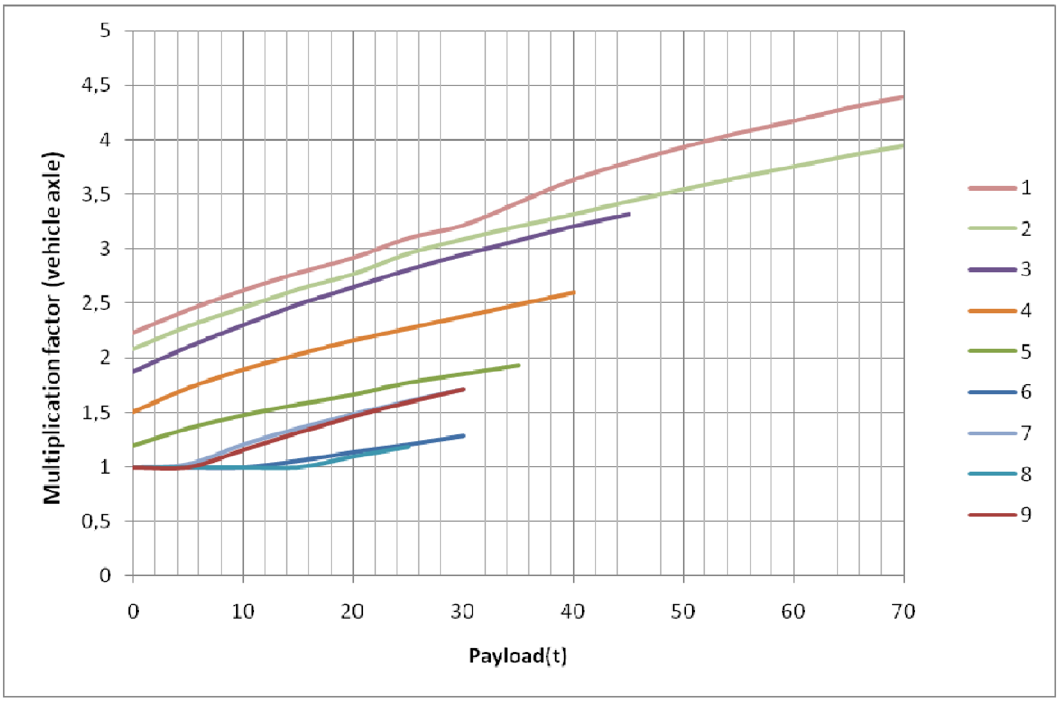

Fig. 3. Nomogram for determining the coefficient c_v for different types of vehicles used for timber transport: 1 - 6x4 truck + 2 axle trailer, single wheels;2 - 6x4 truck + 2 axle trailer, twin wheels;3 - semi-trailer truck; 4 - 4-axle truck (for example 8x4);5 - three-axle truck (6x4);6 - 2-axle truck (4x2); 7 - 3-axle trailer;8 - trailer with 2 axles, twin wheels; 9 - 2-axle trailer, single wheels

In the case of a trailer consisting from a truck and trailer, for variants not included in the diagram, the coefficients determined in the diagram for the two vehicles, depending on the load, can be summed up.

The coefficients determined in the diagram are relative multiplication coefficients to the vehicle equipped with two standard decks (for which the value of the multiplier is 1).

The coefficients are determined from the chart multipliers relative to the vehicle equipped with two standard decks (for which the multiplier value is 1). The subunit values resulting from the calculation were replaced by the value 1 (the lower limit of the multiplier).

For a certain useful mass, the distribution of the deck may vary from case to case. Also, the unloaded mass of the vehicle can be distributed differently on decks.

3. Conclusions

The first principle, although simple to apply and which respects both the values invested in forest roads (maintenance works, current and capital repairs) and the transported volumes, refers to each Forest District in part, which will make a difference between the amounts received. But, it can also be applied at national level, at a unitary value set by the ROMSILVA National Forest Administration.

The principle two can be applied to the whole country, but the amounts collected must be transferred to each road owner, directly proportional to the length of throughput, which can lead to additional calculations and possible misunderstandings between administrators of forest roads.It is the only principle that leads to a full collection of the toll before the start of transport, which is why it is recommended.

The third principle, although referring to some compensation paid by the forest administrator in accordance with the tonnage transported, it must be based on a different way of determining the tax unit of transport, valid for vehicles which fall in tonnage limitand thus a calculation of compensation by identifying the type of vehicle used for transport.

The fourth principle, although very laborious, involves the application of the toll in concrete conditions, depending on the type of vehicle used for transport, and takes into account about the degradations resulting from the exceeding of the maximum allowable tonnage. As in the cases of the first and third principles, determination of the value will be done in the field or in the office after the transport.

Considering the above mentioned, only principle two can be applied uniformly, as the toll is collected in anticipation from all operators (transporters) and provides a separate source of funding for the maintenance and execution of current repairs to forest roads.

Given the fact that the application of principle two is not possible for various reasons (normative acts, modification of the SUMAL application), principle three (Forest vignette) can be applied.

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ASSESSMENT OF FIREFIGHTING FACILITIES AND ROADS REGARDING WITH FIRE-RESISTANT FOREST PROJECT (YARDOP)

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Abstract: *As a result of natural disasters such as fire, storms, avalanches etc., natural resources have been destroying rapidly in the world. Due to global warming and other factors, forest fires result in serious damages on forest resources in arid regions. Therefore, firefighting activities should be well planned and special attention should be paid to grow fire-resistant forest in the regions with high fire risk. For this purpose, firefighting facilities (i.e. fire breaks, fire lines) and roads for the purpose of fire protection and fire-fighting should be specially evaluated in these regions. Road networks are effectively used during and after a fire and are also used to stop the fire. In this study, the firefighting facilities and roads developed for fire intervention within the Fire-Resistant Forest Project (YARDOP) have been evaluated. Within the project, firefighting facilities have been planned to build a fire-resistant stands. These firefighting facilities can also be used for firefighting purposes. This study indicated that the standards of firefighting facilities and roads used in YARDOP projects are likely to be an alternative solution for many countries, especially in the Mediterranean countries and generally in the same environmental conditions around the world.*

Key words: *forest fires, forest roads, fire breaks and fire lines, YARDOP.*

1. Introduction

Forest fires are one of the most disturbing factors affecting natural ecosystems. Currently devastating wild fires affect vast regions throughout the world [5], in particular the fragile ecosystems of the Mediterranean basin that are known to be at high risk of desertification [10].

Forest fires can cause the destruction of a large number of trees and the death or displacement of wild animals. Intense combustion not only burns forest and plants on the ground, but also changes forestry structure, forest biology, climate, and soil performance [11]. In recent years, substantial efforts have been made towards characterizing, forecasting, modeling, planning, and managing forest

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fires in several Mediterranean countries [4].

Forest road network are used for various services such as production, afforestation, transportation, recreational functions as well as fire protection purposes [9]. Forest road networks are very important for quick extinguishing of forest fire since fire trucks carrying firefighting team access fire areas by roads. Fire breaks and fire lines are natural or artificial facilities, which are bare or covered with vegetation to prevent the spread of fire [3]. Fire breaks and fire lines, which can be also used for transportation in fire sensitive areas, are crucial for reaching the fire point using the shortest route, early start of firefighting organization, reducing the impact of fire by limiting the burned area [2].

Various projects have been carried out by forest service in order to fight with forest fire and decrease its effect. Fire-Resistant Forest Project (YARDOP), which was developed for rehabilitation of burned areas and building fire-resistant stands, is the most recent and widely used one. The objective of YARDOP is to increase the physical resistance of stands especially in fire sensitive forest areas. YARDOP and its impact have been studied on various researches [1, 7-8].

In the study, two different fire intervention and protection road plans were introduced regarding with current practices of General Directorate of Forestry (GDF) and new approach proposed by YARDOP project. Both plans have been used for fire intervention and protection in Turkey and it is also possible to use both in combination.

2. Fire Protection Roads

There are two different fire intervention and protection facilities specified by GDF. In some cases, both road types are combined where it is necessary.

Fire breaks: These are uncovered installations built with natural and artificial obstacles which do not contain any flammable material. Their width is 6-15 meters with the average of 10 meters (Figure 1).

Fire lines: These are fire prevention green facilities built on sides of the roads. A wider range of fire hazards are prevented by green spaces generated on one-side or both sides of the roads. One-sided width is 30-60 m (Figure 2).

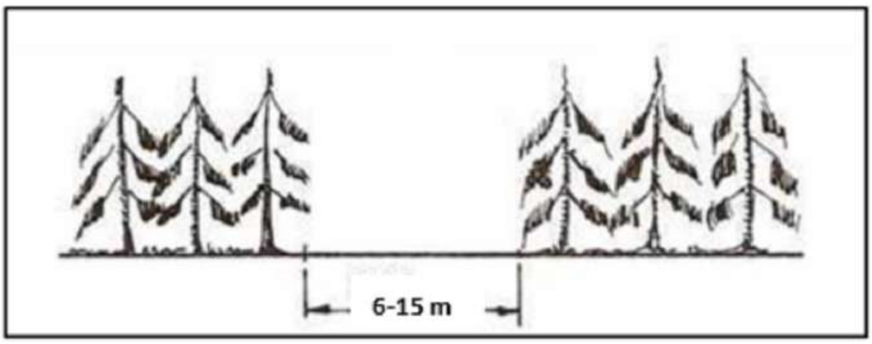

Fig. 1. Fire breaks [3]

Fire breaks and fire lines: These facilities are the combination of fire breaks and fire lines formed on one side or on both sides of the roads. Their width is 60-120 meters (Figure 3). Fire breaks and fire lines installations are made by using natural and artificial obstacles that prevent the spread of fire. They are mostly constructed in forest areas where fire hazards are excessive and extreme. They usually serve four main purposes: a defensive line for fighting against fire, counter-fire application sites, mechanical firefighting, and transportation. It can be said in summary that the aim of these obstacles are to provide a direct barrier to the spread of the fire and to ensure that the fires are kept in small spaces and that the fire damage is minimized.

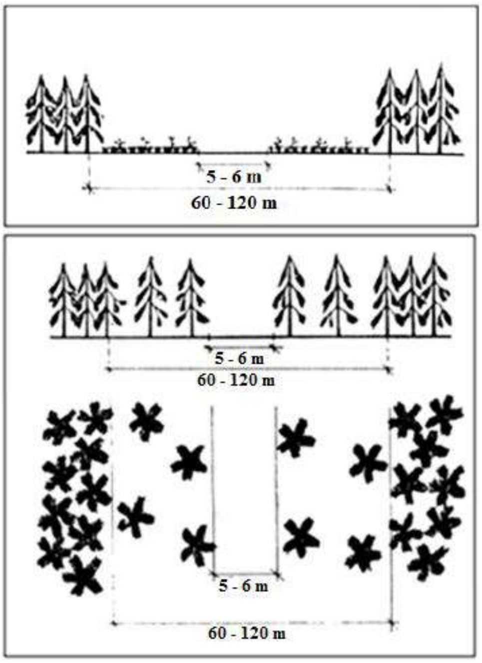

Fig. 2. Fire lines [3]

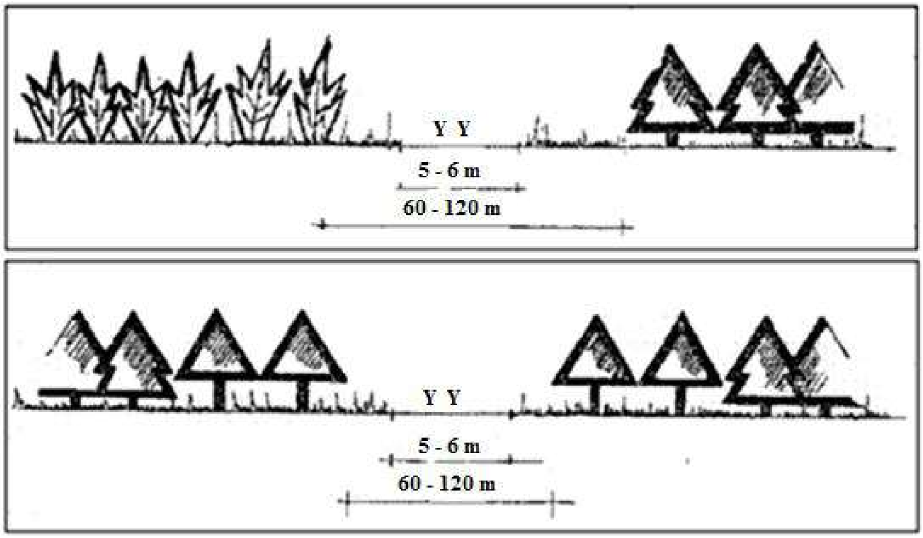

Fig. 3.Fire breaks and fire lines [3]

3. Fire-Resistant Forest Project-YARDOP

Rehabilitation of burned areas and the establishment of fire resistant forests project have been implemented in forest areas with high fire risk. YARDOP project was decided to be developed after the Serik-Tasağıl fires of 2008, which was the largest fire in recent times in Turkey. Projects have been implemented in many different terrain features throughout high fire risk areas.

This project was first developed in 2008, and then several modifications were made to its standards. According to the latest edition prepared in 2014, the information about the fire-stop and intervention facilities in the project has been updated. The main purposes of the project are defined by [6] as: "To increase resistance to fires in fire-sensitive forests, to reduce the amount of combustible materials to establish fire-fighting areas, to reduce the heat energy released during the fire, to construct lines made of trees and shrubs, to make transportation facilities in case of need, and to set up mixed forests with fire resistant species”. There are three different fire intervention and protection facilities specified YARDOP: fire intervention facility, wild land-urban facility, and wild land-agricultural areas facility.

Fire intervention facility: The width of the transportation facility is between 6-15m.From the transportation facilities, two sides are formed in the 20-30 meter part of the forest. The stand on the edge of the transportation facility is protected to prevent negative external factors while the fire weakening areas are being generated. Fire-resistant species in the weakening area should be preserved. Two types of fire intervention facilities are developed; one for reforestation forest damaged by fire and one for fire-sensitive forests (Figure 4).

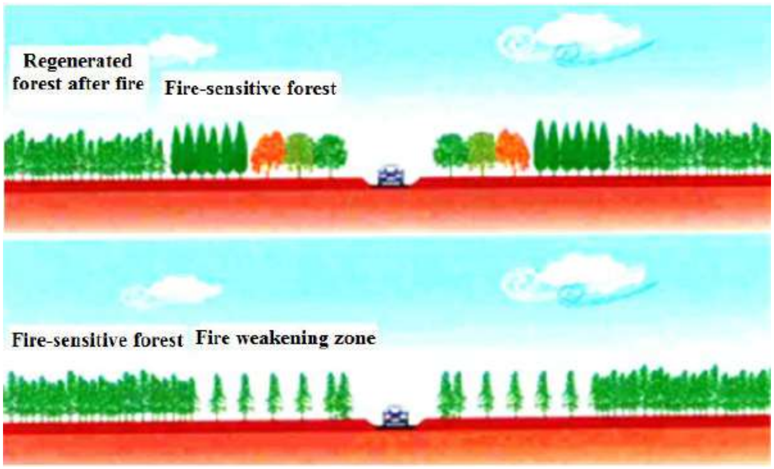

Fig. 4. Fire intervention facility [6]

Wild land-urban facility: Fire weakening zones are established between settlement and fire-sensitive forest lands from the border towards the forest facilities. The width of the transportation facility is between 6-8m. From the transportation facilities, a “weakening zone" will be formed in the 20-30 meter part of the forest. When the weakening areas are built, the edge near the transportation facility should be protected to prevent negative external factors. Again, fire-resistant species in the weakening area should be preserved. There are two types of fire intervention facilities for reforestation forest damaged by fire and fire-sensitive forests (Figure 5).

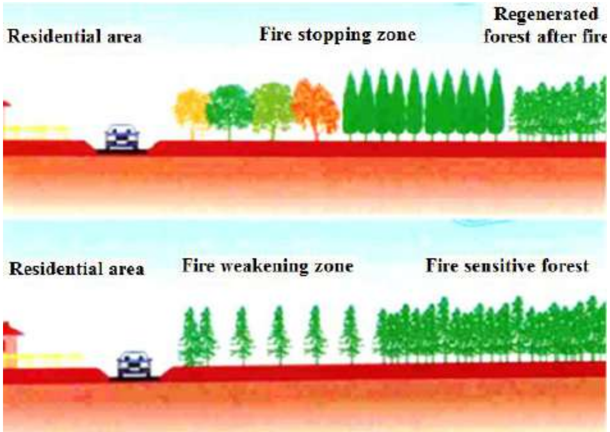

Fig. 5. Wildland-urban facility [6]

Wildland-agricultural areas facility: They are the facilities built from the agricultural land to the forest land. The width should be determined carefully depending on fire sensitivity and terrain structure. Where the transportation facility is not adjacent to the agricultural land, wildland-agricultural areas facility can be installed between the forest land and fire-resistant herbaceous and woody plants which determine the forest-agricultural border. Forest cadastral borders should be taken into account when designing these facilities. There are again two types of fire intervention facilities for reforestation forest damaged by fire and fire-sensitive forests (Figure 6).

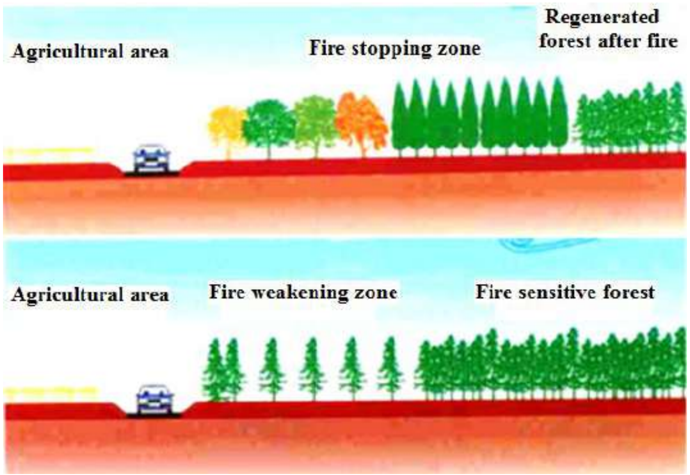

Fig. 6. Wildland-agricultural areas facility [6]

4. Conclusions

As one of the most detrimental natural hazards on forest resources, forest fires can cause serious damages on forest ecosystem especially in arid regions. In order to minimize these affects, firefighting facilities should be installed where it is necessary and fire-resistant forest should be established in the regions with high fire risk. Firefighting facilities and roads are established to protect the stands from fire hazards especially in productive forest areas. While the facilities and roads are mainly used for fire intervention activities, they also serve for stopping fire or weakening them. These facilities should be well planned according to YARDOP project rules and appropriately implemented in the field to reduce potential damages of the fire on forest ecosystem, especially in the fire sensitive areas.

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THE INFLUENCE OF OROGRAPHIC AND TREE STAND FACTORS ON THE PRECISION OF PLANIMETRIC COORDINATES DETERMINED USING GPS EQUIPMENT IN A FOREST ENVIRONMENT

Cornel C. TEREŞNEU[1] Maria M. VASILESCU[1]

Abstract: *This paper reports the findings of a study concerning the statistical analysis of the precision for planimetric coordinates determined using a GPS equipment in a forest environment. A forest area of over 9500 ha was surveyed, located in the area of the Barsa River, close to the Zărnești town. More than 14000 point coordinates were determined. The measurements were carried out with two GPS receivers: Trimble Pro XH and Pro XT, using the Stop&Gomethod with post-processing. Data regarding the field collected coordinates were grouped according to: composition, age and consistency of tree stands, terrain shape, and aspect. This stratified data was processed using the Statistica software. Coordinate precision was analysed by taking into consideration each criteria individually, as well as in combinations of 2 factors (which resulted in 25 combinations), 3 factors (145 combinations), 4 factors (142 combinations) and 5 factors (103 combinations). Looking at the arithmetic means, the best situation is for spruce stand with an age of 101-120 years and the worst situation is for the spruce stands located on northern slopes. Regarding orography, the fact that the lowest precision is found in valleys was highlighted. Stand age also has a significant influence in the analysis of the precision factor, with the young and dense tree stands having the lowest precision. Regarding aspect, research shows that the most favourable situation is for the NE-SV aspect, while the least favourable is for the NS aspect.*

Key words: *forest, GIS, GPS, statistical indice.*

1. Introduction

Forest surveying has always been difficult. Even if the precision required in these situations is not as high as in the case of built-up areas, solutions for accurate measurements are still sought. Difficulties arise especially in the case of retrocession of forest parcels, as their boundaries often do not align with natural

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boundaries [9]. Therefore, in these cases a number of factor have a negative influence upon the accuracy of coordinate calculations. Some examples of such influences are: the time difference between the satellite and the receiver clock [5], landform [8-9], the shape and consistency of tree stands [4, 14-15]. This last effect is much more pronounced if measurement is made during winter, if the canopy is covered with a thick layer of snow [3]. However, it has to be mentioned that significant progress has been made to diminish the effect of canopy and that, because of the evolution of GPS receivers, measurement of acceptable precision have been made even with Garmin-type receivers [7]. Another difficulty for Global Navigation Satellite System (GNSS) measurements in forests is the number of visible satellites [13], which in most cases does not satisfy the required accuracies. Another influence which has to be considered is that of the vegetative season during which the survey is carried out [2, 6]. It is well known that in deciduous stands the most favorable time for surveying is in leaf-off conditions.

Research was carried out in the upper Bârsa River area, close to the town of Zărneşti (Figure 1). Approximate coordinates of the research site are 45^{0}34’ şi 25^{0}16’. More than 9500 ha of forest area were surveying, with over 14,000 point coordinates determined. For this paper the precision for the spruce stands is analyzed.

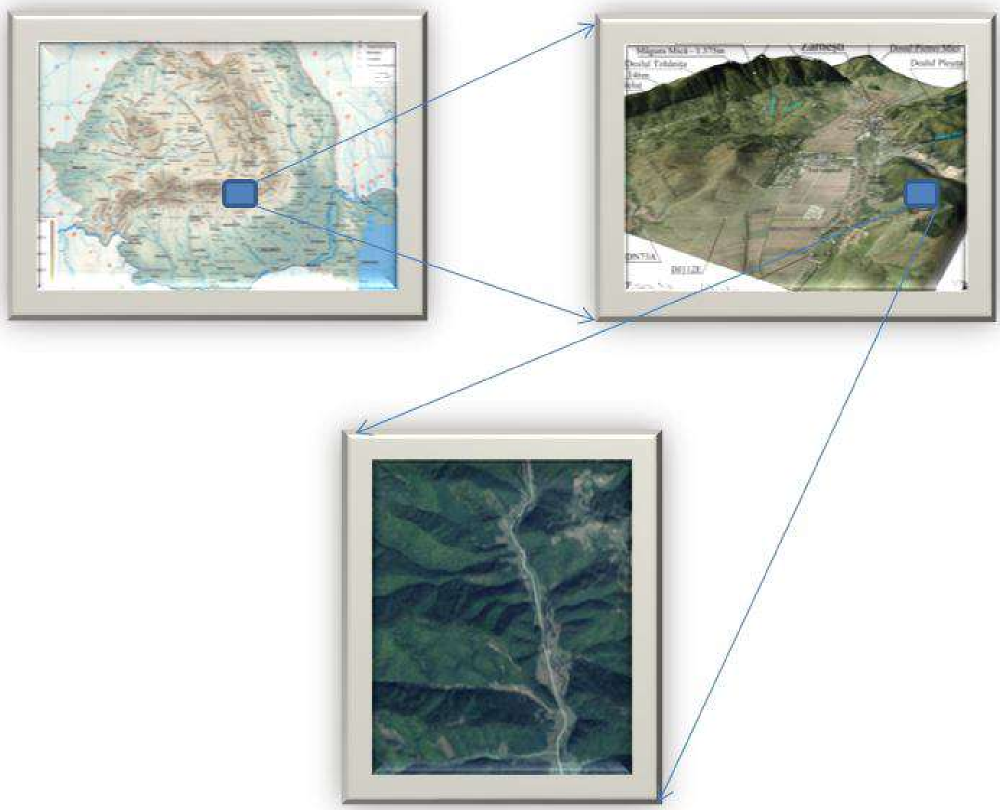

Fig. 1. Location of study area

2. Material and Methods

To carry out measurement in spruce stands in the studied area, photogrammetric methods could potentially be used [11-12], but for now these are cost-prohibitive [1]. Therefore, the only viable alternative is that of using GNSS equipment. Two double-frequency *Trimble ProXT*and *Trimble ProXH*GPS receivers were used to determine point coordinates. In addition, base cadastral plans of the area (1:5000 scale, with silvic boundaries), orto-rectified images obtained from flights carried out in 2012 and all data regarding orographic and tree stand conditions were used.

Regarding the research methods, mainly the direct measurement with the semi-kinematic "*Stop&Go*" method was used. Data from GPS receivers was downloaded and processed using the *Trimble GPS Pathfinder Office* software. Post-processing of this data involved corrections received from the permanent stations of Top GEOCART Brasov. Even if the distance between this permanent station and the research site was adequate, to ensure a high precision a number of points located near the surveyed forest were surveyed using the static method with base receivers. Rovers received signals not only from the aforementioned base station, but also from the points determined earlier. Later, data was imported in the Geographical Information System (GIS) project of the area [10]. To analyze field data in accordance with orographic and tree stand conditions, correlation between these data sources had to be obtained. To this end, the polygons relating to silvic parcels and subparcels were exploded into lines that were homogenous regarding the studied characteristic. The following characteristic were considered: landform, aspect, tree stand composition, tree stand consistency, tree stand age. Point precision was determined by analyzing combinations of:

- Two criteria (composition-landform, composition-consistency, composition-age, composition-aspect): 25 combinations;
- Three criteria (composition-landform-consistency, composition-landform-age, composition-landform-aspect, composition-consistency-age, composition-consistency-aspect, composition-age-aspect): 145 combinations;
- Four criteria (composition-landform-consistency-age, composition-landform-consistency-aspect, composition-landform-age-aspect): 142 combinations;
- Five criteria (composition-landform-consistency-age-aspect): 102 combinations.

3. Results

For an objective analysis, experimental data was graphically represented by the distribution of cumulated relative frequencies (%) by categories (Figure 2). Al distributions are exponential, with obvious differences between the analyzed combinations. The following statistical indices were used: minimum, maximum, mean, mode, standard error, frequency, standard deviation, coefficient of variation.

Figure 2 shows that the best precision is obtained for point located on, while the weakest precision if for points in valleys.

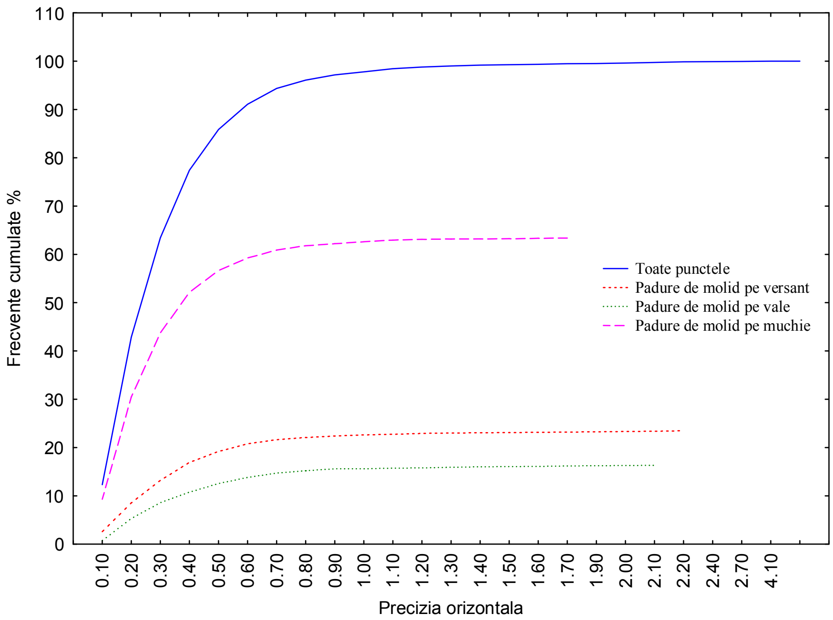

Fig. 2. Cumulative relative frequencies distribution

Analysis of the frequency for various horizontal precisions leads to the following statements:

- For two-factor analysis: the highest frequency is for points having a horizontal precision of 0,316m (16%), while the lowest frequency is for points with a horizontal precision of 0,402 (0,5%);
- For three-factor analysis: the highest frequency is for points with an average horizontal precision of 0,315m (5%), while the lowest frequency is for points with a horizontal precision of 0,367m (a single point);
- For four-factor analysis: the highest frequency is for point with a horizontal precision of 0,3m (56%), while the lowest frequency is for points with a coordinate precision of 0,8m (two points);
- For five-factor analysis: the highest frequency is for points with a horizontal precision of 0,3m (45%), while the lowest frequency is for points with a horizontal precision of 0,7m (4 points).

Further analysis of the variation of horizontal precision as highlighted by the arithmetic mean shows the following:

- For two-factor analysis: the best arithmetic mean is recorded in the case of spruce stand with an age of 101-120 years (0,25m), and the worst situation is for spruce stand on northern slopes;
- For three-factor analysis: the most favorable conditions are for spruce stands with an age of 61-80 years and a western aspect, the mean having a value of 0,117m. The weakest precision is associated with spruce stands with an age of 21-40 years and eastern aspect, it having a value of 0,70m;
- For four-factor analysis: the best precision has a value of 0,10m and is recorded in multiple situations: spruce stands located on ridges, with a

consistency up to 0.6 and a NV-SE aspect; spruce stands located on ridges, with a consistency up to 0.6 and an age of 101-120 years; spruce stands located on ridges, an age of 1-20 years and NE-SV aspect; spruce stands located on ridges, with an age of 101-120 years and an E-V aspect; spruce stands located on ridges with an age of 101-120 years and an N-S aspect, spruce stands located on slopes with an age of 61-80 years and an V aspect; the worst value for the arithmetic mean is recorded for spruce stands located in valleys, with an age of 41-60 years and a N-S aspect;

- For five-factor analysis: the best value for the arithmetic mean is also 0,10m and is also recorded in multiple situations: spruce stands located on ridges, with a consistency up to 0.6, an age of 101-120 years and a NE-SV aspect; spruce stands located on ridges, with a consistency of 0.7-0.8, an age of 1-20 years and a NE-SV aspect; spruce stands located on ridges, with a consistency of 0.7-0.8, an age of 101-120 years and a N-S aspect; spruce stands located on ridges, with a consistency of 0.9-1.0, an age of 1-20 years and a NE-SV aspect; spruce stands located on ridges, with a consistency of 0.9-1.0, an age of 101-120 years and an E-V aspect; spruce stands located on slopes, with a consistency of 0.9-1.0, an age of 81-100 years and a V aspect; the worst value for arithmetic mean in this case is for spruce stands located in valleys, with a consistency of 0.7-0.8, an age of 81-100 years and a NE-SV aspect.

There are cases where the standard deviation has a higher value than the arithmetic mean. This situation leads to cases where the coefficient of variation is above 100%. Such cases are recorded for: spruce stands with a consistency up to 0.6 on northern slopes; spruce stands with a consistency of 0.7-0.8 and a S aspect; spruce stands with a consistency of 0.9-1.0 and a S-V aspect, spruce stands with a consistency up to 0.6 and an age of 121-140; spruce stands with a consistency of 0.7-0.8 and an age of 41-60 years and a NE-SV aspect; spruce stand located on valleys with a N-S aspect; spruce stands on S-V slopes; spruce stands on valleys with an age of 41-60 years; spruce stands on slopes, with an age of 21-40 years; spruce stands on slopes, with an age of 121-140 years; spruce stands with an age of 61-80 years and an E aspect; spruce stands with an age of 121-140 years and a N aspect;

4. Discussion

Global analysis of experimental data for spruce stands leads to a number of conclusions:

- Orography has a strong influence of the horizontal precision for point coordinates, with the most favorable condition associated mainly with high landforms, and the lowest precisions recorded in the case of valleys;
- Aspect has a significant influence on the studied indicator. Although numerous variants for aspect have been taken into consideration (12, specifically), a grouping of these into two main categories was observed: one favorable for satellite motion and one disfavorable for it. In the first category point coordinates precision is always higher compared to points in the second category;
- Stand age does not seem to have a strong influence on horizontal precision for point coordinates, as one might tend to believe. A very good precision is

noticed for young stand, which do influence satellite signals with their height or do not produce the multipath effect, after which precision drops pretty sharply for stands with an age of 21-40 years. Then a certain consistency of precision is noted, up to the age of 80 years. After this, precision again begins to increase. The fact that differences between precision are relatively low is mentioned (the difference between the maximum and minimum value is 34%);

- Consistency has a certain influence on horizontal precision of point precision only when trees are sufficiently sparse (consistency index of less than 0.6). When this index has values above 0.7, precisions are relative close (for both the precision class of 0.7-0.8 or 0.9-1.0);
- Analysis of two factors at once for spruce stands lead to the following: the most favorable situation is for stand with an age of 61-80 years that are located on western aspects, while the least favorable situation is for spruce stands with an age of 21-40 years and a northern aspect; the favorable situation is explained by the fact that thinning operations have begun and satellite signal is therefore less affected by tree stand density, while the expositions is favorable to the satellite motion tracks; the unfavorable situation is somewhat expected due to the fact that the stand is very dense and furthermore, is located on an exposition unfavorable to satellite motion;
- Analysis of three factors at once for spruce stands shows that the best horizontal precision for point coordinates is recorded for: spruce stands located on ridges, with a consistency of up to 0.6 and an E-V aspect; spruce stands located on ridges, with a consistency of up to 0.6 and an age of 101-120 years; spruce stands located on ridges, with an age of 1-20 years and an E-V aspect; spruce stands located on ridges, with an age of 101-120 years and an E-V aspect; spruce stands located on ridges, with an age of 101-120 years and a N-S aspect; spruce stands located on slopes, with an age of 61-80 years and a V aspect. The worst precision is for spruce stands located on valleys, with an age of 41-60 years and a N-S aspect; the explanation for the most favorable conditions is in fact a combination of the favorable individual factors explained above – where tree stands are young or sufficiently mature (and the satellite signal is less affected), or the presence of high landforms and expositions that correlate with the satellite motion tracks; regarding the opposite situations, of tree stands with low precisions – this is mainly due to the unfavorable landforms, with tree stands age and exposition perpendicular to the satellite motion tracks further adding to the effect;
- Finally, analysis of 4 factors that have a simultaneous effect on the horizontal precision of point coordinates in spruce stands shows that the most favorable situations are: spruce stands located on ridges, with a consistency of up to 0.6, an age of 101-120 years and an E-V aspect; spruce stands located on ridges, with a consistency of 0.7-0.8, an age of 1-20 years and an E-V aspect; spruce stands located on ridges, with a consistency of 0.7-0.8, an age of 101-120 years and a N-S aspect; spruce stands located on ridges, with a consistency of 0.9-1.0, an age of 101-120 years and an E-V aspect; spruce stands located on slopes, with a consistency of 0.9-1.0, an

age of 81-100 years and a V aspect. In this case, the worst precision is recorded for spruce stands located on valleys, with a consistency of 0.7-0.8, an age of 41-60 years and a N-S aspect; In this case also, it is noticed that the best results are influenced by a high landform (edge), low consistency, old or very young age that does not block satellite signals and an exposition favorable to satellite motion tracks; to the opposite side are tree stands located in valleys, where the satellite signal is very weak (or even missing), with average ages and consistency and an exposition perpendicular to the satellite motion tracks.

5. Conclusions

Regarding the global precision for the points surveyed during this research, it is noticed that it is a good or even very good one. If data is grouped into precision classes of 25 cm, it is noticed that the highest weight is for points whose precision has a center-class value of 0,175m (62%).

By analyzing the factors that influence the horizontal precision of point coordinates in forests it can be said that each of these factors has a certain influence. If we were to establish a hierarchy of these factors by influence, it would be this: landforms (with the best results on high landforms and the worst results on valleys), aspects (with the best results for aspects favorable to satellite motion and the worst results on aspects perpendicular to the previous ones), tree stand consistency (with very good precisions for consistencies up 0.6 and a certain sameness for the other two studied categories), tree stand age (with the best results for young stands where tree height does not influence satellite signals and in mature stands where regenerative cuts were applied, and the worst results in tree stands with an age class of 2-4 and very high densities).

Regarding the combined influence of these factors, it is shown that the least favorable situation is recorded for tree stands located on valleys, with a N-S aspect, a consistency of 0.9-1.0 and an age of 21-40 years, while the best precision is recorded for spruce stands located on ridges, with an E-V aspect, a consistency lower than 0.8 and an age either above 100 years or below 20 years.

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MALE FERTILITY IN CLONAL SEED ORCHARD OF SPHEROID SCOTS PINE

Murat ALAN [1]

Abstract: *Spheroid scots pine (Pinus sylvestris L. var. compacta (Tosun) Ü. Akkemik) clonal seed orchard was established in April 2004 including 823 ramets of 26 clones at 5m x 5m spacing in Eflani of Karabuk, Turkey. Five ramets per clone were chosen randomly and all of the male strobili over the entire crown on all grafts were counted in 2016 and 2017. Average numbers of male strobili per clone were ranged from 130.0 to 83710.7 for two consecutive years. Pearson correlation for two consecutive years on male strobili production was 0.91 showing stability 2016 and 2017. The top 25% of clones produced 48% of total male strobili in two years. Male fertility variation, effective status number and relative status number were 1.56, 16.61 and 0.64, respectively. Estimation of broad sense heritability and clonal coefficient of genetic variation for male production was 0.49 and 12% respectively. The parameters were discussed for management of Spheroid scots pine clonal seed orchard aiming ex situ gene conservation and landscape activities.*

Key words: *Pinus sylvestris, heritability, male fertility variation, status number.*

1. Introduction

Breeding activities were started in 1964, but first National Tree Breeding Program (NTBP) of Turkey was implemented in 1994 [11]. *Pinus sylvestris* L. (Scots pine) was one of the target species in NTBP. In this context, 21 seed orchards occupying 116.4 ha in Scots pine have been established so far [18]. Two out of 21 seed orchards were established for ex situ conservation in *Pinus sylvestris* L. var. *compacta* (Tosun) Ü. Akkemik (Spheroid Scots pine). These orchards were clonal seed orchards, established by using grafted clones like other Scots pine seed orchards in Turkey. Spheroid Scots pine is a special variety (spheroidal, short, and bushy) and its distribution is scattered and limited in only Bolu province of Turkey [17]. Due to the special form, scions were collected from each parent tree in Bolu province and the scions were grafted to seedlings, then a clonal seed orchard was established by the grafted seedlings for *ex situ* conservation.

Flowering processes in an orchard are of great importance since they affect gene exchange among clones and genetic configuration of seeds obtained from seed

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orchard. Thus, genetic composition of orchards seeds is mainly determined by the numbers of female and male strobili produced by each clone [6, 9, 15]. The high male/female ratio and tremendous pollen production capacity indicate high male competition among trees within populations for successful out-crossing and maximum seed set through sufficient pollen grains reaching each megasporophylls, which addresses ultimately the evolutionary cause of this pattern [16]. On the other hand, male fertility is markedly affected not only by the quantity of fruit and seed production (siring success) but also by progeny quality i.e. seed germination rate and seedling survivorship [19].

Some researches on the flowering system were carried out for Scots pine clonal seed orchards in Turkey [2-3, 5]. There is also a research on the female fertility for Spheroid clonal seed orchard [1], but there is no research on the male flowering system. These orchards were established for ex situ conservation, but they can be also used for landscape service due to its special form [17]. Data on the reproductive mechanism of population of tree species are indispensable for effective genetic conservation and as working tools to our understanding of evolutionary mechanisms [16]. In this context, findings of a research on male flower production can be used for seed orchard management aiming *ex situ* conservation and landscape service. This study aimed to gather information about male production on two consecutive years and to obtain some parameters related to male production and to use it for seed orchard management.

2. Material and Methods

Spheroid scots pine seed orchard was established in April 2004 including 823 ramets of 26 clones at 5m x 5m spacing in Eflani of Karabuk, Turkey (latitude 41º 23′ 45 ″N, longitude 32º 49′ 07″E and altitude 890 m). A number of ramets per clone varied from 3 to 37. Usually, Scots pine seed orchard in Turkey initiates seed production at age ten [12]. The seed orchard was at 12 ages when data were collected in 2016. So, the seed orchard can be considered as a young seed orchard. Clone #339 has 4 and clone #341 has 3 ramets in the seed orchard. Except these two clones, five ramets per clone were chosen randomly and male strobili in 127 ramets were counted in May 2016 and 2017. All of the male strobili over the entire crown were counted on all chosen ramets. Modified Keskin (1999) method was used for counting of male flowers. Ten clusters were determined in the seed orchard including from 5 to 40 number flowers. The cluster number in each ramet was multiplied male flower number. Then multiplied values were summed up for each ramet. Logarithmic transformation was applied prior to analyses of variance for flower numbers. Height and crown diameter were measured and calculated volume index of sphere or cone shape of grafts. Volume index of each graft was used as a covariate in the statistical model. Following the statistical model used was:

$$y_{ijk} = \mu + AX_{ijk} + c_i + t_j + ct_{ij} + e_{ijk} \quad (1)$$

where:

- y_{ijk} is the observation of the j^{th} ramet in the i^{th} clone and the k^{th} year;
- μ - the overall mean;

A - the regression coefficient;
X_{ijk} - the volume index of clones in the t^{th} year (ijk=1,..254);
c_i - the random effect of the i^{th} clone (i=1,...26);
t_j - the random effect of the j^{th} year (j=1,2);
ct_{ij} - the clone x year interaction;
e_{ijk} - the experimental error.

Broad sense heritability and clonal genetic coefficient of variation for male fertility were calculated following formulas:

$$H_c^2 = \frac{\sigma_c^2}{\sigma_c^2 + \sigma_{ct}^2 + \sigma_e^2} \quad (2)$$

$$Cv_g = \frac{\sqrt{\sigma_c^2}}{\bar{X}} \cdot 100 \quad (3)$$

Where:
H_c^2 is the broad sense heritability;
σ_c^2 - the clonal variance;
σ_{ct}^2 - the clone year interaction variance;
σ_e^2 - the error variance;
Cv_g - the clonal genetic coefficient of variation;
$\bar{X}$ - the general mean.

Male fertility variation (Ψ_m) can be described by coefficient of variation (*CV*) in strobilus production, a measure suggested by Kang & Lindgren (1999); Kang & Mullin (2007) as:

$$\Psi_m = CV_m^2 + 1 \quad (4)$$

where CV_m^2 is the coefficient of variation in male strobilus production among clones. Effective number was calculated by the concepts of status number [13] and effective parent number [8]. Status number calculations were based on the fertility variation at male level [7, 9] as:

$$N_{s(m)} = N/\Psi_m \quad (5)$$

where: $N_{s(m)}$ is the status effective number of male strobilus, and N is the census number of clone.

Relative status number (N_r) was calculated as the ratio of the status number ($N_{s(m)}$) over census number (N) [9].

3. Results

Average, minimum, maximum male strobilus production, the coefficient of variation and standard deviation are presented in Table 1. The average of male strobilus production was 2420.74, 4018.53 and 3219.64 per clone in 2016, 2017 and total, respectively. The male strobilus production was ranged from 0.00 to 104482.00 per clone in two years.

Table 1

Average, minimum, maximum male strobilus per clone, coefficient of variation (*CV*), standard deviation (Sd)

Year	Average	Minimum	Maximum	*CV*	Sd
2016	2420.74	0.00	62939.40	0.85	2075.53
2017	4018.53	260.00	104482.00	0.72	2873.12
Pooled	3219.64	130.00	83710.70	0.75	2419.43

The analysis of variance was revealed statistically significant differences among clones and years for male strobilus production. But, differences among clones regarding volume index and clone-year interaction were not statistically significant (Table 2).

Broad sense heritability (H_c^2) was 0.49±0.14, clonal genetic coefficient of variation (CV_g) was 12% for two years. Pearson correlation between 2016 and 2017 on male fertility was 0.91.

Male fertility variation (Ψ_m), status number ($N_{s(m)}$), and relative status number (N_r) were 1.74, 15.0.and 0.58 for 2016, 1.51, 17.2 and 0.66 for 2017 and 1.56, 16.6 and 0.64 for pooled data respectively (Table 3).

Table 2

The analyses of variance for male fertility

Source of variation	Degree of freedom	Mean square	F Value	P
Volume index	1	2.340	0.02	0.903
Clones	25	2.694	2.47	0.012
Years	1	64.458	57.23	<0.0001
Clone*year	20	1.041	0.68	0.829
Error	75	1.523		

Table 3

Male fertility variation (Ψ_m), status number ($N_{s(m)}$), relative status number (N_r) for male strobilus production

Year	Ψ_m	$N_{s(m)}$	N_r
2016	1.74	15.0	0.58
2017	1.51	17.2	0.66
Pooled	1.56	16.6	0.64

The most fertile clone was #339, the less fertile one was #361. The top 25% of clones produced 48% of total male strobili, and the lowest 25% of clones produced 5 % of total male strobili (Figure 1).

4. Discussion

The production of male strobili was found to vary among clones in the clonal seed orchard. Average male strobilus production was 3219.64 per clone in pooled data. On the other hand, the highest production was 8697.5 for clone #339, the lowest production was 130.0 for clone #361 indicating unequal male strobilus contribution at clonal level in the seed orchard based on the 2-year average. The analysis of variance was revealed statistically significant differences among clones (P=0.012) and years (P<0.0001) on male strobilus production but was not revealed statistically significant differences in clone-year interaction (P=0.829). Volume index also was not important on strobilus production as a covariate, in other words, male strobilus production was not related to the crown size of grafts. The difference between years was higher than the difference between clones on male strobilus production, but Pearson correlation between years was 0.91 showing stability of male strobilus production of clones.

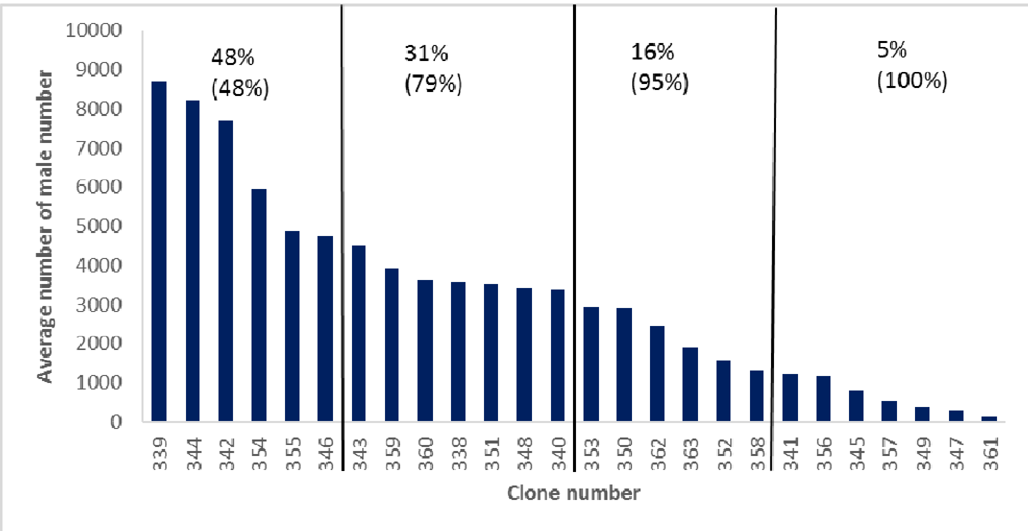

Fig. 1. The contribution of clones in male strobili production based on 2-year average (values in brackets are cumulative percent's)

Broad sense heritability (H_c^2) of male fertility was high in this research (0.49). Bilir et al. (2006) found that broad sense heritability of male fertility was 0.13 for pooled data of three mature scots pine seed orchards. Due to high heritability, selection on male strobilus production could be done in the Spheroid scots pine seed orchard [14]. The clonal genetic coefficient of variation (CV_g) was 12 % for two years showing moderate genetic diversity on clonal male strobilus production.

The sibling coefficients showing fertility variation were 1.74, 1.51 and 1.56 for 2016, 2017 and pooled data in the present research, respectively. If sibling coefficient is 1, then, the coefficient of variation is zero and each clone contributes with equal strobili in a seed orchard [15]. Dutkuner et al. (2008) found that sibling coefficients of male strobili were 1.015 in a mature Scots pine seed orchard, Bilir and Temirağa (2012) found also 1.02 and 1.03 in two mature Scots pine seed orchard. All sibling coefficients founded in mature Scots pine seed orchards were very close to 1 indicating that each clone producing equal strobili. In the present study, the sibling coefficient founded for Spheroid Scots pine was higher than the sibling coefficient of the mature Scots pine seed orchards. This situation might be sourced that Spheroid scots pine seed orchard was young and its grafts were specially formed. In this context, Prescher et al. (2007) claimed that variation in fertility seemed to be higher in young seed orchards and in years when seed production was low.

The status number and the relative status number ranged from 15.0 to 17.2

and from 0.58 to 0.66, respectively in this research. The status number explains how many ideal orchard clones would give rise to the considered crop. It gives a measure to compare different seed orchard designs, seed orchard management actions, consequences of pollen contamination, etc., for the expected relatedness and gene diversity in a seed orchard crop [13]. Due to the relation between the status number and the census number of each seed orchard, using of relative status number is better than using the status number to compare other studies. Dutkuner et al. (2008); Bilir & Temirağa (2012) found that male strobilus relative status numbers were ranged from 0.98 to 0.99 for one year in mature Scots pine seed orchards. The relative status number in Spheroid scots pine was lower than the relative status number in mature scots pine. So, gene diversity in Spheroid scots pine was about half of gene diversity in mature scots pine.

The contribution of male strobilus production was different for each clone in Spheroid scots pine as an averaged 2-year. The top 25% of clones (6 clones) and the lowest 25% of clones (7 clones) produced 48% and %5 of total male strobili, respectively in this research. In the *Pinus koreansis* S. et Z., the top 25% of clones and the lowest %25 of clones produced 90.4% and 0.1% of total female strobili, respectively for five years (Kang & Lindgren, 1999). In the other hand, Burzcyk & Chalupka (1987) found that the top 25% of clone and the lowest 25% of clones produced 45.58 % and 10.42 of total pollen in Scots pine for three years. These explanations were revealed that clonal contributions on any production (flower, pollen etc.) in the seed orchards were not balanced.

5. Conclusions

The study on male fertility was carried out two consecutive years. Some parameters related to male fertility which were obtained could be used for seed orchard management. The clonal contribution on male strobilus production for the two-year was unbalanced like in other seed orchards. Sibling coefficient of male fertility and the relative status number in Spheroid seed orchard were lower than in mature Scots pine seed orchards'. The differences among clones and years on male fertility were high but clonal fertility was stable between years. The spheroid scots pine clonal seed orchard was established for ex situ conservation, but due to a special form, in the same time, the orchard can be also used for landscape service. In this context, the findings of this study can be used for the management of young spheroid Scots pine seed orchard aiming ex situ conservation and landscape services.

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USING IMAGES ACQUIRED FROM A RURAL AREA WITH UNMANNED AERIAL VEHICLE IN ORDER TO ACHIEVE THE LAND AND CONSTRUCTIONS CADASTER

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Abstract: *The present paper aims to establish whether and to what extent Unmanned Aerial Vehicle (UAV) technology proves to be useful and what precision can be obtained within the build-up area with this type of data. The methodology was applied on a series of photogrammetric surveys from the build-up area of Crizbav, Brasov, Romania, that were compared with official data obtained following the registration of all properties from this village. Two cartographic products as orthophotomaps have been obtained for the studied surface (with and without the use of ground control points). The high precision orthophotomap of was used for the vectorization of lands and constructions, and the data obtained have been compared to the official ones, the results being analyzed from different point of views. So, it was discovered that the differences between the coordinates are distributed according to Gauss curve, a percentage of 42 is registered in differences of up to 20 cm, and between them and the surface differences is a connection given by a high correlation coefficient.*

Key words: *UAV, build-up area, ortophotomap, vectorization, coordinates.*

1. Introduction

1.1. UAV in Different Applications

The development of the economy takes place continuously and rapidly, being necessary new products and technologies in order to answer the human needs and requests related to urbanism, environment, cadaster, with the purpose to ease people’s work [13].

In our days Unmanned Aerial Vehicle technology is used on large scale in photogrammetry worldwide, because the flight is completely autonomous and allows the reception of images from the area studied automatically. The reduced cost and automatic flight feasibility, above the interest objectives, may be considered as the main advantages of this technology in photogrammetric applications. Using the GNSS/IMU (Global Navigation Satellite System/Inertial Measurement Unit)

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positioning technology, the images may be taken over according to a pre-established flight project, and the exterior orientation parameters (X, Y, Z coordinates and ω, ϕ, k angles) of the perspective center may be directly determined [5].

At present, the use of UAV in photogrammetry is in the process of development and the information regarding the newest progresses and discoveries in the field come from the results published in the main research centers from the whole world. For example, Colomina and Molina (2014) describe the evolution and the technique stage of aerial systems without pilot in the photogrammetry and remote sensing field putting the accent on regulations, acquisition systems, navigation and orientation.

The use of UAV in applications such as the environment monitoring, landslide, mapping, surface mining, urban cadaster, are described by [8-10, 16, 23]. The results obtained demonstrated that UAV technology has a great potential in this field. Other studies related to UAV use, as mean of image taking over, are presented by [17, 20, 31]. Also, UAVs are used in different mapping applications, such as historical sites mapping, landslides, for topographic and disaster management purposes [4, 15, 21, 25, 30].

In relation to the achievements in the cadaster field, a study made by van Hinsberg et al. (2013) presents the use of UAV for taking over aerial images based on which the lot delimitations have been achieved with a precision of up to 3 cm, similarly with the precision obtained by classical topographic measurements. Also, [11] shows that UAV may take over aerial images with a very high precision and, in a lot of situations, it may be an advantageous alternative for replacing the classical topographic measurements. Studies regarding the use of UAV in the field of measurements and cadastral applications also have been achieved by [1, 6-7, 24].

The use of UAV for topographic – cadastral purposes means the achievement of high precisions, and for this purpose they must be placed at ground control points (GCPs) [22]. These GCPs must be carefully selected, must be evenly distributed and visible in as many images; also CGPs must be easily identified in the acquired images, and, in the field, to be determined with the help of GNSS technology [33].

1.2. The Use of UAV in Romania

For Romania the problem is related to the cadaster materialization within the build-up rural areas, which is significant because, according to the proposed methodology until not long ago, it was based on the use of old mapping materials, which do no longer give the real situation on the field [2]. According to the information given by the National Agency for Cadaster and Land Registration, the institution that governs, operates and checks the works in the cadaster and land registration field from Romania, approximately 29% (August 2018) from the lands are registered in the digital system [35].

The update of cadastral plans in digital format using different techniques is an important preoccupation in Romania. For this subject, different editions of orthophotomaps have been achieved in the period 2003-2005, 2009, 2010, 2012, 2016, but on small sections from the country surface. These, along with the cadastral maps obtained by stereorestitution method according to the technology and methodology of the ’70, are used for the resolution of different problems, but they are insufficient. Moreover, the precision offered by these products is no longer present for the capabilities offered by the new technologies.

Although UAV technology is intensely used worldwide, on the national plan there is no culture for UAV use equipped with digital sensors in order to obtain mapping products of high precision. Still, there are many private companies that make researches in this field with notable results, one of them managed to develop his own UAV that was used for taking over aerial images for forest development, recognition and achievement of systematic cadaster, etc.

In the study achieved by Munteanu (2009) was used the orthophotomap in order to achieve the cadaster plans in the agricultural fund outside the build-up area of localities. The results obtained by comparing the data collected by classical measurements with other obtained by the vectorization of orthophotomaps were satisfactory in terms of precision, according to the regulations in force.

Palamariu et al (2015) used a Dji Phantom UAV equipped with a digital camera Nikon Coolpix L810 and a total station Leica TCR 805 in order to make a work methodology fir 3D cadaster realization for a build-up area of a rural region from our country. The study shows no results regarding the details positioning precisions and it did not introduce into discussion the limitations of the methodology proposed to be used.

The main objective of this study is the use of orthophotomaps obtained with UAV system flights of small dimensions in order to make the cadaster for properties from the build-up area of rural regions. The specific objectives were: (1) drafting the orthophotomap using UAV by using the ground points and without using the points; (2) the identification and realization of differences between the boundaries and surfaces obtained by vectorization of orthophotomap and those from the official database of the National Agency for Cadaster and Land Registration (e terra 3); (3) identification of constructions on the orthophotomap comparatively with terrestrial measurement.

2. Material and Methods

2.1. Study Area

The area studied is located between 45o 48’ 50”and 45o 48’ 56” northern latitude and 25o 28’ 07” and25o 28’ 37”eastern longitude, and is part of the territorial administrative unit of Crizbav from Brasov County, Romania (Figure 1). This area was chosen because here were made and received works of cadaster with the program CESAR (Complementing EU Support for Agricultural Restructuring Project), and this way, these data are references for the results obtained from the researches.

The flights with UAV technique, GNSS observations and terrestrial measurements have been done mainly on the Main Street for all the properties with exits at this street. In total there have been collected data from a surface of approximately 45 ha, of which were studied approximately 150 properties on which are about 300 constructions with different usage.

Fig. 1. Localization of researches

2.2. Materials

For the present study there were used materials from different sources. The reference data have been downloaded from the digital platform of the National Agency for Cadaster and Land Registration, named *e terra 3*, where the geometries of all lands and construction can be found and registered in the national graphic database. For the design of the optimal position of photogrammetric points for the office stage was used the orthophotomap edition of 2006. The determination of photogrammetric points coordinates on the field was achieved with GNSS ASHTECH PROMARK 800 system.

The digital images taking-over was performed with UAV DJ Phantom 4 PRO system, equipped with a digital camera, whose general characteristics are mentioned in the table below (Table 1).

The digital images processing was achieved with Agisoft Photoscan software, and the vectorization with AutoCAD software and the application TopoLT. The high number of images obtained and their size, determined the use of a computer with the following characteristics: two processors *Intel Xeon E5 2.10GHz*, two video cards *3071MB NVIDIA GeForce GTX 780* with *64 GB DDR3 RAM, 802MHz.*

Table 1

Main characteristics of
UAV DJ Phantom 4 PRO system

UAV Model	DJI Phantom 4 PRO
Camera	FC6310
Resolution	20 MP
Sensor width × height	6.48525 × 4.86394 mm
Image width × height	5472× 3648 pixels
Pixel size	2.41 µm
Focal length	8.8 mm
Maximum flight time	28 min

2.3. Methods

2.3.1. Determination of Photogrammetric Points

In order to assure the connection between the land and the aerial images, 12 photogrammetric points have been designed. Their selection was in visible places in order to be identified on the images and determined by GNSS technique, but it was also considered their uniform distribution on the area studied. Ground marking was achieved with metal bolts for the build-up area and special construction landmarks for the areas outside the built-up surfaces. The determination of the coordinates was done by using GNSS technique, Real Time Kinematic (RTK) method, Virtual Reference Station (VRS) work variant. For the determination of coordinates with high precision, the standing time for each photogrammetric point was of 10 minutes.

2.3.2. Taking Over the Aerial Images

In every project involving the use of UAVs or classic procurement techniques, the first stage must begin with the flight planning. For mapping purposes, this stage requires activities such as: obtaining flight permission, software selection, detailed area analysis and ground sample distance (GSD). In addition, other important aspects must be taken into account such as the flight height, the possibility of using the GNSS technique and inertial navigation system (INS), the location of the photogrammetric points in the field prior to the flight and the determination of their coordinates are also to be considered.

The aerial images were taken from a flight plan made with PIX 4D software with 80% longitudinal overlay of images and 70% band overlay (Figure 2). The images were acquired in the form of a photogrammetric block, from an altitude of 80 m, with a flight speed of 14 m/s.

Fig. 2. Flight plans made with PIX 4Dsoftware as four photogrammetric blocks

Due to the safety measures imposed by the UAV construction and control software, the size of the surface that can be overrun could not exceed certain dimensions. For this reason, in order to cover the entire study area (6.5 ha), four separate flights were performed with overlapping areas between them so that, when processing the images, to be enough common pixels between the end bands of the four flights.

2.3.3. Making the Orthophotomap

The main objective of photogrammetry is to extract 3D information from 2D images [18]. For this purpose, the inner orientation (IO - defines the perspective center of the camera view in relation to the image according to the main distance or focal length and the lens distortions) and the outer orientation (EO - defines the position of the camera according to the coordinates of the perspective center and the rotation of its optical axis assembly relative to the mapping frame) of the images that must be calculated. In traditional photogrammetry (with human onboard), the sensors used are metric cameras. These cameras have stable internal orientation parameters, usually estimated by the manufacturer through a camera calibration.

The first models of metric cameras which can be equipped with UAVs have recently been developed [19], but this study envisages the use of low-cost equipment, currently most of the sensors installed on UAVs are non-metric [1]. The consequence of using cameras in this category is that IO parameters need to be evaluated from their own data [18].

If there is GNSS / INS information, then the collected data helps to automatically extract the tie points between images, as it is possible to restore the position of the image at the time of the flight. Moreover, navigation data helps to georeferentiate the whole image, because the image projection centers are known (GNSS-assisted sensor orientation). When these data are unavailable or they have a low precision, the indirect orientation of sensors is made by using GCPs.

Once the IO and EO parameters are available, an alignment technique should be applied to represent the object space through daytime clouds. These point clouds must be structured, interpolated if necessary, simplified and textured for which the presentation and visualization to be as close as possible to reality [27]. A large number of computer-assisted image alignment techniques have been developed and featured over the last decade. They can be divided into two main classes [18]: (1) patch-based approaches and (2) semi-global approaches. In the first class is the multi-image approach presented in Furukawa and Ponce (2010), and in the second is the approach of Hirschmuller (2008) which was later improved [29, 34]. Patch-based approaches are often multi-image (that is, they use multiple images simultaneously to determine their homologous points and their 3D position), while semi-global approaches work with stereo pairs and then merge the clouds of generated points into one data set. Their quality is influenced by flight parameters such as GSD, image overlay and sensor quality.

The images taken with the DJI Phantom 4 PRO UAV were processed with Agisoft Photoscan software in order to get the orthophotomap in the studied area. The steps taken are those in digital photogrammetry [3, 33], but adapted to the system and technique used there in (Figure 3).

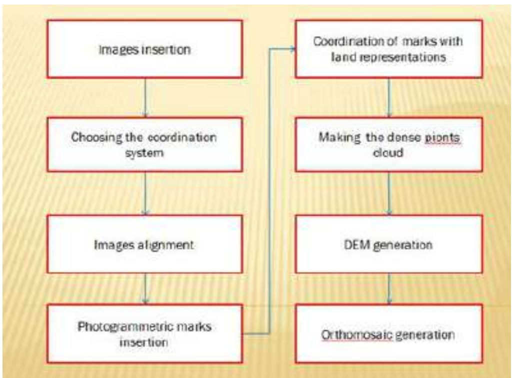

Fig. 3. Steps for realization of orthophotomap

The number of nadiral digital images taken over for the drawn flight project was of 1293 with their size comprised between 8 and 9 Mb.

Obtaining the orthophotomap with Agisoft Photoscan is based on the alignment operation of raw digital images and involves the identification of common pixels from each digital image by finding its position and orientation at the time of takeover. Thus, in the first alignment process a cloud of 786 943 common points was formed. In this process, each point is associated with the corresponding coordinates of the perspective image center from the time of takeover (image coordinates). The software allows the generation and view of a dense cloud of points obtained by the camera's position at the time of shooting for which it recalculates the depth of the information (pixel) in each digital image and combines it in a single cloud of points. Through this process, from the common points previously determined (786 943), 532 046 044 points were reached in the form of a dense cloud. The processing operation lasted 15 hours due to the large number of points determined.

For the orthophotomap with ground references, the dense cloud points are associatedwith the coordinates which result from the process of mark coordinates materialized on ground (land space) with their correspondent from the image space (Figure 4).

Fig. 4. Dense point cloud and distribution of photogrammetric marks within the studies area

The digital surface model (DSM) and the orthomosaic are obtained based on dense cloud points. These two sub-stages are linked to each other, because of the dependence between dense cloud and DSM and between DSM and orthomosaic. In this way, for the generation of DSM, the source is the dense cloud, and for the orthomosaic, the source is the DSM. Since the source of orthophotomap formation is DSM, it is called true-orthophoto (Koeva, 2016). Using these data sources, the risk of lateral images emergence or other type of errors is reduced.

2.3.4. Vectorization of Boundaries

The vectorization of boundaries was achieved by using the orthophotomap based on digital images taken with the

UAV. The boundaries between the buildings in the area studied were tracked manually and placed in different layers. After the vectorization of all reported boundaries, it was performed an overlaying over the official boundaries exported from the ANCPI database (e terra 3) and a visual inspection was made for the first time (Figure 5). At the same time, the coordinates of the two sets of boundaries were agreed in order to determine the possibility of using the orthophotomap in the description of the cadastral limit (Figure 5).

Figure 5. Part of the orthophotomap vectorized: red color-official limit of ANCPI (e terra 3); blue color-vectorized limit based on the orthphotomap made based on the images received with the UAV

3. Results

3.1. Ground Control Points

GNSS devices equipped with UAV of low costs have an increased precision. Phantom 4 PRO has a GNSS system incorporated with the code signal in simple frequency (L1) and with an estimated precision of the position in horizontal plan of ±1.5 m and of ±0.5 m in vertical plan. Due to a low precision, unsatisfactorily for cadaster works, it was compulsory to place and to determine the photogrammetric marks in the study area.

The determination of photogrammetric marks in land stage was achieved with different precisions, but all of them were enclosed in the tolerance admitted by the Romanian norms and regulations from the cadaster for outside the build-up area, namely ±10 cm.

From the GNSS observation sheet, it was noted that the precision indicators given by HRMS (Horizontal Root Mean Square) and VRMS (Vertical Root Mean Square) fall within the range of 0.2-1.2 cm for HRMS and 0.3-1.5 cm for VRMS respectively. The determinations were made directly in the Romanian stereographic 1970 projection system.

3.2. Ortophotomaps

The final representation, which will be used for mapping purposes, is done by orthorectification, which requires precise surface-related information to eliminate the projective distortions of the original images. The orthophotomap represents all the details in a projection perpendicular to the projection plan. The surface on which an orthophotomap is made can be obtained by using the digital terrain model (DTM) or DSM; In the latter case, the result of the orthorectification is called true-orthophoto [18].

Orthophotomaps obtained from aerial image processing with the help of Agisoft Photoscan software are true-orthophoto. The spatial resolution of the orthophotomaps is of 2.14 cm and a root mean square error (RMSE) value dependent on the use or not of the photogrammetric marks in the orthophotomap production process.

From the reports provided by Agisoft Photoscan software at the end of the image processing, the precisions obtained for each case study have been centralized (Table 2).

Figure 6 shows the error ellipses for all photogrammetric marks. These ellipses are determined on the basis of the operator's assessments regarding the position of the photogrammetric mark from the image space and are found in the final report provided by the software. The position of each landmark was identified in at least 20 images due to overlapping of large images.

Table 2

Precisions obtained for the two types of orthophoto map

No.	Error	Crizbav Locality	
		With marks	Without marks
1	axis X (m)	0.008	1.41
2	axis Y (m)	0.007	3.88
3	axis Z (m)	0.003	1.45
4	axis X and Y (m)	0.011	4.12
5	RMSE (m)	0.011	4.37

Fig. 6. GCP location and error estimates Z error is represented by ellipse color. X, Y errors are represented by ellipse shape

Estimated GCP locations are marked with a dot or crossing.

An important factor in the performance of the works is also the time necessary to obtain the final product. Thus, with the help of the computer, the processes of execution lasted for 18 hours in the case of orthophotomap without ground marks and 19 hours with marks.

4. Discussion

4.1. Orthophotomap Obtained

The orthophotomap obtained from images taken with low altitude and ground marks UAVs was compiled according to the methodology of digital photogrammetry. Its accuracy depended on the quality of digital images, image acquisition, quality and accuracy of photogrammetric render measurements. Regarding the ellipse of errors in determining the photogrammetric marks and their identification in the image space, no connection was found between the size and direction of the orientation of the large axis of the ellipses. The obtained orthophotomap has served as a support for manual vectorization of land boundaries and building sites, the most important factors in their establishing being the contrast and texture of the image, but also the operator's experience and intuition.

The quality of the image orientation and, implicitly, of the orthophotomap, were analyzed from the qualitative and quantitative point of view. Due to the conditions encountered on the field, different distortions may occur within the orthophotomap. Therefore, a qualitative and quantitative assessment and the correction of the orthophotomap are necessary. For example, in true-orthophoto, lateral dense details should not appear, although in the row image the lateral view is visible (Figure 7).

Fig. 7. Raw images in which can be seen lateral view of details (a) and orthorectified images based on DSM (b)

The visual inspection of the orthophotomap did not reveal errors in terms of lateral views, but there were noticed distortions caused by differences in texture and color (Figure 8).

In all the analyses performed below was used the orthophotomap obtained from images taken with UAV and using GCP.

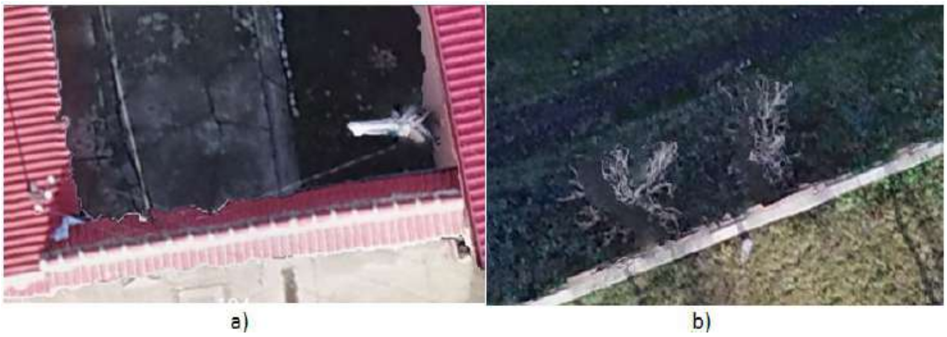

Fig. 8.Types of distortions caused by: a-color differences; b- texture differences

4.2. Analysis of Coordinates of Land Boundaries

From the visual comparison of the boundaries obtained following the vectorization of the orthophotomap with the official ones in the National Agency for Cadaster and Land Registration database it was found that in many cases they do not correspond.

Based on the differences between the coordinates of the boundaries in which the reference value was considered that from the National Agency for Cadaster and Land Registration (e terra 3) database, the movements on the X and Y axes were calculated, and then the total movements have been calculated and classified on groups of 20 cm (Figures 9 and 10).

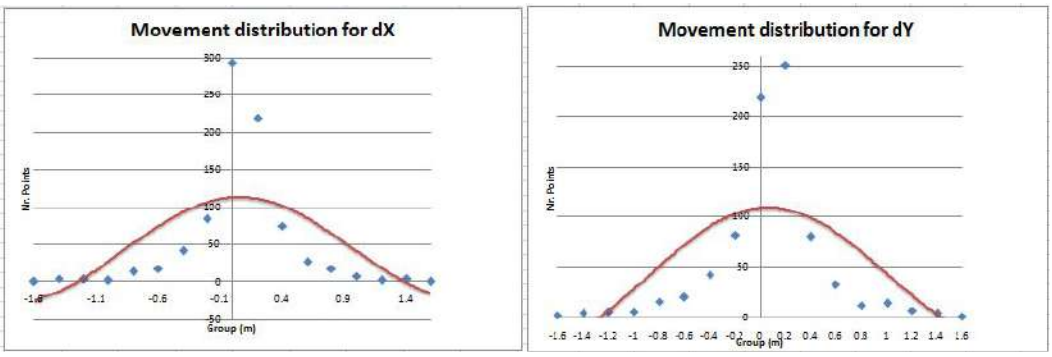

Fig. 9. Movement distribution on axis X and Y

Analyzing the number of points for a particular group it was noted that the highest frequency corresponds to the groups of 0-20 cm and 20-40 cm, with 42%

and 23% percentage of the total number of points (Figure 10). The movements on the X and Y axes are arranged after a Gauss curve, with the symmetry given around zero. The standard deviation shows that the average set boundaries are within ± 35 cm for the X axis and ± 49 cm for the Y axis. According to Romanian technical norms,if the ± 10 cm tolerance is considered for the lands within the build-up area, it is found that there are no correspondences between the existing official data and those obtained on the basis of the orthophotomap performed with UAV, only 15% of the total score being within ± 10 cm tolerance.

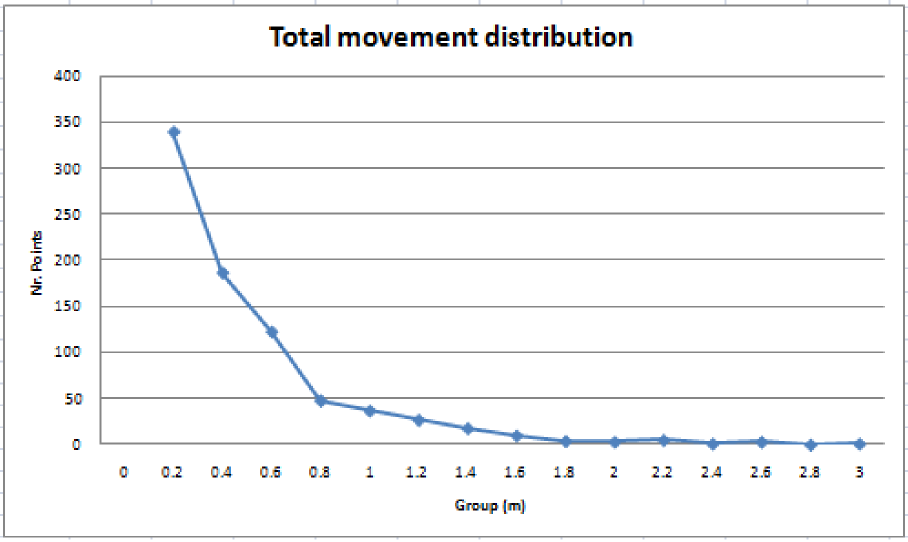

Fig. 10. Total movement distribution

Significant differences identified by analyzing the coordinates of the official database with those from vectorization may be explained, in particular, by the working methodology adopted for the implementation of the CESAR program (Complementing EU Support for Agricultural Restructuring Project). It was found that the points describing the street boundary have movements that fall within the allowed tolerances, instead of the ones inside the buildings and many more have movements that can reach up to 1.5 m. One possible explanation would be that precise measurements were made for the street frontage of the real estates, while the points forming the inside existing boundaries were extracted from the old cadastral plans morally outdated and of unsatisfactory precision.

Figure 11 shows the distribution of the cumulative percentages corresponding to the groups in which the total movements were classified. Thus, total movements of up to 10 cm represent 15%, those up to 0.5m 73%, and movements up to 1m 91%. Therefore, only a small part of the boundaries in the official database falls within the tolerance currently allowed in Romania. For the other, much more numerous, the limits in the National Agency for Cadaster and Land Registration database does not reflect the situation on the ground, which shows that it is necessary to modify the boundaries by updating cadastral works.

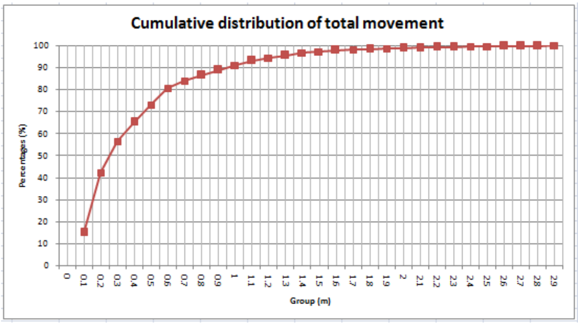

Fig. 11. Cumulative percentage distribution according to the groups of total movements

4.3. Identification and Analysis of Land Surfaces

The non-correspondence of the boundaries between the official database and those vectorized on the orthophotomap leads also to surface differences for each building. The base surface, considered reference, was the surface in the National Agency for Cadaster and Land Registration database and downloaded from the platform e terra 3.

According to the results obtained from the comparison of the two surfaces for the properties studied, it was determined that 30% of the total properties are in 1%, 59% in 2%, and all real estate's fall into one percentage of 10% (Table 3).

Table 3

Summarization of surface differences on classes, number of properties and percentages

No.	Class	No. of properties	Cumulated no.	Percentage of properties	Cumulated percentages
1	[0-1%]	33	33	30	30
2	(1-2%]	32	65	29	59
3	(2-5%]	37	102	34	93
4	(5-10%]	8	110	7	100

Based on the total movements of each point describing the boundaries of a building, a mean total displacement was calculated and analyzed in relation to the value of the surface difference of the same building considered in the module. From the graphical representation of the obtained values it is deduced that there is a tight connection between the two variables considered, given by a determination coefficient of 0.56, respectively a correlation coefficient of 0.75 (Figure 12).

The study of the graph, together with the high correlation coefficient value (0.75), suggests that the differences of significant coordinates may lead to surface differences that are directly dependent on their size, even though basically it can be brought into discussion the rotations and translations of vector geometries compared to the official ones.

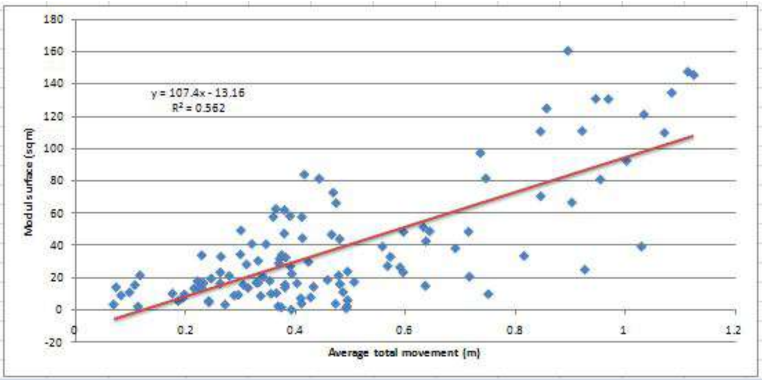

Fig. 12. Predictive model between total mean movements and the surface differences in module

The separation of the properties on the orthophotomaps, their correct identification and delimitation, is an important operation as it illustrates, from the beginning, the possibilities of vectorization of the orthophotomap. In this sense, the reals estates resulting from the vectorization were identified and counted and then compared with those existing in the official database. From the 146 official properties there were identified 110 obtained by the vectorization process, this result totalizing 75% of the identified real estates, the rest being unidentified (Figure 13).

The lack of identification of all the properties can be explained by the specificity of the locality (whether or not it has been part of the co-operative areas), as well as the legal aspects that characterize that building. In the present case, with the co-operative process that began in the 1950s, there were many cases in which the owners by right had abusively taken over part of their land, leaving only 250 square meters of land to be built. Thus, this process led to the formation of two Cadaster Registers, even though the land actually forms a single property. Crizbav was part of the cooperative process and implicitly the situation described above.

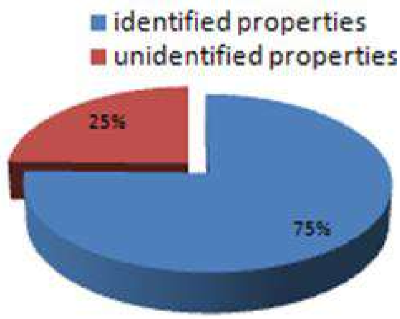

Fig. 13. Identification situation of the properties by vectorization on orthophotomap

4.4. Identification of Constructions

The specificity of the build-up area inside the localities of any rank is given by the existence of the constructions. They can be of different shapes and sizes regulated by law and local authorities depending on the specificity of the area. The obligation of each owner of a new building is to register the property in the Real Estate Register when it is completed, and if the locality is subject to a full registration process in the Cadaster, it is necessary to register all the constructions, regardless of the year of construction or acquisition. Through the CESAR (Complementing EU Support for Agricultural Restructuring Project) program from which Crizbav was part of, once the land registration was completed, all the constructions were registered, regardless of form, size and destination.

According to the legislation in force [36] the registration of the constructions is done by measuring the ground footprint of the buildings, this mark footprint being given by the walls of the constructions and not by the projection of other details that make up the construction (the rain shadow). Being an orthogonal projection, the orthophotomap obtained based on digital images taken with the UAV renders the upper part of the buildings (including the rain shadow), making it impossible to render the walls that make up the construction. For this reason, it is not recommended to use the orthophotomap exclusively in the measurement process, even if it is made by using DSM, but to combine these measurements with terrestrial measurements involving the use of some technologies such as total stations, robotic stations or multiscan stations, even terrestrial photogrammetry.

The high-precision orthophotomap obtained for the studies surface captures constructions of different shapes and sizes and was used in particular for checking the accuracy of the building site. From the study of about 300 constructions, the following general and specific conclusions were drawn: (1) within the build-up rural areas, the UAV technology is insufficient to establish precisely the perimeter and including the surface of the constructions (the surface built on the ground) (2) the obtained orthophotomap can be used as a mapping support, (3) accurate measurement of the construction with rain shadow is impossible, but the measurement of the dead wall (without rain shadow) construction can be done with high precision, (4) from the comparison of the building site from the official data with that deduced from the orthophotomap, there are few cases that fully correspond to one another.

5. Conclusions

The achievement of high-precision orthophotomaps has become a rather mild task with low costs, and their use is increasingly necessary given the social-economic changes that have taken place in Romania since 1989. A result of these changes is the lands that were scattered a lot, reaching up to several hundred square meters for a building. In this sense, building a general cadaster, using current field data collection techniques, such as UAVs combined with terrestrial techniques, can be a viable alternative. Large-scale and increasingly accurate digital orthophotomaps are becoming more and more practical, ensuring both the metricity of the product and the presentation of the land as a representative image. Moreover, by using this technology, it is possible to quickly and efficiently perform a status check for a certain area, and to overcome the changes that have been made to continuously update the maps.

In this study, the steps taken to develop a high-precision orthophotomap, the possibilities of use, as well as its limitations, were highlighted. The results show that the implementation of the general cadaster through the CESAR

(Complementing EU Support for Agricultural Restructuring Project) program for the Crizbav locality has not been carried out according to the norms and regulations in force, the results obtained by comparing the coordinates and the surfaces, giving an overall picture suggesting deficiencies in the establishment of the land boundaries and the location of the constructions. At the same time, the necessity of using GCP was brought up into discussion in the process of obtaining the orthophotomap, the comparison of the precisions obtained in the two situations and presented in the report of Agisoft Photoscan program being persuasive.

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ECOLOGICAL NICHE RELATIONSHIPS IN GOLDEN JACKAL'S CORE AREA OF DISTRIBUTION IN EARLY STAGES OF CUB REARING SEASON

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Abstract: *Despite of their indigenous status in Romania, the golden jackal (Canis aureus L.) act as a new species in many recently re-colonized habitats. In such areas, we have limited knowledge about the distribution of animal species within community assemblages. We identified a study site with resident breeding golden jackal populations, confirmed their constant presence with acoustic method and direct observations, then deployed there 20 remote cameras in 24 locations during 206 trap nights. The camera survey period was May – June 2018, known as the early stage of cub rearing season for most of indigenous wildlife species. We recorded 625 photos and video captures of 7 mammalian and 1 bird wildlife species across 18 camera stations in 174 trap days. On 6 camera stations were not detected any animal species, or the cameras disappeared, thus we excluded those from the analyses. Wild boar was recorded at 14 camera stations (74.78%), Golden jackal at 13 (72.22%), Roe deer at 9 (50.00%), the Red fox, Brown hare, and Pheasant were captured in 4 locations (22.22%), while Eurasian badger in 3 (16.67%), and Wild cat in one single location (5.55%).We did not find any significant differences between recorded species nor in number of days to first detection, neither in percent of days with photo or video captures per location. Regression analyses revealed statistically significant positive correlation based on presence or absence at camera stations between Red fox and Pheasant (r=0.38; p<0.001), Eurasian badger and Pheasant (r=0.47; p<0.001) as well as between Red fox and Badger (r=0.38; p<0.001). Ecological niche overlap calculations show relatively small values between the golden jackal and the other carnivore species (11.06%; 16.06%), while these values between the jackal and their potential prey species were slightly higher (17.66% - 34.89%). Conservation and management implications of our results are discussed.*

Key words: *Golden jackal, niche relationships, community assemblages, camera trapping, Romania.*

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1. Introduction

Within the current Romanian distribution area of the golden jackal (*Canis aureus* L.), there are habitats which can be considered as re-colonized, with stable resident breeding populations [9-10]. The scientifically based knowledge about the possible effects of the jackals on the indigenous animal communities is scarce. Studies typically focus on status, distribution, and expansion patterns [1, 18, 24], legal implications of range expansion [30], population densities [26] and feeding habits in different type of habitats [2, 5, 7, 16, 21, 23].

Regarding the species interactions there are available data of comparative studies between the red fox (*Vulpes vulpes* Frisch.) and golden jackal based on their diet [8, 12, 14-15, 17, 31]; the impact of the high level of nutritional niche-overlap on the body size of juvenile foxes [9] and fear behaviour of foxes against jackals [27]. Relationships between the golden jackal and the other sympatric species are less studied.

In Romania basic data about the animal species living in a certain habitat could be found from stock assessment results performed by the hunting organizations. These data are relevant on game management unit level whose minimum legal surface is 50 km^2, but the average size of Romanian hunting grounds is 102.44 km^2 [10]. About the habitat use patterns of the wild fauna inside game management units – without physical borders – there are no conclusive information. Moreover, effects of the relatively new appearance of the golden jackal on the animal community assemblages previously were not studied.

Complex vocalization repertoire – known as spontaneous howling – exhibited by golden jackals [11] makes possible the identification of habitat parts with constant jackal presence, at least in some periods of the nights starting with the sunset. Such study sites with confirmed golden jackal presence could be surveyed using remote cameras. Camera traps are considered reliable, minimally invasive, cost efficient and less time-consuming tools in surveying wildlife [3-4]. Former study results have proven that the camera traps can be efficiently used in surveying wild ungulates [25], birds [20], and carnivores [22]. Even the smallest body sized mustelids can be captured by camera traps but, the capture rate of these species varies from 0.4 to 4.5 captures per 100 days [19].

The purpose of this study was to inventory a terrestrial animal community where the golden jackal is the apex predator species and conduct an analysis of possible ecological niche relationships based on camera survey data.

2. Material and Methods

Using camera traps, we surveyed the whole animal community assemblages and the strength of their interactions, studied the latency to first detection for every species recorded and performed ecological niche overlap calculations.

2.1. Study Site

The study area was in the Golden jackal’s core area of distribution in Romania, Teleorman county, game management unit (GMU) number 4 - Turnu Măgurele (Figure 1).

Fig. 1. Locations of camera traps across the GMU 4 Turnu Măgurele

This GMU was specially selected because previous study results conducted by us in the same area revealed that there are living the highest densities of golden jackal and red fox populations as well [9]. GMU no. 4 is a flatland (1-100 m a.s.l.) habitat with a total surface of 11,857 hectares, the Southern border being the Danube, and the country border, while the Western border follows the Olt river. Forests cover 1,718 ha (14.49%); agricultural arable lands occupy 8,115 ha (68.44%); pastures 1,850 ha (15.60%); water courses 105 ha (0.89%) and 69 ha (0.58%) of the GMU area are unproductive lands (localities, roads etc.). The mean multiannual temperature is 11.5°C and the average annual precipitation is 518 mm. The forests also have productive and protective functions and they are dominated by oak species (*Quercus* ssp.), ash species (*Fraxinus* ssp.) and white poplar (*Populus alba* Linn.). According to annual stock assessments performed by the game management organizations there are present in the GMU no. 4 the following wildlife species in decreasing order of density / 1000 ha: Pheasant – *Phasianus colchicus* (59.05), Brown hare – *Lepus europaeus* (57.68), Grey partridge – *Perdix perdix* (23.07), Roe deer – *Capreolus capreolus* (8.95), Wild boar – *Sus scrofa* (8.24), Golden jackal – *Canis aureus* (2.83), Red fox – *Vulpes vulpes* (1.68), Eurasian badger – *Meles meles* (1.15), Least weasel – *Mustela nivalis* (1.04), European polecat – *Mustela putorius* (0.88) and European pine marten – *Martes martes* (0.44). Golden jackal and red fox are the apex predator species of the area. About the protected animal species there are no available data.

2.2. Camera Trap Design

We deployed 20 remote cameras (10 Minox DTC 550 - IR, 2-12 MP, Minox GmbH, Germany; 4 PNI Hunting 2C - IR, 2-

8 MP, S.C. Onlineshop S.R.L., Piatra Neamt, Romania; 2 Moultrie M990i - IR, 0.5-10 MP, Pradco Outdoor Brands, Birmingham, AL, USA; 2 Uway NT 50B - IR, 0.3-8MP, Uway Outdoor Products, Lethbridge, AB, Canada; 1 Suntek HC-300M - IR, 5-12 MP, Shenzhen IME Technology Co., Ltd., Guangdong, China; 1 Ltl Acorn 5210MG - IR, 5-12 MP, Shenzhen Ltl Acorn Electronics Co. Ltd., Guangdong, China.) on 24 camera stations. One single remote camera was deployed at each station, in those parts of the habitat where constant presence of jackals was recorded based on spontaneous vocalizations. Positioning was random, but we also considered the avoidance of possible human presence especially the roads. Cameras were attached to trees or wooden posts with their standard mounting straps, approximately 0.4 – 1.0 m above the ground and were set facing the surveyed habitat type. We set cameras to medium sensitivity, fastest trigger rate, 8 MP resolution and to take one picture plus one 15 – 30 seconds long video at every detected motion. There were not activated any delay settings. According to the study objectives we did not used scent lure, food, or any other type of attractants for carnivores.

2.3. Ecological Niche-Overlap Calculations

The ecological niche overlap was calculated between golden jackal and the other recorded animal species (Figure 2, except wild cat, because of the single record) by the Renkonen index [13]: $P_{jk}=[\Sigma n(\text{minimum } p_{ij}, p_{ik})]100$, where P_{jk} is the percentage overlap between species j and species k; p_{ij} and p_{ik} are the proportion of photo + video captures at camera station i which is represented within the total photo + video captures with species j and species k (the minimum means that the smaller value should be used); n is the total number of the camera trap locations.

2.4. Statistical Analyses

The basic statistical parameters (range, mean, and the standard error of mean values) were calculated for number of camera nights deployed and latency to first detection of all species captured. For the comparison of the average number of nights to first detection within the studied animal community assemblage, we used independent t-test by samples. Numbers of nights to first detection of every species were treated as independent samples. The homogeneity of variance among the species was tested using Levene’s test.

Pearson correlation between presence and absence of species at camera stations was calculated, the variables being the number of trap night per species captured. Comparisons were made on species pairs.

All variables were checked for normality. Statistical significance for all tests was inferred at $\alpha = 0.05$. Statistical analyses were carried out using STATISTICA version 13 [6] and Microsoft Excel.

3. Results

In the period of 08 of May and 14 of June 2018 we deployed 20 remote cameras in 24 stations located in the golden jackal’s core area of distribution in Romania, during 206 trap nights. Our aim was to assess the animal assemblages in a habitat with constant presence of golden jackals and to study the ecological niche relationships in such communities.

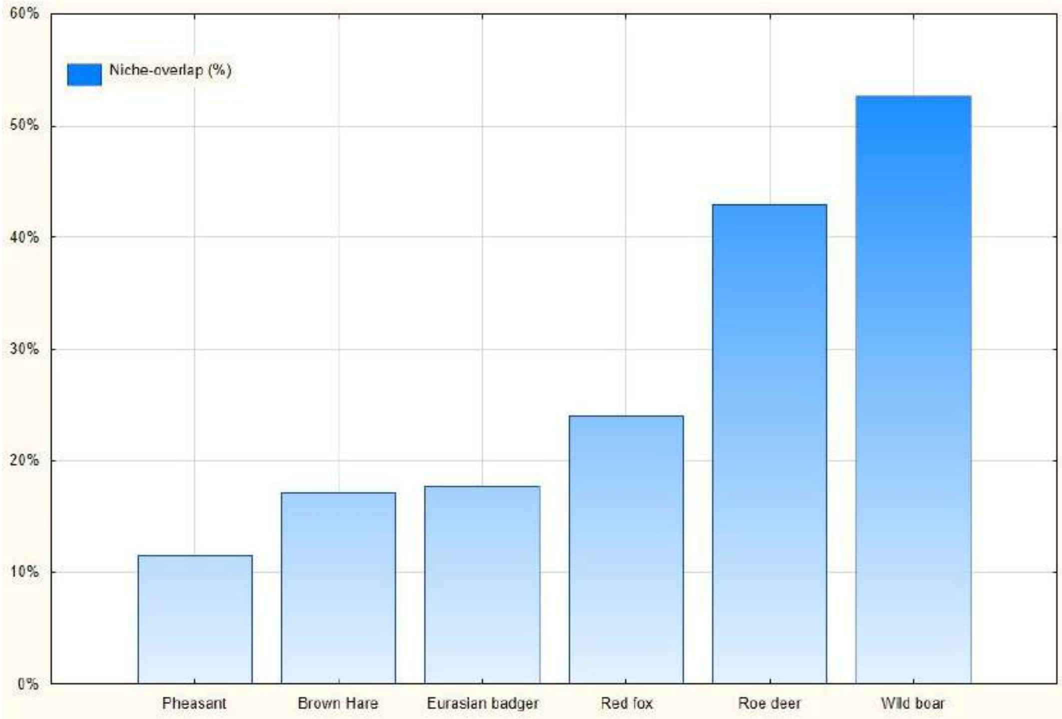

Fig. 2. Ecological niche-overlap between the Golden Jackal and other detected species

At 6 camera stations deployed during 32 camera trap nights we're not detected any animal species, or the cameras disappeared, thus we excluded those from the analyses. We recorded 625 photos and video captures of 7 mammalian and 1 bird wildlife species across 18 camera stations in 174 camera trap nights (Table 1). From the list of 11 species assessed by the hunting organization 7 were detected, plus the protected wild cat (*Felis silvestris*). The undetected species were the Grey partridge and the mustelid species with the smallest body size and lowest density.

3.1. Capture Rate and Latency to First Detection

The species with the highest frequency of occurrence was the wild boar captured at 74.78% of the camera stations followed by the golden jackal with a capture rate of 72.22%.

The mean number of nights to first detection for all species ranged between 2.50 and 5.67 (Table 1) without statistically significant differences between latency to first detection of the golden jackal and the other captured species within the studied animal community assemblage (Table 2).

Table 1

Number of cameras that detected wildlife species, range, mean and standard error of mean for total nights deployed and nights to the first detection per species captured

Species	No. camera stations with detection (%)	No. nights deployed			No. nights to first detection		
		Range	Mean	SE	Range	Mean	SE
Golden jackal	13 (72.22%)	7-13	10.15	0.63	1-8	4.15	0.54
Roe deer	9 (50.00%)	8-13	10.33	0.65	1-11	4.22	1.02
Pheasant	4 (22.22%)	9-13	10.75	0.85	2-10	5.50	1.85
Brown hare	4 (22.22%)	11-13	11.75	0.48	2-8	4.50	1.26
Red fox	4 (22.22%)	11-13	12.25	0.48	1-4	2.50	0.65
Wild boar	14 (74.78%)	5-13	9.64	0.68	1-11	4.93	0.77
Eurasian badger	3 (16.67%)	8-13	11.00	1.53	3-10	5.67	2.19
Wild cat	1 (5.55%)	13	N/A	N/A	3	3	N/A

3.2. Species Interactions in Animal Community Assemblage

Presence and absence of species at camera stations was tested by correlation analysis. Statistically significant differences were found only between Red fox and Pheasant ($r=0.38$; $p<0.001$), Eurasian badger and Pheasant ($r=0.47$; $p<0.001$) as well as between Red fox and Badger ($r=0.38$; $p<0.001$). Detailed results of correlation analysis are presented in Table 3.

Table 2

Comparisons between average number of nights to first detection of golden jackal and the other captured species within the studied animal community assemblage (T-test for independent samples)

Species groups (Gr_1 vs. Gr_2)	Mean Gr_1	Mean Gr_2	t-value	df	p
Golden jackal vs. Roe deer	4.153846	4.222222	-0.06404	20	0.949573
Golden jackal vs. Pheasant	4.153846	5.5	-0.97933	15	0.342951
Golden jackal vs. Brown hare	4.153846	4.5	-0.29152	15	0.774648
Golden jackal vs. Red fox	4.153846	2.5	1.57343	15	0.136472
Golden jackal vs. Wild Boar	4.153846	4.928571	-0.80879	25	0.426265
Golden jackal vs. Badger	4.153846	5.666667	-1.02484	14	0.322821

3.3. Ecological Niche-Overlap

Comparison of ecological niche-overlap between golden jackal and the other animal species in the studied community assemblage increased as follows: Golden jackal vs. Red fox (11.06%) <Golden jackal vs. Eurasian badger (16.06%) < Golden jackal vs. Brown hare (17.66%) < Golden jackal vs. Pheasant (18.18%) < Golden jackal vs. Roe deer (32.46%) < Golden jackal vs. Wild boar (34.89%).

4. Discussion

Our study results offer insights in the componence and niche relationships of animal community assemblages in habitats where the golden jackal is considered an indigenous predator, but after a few centuries of absence in many European countries (e.g. Hungary) as well as in Romania – in terms of intensive spreading – shows the characteristics of invasive species [10, 29].

Table 3

Coefficients of correlation and p-values of significance between presence and absence of species at camera stations. Bold marked correlations are significant at p < .05000

Species	Golden jackal	Roe deer	Pheasant	Brown hare	Red fox	Wild Boar	Badger
Golden jackal	1.0000	-.0128	-.0371	-.0089	-.0985	.1095	-.0987
	p= ---	p=.856	p=.597	p=.899	p=.159	p=.117	p=.158
Roe deer	-.0128	1.0000	-.0610	-.0506	-.0234	.0830	.0288
	p=.856	p= ---	p=.384	p=.470	p=.738	p=.236	p=.682
Pheasant	-.0371	-.0610	1.0000	-.0424	**.3837**	-.1228	**.4745**
	p=.597	p=.384	p= ---	p=.545	**p=.000**	p=.079	**p=.000**
Brown hare	-.0089	-.0506	-.0424	1.0000	.1195	-.1020	-.0424
	p=.899	p=.470	p=.545	p= ---	p=.087	p=.145	p=.545
Red fox	-.0985	-.0234	**.3837**	.1195	1.0000	-.1001	**.3837**
	p=.159	p=.738	**p=.000**	p=.087	p= ---	p=.152	**p=.000**
Wild Boar	.1095	.0830	-.1228	-.1020	-.1001	1.0000	-.0690
	p=.117	p=.236	p=.079	p=.145	p=.152	p= ---	p=.325
Badger	-.0987	.0288	**.4745**	-.0424	**.3837**	-.0690	1.0000
	p=.158	p=.682	**p=.000**	p=.545	**p=.000**	p=.325	p= ---

Camera trap captures revealed that the studied habitats are rich in game species and there is present also the protected wild cat. This result shows that in the studied habitats, camera trapping could be an appropriate method also for biodiversity estimates [32]; species abundance studies [19, 25, 28]; or spatial distribution analyses across habitats [22]. However, the grey partridge and the mustelids with smallest body sizes and lowest densities could not be detected in the studied habitats. Unequivocal explanation for the lack of detection was not found. Suspected causes could lay in lower real population densities of the grey partridge than the official stock assessment data, and the generally lower capture rates of small mustelids [19]. In the studied animal communities there are two dominant species (i.e. the wild boar and the golden jackal) with capture rates above 70%, the second most recorded species is the roe deer, and the frequency of occurrence of the rest of inventoried species is slightly similar (16 - 22%). The high frequency of capture rates of the jackal and the wild boar could be explained with the fact that, based on feeding habits studies performed in the same habitat, the wild boar is the most important prey species of the golden jackal in the spring period [7]. The top predator species of the animal community are the jackal and the fox. The mean number of days to first detection at a camera station was 4.44 ±2.64 without any significant differences between the species. Furthermore, despite of variable numbers of camera stations with detection of certain species, the differences between percent of days with photo or video captures per day were not statistically significant either. Lack of significant differences suggests an even spatial distribution of species in studied community assemblages.

Minimum number of days to capture a certain species at all the camera stations with detections varied as follows: red fox 4 (n=4), golden jackal 8 (n=13), brown hare 8 (n=4), badger 10 (n=3), roe deer 11 (n=9), wild boar 11 (n=14) and pheasant 11 (n=4). In other words, after 4 to 11 nights – depending on the species – the number of camera stations with detection does not increased. Despite of apparent even spatial distribution of captured species, the variations in number of camera stations with detections suggest at least two group of species with different habitat use. The first group could consist from: golden jackal, wild boar and roe deer detected on at least 50% of deployed camera stations; while in the second list of species we could include the rest of the captured species with a percent of positive camera stations below 23%.

Regression analyses revealed statistically significant positive correlation based on presence or absence at camera stations between Red fox and Pheasant ($r=0.38$; $p<0.001$), Eurasian badger and Pheasant ($r=0.47$; $p<0.001$) as well as between Red fox and Badger ($r=0.38$; $p<0.001$). Ecological niche overlap calculations show relatively small values between the golden jackal and the other carnivore species (11.06%; 16.06%), while these values between the jackal and their potential prey species were slightly higher (17.66% - 34.89%).

Ecological niche overlap calculations between the golden jackal and the other detected species, also suggests the clustering suspected based on variation of number of camera stations with detection of a certain species. There are signs of spatial niche segregation between the golden jackal and the other sympatric carnivore species, which aspect needs further investigations.

5. Conclusions

Remote cameras are suitable tools to inventorying animal communities in certain habitats. Our results suggest some clustering of species in the studied animal community assemblage, but statistically significant differences were not found in the tested variables. Despite of lack of statistically significant differences the research activity must to be continued to reveal the structure and manifestation of the ecological niche relationships.

5.1. Conservation Implications

Remote cameras represent a new monitoring tool of the golden jackal populations. As species is listed on Annex Five of Council Directive 92/43/EEC (known as Habitats Directive), taking in the wild and exploitation may be subject to management measures. A correct approach from all aspects must to be based on reliable monitoring data. Remote cameras, together with other methods could increase the accuracy and confidence of a further golden jackal monitoring system.

5.2. Management Implications

The positioning of camera trap stations is a highly important issue because of the experienced 12.5% loss of cameras in approximately 2 weeks (13 days) study period (3 out of the total 20 cameras disappeared). Additional lack of records was found on 3 camera stations, by which the percent of ineffectual locations reached 25%. In the studied habitats, the losses or inefficiency makes necessary to be deployed a minimum number of 4 cameras to wildlife surveillance independently of the aims and scope.

The mean number of days to first detection at a camera station of 4.44 ±2.64 without significant differences between the species means that in a survey period of 7 days the first detection of resident species could be confirmed. However, the minimum number of days to capture a certain species at all the camera stations depends on the targeted species and varied between 4 and 11. That's mean that in maximum 11 days a certain species should be detected with camera traps if it is present in the covered area. In the studied habitats a minimum number of 4 remote cameras, deployed for a period of 7 – 11 days should show a conclusive image of species living in surveyed animal communities.

Conflicts of Interest

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