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Carbon stock in European Forests: State of the Art, Uncertainties and Political Challenges

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Abstract: The article summaries the most important papers published in the last decade on three issues dealing with carbon sink: methodological issues on assessing the carbon stored by the forest vegetation, life-cycle analyses and bio-energy. The first section presents the progress made in evaluating the carbon contents in different components of the forest ecosystem, ethenone one is being focused on the complexity of life-cycle analyses with the bio-energy section mostly deals with the dilemmas concerning the use of use pellets, bio-ethanol and bio-diesel.

Keywords: carbon sink, forest management, climate change

1. Introduction

Most of the processes triggered by climate change alter the forests on short time (Schlyter et al. 2006; Frank et al. 2015; Hanewinkel et al. 2012) while the forests have a tremendous potential to offset the emissions of greenhouse gases released into the atmosphere by burning the fossil fuels. Forest management, on the one hand, and land use change, on the other hand link the forests and climate for good either at global and regional scale (Cienciala et al., 2008). Forests may produce carbon-neutral fuel, if the trees are being harvested when the average growth reaches a peak (substitution effect), or may store the carbon sink as standing biomass (offset effect). Between these two extreme solutions there are a myriad of mixed managerial options unless other objectives are pursued, the most important being the biodiversity conservation. Shifting the goals from timber production to bio-energy or conservation brings about serious changes throughout all carbon pools and also modifies the amount of fossil fuel substituted by biomass (Böttcher et al. 2012).

In Europe, the forest growth accelerated in the last century as Pretzsch et al., (2014) showed for the Norway spruce, and European beech respectively. Based on long term measurements carried out in permanent plots installed in 1870 (36 for Norway spruce and 22 for beech) collecting climatic data from four meteorological stations and using a growth simulator fed with field and climatic data the research team concluded that the growing season is 22 days longer now than 110 year ago; noteworthy, the main increase occurred in the last 50 years and triggered faster growths for the two species: 32% for Norway spruce and up to 77% for beech. The additional amount of 34 million tons of carbon per year estimated by simple extrapolation across the area covered by the two species in Central Europe yet deserves more precaution.

Due to the high intrinsic complexity of any forest policy, most of the forest management scenarios and prognoses have tried to account for this variety of goals; however, things are more complicated because these `end-use` or 'management' scenarios must be enveloped by three types of scenarios, as Moss et al. (2010) suggested: emission scenarios, climate scenarios and environmental scenarios.

2. Which are the most important terrestrial sinks

Assessing the content of soil organic carbon (SOC) under the forests provides a better understating the dynamics of carbon stock under different scenarios of land use change (Strand et al., 2016), while the distribution of carbon across different components of the living plants has too large variations. In Turkey for example, an extensive assessment based in the 2004 National Forest Inventory data showed that about 75% of the total stock is in the soil, 21% in living biomass and 4% in deadwood and litter (Tolunay, 2011). In Italy, a similar study carried under the second NFI cycle concluded that 58% of the carbon stock is to be found underground, 38% above ground, 2.3% in litter and 2% in deadwood (Gasparini and Di Cosmo, 2015).

According to a very extensive study carried out in Southern Spain by Muñoz-Rojas et al. (2012,) SOC varies between 33.2 Mg C/ha corresponding to Arenosol to 96.9 Mg C/ha, corresponding to Calcisol; worth-noting, the highest value across all types of soils were reported under shrubs vegetation, not under forests.

Because the photosynthesis is the paramount ecosystem service provided by forests (Hodas 2013), and the old-growth forest is best able to mitigate the CO2 concentration of the atmosphere, any scenario shall consider this option, opened by the unmanaged forest category. The next equally important condition for developing whatever scenario is an initial reference level, whatever it be.

In Germany, Wutzler et al., (2011) assess the tree biomass carbon stock through basal area measurements carried out on stand level, or cohorts of trees within each stand (for un-even aged structures). The carbon accumulation was appraised at 1.8 t C/ha/annum. Across the 550000 hectares of the study area, the carbon stock varies between 0.4 t C/ha/year in the northwest and 3.0 t C/ha/yr in the south. At regional level, in North Rhine Westphalia, Knauf et al. (2015) developed two scenarios regarding the wood usage and concluded that on middle and long term (2050 and 2100, respectively) and concluded the net climate protection function of forest management is better with changing levels of wood usage than the base-line scenario, without wood mobilization in long-term wooden-based products.

Estimating the total biomass is a challenging issue because it implies inevitable extrapolations of volumes per hectare across much larger areas within the forest is considered homogeneous although it is not. Hence, whoever wants to make such evaluations shall firstly contemplate how many and how representative are the types of forest worth working with (Mason et al. 2011; Allen et al. 2010; Verkerk et al. 2015; De Wit et al. 2006).

Any assessment on the total carbon stock depends on a large extent to the methodology used to evaluate the total biomass, on the one hand, and the carbon stored in the forest soils, on the other hand. Either ways the forest area is the first requisite for having a proxy of the carbon stock and the main source of data is the national forest inventories (Herrero & Bravo, 2012; Cienciala et al. 2008; Romijn et al. 2015; Pilli et al. 2013; Wit et al. 2006; Muukkonen & Heiskanen 2007). Yet these baseline references are further used to foresee the forest areas after a couple of decades, most prognoses being made up to the end of this century.

Inevitably all studies aiming at foreseeing the forest structure after a couple of decades are based on models, and a series of assumptions depending on the goals and the scope put forward by the academic community. hence the first issue addressed is the overruling approach: bottom-up (or inductive reasoning), top-down (deductive reasoning) or a mixture of the two (Mantau 2015; Smeets & Faaij 2007; Nidumolu et al. 2009).

In addition to the growth models, different additional sources of data are being used to cope with aggregating the data over long period of time, different forest types and areas encompassing many countries, with different forest management peculiarities. Van Breugel et al. (2011) came to the conclusion that allometric models fail to predict with accuracy the carbon stock over large areas and developing new regional or local models is justified if the sampling is reliable at landscape level.

Pilli et al. (2017) parametrized the Canadian Carbon Budget Model (CBM) to the European conditions and concluded that between 2000 and 2012 the net primary productivity (NPP) of the forest pools at the EU22 level averaged 639 Tg C yr^{-1}. The analysis spans over all 26 countries and took into account the land-use changes, natural disturbances (storms and ice damages, insects attack) and the forest management. Forecasts to 2030 were carried out considering two scenarios and to assess the impact of specific harvest and afforestation scenarios after 2012 on the mitigation potential of the EU forest sector. Substitution effects and the possible impacts of climate were not included in this analysis.

For instance, d'Annunzio et al. (2015) based on GEOMOD model (a spatial model that predicts forest areas likely to be lost for other land-uses, concluded that over 95% of primary forest loss is projected to occur at Tropics.

Due to higher productivities in agriculture, the marginal farmlands are abandoned in Europe and turned into forest, but the whole process is not determined by the EU climate change mitigation policies (Burrascano et al. 2016).

The dynamics of forest cover and forest growth span over long periods of time and the carbon sink depends on forest management practices and forest policies. The annual rate of afforestation is about 2% globally, since 1990 (Payn et al. 2015). The mean volume per hectare increased in East Asia, Caribbean, Western and Central Asia, North America, Europe, and Oceania, while the carbon sink declined by 13.5 Pg C in the same period of time (Kohl et al. 2015). Discrepancies between continents are obvious and the most deforested continent remain Africa and South America (Keenan et al. 2015). At EU level the carbon sink seems to approach a maximum level, thus challenging the forest management (Nabuurs et al. 2013; Pilli et al. 2015).

One important challenge is to figure out the differences in carbon per hectare between managed and unmanaged forests. Allen et al., (2016) used the LPJ-GUESS model to gauge the influence of relative CO2 increase, temperature growth and management on carbon storage in the biomass of unmanaged temperate deciduous forests. LPJ-GUESS model is dynamic vegetation model based on gap modeling approach. The author used the concept of plant functional type (PFT) to classify the vegetation and as many as 22 PFT were modeled. Climatic data from the first three decades of the XX century were used to calibrate the model. The authors simulated the relative effects of increasing temperature, increasing CO2 concentration in atmosphere and forest management measures in a pilot semi-natural forest located in UK. Forest management has had the greatest effect on carbon stocks throughout most of the study period but, towards the end of the study period, the CO2 concentration turns into a bigger driver. Main results regarding the carbon sinks under different scenarios are presented in Table 1.

Tab.1 Main reference figures referring to the Carbon sinks

Reference area	Method	Reference period	Carbon storage	Authors
UK, Lady Park Wood 35.2 ha	LPJ-GUESS Dynamic vegetation model	1900-2005 calibration 2005-2100 forecast	Two scenarios: IPCC 4.5 and 8.5 tC/ha stock in old growth forest Up to 30 tC/ha stock in 2100 181.1 tC/ha in old-growth stands	(Allen et al. 2016)
Global, living biomass	Aggregated data from literature	2013	300 Pg C (300 Gt)	(Mackey et al. 2013)
Northern hemisphere	Satellite observations 1981-1999	Late 1990s	61 ± 20 Gt pool 0.684 Gt C/yr. sink	(Myneni et al. 2001)
Eurasia		Late 1990s	37.68 Gt C pool 0.46 Gt C/yr. sink	
Bohemian forest	Ground measurements	2015	Average 41 tC/ha range between 14 and 112 tC/ha	(Seedre et al. 2015)
Meta-analysis on 432 studies	Soil response ratio at clearcutting	2010	On average, 8% reduction in soil carbon	(Nave et al., 2010)

Collecting the wood residues left after harvesting operations is an attractive managerial option but its impact on the long-term site productivity could be quite problematic. Based on an extensive literature and case studies (Achat et al. 2015) estimated that tree growth diminishes with 3-7% on medium term as a consequence of reduced site fertility.

3. Relevance and magnitude of carbon in forest products

Life Cycle Assessment (LCA) became in the last decades the most important method involved in evaluating the environmentally-related side effects of different products and also an important means of eco-designing (Linkosalmi et al. 2016; Peuportier et al. 2013).

Cherubini & Strømman (2011) summarized 104 LCA studies and found as many as four types of functional units the LCA studies referred to as in order to estimate the GHG and GWP of wood-base products or bioenergy: input oriented (helps finding the best use of whatever input), output oriented (the best provision of given a service from different sources), unit of agricultural land, and a given reference year. Most of the studies (73 in total) were output-oriented. Another clear delineation highlighted in this study is the difference between attributional LCA and consequential LCA: the former ones describe the flows that enter and leave the reference system, while the latter explains how the input and output flows are changed by a given production process. Attributional methods are the most used ones but when it comes to bioenergy systems the consequential LCA are preferred, because the reference system is the fossil fuel. Attributional LCA are preferred by policy makers, while consequential LCA are preferred by decision makers.

An important driver of the forest policy is the wood-base products capacity to store carbon on longer period as well as the two substitution effects: fuel substitution and material ubstitution respectively (Marcus Knauf et al. 2015). When it comes to material substitution the key issue of storing the carbon in wood products is the service period and, inevitably, the longest service period is being assigned to wooden buildings. (Sartori & Hestnes 2007) summarized 60 case studies of LCA on houses revealed that the since periods of wooden houses vary between 30 to 100 years, depending on how many houses are gathered into a block; however, most of the case studies assumed 50 years of service.

Trying to assess the global warming potential of two alternatives of using the wood residues, Kim & Song (2014) used the LCA methodology on a functional unit of one ton of wood waste. The two alternative scenarios were particle board production, and combined heat and energy production, from the same tone of wood waste. The average life service of particle board was estimated at 14 year by a Weibull function and 16 round of recycling were also considered. The net carbon emission in the first scenario (a series of 16 recycling cycles of particle board followed by combustion) was -428 kg

CO_2 eq. and -154 kg CO_2 in the second one (combined heat and energy directly from wood waste).

A quite similar study was performed by Rivela et al. (2006) who analyzed two different scenarios of using wood residues: recycling wooden waste into particleboard and energy generation from natural gas (Scenario 1) and energy production from wood waste combined with particleboard manufactured from conventional wooden resources (Scenario 2). The authors carried out the whole study on the raw data coming from the Barcelona annual trade fair, where about 8,000 tons of particle boards are used as ephemeral constructions and 70-8% of the wooden waste generated goes eventually to the landfill. The functional unit considered was 1 m3 of particle board 260 kWh of electricity and 1570 kWh of heat. The study took into consideration most of the detrimental effects on human health, climate change, ozone layer, acidification and water eutrophication. Two conclusions have been drawn: crushing the wood residues on site is more effective in terms of diesel consumption and 2) wood residues recycling, (without producing energy from wood residues) is a more environmental-friendly option.

The cascading effect of using wood firstly in construction then waste from construction as fuelwood, was modeled by Werner and Richter, (2007) in Switzerland, assuming a lifespan of 80 years for the wood mobilized in constructions. In order to better assess the GHG substitution effect the two authors took into account 12 wooden-based products used in a house and their non-wood substitutes, such as: exterior walls, pillars, ceiling, insulation, roofing, flooring, furnishing, furniture and so on. They also hypothesized a 2% growth of the wood products market share every 10 years and a steady flow of non-wood construction materials imported from abroad; moreover, they considered that all the additional wood needed will harvested from Switzerland. The conclusions are quite interesting although the model seems to be too deterministic. So, the GHG effect on material substitution is about -6 M tone CO_2 equivalent, while GHG emissions of the wood residues reach about 3 Mito CO_2; the avoided GHG emissions due to thermal use of wood residues levels out after 2050 and only after 150-200 year the cumulated production and disposal emissions match the additional carbon stored by the whole ecosystem (in a broader sense). This study is important for a series of graphs that describe potential carbon pools of different parts of building worth being replaced by wooden-based equivalent.

A sort of ‘gate to gate’ LCA analysis was carried out by a Croatian team (Vusić et al. 2013) to evaluate the labor productivity and energy consumption under two different silvicultural interventions: thinning, and regeneration fellings respectively. The data were collected from two tracts of fellings located in Croatian mountains. It was fond that thinning operations need two times more energy per cubic meter of harvested wood (the functional unit) that regeneration felling. Such a conclusion is important for drafting different management scenarios, assuming that more energy consumed over a series of rotations means diminishes the carbon stock accumulated into the woods and wooden products.

4. Role of forest management in CO_2 mitigation

Forest management planning has two major effects: on the one hand, it may increase the forests' CO_2 mitigation potential (longer rotations, new forest species), on the other hand, the forest management may also reduce the forests' resilience to the climate change if the higher rates of tree mortality brought about by draughts, heat waves, fires and insects are not compensated by higher growths and newly afforested areas. Allen et al. (2010) summarized as many as 15 studies published between 1980 and 2008 concerning the draughts and heat-induced forest mortality in Africa, 22 articles about tree mortality in Asia and Australia, 36 in Europe, 54 in North America and 10 in South America.

As the concept of forest management envelopes not only silvicultural system but also any type on intended human interventions, the main management practices are those meant to improve the site productivity, disturbances (structural and soil disturbances), nutrition and genetic factors (Noormets et al. 2015).

Tab.2 Main results on assessing the carbon sinks under different management scearios

Reference area	Management scenarios	Estimated values	Author(s)
Northern boreal and temperate forests	Change the composition of species	62.1 ± 20.7 C/ha in coniferous forests 58.0 ± 22.1 tC/ha in broadleaf and mixed forests 40.0±15.4 tC/ha for boreal forests over 3 Asia, Europe and North America	(Thurner et al. 2014)
EU 27	Maximizing standing biomass	From 30 tC/ha to 50 tC/ha in 2100	(Kindermann et al. 2013)
	Maximizing growth	From 30 to 20 tC/ha in 2100	
North Rhine-Westphalia	Conservation and wood use	3.6 tC/ha/year = wood use strategy; 3.42 tC/ha/year biodiversity conservation strategy	(M Knauf et al. 2015)

Climate change projections are based on general world-wide circulation models; hence the pixels with different climatic features are too large to allow for modeling the connections between the forest management measures, species and terrain conditions (Lindner et al., 2010). Therefore a great deal of research was devoted to downscaling the aggregated results provided by official data (Kindermann et al. 2008;(Rupert Seidl et al., 2014); Blanke et al. 2016) and satellite images (Townshend et al. 2012; Srivastava et al. 2012; Muukkonen & Heiskanen 2007; Bayat et al. 2012; Gallaun et al. 2010).

(Kindermann et al. 2013), concluded that maximizing the increment will be more effective than maximizing the standing biomass at the end of the forecast period, in 2100. The estimations were done at EU27 level. The additional amount of carbon compensated by forest growth and wood products is about 1750 million tC compared with the management focused on maximizing the standing biomass. Because maximizing growth implies lower rotations, by the end of the forecast period the authors estimated that the average amount of carbon stored by a hectare of forest will decrease from 30t C/ha to 20 tC/ha. Although the credibility of management scenarios stretching over a couple of decades is questionable, on much larger areas their results are sensible, as shown in Table 2.

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5. Role of forests in providing fuel for bio-energy

Birdsey & Pan (2015) based on an extensive literature review, concluded that: 1) harvesting for bio-fuel has recently increased, although the timber production has been relatively stable since 1990, globally; 2) the terrestrial long-term carbon sink decreased due to a higher intensity of management, regardless the land use or the land cover.

Global Biosphere Management Model (GLOBIOM) is a global partial equilibrium model designed for forestry and agriculture, based on spatial optimization. The supply is estimated within a square grid of 200 km resolution while the demand is and trade with biomass operate at regional level, the world being divided into 30 regions. The competition between regions is considered to perfect and some by-products from each production flow are also included into the inputs. The model operates with the following six land cover types: cropland, grassland, managed forests, unmanaged forests, plantations and other natural vegetation land. This model was utilized by (Lauri et al. 2014) to examine the effects of setting aside all primary forests for protection against the baseline scenario, from the biomass energy perspective in 2050. Energy wood supply curves were outlined at various hypothetical energy wood prices. The authors concluded that by the year of 2050, as much as 18% of the energy demand could be satisfied through the baseline scenario, or 14% under the primary forest conservation scenario.

A more detailed study was carried by Smeets & Faaij (2007) who foreseen the demand and supply of wood up to 2050, using the database, scenarios and provisional studies available. The core concept of the study is the forest surplus growth, defined as the forest growth not needed for wood industry and fuelwood; explicitly, the authors have split the demand for bio-energy into two components: the existing demand of fuelwood and the wood surplus that may feed modern bioenergy production. The study concluded that the economical–ecological potential of the wood supply from natural forests will be insufficient to meet the projected demand for 2050. However, the potential supply of bioenergy from logging and wood processing residues was estimated to be somewhere between 3,6 million and 6,1 million GWh in 2050.

Moiseyev et al. (2011) addressed the effect of higher prices for the wood biomass needed to reach the goal of using more renewable energy sources (RES). The research team used the EFI-GTM (European Forest Institute Global Trade Mode) to simulate the behavior of the European wood industries assuming that all wood and forest products are sold and bought on a global competitive market. At high costs, the available wood resources suitable for energy may provide 24% of EU-RES target; if additional by-products would have been mobilized (black liquor from pulp industry, household waste wood and demolition wood, the contribution would barely reach 32%.

In 2014 EU launched the new climate and energy framework, setting up a new target for 2030, when the share of renewable resources is expected to reach 27% of the total energy consumption. The amount of wood needed to satisfy this target is about 108 Mtoe . If all of this would have to come from round wood, it equals 550 million m3 of round wood; equal to the current total harvesting of round wood in the EU. An important concept of this policy is the carbon parity, which actually refers to the year when the biomass growth will compensate the avoided CO2 emission brought about by fossil fuels. This lag occurs because the effectiveness of burning fossil fuels for energy is much higher for coal and natural gas. Nabuurs et al. (2017) estimated that party of wood against coal will be reached by the year of 2120 and the year 2200 for parity against natural gas. These prognoses are not optimistic at all considering the accumulation rate of biomass and the risk of wild fires that would compromise the whole substitution scheme (Mackey et al. 2013; Seidl et al. 2014).

In Japan, Nishiguchi & Tabata (2016) analyzed the social, economic, and environmental aspects of utilizing woody biomass for energy by direct burning and burning wood pellets. They findings indicated that if 8.58 million tons of annually unutilized woody biomass were collected and utilized for direct burning method would have the advantage of reducing 13.7 million tons of CO2 emissions. Analyzing the two options of direct burning and pellets burning respectively and considering all additional side-effects regarding job creation, as well as the production new stoves tailored for pellets, they concluded that direct burning is the best option in terms of induced CO2 emission.

A very interesting study on pellets durability was carried out by Paukkunen (2014) on eight plots of small diameter pine logs on which different technologies of production were tested. The author concluded that longer press tunnels, proper timing of harvesting, and steamed raw material contribute the most to the durability of pellets. Worth noting, pellets durability is a key issue of LCA because the production of steam-treated pellets requires more energy but, at the same time, their breaking strength is 1.4-3.3 times greater than the breaking strength of untreated ground softwood (Lam et al. 2011). The moisture content is important in producing high quality pellets because water is a binding agent that affects pellets durability (Samuelsson et al. 2012; Ahn et al. 2014).

6. Conclusions

In spite of the common sense arguments that forests store high quantities of CO2 by default, their role in carbon mitigation is still controversial due to the numerous uncertainties pending the forest management, on the one hand, and the wide variety of wood mobilization: fuelwood, furniture, composite materials, and so on. LCA is also a very useful tool that allows consistent and coherent analyses of the carbon food print, under different scenarios. However, when it comes to defining the functional unit and the different alternatives of matching its requirements, non-wood products seem to be more reliable, at least for the fact that all non-wood products used in construction and different industries are characterized by well-defined and precise technological inputs, which is not the case for the wood.

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The potential of non-wood forest products for Brașov County

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Abstract: In Romania, forest management is mainly focused on timber production, little attention being given to the potential of non-wood forest products (NWFPs). Compared with wood industry, the economic activities related to the harvesting and marketing of the NWFPs (especially mushrooms, forest fruits and game products) have a very low contribution to the turnover of the forestry units in Romania. The low importance of NWFPs is also indicated by the lack of the policies and normative acts in this domain, harvesting and marketing of NWFPs being done in most of the cases in a chaotic way, without respecting the principles of sustainable management. Across the country, there are several regions with high potential in terms of harvesting NWFPSs, Brașov County being one of them. The aim of this research was to highlight the most important non-wood forest products from Brașov County. The analysis model proposed within FP1203 COST Action *European non-wood forest products network* was used and therefore four categories (Mushrooms, Understorey plants, Tree products and Animal origin) of NWFPs and nineteen criteria were taken into consideration. The Analytic Hierarchy Process (AHP) was used and the alternatives (i.e. the NWFPs) were pairwise compared against each in order to determine the NWFPs with the highest potential for Brașov County. The analysis were done with Expert Choice Desktop software package. The selected NWFPs consisted in dog rose (*Rosa canina* L.), raspberry (*Rubus idaeus* L.), honey fungus [*Armillaria mellea* (Vahl) P.Kumm.], truffles (*Tuber* spp.), Christmas trees (*Abies alba* Mill.), chamois (*Rupicapra rupicapra* L.), brown bear (*Ursus arctos* L.) and St John's wort (*Hypericum perforatum* L.). The truffles were the NWFPs with the highest potential for Brașov County, followed by the Christmas trees and the chamois. The less promising (i.e. with the lowest potential) NWFPs were dog rose' berries and the St John's wort. By taking into consideration that in the case of more than half of the forests from Brașov County wood harvesting is not permitted, it is expected that the forest managers and forest owners will pay more attention to the NWFPs, that could become an important source of income.

Keywords: AHP, Brașov, non-wood forest products, NWFPs

1. Introduction

Non-wood forest products (NWFPs) represent natural resources of vegetable origin, other than wood, supplied by forests or other lands without tree cover from the forest fund, being valued raw or in different processing stages in several purposes (Beldeanu, 2008). Worlwide, it is estimated that more than 150 NWFPs are the subject of international trade

(Schvidenko et al., 2005), the most common categories of NWFPs being represented by forest fruits, truffles and edible mushrooms, forest seeds, medicinal plants, understory plants, game products and tree saps.

The marketing of non-wood forest products represents an important source of income for rural households (Shackleton et al., 2007a, b). This is mainly due to the fact that the harvesting requires little capital and labor resources, and people have the knowledge and skills needed to carry out these activities. Also, in many cases, access and collection rights are not regulated (Beck and Nesmith, 2001), this activity being essential for poor and marginalized households (Beck and Nesmith, 2001; Fisher, 2004; Shackleton et al., 2008).

In Romania, the capitalization of NWFPs was a major concern, especially after the Second World War, when technical means of processing were developed (Beldeanu, 2008). During the communist era, the value of NWFPs had a high share in the production of forestry units (40% in 1978), the share of income from activities of marketing of NWFPs fluctuated at county level between 22% and 73% (Petrescu et al., 1984).

Nowadays, in Romania, due to the diversification of the forest fund ownership, but also thanks to the legislative transition, the harvesting of NWFPs from the forest fund is no longer a priority, selling timber products being the main source of income for the forest managers and forest owners. The very little attention that is given to the management of the NWFPs in Romania is also highlighted by the low level of economic contribution of specific NWFPs to the turnover of the forest districts, like in the case of game products (Enescu and Hălălișan, 2017), but also by the low harvested quantities of forest fruits, mushrooms and forest seeds recorded in the last years. For example, in the last decade, as regards the forest fruits, the harvested and marketed quantites ranged between 2.442 tons (in 2016) and 6.562 tons (in 2010), while in the case of the edible mushrooms, the lowest quantity was recorded in 2008 (312 tons) and the highest quantity in 2012 (717 tons), respectively (INS 2008-2016).

Across the country, there are several regions with high potential in terms of harvesting and marketing of NWFPs, Brașov County being one of them.

The aim of this study was to highlight the potential of the non-wood forests products from Brașov County.

2. Materials and methods

Brașov County is situated in the center of Romania (Figure 1), being the county with the highest share (88.5%) of managed forests by private forest districts (INS, 2016). Only about 20.000 hectares of forests are managed by Brașov Forestry Department (a branch of National Forest Administration Romsilva) throught its three forest districts, and 2.400 hectares are managed by Săcele Exprimental Base (a branch of "Marin Drăcea" National Institute for Development and Research in Forestry) (Dincă and Enescu, 2017).

The total woodland area in Brașov County accounts for 202.200 hectares, with a share of two-thirds of hardwood species, mainly beech (*Fagus sylvatica* L.), and one third of coniferous species, mainly Norway spruce [*Picea abies* (L.) H.Karst] (INS, 2016).

Fig. 1 Location of Brașov County (Source: Wikipedia)

Based on the centralized quantitative data contained in the forest management plans of the forest districts from Brașov County and by taking into account the information from the ministerial orders regarding the size of population and annual quota of the main hunting species, a selection of the most common NWFPs was done.

The analysis model proposed within FP 1203 COST Action *European non-wood forest products network* was used and therefore four categories (Mushrooms, Understorey plants, Tree products and Animal origin) of NWFPs and nineteen criteria were taken into consideration (Huber et al., 2016). The same 19 criteria were used in similar studies conducted for Ialomița County (Enescu, 2017) and Maramureș County (Enescu et al., 2017).

For each criterion a scale ranging from 1 to 8 was used, namely: criterion 1: harvesting period (from 1: the shortest harvesting period to 8: the longest harvesting period); criterion 2: portfolio of derived products (from 1: the smallest number of deriver products to 8: the highest number of derived products); criterion 3: harvested quantity by one worker in 8 hours (from 1: the lowest quantity to 8: the highest quantity); criterion 4: harvesting cost (from 1: the lowest cost to 8: the highest cost); criterion 5: knowledge for recognition (from 1: most recognizable product to 8: hardest recognizable product); criterion 6: knowledge for harvesting (from 1: the less knowledge necessary to 8: most knowledge necessary); criterion 7: tools needed for harvesting (from 1: the least to 8: the more); criterion 8: complexity of harvesting process (from 1: lowest to 8: highest); criterion 9 - distribution range (from 1: lowest to 8: highest); criterion 10 - market potential (from 1: lowest to 8: highest); criterion 11 - the price of raw product (from 1: lowest to 8: highest); criterion 12 - the price of the derived product (from 1: lowest to 8: highest); criterion 13 - transport from the harvesting point to the storage center (from 1: the most easy to 8: the most complicated); criterion 14 - perishability (from 1: lowest to 8: highest); criterion 15 - “celebrity” of the product on the market (from 1: the least known to 8: the most popular); criterion 16 - market demand (from 1: lowest to 8: highest); criterion 17 - biotic threats (from 1: the fewest threats to 8: the most threats); criterion 18 - abiotic threats (from 1: the fewest threats to 8: the most threats) and criterion 19 - development of the process of harvesting (from 1:

undeveloped to 8: extremely developed).

The Analytic Hierarchy Process (AHP), developed by Thomas Saaty (Saaty, 2008), was applied to generate an explicit ranking of the alternatives (*i.e.* the NWFPs) that are represented in Brașov County. By the aid of AHP, the decision problem (*i.e.* the aim of this research) is decomposed into a hierarchy sub-problem (*i.e.* the selected criteria) which can be independently and deeply analyzed, by comparing them to each other two at the time. The analysis were done with Expert Choice Desktop software package v. 11.5.1683.

3. Results

The selected NWFPs consisted in dog rose (*Rosa canina* L.), raspberry (*Rubus idaeus* L.), honey fungus [*Armillaria mellea* (Vahl) P.Kumm.], truffles (*Tuber* spp.), Christmas trees (*Abies alba* Mill.), chamois (*Rupicapra rupicapra* L.), brown bear (*Ursus arctos* L.) and St John's wort (*Hypericum perforatum* L.). The AHP alternative ranking, based on experts' opinion, is presented in Table 1.

Table 1. AHP alternative ranking

Criterion	Mushrooms		Tree products	Understory plants			Animal origin	
	Armilaria mellea	*Tuber* spp.	*Abies alba*	*Rubus idaeus*	*Rosa canina*	*Hypericum perforatum*	*Ursus arctos*	*Rupicapra rupicapra*
1	4	7	1	5	6	3	8	2
2	5	8	1	7	6	4	2	3
3	6	1	3	5	4	2	8	7
4	3	7	8	2	6	1	4	5
5	7	8	2	5	4	6	1	3
6	3	7	1	2	5	4	6	8
7	5	7	8	2	6	1	3	4
8	3	7	8	2	4	1	5	6
9	8	7	5	2	4	3	6	1
10	6	8	7	5	4	3	1	2
11	3	6	5	4	2	1	8	7
12	5	8	1	4	3	2	7	6
13	4	5	6	2	3	1	7	8
14	6	8	1	7	2	3	5	4
15	5	6	3	4	2	1	7	8
16	5	8	7	6	4	3	2	1
17	7	6	3	8	5	4	1	2
18	6	7	4	8	5	3	1	2
19	3	8	7	2	4	1	5	6

According to AHP results, the non-wood forest products with the highest potential for Brașov County were the truffles (*Tuber* spp.) and the Christmas trees (*Abies alba* saplings), while the less important ones were the dog rose and St John' wort (Figure 2). The truffles had a low performace only in the case of criterion no. 3 (harvested quantity by one worker in 8 hours).

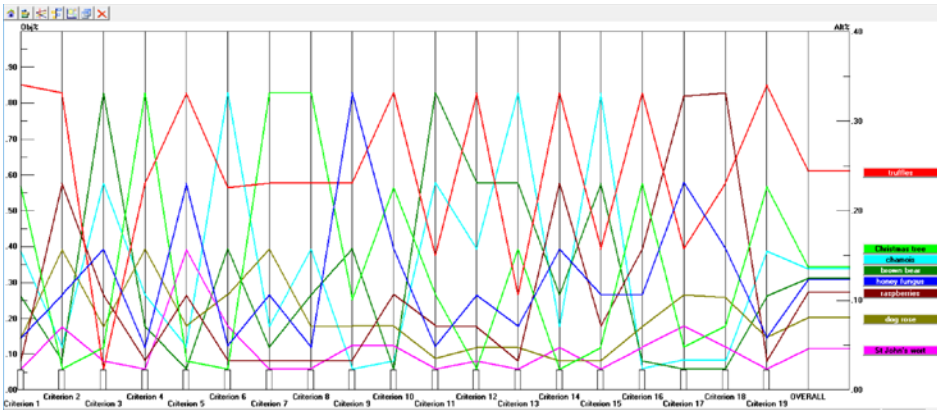

Fig. 2 The ranking of the selected NWFPs

4. Discussion

Even if there is no centralized statistics regarding the annual harvested quantities of truffles at national level, Brașov County represents one of the hotspots, the most well-known regions rich in truffles being Făgăraș, Rupea and Valea Bogății (Dincă and Dincă, 2012). Special attention should be given to the harvesting methodology, that should have a very low impact to the environment. The most common used and environemntal friendly method consists in using trained dogs (Dincă and Dincă, 2012).

By taking into consideration the particularities of Brașov County in terms of ownership status, diversity of forest owners and forest managers, high number of protected areas, but especially its eco-touristic potential (Iacob, 2013; Sălăgean, 2013; Gheorghe and Pârvu, 2016), we believe that the harvesting and marketing of the non-wood forests products should not be an obstacle, but a very important activity integrated in several economic sectors. Moreover, focusing on this type of resourse, the pressure on wood harvesting will decrease.

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Current distribution of golden jackal (Canis aureus L.) in Romania and its effects on competitors and prey species

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Abstract: In the period of 2006 – 2017 based on stock assessments data performed by hunting organizations, the Romanian golden jackal (*Canis aureus L.*) populations had increased their distribution area from 13 to 37 counties out of the total 41. In the same time the stock assessment data shows a 6.7-fold exponential growth from 1,871 specimens to 12,206. However, many European previous study results denote an uneven distribution pattern and regional core areas inside distribution range. These features are characteristic for Romanian distribution range as well, but only in terms of differing densities. At the level of year 2017, the current distribution area of golden jackal in Romania seems to become continuous and covers approximately 90,000 km^2 that represents about 41% of the country total area.

We studied the diet of jackals and those of red foxes *(Vulpes vulpes L.)* using stomach content analysis, and body weight of foxes from areas where they live sympatric with golden jackals and from golden jackal-free habitats. Effects of the jackal's diet on prey species and issues of the competition between mesopredators are discussed.

Our diet analysis results show a wide trophic niche breadth, lower small mammal consumption and higher plant matter consumption in comparison with other study results. Anthropogenic food did not occur in substantial proportions, neither small game (hare and pheasant) species. We found that the most important big game species in golden jackal's diet is the wild boar. Protected prey species were not found in golden jackal's diet. It seems that the golden jackal is a typical food generalist omnivorous species, without any constraints in terms of abundance limiting food source. Nevertheless, we have found high nutritional niche overlap between golden jackal and sympatric red fox. Comparative analyses of body weights of red foxes living sympatric with golden jackal and of those without contact with this species revealed that the golden jackal does not affect the population densities of red foxes, but the mean body weight of sympatric juvenile red foxes is smaller than in golden jackal free areas.

Keywords: golden jackal, spatial distribution, Romania, red fox, mesopredator competition

1. Introduction

Since the late 1960's when the Danube was considered as the northern boundary of the golden jackal's (*Canis aureus L.*) spreading area (Cotta and Bodea 1969), and in Romania were registered only random occurrences, nowadays this carnivore species is common in many parts of the country.

However, the knowledge about the jackal is limited both in local game management and nature protection fields as well.

In cases when a new predator species arrives into an ecosystem, biodiversity losses are suspected. In assessing the impact of golden jackal, the question must be considered trough, dispersal patterns, predation aspects and competition (Stratford 2015).

Describing dispersal patterns of golden jackal in different European countries, there were used many similar terms as e.g. intermittent (Banea et al. 2012), discontinuous (Szabó et al. 2007), scattered or sporadic (Kryštufek et al. 1997; Lapini et al. 2011), fragmented (Comazzi et al. 2016) and patchily (Lanszki et al. 2007).

There is a very important aspect which must be considered when distribution area estimations are performed. This is the clear distinction between areas colonized by resident breeding populations, and territories where only some vagrant specimens were observed (Kryštufek et al. 1997).

Despite of controversies of game management data, these are the most appropriate to range expansion studies. In special the yearly approved hunting quotas can provide useful information.

Approval process of hunting quotas in Romania starts from the hunting organizations. Based on stock assessments performed in spring period, the hunting organizations requests quotas for a number of individuals they want to extract. The authorities, (Romanian Ministry of Environment, Water, and Forests – MEWF) as a rule, approve the requested golden jackal quotas except the cases when the quotas approved for the previous hunting season were not extracted. Such situations occur mostly within recent distribution area. In those areas, hunting quota requests are based on sightings of some vagrant individuals, whose extraction is very difficult. In other words, if at a game management unit there is hunting quota for golden jackal in two consecutive years that means that the quota of previous hunting season – at least partially – was extracted. Therefore, these hunting grounds could be considered as colonized and part of the recent distribution area.

Once known the distribution area, population growth trends and range expansion rate, the suspected effects of golden jackal on indigenous fauna can be analyzed. The predation effect of the jackal on indigenous fauna can be assessed trough diet studies.

In natural ecosystems diet of golden jackal is dominated by rodents, while other wild living prey species and plants are secondary foods (Demeter and Spassov 1993; Lanszki and Heltai 2002; Lanszki et al. 2006; Lanszki et al. 2010; Markov and Lanszki 2012; Farkas et al. 2015; Penezic and Ćirović 2015). In terms of potential ecologic and economic losses, impact on protected and game species must to be studied.

At the same time, it is generally accepted that wolves dominate jackals, and jackals dominate foxes (Kryštufek et al. 1997; Giannatos et al. 2005; Lanszki et al. 2006; Scheinin et al. 2006; Stoyanov 2012; Farkas et al. 2017). The golden jackal could affect the red fox populations directly, trough intraguild predation or indirectly through feeding competition. However, competition can occur if a given number of organisms exploits the same scarce, vital resources (Elmhagen and Rushton 2007). One powerful evidence of premises for feeding competition between golden jackal and red fox can be a high dietary niche overlap.

In this study: (1) we made an update of golden jackal's current distribution area in Romania, and (2) presented preliminary data for assessing their effects on prey species and the most important competitor, the red fox, trough feeding habits.

2. Materials and methods

Romania covers an area of 238,391 km^2 (National Institute of Statistics http://statistici.insse.ro/shop/TEMPO_AGR101A downloaded at 16.02.2017). According to the last update (M.D. no. 2298 from 29.11.2016) of Decree no. 193/2002 of Ministry of Agriculture, Food, and Forests (MAFF), the hunting area comprises 220,455.33 km^2 or 92.47% of the country total area. The total hunting area is delimited in 2,152 game management units commonly named as hunting grounds. The management of wildlife and its habitats, within game management units is accomplished by 552 hunting organizations.

Based on data provided by MEWF, we calculated the tendencies of stock assessments as well as that of approved and executed hunting quotas for the period of 2006 - 2017.

From the same data and the same period, we extracted the numbers of counties and hunting organizations with jackal presence, and studied the evolution of those.

For trend calculations, we fitted the most common models on basic data. Correlation coefficients were calculated between the raw data and fitted models. As characteristic for tendencies we accepted the models with stronger values of correlation coefficients because of p-significance values below five decimals.

Estimation of the golden jackal rate of increase was performed based on 2006 – 2016 period's official stock assessment data gathered from MEWF.

As stock assessments data could be controversial using inappropriate census methods and periods for carnivores (Stoyanov 2012), we performed the golden jackal distribution area estimations based on official hunting quotas. Game management units with approved hunting quotas in two consecutive years could be considered as areas with resident breeding populations.

Diet of the golden jackals and red foxes was studied during three consecutive years between 2013 and 2015, using stomach content analysis. The locations of the studies were 10 hunting grounds in the southern part of Romania. The grounds, having a total surface of 88,185 ha, are typical lowland habitats (1-100 m a.s.l.). The mean multiannual temperature is 11.5°C and the average annual precipitation is 518 mm. 78.6% of the total surface is occupied by arable lands, 12.1% by pastures, 7.9% by forests, wetlands and water courses cover 0.86%, while the rest of 0.54% are unproductive areas. The forests are distributed in patches and are dominated by oak species (*Quercus* ssp.), ash species (*Fraxinus* ssp.) and white poplar (*Populus alba*).

The stomach contents were examined macroscopically, and the remains were categorized into 16 categories (table 1). The diet composition was expressed as relative frequency of occurrence per food item. The relative frequency of occurrence was calculated as number of occurrences of a certain food category divided by the total number of occurrences of all food categories and then multiplied by 100 (Penezic and Ćirović 2015).

Trophic niche overlap between golden jackal and red fox was calculated by means of the Renkonen index: $P_{jk} = [\Sigma n \text{ (minimum } p_{ij}, p_{ik})] \times 100$, where P_{jk} is the percent overlap between species j and species k, p_{ij} and p_{ik} are the proportions of resource i represented within the total resources used by species j and species k, and n is the total number of resource taxa (Krebs 1989).

Trophic niche breadth was calculated for both species in accordance with Levins (Krebs 1989): $B = 1/\Sigma p_i^2$, where p_i is the relative frequency of occurrence of the i-th taxon. Standardized across n = 16 food taxa: $BA = (B–1)/(n–1)$, rating from 0 to 1.

Thematic mapping was performed using QGIS version 2.16.3, while statistical analyses were carried out using STATISTICA version 13 (Dell 2016) and Microsoft Excel. Statistical significance for all tests was inferred at $\alpha = 0.05$.

3. Results

In period of 2006 – 2017 based on stock assessments data performed by hunting organizations, the Romanian golden jackal populations had increased the distribution area from 13 to 37 counties out of the total 41. In the same time the stock assessment data shows a 6.7-fold exponential growth from 1,871 specimens to 12,206.

We accepted as characteristic for tendencies of golden jackal population growth the exponential model because of stronger correlations ($r_{exponential} = 0.9903$, $p < 0.00001$; $r_{linear} = 0.9738$, $p < 0.00001$).

From stock assessment data we estimated the finite rate of increase (FRI) of golden jackal population size, which result is λ=1.194. Accuracy of this estimation will be tested in the spring of 2018, when the stock assessments will be executed. Our estimated FRI of λ=1.194 should result in stock assessment data around 14,570 specimens in 2018.

In the 2017/2018 hunting season there are approved hunting quotas on 963 game management units, with a total area of 102.703 km^2. One season before, the number of game management units with golden jackal quota was 855 and their area summed 89.869 km^2. Number of game management units with approved hunting quotas in two consecutive years (2016 and 2017) is 808, and their area covers 85,204 km^2 (Figure 1).

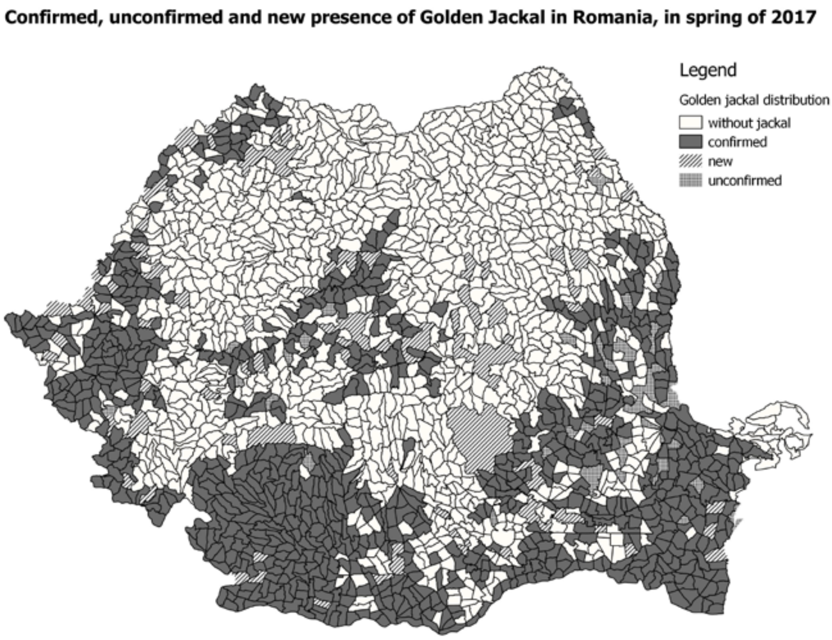

Figure 1 - Different types of golden jackal distribution in Romania

Stomach content analyses, without testing the seasonal patterns, showed a brief image of mesocarnivore's yearly diets (table 1).

Small rodent consumption was important but not as dominant as we could expect (21.29% on jackals and 27.11% on foxes). Different bird species appeared more frequently in fox's diet (27.70%) than in those of jackals (6.93%). Wild game species such as wild boar, brown hare, roe deer and pheasant were present generally in small amounts (0.29-5.54%) in stomachs, except the jackal's wild boar consumption which was 12.38%. Domestic animals and other anthropogenic food items occurred only occasionally both in jackal and fox diet (0.87-3.47%). Seeds, fruits, and other plants were very important for jackals (37.62%) as well as for foxes (19.53%).

Food item	Jackal n=119	Red fox n=238
1. Shrews (Soricidae)	0.00%	0.29%
2. Voles	15.84%	21.28%
3. Mice	4.46%	4.37%
4. Other rodents	0.99%	1.17%
5. Brown hare	1.49%	0.29%
6. Cervids (Roe deer)	0.50%	0.29%
7. Wild boar	12.38%	2.62%
8. Carnivore mammals	0.99%	0.29%
9. Domestic animals	1.98%	0.87%
10. Birds	6.93%	27.70%
Pheasant	1.98%	5.54%
Other birds	4.95%	22.16%
11. Reptiles, amphibians	3.47%	2.33%
12. Fish	0.50%	0.00%
13. Invertebrates	9.41%	17.20%
14. Seeds and fruits	24.26%	13.12%
15. Other plants	13.37%	6.41%
16. Anthropogenic food items	3.47%	1.75%

Table 1 – Diet composition of golden jackal and red fox

Comparative analyses of diet of golden jackals and red foxes, revealed that jackals have wider trophic niche breadth (B = 7.35; BA = 0.45) than the foxes (B = 5.66; BA = 0.33). The trophic niche overlap between these carnivore species is 65.51%.

4. Discussion

The uneven distribution pattern and regional core areas inside distribution range found in previous European studies (Kryštufek et al. 1997; Lanszki et al. 2007; Szabó et al. 2007; Lapini et al. 2011; Banea et al. 2012; Comazzi et al. 2016) are characteristic for Romanian distribution range as well, but only in terms of differing densities. At the level of year 2017, the current distribution area of golden jackal in Romania seems to become continuous and covers approximately 102,703 km^2 that represents about 43% of the country total area.

However, it must be clearly distinguished the resident breeding populations and vagrants (Kryštufek et al. 1997). The realistic current colonized distribution area – in the context of ongoing expansion – could be between the confirmed 85,000 km^2 and estimated 102,000 km^2, somewhere near 90,000 km^2.

Golden jackal's prey preferences could not be tested with our methodology. At annual scale, the seasonal predation effects may remain hidden. The small rodent consumption can be considered as an ecosystem service, but we have found these food items in smaller amounts then in previous study results (Lanszki and Heltai 2002; Lanszki et al. 2006; Markov and Lanszki 2012). At the same time, the game species consumption – if derive from predation and not from scavenging – could cause substantial economic losses, mainly if it is concentrated upon the recruitment in the spring period. Our dietary study results suggest that the golden jackal in Romanian habitats acts as a typical food generalist omnivorous species, without any constraints in terms of abundance limiting food source.

The nutritional niche overlap of 65.51% between the golden jackal and red fox can be considered as very high. Similar results of dietary niche overlap were found previously in Hungary (60-77%) in winter – spring period (Lanszki and Heltai 2002) and an average of 73% in a four years research period (Lanszki et al. 2006). In Romania 72.22% of nutritional niche overlap was found at annual scale between sympatric golden jackal and red fox (Farkas et al. 2015). However, despite of the high trophic niche overlap, in Romania at the actual population densities only indirect evidences of feeding competition were found between the sympatric golden jackal and red fox (Farkas et al. 2017).

5. Conclusion

As result of the present study we made an updated map of golden jackal's current distribution area in Romania. We considered this important, because the previously used distribution maps (including the IUCN's global distribution map) nowadays are outdated.

The current management practices with hunting quotas and without hunting seasons, are hard to be evaluated. But at least, the hunting bag data makes possible the indirect monitoring of the expansion range. At the same time, the specimens extracted by regulated hunting could provide samples to various studies on biometry, age structure, reproduction, or diet.

Our dietary study results present only preliminary data on feeding habits of the golden jackal. Based on these, we did not found evidences of serious damages caused to livestock or game species, nor threats on biodiversity. Further dietary studies should investigate the seasonal patterns and prey preferences in various types of habitats, as well as the effects on the most plausible competitor species, the red fox.

Acknowledgments

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Forest melliferous resources in the Republic of Moldova

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Abstract: Exploiting of forest melliferous resources is within the sphere of activity of various production and processing enterprises but also is a subject of increased attention of scientific, social and environmental organizations. The purpose of the research is to describe the forestry melliferous resource sector of the Republic of Moldova, identification of melliferous capacity of plants and influence of some factors on honey resources. The research objectives were: inventory of taxonomic composition of forest melliferous plants of the Republic of Moldova; analysis of the phenological spectrum of flowering of forest melliferous plants; identification of factors that influence honey resources; melliferous capacity of some forest plants; identification of the opportunities for the development of honey resources. The research methods were: studying of specialized scientific literature, analysis and synthesis, organizing and systematization of information, analogy and comparative data analysis. Taxonomic composition of the forest melliferous plants from the Republic of Moldova comprises 41 families, 129 genera and 224 species. After the flowering period forest melliferous flora consists of 136 spring species and 88 summer species. Spring plants belong to 32 botanical families dominated by *Fabaceae* (21 species) and *Scrophulariaceae* (18 species), *Lamiaceae* (16 species), *Rozaceae* (13 species). Summer plants belong to 20 botanical families dominated by *Fabaceae* (14 species), *Lamiaceae* (14 species), *Asteraceae* (12 species), *Scrophulariaceae* (11 species). According to biological cycle forest honey plants are presented in such a way: annual-13%; biennial-9% and perennial-78%. According to biological form forest melliferous plants are represented by trees-15%; shrubs-11% and herbaceous plants-74%. Most of the forestry plants of the Republic of Moldova have a medium beekeeping share (46%), 28% have a small apiculture share. Plants with a very high apiculture share account for 1% and high apiculture share have 5%. The current area of the forestry fund (421.7 thousand ha) can feed around 1000000 bee families.

Keywords: forest resources, melliferous plants, forest, pollen, honey-dew.

1. Introduction

The Forest is a precious alive treasure of Terra, an ecosystem that provides protection and some vital global conditions for humanity. Since the antiquity, the multifunctionality of the forest has been recognized in the natural and economic environment (Popescu, 2008).

The issue on evaluation of natural resources including the honey one began in the middle of 1960s of the last century. However, the approach of the economic evaluation of forest resources during the soviet period has narrow specific at branch level, only the wood being considered the main wealth. The honey products of the forest were not part of the country's wealth, their economic potential was not analyzed, as an additional source of income to contribute to the development of the forestry sector.

Utilization of melliferous forest products is a concern in many countries of the world and depends on geographical area, specific flora, needs and habits.

Providing the country with natural honey resources is an important economic factor in national development. The structure of these resources, their value, quality, study degree and impact on economic potential.

A successful development of beekeeping is closely linked to the forest.

Life, evolution and development of bee families depend on the existence of melliferous plants and the way of production of pollen and nectar secretions (Pashcalau, 2009).

The specialty literature mention the fact that there are known more than 1000 species of melliferous plants, of which only 200-300 are important for bee feeding (Pârvu, 2000).

The level of development of beekeeping, productivity of bee families and the quality of honey directly depends on natural conditions, primarily with floral composition and then follows climatic, pedological and phenological factors (Burmistrov and Nikitina, 1990).

Honey resources are part of the natural and agricultural ecosystems. Their rational evaluation and use is a current and perspective theme.

Bee action solves a wide range of socio-economic issues, from increasing plant productivity up to securing population with unique apicultural products for health maintaining.

Development of beekeeping within the forestry fund contributes to the increase of the productivity of agricultural plants by 40% (sunflower, buckwheat), by 60% (pumpkin cultures), by 65% (fruit trees). According to the appreciation of the experts, annual additional income, obtained due to the pollination of crops by insects exceeds 8-10 times the direct income from the honey products (Samsonova, 2014).

Therefore, correct organization of beekeeping and complex use of melliferous resources bring considerable revenue and pollination by bees of agricultural crops increases production by 20-30%. Beekeeping is very productive if natural honey resources are used, agricultural crops as well as spontaneous flora, not just around the bee-garden but also within a reasonable distance. For the advantageous location of beehives, the optimal distance where the bee flies for nectar collection must also be taken into account, which is up to 2 km (Sidorova, Pashaian, Kalashnikova, 2014).

That's why beekeepers need to know and consider local conditions, regarding the distribution of honey resources.

Due to bee pollination by bees, the income is 20 times higher than that obtained from the sale of honey, propolis, beeswax (Tyshkevich, 1991).

The majority of flower plants are pollinated by pollinating insects. About 80% of superior plants are entomophiles, and 20% are pollinated by the wind (Jerukov et al, 2012).

For the Republic of Moldova forest as a natural melliferous resource is very important because it is renewable and allows sustainable use.

According to the Forestry Code of the Republic of Moldova, honey plants are included in the category of non-wood products of the forest (Forestry Code, 1996).

A complex approach to the use of forest products, in case of rising food shortages, especially in densely populated areas, non-timber forest products pass to the first place, and wood collecting to the second place (Hisamov and Kulagin, 2008).

Honey production depends on several factors: genetics of the bee, pedoclimatic conditions, composition of melliferous resources, phenology of flowering, beekeeper's knowledge and applied technology. An important differentiation of honey is made by botanical origin (acacia, linden) which also has some specific features and properties (smell, color, taste) (Malaiu, 1976).

Depending on environmental conditions honey resources of plants vary quantitatively and qualitatively.

Proskureakov M. (2007) states that productivity of nectar at plants is directly influenced by air temperature and humidity, degree of illumination, moisture and soil quality, age and density of plants (Proskureakov, 2007).

One of the decisive meteorological factors, which influence the production of nectar, is temperature and humidity. Generally the optimal temperature for nectar secretion is 25-30^{0}C. Atmospheric humidity of 40-80% has a positive influence on nectar secretion. Increase or decrease of these indices negatively influences the secretion and production of nectar (Bura, 2005).

At air humidity of 51%, linden flowers (*Tilia* sp.) contain about 70% of sugar, but at air humidity of 100% they contain only 22% of sugar. At air temperature of +18^{0}C…+21^{0}C nectar is produced in increased quantity (1.62 mg), at a higher temperature the amount of nectar decreases. All melliferous plants produce nectar in larger amounts on fertile soils, well-structured, sufficiently moist and rich in natural fertilizers. Most important for apiculture are the following species: *Tilia* sp., *Robinia pseudacacia* L., *Acer platanoides* L., *Salix* sp., *Malus sylverstris* L, *Aesculus hippocastanum* L., *Crataegus monogyna* Jacq. (Vorobieva, 2015).

It has been established that during the flowering period productivity of mature linden trees is about a ton of nectar per hectare. The difference of melliferous productivity at linden stands between the ages of 51 - 60 years is 1.3 times higher than in the stands of 41 - 50 years. Researches have shown that the optimal temperature when a maximum amount of nectar is eliminated is 26^{0}C. The temperature difference of 5^{0}C between day and night causes the maximum elimination of nectar, and less or higher temperature difference decreases the amount of nectar. Reducing of daytime temperature by one degree during the flowering period decreases the productivity of bee family by 1-2 kg of honey (Madebeikin and Shilov, 2013).

According to the data from the specialty literature, 1 ha of *Tilia* sp. with mature trees has melliferous productivity of 500-1000 kg, depending on stationary conditions (Krivtsov and Burmistrov, 2004).

Locust tree (*Robinia pseudacacia* L.) has a very large melliferous potential. Productive average of one flower is 2.85 mg of nectar containing 56.5% of sugar. A young tree can produce 0.4 kg of honey. At the age of 12 years a locust tree has about 24.1 thousand/flowers, and at the age of 25 years 64.4 thousand/flowers. Depending on biotope conditions, one hectare of locust tree has a productivity of 50-1500 kg/honey/ha. The period of nectar collection lasts for about 19 days (Kurgina, 2012).

Locust tree is of particular importance because it insures the main spring picking. Honey production varies in dependence of how trees are planted: rarely planted trees produce 1100-1700 kg of honey/ha, trees from the massive 900-1500 kg/ha, and from the stands 300-700 kg/ha (Lazar, 2002).

Pozdeev D. investigated the influence of environmental factors on plant nectar, perfected the method of prognosis for melliferous plant productivity from forestry fund. Density decrease of the stand with *Tilia* sp. until the optimal degree rises the nectar quantity from 3.3% to 13.5%. Flowering is more abundant in mature and old stands with *Tilia* sp. Productivity average of honey at linden trees with small leaf *(Tilia cordata* Mill.) was 550 kg/ha; at willow (*Salix triandra* L.) male flowers 94 kg/ha, female flowers 129 kg/ha; at *Caragana arborescens* Lam. 58 kg/ha. The greatest influence of temperature on the productivity of nectar was at *Caragana arborescens* Lam. in a proportion of 97% and at *Salix triandra* of 84% (Pozdeev, 2004).

The researches Hisamov R. and Kulagin A. (2009) aimed at investigation of situation and perspective of using the melliferous resources from the forestry fund. The results of research demonstrated that there is a direct link between the number of bees, quantity of honey products and afforested area (r=0,58-0,69), and especially the area of honey plants (r=0,74-0,78) in linden stands. A closed link is established between the productivity of a bee family with mature and old trees of *Tilia* sp. (r=0,88), nominally this age category has an influence on the whole honey surface (r=0,77) (Hisamov and Kulagin, 2009).

Gluhov M. (2012) gives special attention to characterization of stationary conditions and to the methodology of melliferous products collection. There were described some methods of raising the productivity of the areas with melliferous resources, at approximately 200 honey plants. Major influences on the production of nectar by the plants have age, weather and day time, climate, soil, light etc. More nectar is produced by the plants in the first half of the day (in the morning), during warm and humid weather. The melliferous productivity of linden is the most sensitive to weather conditions. Plant areal, soil, rock and cultivation technology have less influence on the amount of produced nectar. The earliest melliferous resources are trees and coppice (April-May), followed by meadows (May-June) and plains (July-August) (Gluhov, 2012).

Due to bee pollination plants grown from these seeds have a higher germination energy and more intense development (Malkin and Buharkin, 2009).

At present, there are about 124330 bee families on the territory of the Republic of Moldova, with an average productivity of 33.6 kg/honey/family (Modvala, 2015).

Due to intensive exploitation of the afforested areas the number of spontaneous bees decreased.

There are clear evidences that intensification of agriculture has negative effect on apiculture. This trend is more visible in western countries, due to intensive use of pesticides and enlargement of cultivated areas, all of them contributing to reducing the biodiversity of honey plants (Decourtye, Mader, Desneux, 2010).

Due to the diversity of forest melliferous plants, a large amount of apicultural and pure ecological products can be provided.

2. Materials and methods

The purpose of the research is to describe the forestry melliferous resource sector from the Republic of Moldova, as well as identification of melliferous capacity of plants.

The research objectives were: inventory of the taxonomic composition of the forest melliferous plants from the Republic of Moldova; analysis of the phenological spectrum of flowering of forest melliferous plants; melliferous capacity of some forest plants; identifying opportunities for the development of honey resources.

Forest honey plants species from the Republic of Moldova had been inventoried using the specialty literature (Cîrnu, 1973, 1980; Gheideman, 1986; Nesterov, Pinchiuk, Leonteak, 1988; Cebotari, Gheideman, Nikolaeva, 1986; Chifu, Mânzu, Zamfirescu, 2006; Negru, 2007; Pînzaru, Sîrbu, 2016).

The research methods were: reading of specialized scientific literature, analysis and synthesis, organizing and systematizing of information, analogy, calculation and comparative analysis of data.

For better familiarization and systematization of melliferous plants, we used the following classifications (Cîrnu, 1980):

Phenological classification refers to the flowering period of the melliferous plants:

- Early spring melliferous plants (February-March);
- Spring melliferous plants (April-May);
- Summer melliferous plants (June-July);
- Autumn melliferous plants (August-September);
- Late autumn melliferous plants (October-November).

After the flowering phenophases, plants within the study were grouped in two periods: spring and summer.

Beekeeping classification is based on the nature of the feed source provided to bees and comprises 3 groups:

- Polliniferous plants group includes species from which bees collect only pollen;
- Nectariferous plant group includes species from which bees

usually collect nectar.

- Nectariferous-polliniferous plant group is the most important including melliferous species with the largest economic and beekeeping ratio. Melliferous plants from this group are the most numerous and provide bees with pollen and nectar.

Depending on the quantity of the eliminated nectar during the flowering period, melliferous plants from the Republic of Moldova have been divided into five groups (Nesterov, Pinchiuk, Leontyak, 1988):

- Plants with high nectar potential (abundantly secret nectar and occupies large areas);
- Plants with good nectar potential (abundantly secret nectar in local areas);
- Plants with medium nectar potential (annually secrete nectar and contribute to the formation of minor honey reserves);
- Plants with weak nectar potential (secrete inessential amount of nectar and don't contribute to the formation of honey reserves);
- Plants with non-significant nectar potential for beekeeping.

In order to determine melliferous productivity of plants per hectare, the following relationship is used (Nesterov, Pinchiuk, Leontyak, 1988):

$$X=a\times b\times c,$$

where: X – sugar productivity per hectare;

a – amount of sugar at a flower (mg);

b – number of flowers per hectare;

c – flowering period (days).

If plant's sucrose productivity of plants per hectare is known and 100% of honey consists of 80% of sugar and 20% of water, honey production per hectare is calculated according to the following formula:

$$Y=X\times 1.25$$

where: X – amount of sugar, kg/ha, and 1,25 – the sugar convection factor in honey.

The production of sucrose per hectare of the main forest melliferous plants from the Republic of Moldova is 800 kg at white acacia (*Robinia pseudoacacia* L.), 400 kg at linden (*Tilia* sp.), 200 kg at *Acer* sp., 100 kg at *Salix* sp., 20 kg at shrubs, and 15 kg at meadow (Nesterov, Pinchiuk, Leontyak, 1988).

The number of bees' families that can be maintained on a particular surface is determined by using the following formula (Cîrnu, 1980):

$$F= \frac{M}{m}, \text{ where:}$$

M – represents 1/3 of total honey production;

m – quantity of honey necessary for a family of bees for one year which is approximately 130 kg.

3. Results

Forests of the Republic of Moldova constitute a part of the national natural heritage. They play a special role in maintaining of ecological balance, conservation of biodiversity, landscape protection, and food and energy security.

According to the National Bureau of Statistics of the Republic of Moldova, the current area of the forestry fund is 421.7 thousand hectare (http://statbank.statistica.md).

By their composition forests of the Republic of Moldova are divided into deciduous (97.8%) and coniferous (2.2%). Figure 1 shows the distribution of the forestry fund species (Andreev et al, 2017).

Among melliferous species with high beekeeping potential, acacia predominate (33.1%). Linden represents 1.5%, willow and poplar 3%. Other species (6.1%) which feed bees are the following: maple, field maple, cherry etc.

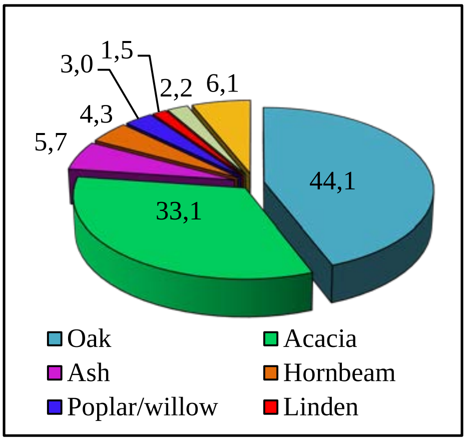

Fig. 1 Distribution of forestry fund species from the Republic of Moldova %

Honey plants offer nectar and pollen for bees. Due to the succession of flowering during the vegetation period, they provide a high maintenance pickup, for the development of bee families.

Deciduous forests consisting of trees and shrubs mixtures are the richest in melliferous vegetation. Bees have an almost uniform and long-lasting picking in this stands, which starts from spring and keeps until autumn.

In appreciating the forests from a melliferous point of view, we must take into account that, the forest offers a more abundant pick, the more varied is vegetation.

In case of establishing of taxonomic composition of species, flowering period, intensity, melliferous capacity, it can be developed a plan to highlight this natural resources.

Due to the favorable environmental conditions there is a rich and varied melliferous flora in our country.

For a superior exploitation melliferous resource it is necessary to know the main melliferous species.

Forest melliferous plant under inventory are: **trees** - *Acer campestre* L., *A. negundo* L.. *A. platanoides* L., *A. pseudoplatanus* L., *A. tataricum* L., *Aesculus hippocastanum* L., *Cerasus avium* L., *Fagus sylvatica* L., *Fraxinus excelsior* L., *F. ornus* L., *Gleditsia triacanthos* L., *Malus sylvestris* Mill, *Populus alba* L., *P. nigra* L., *P. tremula* L., *Prunus divaricata* Ledeb., *P. insitia* L., *Quercus petraea* Liebl., *Q. pubescens* Willd., *Q. robur* L., *Q. rubra* L., *Robinia pseudacacia* L., *Salix alba* L., *S.caprea* L., *S. fragilis* L., *Sorbus aucuparia* L., *S. domestica* L., *S. torminalis* L., *Styphnolobium japonicum* L., *Tilia cordata* Mill., *T. europaea* L., *T. tomentosa* Moench, *Ulmus campestris* L., *U. glabra* Huds., *U. laevis* Pall.; **shrubs** - *Amorpha fruticosa* L., *Amygdalus nana* L., *Caragana arborescens* Lam., *Cerasus fructicosa* Pall., *Chamaecytisus austriacus* L., *Clematis vitalba* L., *Cornus mas* L., *Corylus avellana* L., *Crataegus* *monogyna* Jacq., *Daphne mezereum* L., *Frangula alnus* Mill., *Ligustrum vulgare* L., *Lonicera xylosteum* L., *Prunus divaricata* Ledeb., *Prunus spinosa* L., *Rhamnus catharica* L., *Rosa canina* L., *Rubus caesius* L., *R. idaeus* L., *Salix cinerea* L., *Sambucus nigra* L., *Spiraea hypericifolia* L., *Staphylea pinnata* L., *Swida sanguinea* L., *Viburnum opulus* L., *Teucrium chamaedys* L.; **herbaceous plants** - *Abutilon theophrasti* Medik., *Acinos arvensis* Lam., *Adonis vernalis* L., *Aegopodium podagraria* L., *Ajuga reptans* L., *Alium rotundum* L., *Althaea officinalis* L., *Anchusa italica* Retz., *A. officinalis* L., *A. procera* Bess., *Angelica arhangelica* L., *Anthiriscus cerefolium* L., *Arctium minus* Hill., *Aristolochia clematitis* L., *Astragalus glycyphyllos* L., *Ballota nigra* L., *Berteroa incana* L., *Campanula glomerata* L., *Carduus crispus* L., *Carduus hamulosus* Ehrh., *Carum carvi* L., *Cerinthe minor* L., *Chamaenerion angustifolium* Hill., *Cichorium intybus* L., *Cirsium oleraceum* L., *Clematis integrifolia* L., *Crepis biennis* L., *C. pannonica* (Jacq.) C. Koeh., *Coronilla varia* L., *Corydalis cava* L., *C. solida* L., *Descurainia sophia* L., *Digitalis lanata* Ehrh., *Dipsacus fullonum* L., *D. laciniatus* L., *D. pilosus* L., *D. strigosus* Willd ex Roem, *Echinops ritro* L., *E. sphaerocephalus* L., *Echium vulgare* L., *Epilobium hirsutum* L., *E. montanum* L., *Eryngium campestre* L., *E. planum* L., *Erysimum canescens* Roth., *Eupatorium cannabinum* L., *Ficaria verna* Huds., *Filipendula ulmaria* L., *F. vulgaris* Moench., *Fragaria moschata* Duch., *Gagea lutea* L., *Galanthus nivalis* L., *Galeopsis ladanum* L., *G. speciosa* Mill., *G. tetrahit* L.,*Geranium pratense* L., *G. sanguineum* L., *Glechoma hederacea* L., *Hypericum elegans* Steph., *Lamium album* L., *L. maculatum* L., *L. purpureum* L., *Lathyrus aureus* Stev., *L. niger* L., *L. nissolia* L., *L. pratensis* L., *L. tuberosus* L., *Lavatera thuringiaca* L., *Lembotropis nigricans* L., *Leonurus cardiaca* L., *L. quinquelobatus* Gilib., *Leontodon autumnalis* L., *Lilium martagon* L., *Lotus corniculatus* L., *Lycopus europaeus* L., *Lythrum salicaria* L., *Malva sylvestris* L., *Marrubium vulgare* L., *Medicago falcata* L., *M. lupulina* L., *M. romanica* Prod., *Melilotus albus* Medik., *Melissa officinalis* L., *Oenothera bienis* L., *Onobrychis arenaria* Kit., *O. vicifolia* Scop., *Ononis arvensis* L., *Onopordum acanthium* L., *Origanum vulgare* L., *Oxytropis pilosa* L., *Phlomis pungens* Willd., *P. tuberosa* L., *Pimpinella saxifraga* L., *Prunela grandiflora* L., *P. vulgaris* L., *Pulmonaria obscura* Dumort., *Pulsatilla grandis* Wend, *Ranunculus illyricus* L., *R. oxyspermus* Willd., *R. polyanthemos* L., *R. stevenii* Andrz., *Reseda lutea* L., *Salvia nemorosa* L., *S. pratensis* L., *S. verticillata* L., *Sambucus ebulus* L., *Sanguisorba officinalis* L., *Saponaria officinalis* L., *Scilla bifolia* L., *Scrophularia nodosa* L., *S. vernalis* L., *Sedum acre* L., *Silene nutans* L., *Solidago virgaurea* L., *Sonchus arvensis* L., *Stachys annua* L., *S. germanica* L., *S. officinalis* L., *S. palustris* L., *S. recta* L., *S. sylvatica* L., *Stellaria media* L., *Symphytum officinale* L., *Taraxacum officinale* Wigg, *Tragopogon orientalis* L., *Trifolium hybridum* L., *T. pratense* L., *T. repens* L., *Trigonella caerulea* L., *Tripolium vulgare* Nees, *Tussilago farfara* L., *Verbascum phlomoides* L., *V. phoeniceum* L., *V. nigrum* L., *Veronica agrestis* L., *V. arvensis* L., *V. austriaca*

L., *V. barrelieri* Schott, *V. chamaedrys* L., *V. hederifolia* L., *V. jacquinii* Baumg, *V. longifolia* L., *V. montana* L., *V. officinalis* L., *V. orhidea* L., *V. persica* Poir., *V. polita* Fries, *V. prostrata* L., *V. scutellata* L., *V. serpyllifolia* L., *V. spicata* L., *V. spuria* L., *V. tetrasperma* L., *V. teucrium* L., *V. triphylos* L., *V. verna* L., *V. villosa* Roth, *Vicia angustifolia* Reichard, *V. sepium* L., *V. cracca* L., *V. hirsute* L., *V. pannonica* Crantz, *V. sativa* L., *V. tenuifolia* Roth, *Vincetoxicum hirundinaria* Medik., *Viscaria vulgaris* Bernh.

Biological form of melliferous flora, determines the quantity and quality of honey, especially the trees of acacia and linden. Acacia and linden honey is the most demanded on the internal and external markets, and the trading price is also the highest.

There are about 6 thousand hectares of linden forest and about 140 thousand hectares with acacia in the national forestry fund of the Republic of Moldova. Linden occupies important areas in the central region of the Republic of Moldova, and acacia in the south region. Acacia forms pure stands, and linden comes into the composition of oak stands and sessile oak stands, practically lacking the pure stands.

Plants inhabit all living environments being under the influence of environmental factors. To survive plants have changed their structure and physiognomy.

Figure 2 shows the ratio of the species of melliferous plants according to the biological form. From the totality of inventoried species trees represent-15%, shrubs-11% and herbaceous plants -74%.

According to the biological form, the species of herbaceous plants predominate, and the highest amount of honey in the forestry fund is harvested during the flowering period of trees and shrubs.

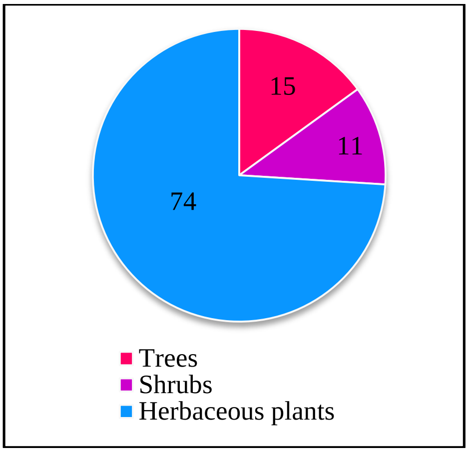

Fig. 2 Biological form of forest melliferous species, %

Systematization of forest melliferous plants by biological cycle offer information about surfaces which ensures collection of nectar and pollen.

Life cycle is different due to the diversity of plants.

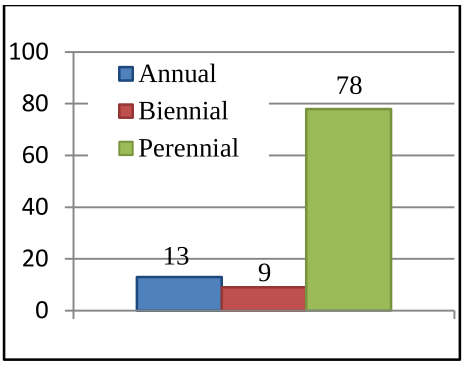

Fig. 3 Forest melliferous species by biological cycle, %

Figure 3 shows forest melliferous species by biological cycle: annual-13%, biennial-9%, perennial-78%. Grassy and woody plants are part of the perennial plant group.

Information on flowering phenophase of melliferous plants and its prognosis is very important for forestry and apiculture, because between the flowering period and occurrence of pollinating insects is a directly proportional relationship.

Figure 4 shows the percentage of melliferous species after the flowering phenophase, which were divided into two groups: spring (61%) and summer (39%).

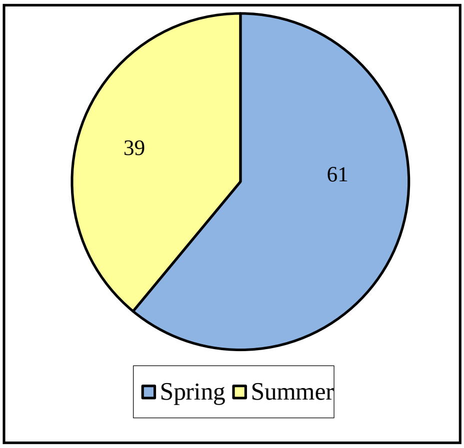

Fig. 4 Forest melliferous species after the flowering phenophase, %

An important source for bee feeding during early spring constitutes flowers of the plants that bloom first (hazelnut tree, dogwood, maple, willow).

Figure 5 shows the spring forest melliferous plants, identifying in 136 species and belonging to 32 botanical families.

In the group of spring forest plants there are predominant species from the following families *Fabaceae* (21 species), *Lamiaceae* (16 species), *Rozaceae* (13 species), *Scrophulariaceae* (18 species), *Ranunculaceae* and *Salicaceae* (7 species) Many botanical families are represented by 1-5 species (*Aceraceae*, *Amaryllidaceae*, *Apiceae*, *Aristolochiaceae*, *Boraginaceae*, *Brasicaceae*, *Caprifoliaceae*, *Caryophyllaceae*, *Cesalpinaceae*, *Cornaceae*, *Corylaceae*, *Crassulaceae*, *Fageceae*, *Fumariaceae*, *Hippocastanaceae*, *Liliaceae*, *Malvaceae*, *Oleaceae*, *Resedaceae*, *Rhamnaceae*, *Sambucaceae*, *Staphyleaceae*, *Thymelaeaceae*, *Ulmaceae*, *Viburnaceae)*.

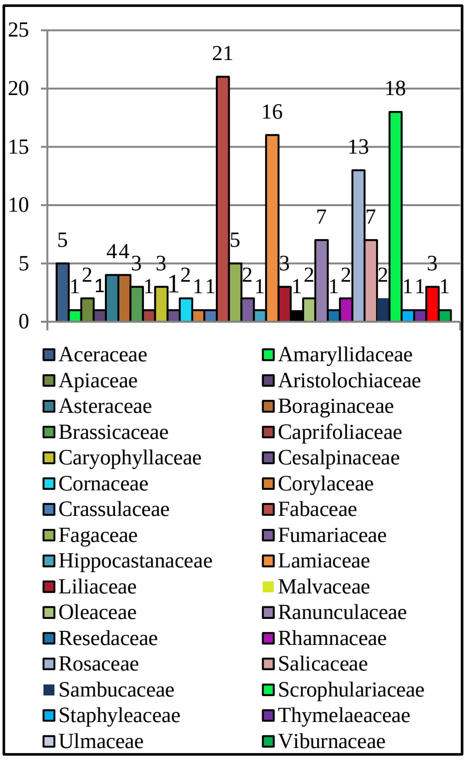

Fig. 5 Number of spring forest honey species

An important condition for the cost-effective growth and maintenance of bee families constitute information about melliferous plants from the area where bee-garden is located, flowering period of them, as well as their nectaro-polliniferous value.

All these data, as well as weather conditions make possible planning measures for rational development of a bee family, in order to obtain rich and constant honey harvests.

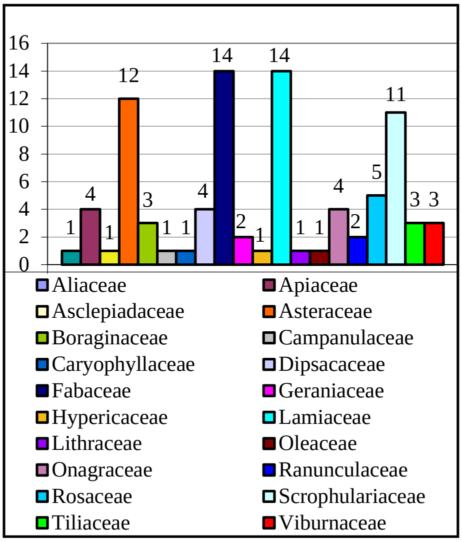

Fig. 6 Number of summer forest honey species

Figure 6 shows summer forest melliferous plants, identified in a number of 88 species belonging to 20 botanical families.

In this group predominates species from the families *Fabaceae* (14 species), *Lamiaceae* (14 species), *Asteraceae* (12 species), *Scrophulariaceae* (11 species). The rest of the families, 16 in number include 1-5 species. Families *Aliaceae*, *Asclepiadaceae*, *Campanulaceae*, *Caryophyllaceae*, *Hypericaceae*, *Lithraceae*, *Oleaceae* are represented only by one of honey forest plants.

For the rational use of the phytocenosis melliferous potential it is necessary to know the distribution of melliferous resources, phenology of flowering, the ability of nectar and pollen elimination. These processes are dependent on several natural factors.

Flora of the Republic of Moldova cover a number of melliferous plants remarkable for good honey production.

Figure 7 shows the percentage of apicultural economic share of inventoried forest species. Most species (46%) have a medium beekeeping share, 28% have a small share, and 20% are without weight. 1% from the inventoried species have a very high apicultural share (*Robinia pseudacacia* L., *Tilia* sp., *Rubus idaeus* L.), 5% from species (*Acer campestre* L., *A. tataricum* L., *Melilotus albus* Medik., *Onobrychis viciifolia* Scop., *Salix* sp., *Trifolium repens* L.) have a high apicultural share.

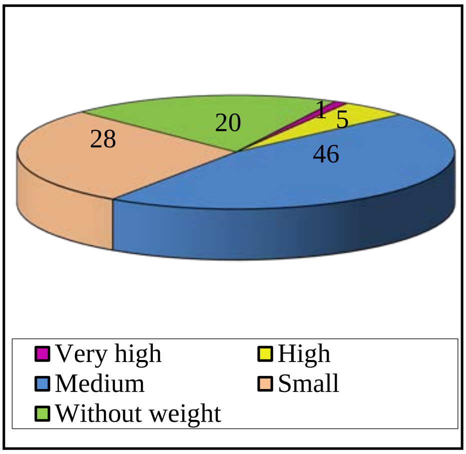

Fig. 7 Apiculture economic share of forest species, %

Interest for beekeeping products, especially for honey is steadily increasing. This kind of activity ensures preservation of natural ecosystems and development of biological diversity.

Actually, forestry enterprises, subordinated to Moldsilva Agency have around 900 families of bees, with an average productivity of 5 kg/honey/family. The majority bee families (67%) are situated on the territory of the northern republic's forestry enterprises (Edineț, Soroca, Glodeni, Natural Reservation ,,Pădurea Domneasca").

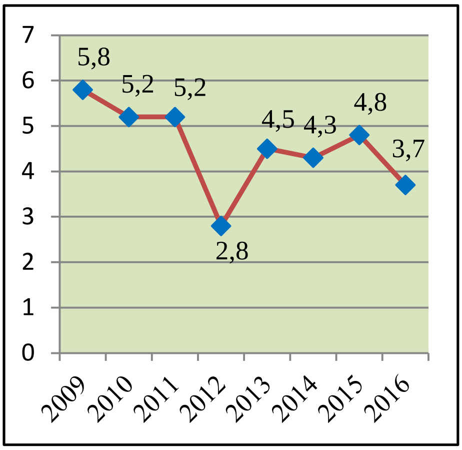

Fig.8 The amount of honey harvested by Moldsilva Agency, tons

Average productivity of sucrose in the forestry fund of the Republic of Moldova is approximately 256 kg/ha or 320 kg/honey/ha and can feed around 1.000000 bee families.

Data base provided by Moldsilva Agency shows that the amount of honey annually harvested decreases (http://www.moldsilva.gov.md).

Table 8 shows that during the years 2009-2016 the amount of harvested honey decreased from 5.8 tons during 2009 until 2.8 tons during 2012, then returning to 4-4.5 tons during coming years.

Superior utilization of the existing nectaro-polliniferous resources is an imperative for complete satisfaction of current requirements of the development of beekeeping production.

4. Discussion

Honey plants are the only source of organic feed for bees, which provides human beings directly or through bees with valuable biological products as honey, pollen, nectar, propolis, mother bee milk, bee wax.

Honey resources are part of the natural and cultivated ecosystems. Their rational evaluation and use is a current and perspective theme.

National forestry fund has a high melliferous capacity, but the annual share of collected bee products is among the smallest.

Being specie with a high apiculture share and comprising 1/3 of the forest area acacia is an underestimated melliferous resource thus reducing the income of the forest branch.

Honey is a product which is exported to the European Union and could bring major additional revenues to forestry enterprises. This is a reason to set up apiaries with professional staff.

Internationally, there are a lot of researches on melliferous forest resources, and internally these researches basically are missing.

The importance of beekeeping is proven by both scientific and practical research. It is known that the main pollinators are bees, which is not taken into account and as a result negatively affects the profit of economic agents.

Providing the country with honey natural resources is an important economic factor in national development. The structure of these resources, their value, and quality, the degree of study and direction of capitalization, all of them have a direct impact on the economic potential.

Efficiency and yield of the forest fund may increase based on the complex and rational use of all resources under market economy conditions.

Utilization of the forest honey base has been recognized lately by the international community as a profitable business.

The use of honey forest products fall into the sphere of activity of various production and processing enterprises, and it is also a subject of increased attention for scientific, social and environmental organizations.

The melliferous productivity of forest resources is higher if floral biodiversity is more different and flowering period is longer.

Forest ecosystems have the greatest melliferous resources due to the diversity of plants.

Mixed and multi-tiered stands are more productive than the purely one.

There is an increase in the trend of moving to the principles of sustainable forest development in many countries of the world, through which economic viability, ecological responsibility and advantageous social use are achieved.

The gradual increase of the number of bee families and introduction of modern technologies for their growth and maintenance requires a number of effective measures to improve and expand the honey base.

During the period of years 2002-2008 on the
degraded lands allocated by mayoralties forest plantations have been carried out on the area of 60000 ha. Most of these areas were covered with acacia (*Robinia pseudacacia* L.), which has significantly contributed to the increase of forest melliferous base of the Republic of Moldova.

More recently has been planted areas of about 1000 ha, with *Paulownia* trees that will be a very good malliferous source.

In parallel to the improvement and expansion of the honey base it is necessary to apply some measures for the conservation of nectaro-pollinifer resources and at the same time for biological protection of bee families.

One of the ways to solve the problem of sustainable forest development in the Republic of Moldova is a complete and effective involvement of non-timber forest products including melliferous products.

Expansion of market relations in the forest sector will create conditions for more dynamic development, efficient economic management of forests and formation of products for local markets, for a better respond to the needs of population not only in wood but also in other forest products.

Small number of bee families on the territory of the Republic of Moldova and uneven distribution of the melliferous plants determines the inability to use sufficient honey resources. It is possible to overcome this problem by using of mobile beehives.

The action of bees solves a wide range of socio-economic problems from increasing plant productivity to providing people with unique apiculture products and for health maintenance.

Beekeeping is an important branch for the economy of the Republic of Moldova, but it families at the moment.

Improvement of melliferous potential can be achieved through the development of nectaro-polliniferous plants, afforestation, specific forestry operations, conservation of resources and protection of bees, limitation of grazing, use of productive bees, introduction of new species which will increase the capacity of forests, and at the same time will increase the areas occupied with valuable honey species.

Due to the multiple properties of honey, melliferous resources comprise an important component of non-timber forest products and determine taking into account the sustainable development of the forest sector.

Further study of honey resources will open new opportunities for humanity for their usage and management.

5. Conclusion

Melliferous plants are part of the group of non-timber forest products.

The inventoried forestry melliferous flora from the Republic of Moldova consists of 41 families, 129 genera and 224 species.

Most melliferous plants (61%) bloom in the spring and at the beginning of summer.

Spring forest melliferous flora of the Republic of Moldova belongs to 32 botanic families including 136 species. The most representative families of spring species are: *Fabaceae* (21 species), *Scrophulariaceae* (18 species), *Lamiaceae* (16 species), *Rozaceae* (13 species).

The summer forest melliferous flora lists 20 botanical families with 88 species. Families with most species are: *Fabaceae* (14 species), *Lamiaceae* (14 species), *Asteraceae* (12 species), *Scrophulariaceae* (11 species).

The most important species of honey plants in the forestry fund of the Republic of Moldova are: *Robinia pseudacacia* L. (600 - 1000 kg/honey/ha) and *Tilia* sp. (800 - 1200 kg/honey/ha).

Most of the melliferous species (46%) from forestry fund have a medium beekeeping share; with a very large weight is 1% and 5% with high weight.

Moldsilva Agency has around 900 of bee families with an average productivity of 5 kg/honey/family. The average sucrose productivity of the forestry fund from the Republic of Moldova is approximately 256 kg/ha or 320 kg/honey/ha and can feed around 1000000 of bee families. Production of honey obtained by the forestry enterprises is very low in comparison to private owners and melliferous capacity of the national forestry fund.

Most bee families (67%) are situated on the territory of the northern forestry enterprises (Edinet, Soroca, Glodeni, Nature Reservation ,,Padurea Domneasca").

Improvement of melliferous potential can be done through afforestation, conservation of honey resources and protection of bees.

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Afforestation and reforestation management in Romania - migrating to sustainability and responsibility

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Abstract: Considering the present state of afforestation and reforestation management in Romania, the process of renewing the forestation paradigm is analysed. Most of the management systems use an iterative method of improving the outcomes. Considering the classical phases Plan-Do-Check-Adjust, the forest management system is broken into pieces in order to reveal potential gaps from planning to system adjustments regarding forestation in Romania. The official data reports, national statistics and forest regulations represent evidences of a system that fails to progress. The weak integration of Pan-European criteria and indicators for sustainable forest management, the lack of a robust planning system and the poor capacity of accessing European funds are considered major gaps. The whole framework of afforestation and reforestation should be revised to comply with recent realities and objectives (social, economic, environmental). At present time Romanian forest management still forges tomorrow’s forests using regulations fitted to communist era, without taking into account updated objectives regarding social needs, economic benefits, climate change mitigation or the new types of property. Several suggestions for improving the afforestation and reforestation framework were provided.

Keywords: afforestation, reforestation, forest management, responsibility.

1. Introduction

What we understand by sustainability and responsibility defines our relationship with the environment and the many resources we control. As we are increasingly confronted with environmental, social and economic issues, we need to reconsider how the community is responsibly involved in resource management activities. Facing new realities requires an adequate response from the resource managers.

Undeniable, nowadays forests mean more than timber and we all understand the importance of this multifaceted resource which provides benefits in different areas: environmental, economic, social and cultural.

Forest delivers a broad range of ecosystem services concerning climate regulation, water and soil quality, carbon sequestration, biodiversity, sociocultural and recreational values.

Many of these eco services became more visible in recent years and the society is aware of the potential costs of it (Ninan & Inoue, 2013). Moreover, the last decade was considerable influenced by the publication of the Millennium Ecosystem Assessment (MEA, 2005) which emphasised the ecosystem services value.

In this context, afforestation and reforestation represent a form of increasing or at least preserving forest ecosystems benefits. For instance, afforestation, reforestation and deforestation control are considered the main types of climate change mitigation projects in the forestry sector (Reyer et al. 2009).

Considering forest as a natural resource which replenishes itself, the forest management should avoid resource depletion caused by increased wood consumption. The key is represented by sustainability which guarantees long-term availability of the forest.

Sustainability should also involve responsible management. And by being responsible we understand taking action and adjusting locally the economic, social and environmental issues and linking relevant stakeholders.

How could we define responsible forestation? Keeping in mind that forestation role, in regard to sustainability, is to ensure forest continuity or even increase forest cover, acting responsible in this direction would imply to ensure the future resource needs, securing jobs, providing recreation and wood for nearby communities, maintaining ecosystem functions or climate change mitigation role.

Swapping the socioeconomic system after 1989 was a challenging effort for Romanian forest management. The political and economic changes in Romania shaken the forest management system, causing an unpredictable pattern of transformation: legislative amendments, property fragmentation / forest cover dynamic, adjustments of technical regulations and tunings of the management systems.

Numerous scientific researches highlighted the radical changes produced in the Romanian forestry sector (Bouriaud 2005; Ioras and Abrudan 2006; Dutcă and Abrudan 2010; Palaghianu and Nichiforel 2016; Munteanu et al. 2016; Scriban et al. 2017) but fewer were focused on forestation (Palaghianu and Dutca 2017). In light of this new realities it is thought-provoking to analyse the forestation management system of Romania.

2. Forestation management cycle

It is common for a management system, whatever it refers to forest or not, to use an iterative method of improving its results, processes, products or services.

We will apply a classical management cycle Plan-Do-Check-Adjust for the forest management system, in order to reveal potential gaps from planning to system adjustments regarding forestation in Romania.

The Plan – it is well known that during the communism period, the plans were carefully developed and executed.

After the massive deforestations caused by the payment of war compensations to Soviet Union in timber (Banu, 2004), Romania had a determined reforestation strategy designed to reforest 1 million hectares. The project was accomplished by the year 1963, due to an impressive endeavour of reforestation (e.g. 98,400 hectares afforested in 1953) (Negrutiu et al. 1999). This effort continued consistently afterwards, and by the year 1976 nearly 2 million ha were regenerated or forested (Law no. 2/1976).

The Law no. 2 / 1976 (National Program for the preservation and development of the forestry fund) projected forestation measures for 1976-2010. The plan was to concentrate on nurseries and plantations, with an average of approximatively 50,000 forested hectares per year (Palaghianu and Dutca, 2017). After the communism collapsed in 1989, plans for 2010 were interrupted by the political changes and the Law no. 2/1976 was abolished in 1990.

A new order, a new forestation plan and the interest in this field was resumed. One important official objective of the National Afforestation Programme (2004) and Forest Code (Law no. 46/2008), was the afforestation of 2 million hectares of degraded lands till 2035. Later, the interest in this forestation goal was reinforced by the Law no. 100 /2010 regarding the afforestation of degraded lands.

However, later versions of the National Afforestation Programme (2010 and 2013) have resketched the goal, turning it from 2 million hectares to 0.422, respectively 0.229 million hectares (Palaghianu and Dutca, 2017).

These negative adjustments of a national forestation plan cannot be interpreted as robust actions towards responsibility, but additional targets were set using the European systems of funding.

The National Rural Development Program encompassed the funding of forest measures, including afforestation. The target was to forest 15 thousand hectares by SAPARD (2000-2006), nearly 50 thousand hectares by European Agricultural Fund for Rural Development (EAFRD 2007-2013) and 10 thousand hectares FEADR (2014-2020).

Do – Maybe the plan was not a solid one, but were the results and actions better?

Despite some data inconsistency between INS (National Institute of Statistics) and Romsilva (National Forestry Administration) reports, the forestation effort seems to gradually decline after 1990 (INS and Romsilva reports) to an average that ranges between 10 and 15 thousand hectares per year.

Furthermore, the forestation funding mechanisms failed to achieved their targets. The funding absorption rate for SAPARD funds (2000-2006) Measure 3.5 was 1.3% and for (EAFRD 2007-2013) Measure 221 (The first afforestation of agricultural land) was 0.08% (Palaghianu and Dutca, 2017).

Check – A simple raw evaluation is showing that results deviated far enough from the expected targets. The Romanian forestation engine seems to have gripped over the past few decades and the comparison with pre-1990 afforestation rate is not favourable to present.

Adjust **–** Observing the poor results, how much the afforestation and reforestation framework was adjusted in the last decades?

The Romanian forest management is generally negatively influenced by the strict regulatory system (Nichiforel et al. 2017; Scriban et al. 2017).

Despite the overwhelming interest in regulations regarding the harvesting process and traceability of timber products, few adjustments were made regarding afforestation and reforestation management.

Nowadays, forest regeneration framework is based on the old and extremely standardized technical regulations used in the pre-1990 period (MAPM, 2000).

After we went through the whole cycle Plan-Do-Check-Adjust, we can pinpoint some potential gaps in the Romanian forestation framework.

3. Beyond forestation regulations

Romania has a very strict system of regulations regarding forest regeneration and afforestation. The current technical framework was republished in 2000 (MAPM, 2000), but it is essentially based on the same versions of guidelines and procedures used prior to 1990.

The forest owners, regardless of the type of property (state or private owned forests), are forced to comply with several compulsory solutions regarding species composition or planting density, even if these have not ever been scientifically validated. These solutions and regulations were not questioned in the communist time, because they were tailored to centralised plans, but after the forest property pattern was fundamentally changed, many of the new owners did not trust the previous management system and they wanted to propose new objectives and targets for their forests.

Even though the new version of the technical regulations were published in 2000 (10 years after the fall of communism), they did not integrate new principles of forest management.

In the context of sustainable forest management (SFM) at international level there were established criteria and indicators for SFM (Pan-European criteria and indicators for sustainable forest management Lisbon, 1998; Improved Pan-European Indicators for Sustainable Forest Management, Vienna, 2003 and Madrid, 2015).

Six criteria of SFM were recognized and remained unchanged and at the 7th Ministerial Conference, held in Madrid in 2015 were endorsed two resolutions: Resolution 1: Forest sector in the centre of Green Economy and Resolution 2: Protection of forests in a changing environment.

Nevertheless, none of the six criteria were explicitly included in Romanian technical guidelines. There is a weak integration of Pan-European criteria for SFM, due to the fact that current technical guidelines were republished in 2000 and they contain minor changes from the previous versions published in 1977 and 1987.

It stands to reason that numerous changes in the forestry management system at international level have made since 1977/1987 which are not integrated in current guidelines.

Nevertheless, neither of the provisions of the EU Forest Strategy

(EU 2013, 2015, 2018) have been integrated.

Another sensitive issue which is not addressed by the current forestation regulations is represented by the use of invasive alien species. EU has clarified the management of invasive alien species by Regulation no 1143/2014 (EU, 2014). Still, the Romanian forestation technical framework offers some forestation solutions which use invasive alien species. This issue is delicate and debatable, especially in the context of degraded lands or concerning the use of certain species (Nicolescu et al, 2018).

Moreover, the problem should be shortly clarified so that forest management does not contradict some requirements of forest certification schemes (FSC / PEFC) concerning invasive alien species.

Additional technical aspects regarding current forestation regulations were previously highlighted (Palaghianu and Dutca 2017):

- the procedures are too detailed and very restrictive (e.g. regarding species composition, density);
- current species composition solutions have not been scientifically substantiated;
- there are not emphasised new realities/targets expressing economic, social or climate-related mitigation trends.

It is obvious that Romanian forestation technical guidelines should be updated and a change was ineffectively attempted in 2016. In the recent months a new project for designing new regulations has started and we are confident that we will witness a shift towards a sustainable forest management.

Clearly, we will see some changes in several key aspects regarding afforestation and reforestation framework.

The procedure for species composition selection should be simplified using a scheme based on forest types or nominating only the main species and its minimum percentage. It is important to have a more flexible procedure because based on current species composition solutions we create the future forests, which will provide a great variety of ecosystem services for the next generations.

The tree density procedures should also be revised. It could be more efficient to establish a minimum threshold and to check tree density at stand closure not at the end of the planting activity. Furthermore, for several species tree density should decrease, according to practitioners and studies (Nicolescu et al, 2003).

It is also important for forest owners to have an increased flexibility in setting management objectives, more adequate to current realities.

4. Conclusion

Currently in Romania the official data reports, national statistics and forest regulations represent evidences of a system that fails to progress.

Unfortunately, forests created today in Romania, forests of the future generations will reflect the past realities of 1970-1980 type of management. There is a huge gap between present realities / forestry management system at international level and the outdated framework of forestation used in Romania.

The weak integration of Pan-European criteria for sustainable forest management, the lack of a robust planning system and the poor capacity of accessing European funds are considered major gaps. The whole framework of afforestation and reforestation should be revised to comply with recent realities and objectives considering the social, economic and environmental pillars of sustainability.

The Romanian forestry system had plans to draw up, took action and had enough time to observe the effects of the current management system. Considering the adaptative management cycle Plan-Do-Check-Adjust, now it is more appropriate to be oriented towards the adjustment phase.

New realities and the significant role of forests in the environmental and social paradigm should help foster new objectives and major updates of the forestation management.

Currently Romania shapes its future forests with tools from the past. The present forestation regulations were designed for a different socioeconomic environment. The socialist settings do not match the present realities.

Adjustments were made, but mostly on forestry legal framework. An outdated management system can not be patched only by providing new sets of legal regulations. The robust approach implies the design of a brand-new technical management framework, suited for objectives regarding social needs, new property patterns, economic benefits or climate change mitigation.

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Using satellite image classification and digital terrain modelling to assess forest species distribution on mountain slopes – a case study in Varatec Forest District

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Abstract: The relation between ecological conditions and geomorphological factors is considered the basis for species distribution in Romania. In this context, the location of each species within parts of the mountain slopes is difficult on a medium to brad scale level. The paper presents methodology to combine vegetation data, obtained from IKONOS satellite images, and Digital Elevation Model obtained from digitized topographic maps. The study area is a northern slope of the Stanisoarei Mountains with a gradient of species from beech mixed and coniferous stands

Keywords: image segmentation, classification, GIS, DEM

1. Introduction

Remote sensing applications in the forest area are numerous as the information extracted from the satellite images can be useful in describing the forest stand and forest sites. In this general framework the large ecological studies are included, which observe the spatial distribution of some details of interest of the forest species on different geomorphological formations. Such a mapping of the species distribution can, of course, be done on the field by partial inventories and interpolations within some relatively homogenous populations. The advantage offered by an approach using of remote sensing is offered by the possibility of full inventory of the areas with certain characteristics. Although such a characterization of the forest stands is more general then the one inventoried on the field, the mapping accuracy can be seriously improved because of the current high quality recordings (Franklin 2001, Gao, 2009).

In this context is also included the distribution of some forest species on the geomorphological units and especially of the slopes. The aspect is attractive as the vegetation conditions are variable and impose a certain distribution of species, especially in the stands resulted from natural regeneration. The analysis possibilities are high, and the results are valuable, if we take into account the integration of the data resulted from satellite images classification with Geographical Informational Systems (GIS). Based on the satellite data there can be done rapidly and easily distribution maps which can comprise the information regarding certain geomorphological characteristics, even the meteorological and phenology data.

The objective of the study was to develop an interdisciplinary method to delineate tree species distribution in topographically-complex habitats.

2. Materials and methods

The study is located in the Vanatori Neamt National Park. As materials, we used pan-sharpened IKONOS 2 multispectral images and topographical plans (scale 1:5000) with contour lines.

For the satellite image classification we used field data regarding vegetation characteristics, composition, biometrical parameters. In order to choose the best classification there were compared two distinct work methods: one based on pixel classification (Pixel-Based Classification), done with ERDAS Imagine 9.1 and the second one based on multiresolution segmentation within the textural analysis program eCognition Professional 4.0. The classification precision was calculated in each case using field data, portions known form IKONOS satellite image and high resolution aerial photos. The vector data resulted from the classification allow the information integration in thorough ecological studies, in which geological and geomorphological aspects are to be taken into consideration. Keeping in mind that for the above situation presented above the geological characteristics are almost constant, there were studied the morphometric parameters, attempting their correlation to the vegetation characteristics, extracted from the available satellite images.

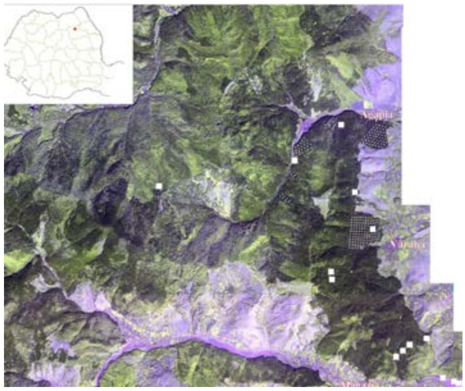

Fig. 1 Location of the study area

For the GIS information and remote sensing data integration it was imperative the designing of filed three-dimensional model based on the vectorised contour lines. As a cartographic source we used 1:5000 topographic plans with contour lines, which were turned into digital form with ArcGIS 9.3. For the interpolation Krigging method was used, and the terrain model was analysed in raster format (grid); the processing was done with the 3D Analyst module from ArGIS 9.3.

A brief interpretation of the geomorphological information and data related to the forest vegetation is represented by the designing of a three-dimensional image; it was done by correlating the image pixels flat position with the values corresponding to the three-dimensional terrain model, designed after the contour lines on the topographic plans using ArcScene from ArcGIS 9.3 (fig. 5). The utility of the application is more one of 3D visualising of general data, extended the observations at a large scale.

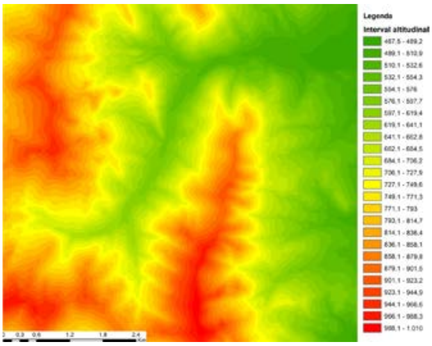

Fig. 2. 3D terrain model for an area within Production Unit III Agapia

Specific geomorphological parameters were extracted from the 3D terrain model using the GIS application specific modules which allowed the precise quantification and on large areas as it follows:

- Elevation can be extracted directly from the 3D terrain model, by identifying the areas of interest and applying them as a mask on the DEM.
- Slope is calculated for each triangle constituted in the elevation values interpolation process, designing work „facets" with constant slope.
- Aspect is associated to each facet as well as an orientation of the steepest slope line (ArcGIS Userguide).

Fig. 3 IKONOS image overlay on terrain elevation model (vertical exaggeration 1.5 x)

In the case of each terrain model there were used interpolation algorithms. These, in vector format led to the projection of some triangles which cannot be overlapped with polygons designed by raster formats interpretation, as the satellite images are. In order to ensure compatibility of the data the specific files were transformed into raster files with the same resolution as IKONOS images used in Object Oriented Classification respectively 1m (Haralick, 1973, kayitakire, 2002).

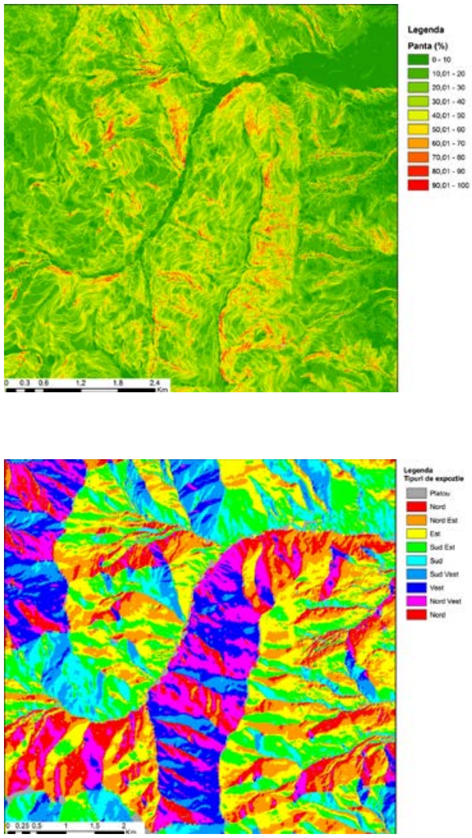

Fig.4. Slope and aspect of an area within the Production Unit III, Văratec Forest District

Even if the overlapping cannot be done by the real limits of the pixels, the methods based on the nearest neighbour identification can ensure a good overlapping precision.In order to exemplify the information usage mentioned in ecological studies a slope of Stanisoara Mountains was taken into consideration in the area Văratec – Agapia, slope with a shaded general exposition, extended on an altitudinal interval between 540 and 900 meters, with an average slope of approximately 25% (fig. 4).

The data regarding forest vegetation were taken from the vector file derived from the classified image segmentation. For the information representativity there were separated only the vectorial objects outlined as polygons corresponding to the portion of ridge taken into account. In this manner, the spruce plantations from the vicinity of the stream and the vegetation from the other slope were eliminated from the analysis.

Data overlay was based on the use of the same datum in the processing of georeferenced images (Stereo 1970, as defined in ArcGIS 9.3). IKONOS images georeferenced in the GCS WGS - 84 –UTM projection (Universal Transversal Mercator) were verified and then projected in the national datum - Krasovski ellipsoid and Stereo 70 projection. The digital terrain model was obtained from topographical plans with contour lines on a scale of 1:5000, by vectorisation and transformation using Topo to Raster function. For the overlay of vector and data extraction the Zonal Statistic (as a table) module of ArcGIS 9.3 was used.

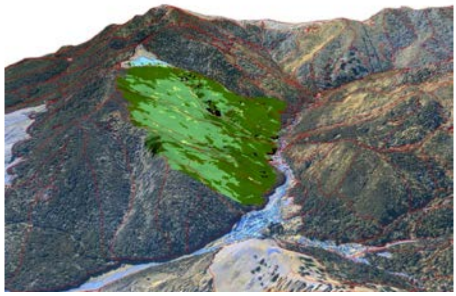

Fig. 5. Vegetation related classified image – study area for ecological application, in the topographical context of the Văratec area (vertical exaggeration 2x)

3. Results

By applying Zonal Statistic as a table function of ArcGIS a complex database was obtained, recording the computed geomorphological parameters for each exported polygon, originated from the segmentation and per object classification. The database can be interrogated in order to delineate the distribution of areas occupied by different vegetation classes in relation to the topographic parameters.

The distribution charts for the distribution of the identified groups of species on the slopes show that there is a distinct pattern of distribution of the species with specific requirements for ecological parameters (fig. 6):

Coniferous forests have higher proportions in the lower and upper part of the slope, between 540 and 700 m and between 800 and 900 m;

Areas classified as mixed forests with beech and coniferous are mainly present lower-middle part of the slope between 600 and 850 m, with a maximum around the elevation class 750 m;

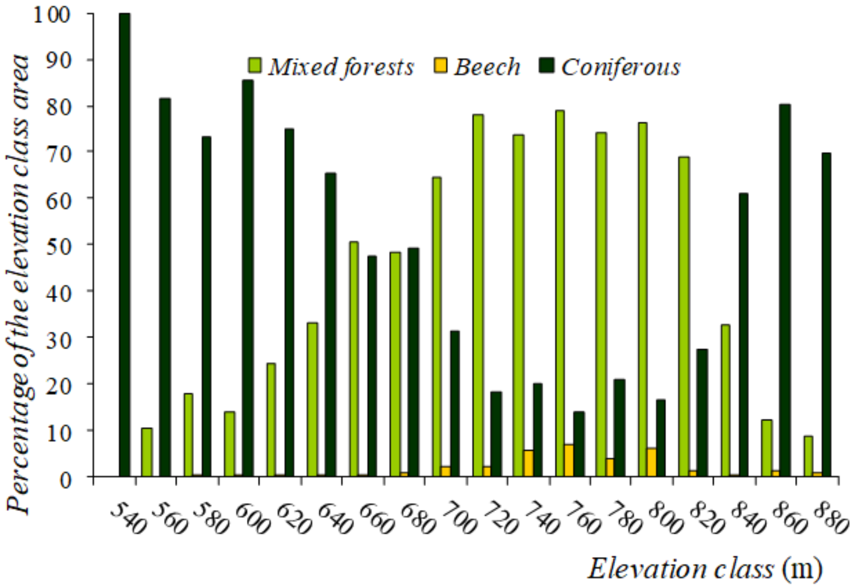

Fig. 5. Area percentage distribution in relation to the specie and the altitude class

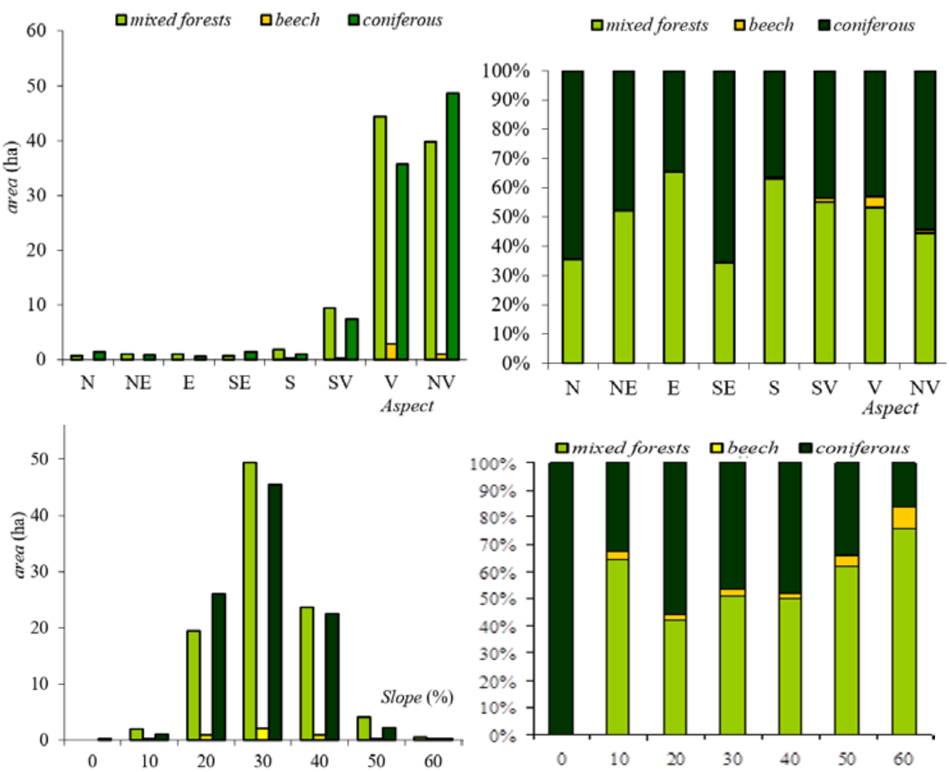

Fig. 6. Vegetation distribution on the slopes: a, b according to aspect; c,d according to declivity classes

Small portions of beech stands are located in the central part of the slope, on elevations between 700 and 800 m.

The alternant distribution of vegetation on the slope can be related to the temperature inversion that is a phenomenon characteristic for narrow valleys and predominant shaded slopes. The effect of the phenomenon is revealed by the natural regeneration of the stands on the entire slope, which can offer information on the specific requirements of the species involved.

In the lower part of the slope, exceptions from the natural distribution of species can be noticed: sycamore and scots pine plantations on areas less than 0.5 ha. During the segmentation and per object classification process, these areas have been included in the corresponding classes mixed forests and coniferous forests (which they actually represent).

The elevation related variation of stand composition can be correlated with respective climatic parameter modification, which can also be modelled through GIS analysis, based on recurring meteorological data. The chart information can be compared with the ecological distribution charts presented in the literature (Stănescu et al., 1997), which do not account for the inversion that can be present in such areas. Any comparison with such charts must also include a correction of the altitude with the values of the latitude, as the charts are constructed for the latitude of 45o (Florescu, Nicolescu, 1996).

The spatial distribution of species groups on different topography was obtained by GIS overlay of classified image objects on the surface model (fig. 3). The morphological parameters taken into account are the aspect and slope of each pixel, defined by comparison with the other pixels around (moving window). The analysis of the absolute values and percentages of each class showed that:

- Predominant slope aspect is North and Northwest; other aspect types are found on smaller areas and are related to the fragmentation of the slope due to the secondary valleys;
- Pure beech stands are found only in shaded parts of the slope; the other areas are covered with mixed forests and coniferous;
- The entire slope has a high declivity, which increase the effect of aspect on the forest vegetation.

The repartition on elevation, slope and aspect classes showed particular cases of species distribution interference, given by the different behaviours of species in regard to the values of the ecologic factors. Due to the temperature inversions given by the narrow valley bottom, the pure beech stands are found only in the middle of the slope, where the species found favourable environmental conditions (Stănescu et. al., 1997) and “wins” the interspecies competition. On higher elevations, the beech decreases in proportion due to the vertical temperature gradients.

The species composition modification is intensified by the increases in slope, which enhances the effect of the slope. The beech occupies sites with low variations in terms of aspect and slope, especially since the species is at the limit of the natural area.

The results of the study showed that species distribution on the slope can be highly variable, especially on long slopes with variable aspect and declivity. In such cases, is important to identify and map the areas with significant composition differences as distinct stands during the forest management planning activities. Once identified, the forest site conditions need to be assessed, including the topographical parameters included in the general database (altitude interval, slope, aspect, terrain configuration).

4. Conclusion

Ecological applications related to species distribution on the mountain slopes are important in the cases of mixed forests, with species that have different growth behaviours in relation to light and temperature. A particular case taken into study was represented by the thermic inversions that occur on narrow valley bottoms, which enhances the climatic ranges during the vegetation season.

The natural regeneration on the slope was essential for the investigation of the species behaviour on different site conditions. The basis for vegetation mapping was a multispectral IKONOS image, segmented and classified to highlight the main ecosystem types in the area.

The application is important in terms of ecological study, forest management planning. Also, the visual impact of the image overlay and distribution statistics are important in ecological education and understanding the species ecological requirements.

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