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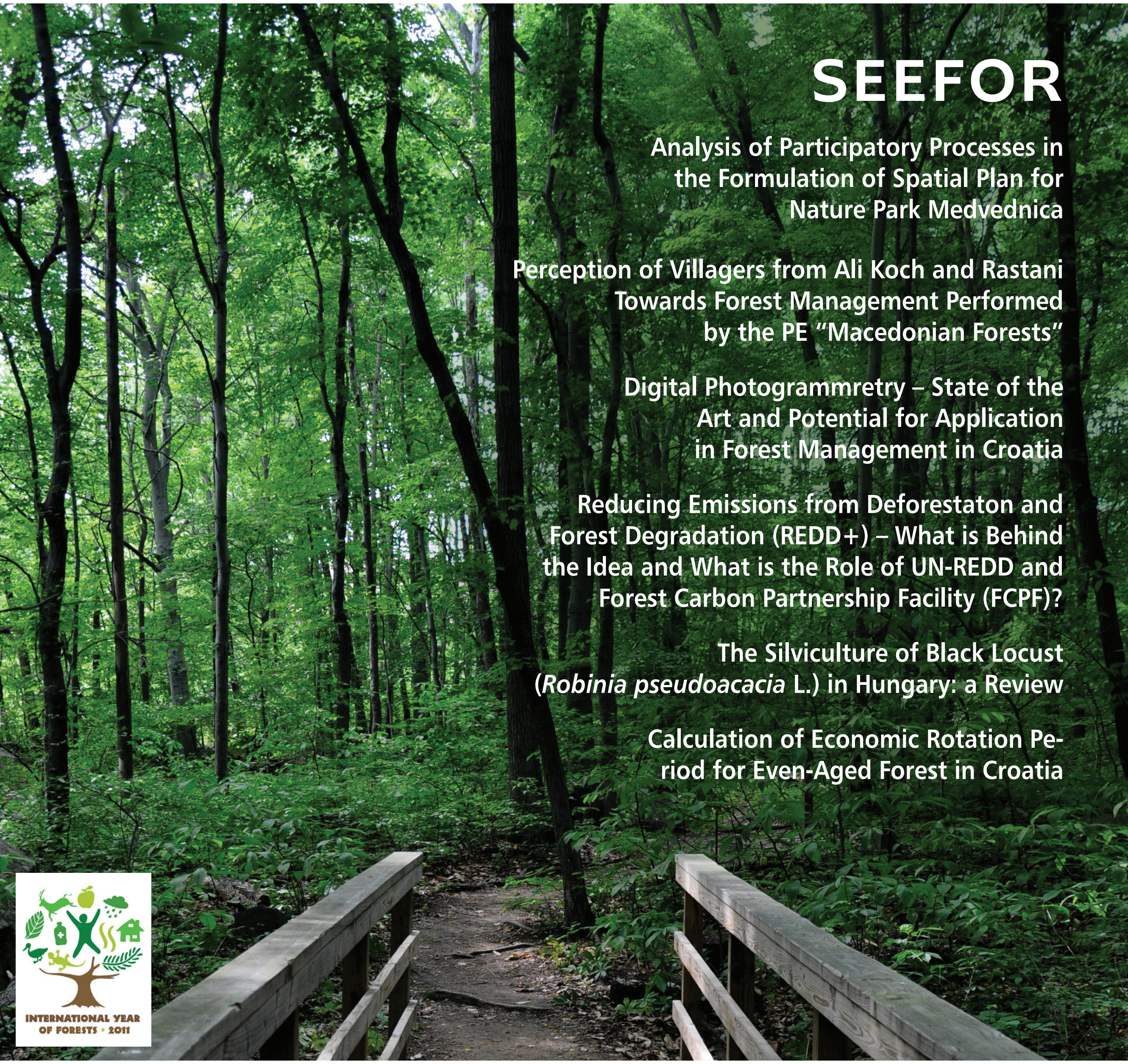

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Contents

SEEFOR - Vol 2, No 2, p 59 -113, 2011.

Dear readers,

It has been two years since SEEFOR Journal was published for the first time. In such short period of publishing SEEFOR has been included in CAB Abstracts database, and all articles starting with those from first issue was indexed. Thus, our first goal, to be recognized as quality scientific journal, has been accomplished.

In order to continue with quality work and publishing, and even more to improve and enhance the journal quality, we cordially invite all interested researchers to contribute with papers and to present their scientific and professional work. For detailed information on preparing and submitting manuscripts please see Instructions for authors at the end of this issue or visit our internet site (http://www.sumins.hr/seefor).

As was the case in previous issues, this issue also comprises of six interesting scientific and professional papers covering different aspects of forestry. So we truly hope that some of those papers will occupy your attention.

First paper, written by ***Lovrić et al.***, assess the stakeholders influence on spatial planning of Nature Park Medvednica, a mountainous protected area adjacent to Zagreb, which tries to hold on to the pressure of the urbanization. Since that is the first research of that kind conducted in NP Medvednica, it provide a contribution to the process of developing a spatial Plan for Zagreb such valuable forest area.

Second paper ***(Stojanovska et al.)*** dealing with the perception of the local population from two villages Ali Koch and Rastani regards the forest management of the Public Enterprise Macedonian Forests. Paper bringing some interesting and partially unexpected perceptions and understanding of forest management from the side of local population.

In the third paper ***Balenović et al.*** are presenting current state of technological development of digital photogrammetry' main tools (digital aerophotogrammetric cameras and digital photogrammetric work stations). Furthermore, two adjusted methods of manual digital photogrammetry for application in forest management, namely: method for strata delineation (i.e. creation of forest management division), and method for measuring stand structure elements have been developed and presented.

Danon and Bettiati describing the main idea behind REDD+ (Reducing Emissions of Deforestation and forest Degradation) mechanism, the roles of UN-REDD and FCPF (Forest Carbon Partnership Facility) in creating REDD+ national policies and what are the challenges and main obstacles in successful implementation of REDD+.

To emphasize important role of Black locust in Hungarian forest management and increasing interest for growing in many countries, ***Rédei et al.***, gave comprehensive review on the silviculture of Black locust in Hungary over past thirty years.

In the last paper,

Posavec et al. compares rotation period based on economic parameters and rotation period determined by using forest inventory data for even-aged beech stands in Croatia. The results obtained shows that is necessary to adjust current optimal rotation period based on management goals as the main factors.

At the end of this Editorial we would like to cordially invite you to participate at scientific conferences organized and hosted by one or more founders of SEEFOR Journal and in collaboration with International Union of Forest Research Organizations (IUFRO) (http://www.iufro.org/events/), as well as in collaboration with many other important Institutions from Europe and Region.

First, International conference **"Forests for cities, forest for people – Perspectives on urban forest governance"** which will be held on 27 – 28th October, 2012 in Zagreb is organized by Croatian Forest Research in collaboration with IUFRO's Research Group on Urban Forestry and FOPER project. This conference targets scientists, policy-makers and practitioners involved with different aspects of urban forestry. The main topics of the conference are: urban forest governance, citizens' perceptions and needs, human health and recreation, valuation of urban forest benefits, urban forest health, and cultural and aesthetic aspects of urban forests and trees. For more information you can visit conference website (www.sumins.hr/IUFRO2012/index1.html).

Second one, International Scientific IUFRO Conference **"Forests in the future-sustainable use, risks and challenges"** organized by Institute of forestry, Belgrade will be held in the period of 4-6th October, 2012 in Serbia. The aim and inten-

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tion of the Conference organisers is to examine scientifically all aspects of the current state of forest ecosystems, expected course of further ecological changes in the light of 'greenhouse' gases reduction, necessity for expansion of forest systems and their sustainable use in future. Conference will be organized through ten scientific sessions covering various areas of forestry: (I) Forest assessment, modelling and management; Forest management planning, (II) Biodiversity of forest ecosystems, (III) Climate changes, (IV) Forest genetics, nursery production and plant breeding, (V) Afforestation, silviculture and forest ecology, (VI) Forest protection, (VII) Forest policy, (VIII) Environmental protection, (IX) Biomass and carbon of forest ecosystems, and (X) Wildlife management. More information on conference you can find at www.forest.org.rs.

And the last, but not less important is International Scientific Conference **"Forestry science and practice for the purpose of sustainable development of forestry - 20 years of the Faculty of forestry in Banja Luka"** organized and hosted by Faculty of Forestry in Banja Luka in cooperation with IUFRO, EFI, three Ministries of the Republica Srpska, University of Banja Luka, Public forestry enterprise "Šume Republike Srpske", Forest Agency and NP "Kozara". The Conference will be held in Banja Luka from 1-4th November, 2012 and will address the role of forestry science in forestry practice. Ecological, economic, and social functions of forest ecosystems under different management regimes will be discussed through six scientific sessions: (I) Forest ecology, climate change and biodiversity of forest ecosystems, (II) Forest management planning, (III) Silviculture and forest protection, (IV) Forest utilization, (V) Seed husbandry, nursery, reforestation, and urban forests, (VI) Forest policy, economics, and organization in forestry, and (VII) Forestry education. As can be seen from the conference title, this Conference also marks 20th anniversary of the Faculty of Forestry in Banja Luka. All important information you can find at http://www.sfbl.org/conference/.

We are looking forward to seeing you in Zagreb, Belgrade and Banja Luka.

Until then enjoy reading,

Dijana Vuletić, Editor-in-Chief

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Original scientific paper

Analysis of Participatory Processes in the Formulation of Spatial Plan for Nature Park Medvednica

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Abstract

Background and purpose: This research aims to assess the stakeholders influence on spatial planning of Nature Park Medvednica, a mountainous protected area adjacent to Zagreb, the capital city of Croatia, which tries to hold on to the pressure of the urbanization. Because of the inexistence of spatial plan which is required with the Croatian laws, its area was significantly decreased in 2009. This kind of research has not been done yet for NP Medvednica, and it will provide a contribution to the process of developing a spatial Plan for NP Medvednica.

Materials and methods: The study was conducted in the framework of stakeholder analysis, for which a series of in-depth interviews with - stakeholders were performed, and documents concerning the spatial plan were analysed. The data gained was processed in MAXQDA software for qualitative analysis.

Results and conclusions: The gathered data explains which are the disadvantages of the tree processes of the formulation of the spatial plan and is giving a possible theoretical explanation or a model which can be implied in any decision making process involving stakeholders in natural resources management in within a given political and cultural context. Description of the past and current spatial planning situation of the NP Medvednica was specified and issues and stakeholders concerning the creation of the spatial plan where identified. The key conflict areas that affect the formulation of spatial plan were detected and examined. The level of participation of stakeholders in the context of fulfilment of their own interests was assessed as well as the influence on participation processes of different stakeholder groups on the formulation of the spatial plan. In order to have proper citizens and stakeholders participation some changes in the legislation should take place.

Keywords: stakeholders, participation, spatial planning, protected areas

INTRODUCTION

Protected Areas (PAs) are some of the most important refuggium of biodiversity on earth and recent literature has emphasized their importance [1]. Their stakeholders often have divergent demands like biodiversity conservation and local livelihoods, and aspire for the PA ecosystem to be utilized/ exploited/ protected according to their priorities. PAs do not exist in socio-political vacuum, and are prone to negative feedbacks from these societal implications. If only for the sake of conservation, it is important to reduce conflicts in conservation and to incorporate local perspectives in PA policies. However, recent literature does not offer clear consensus on the most suitable approaches for inclusion of local communities in decision making. A good tool for the above mentioned is Stakeholder Analysis (SA), a technique developed in management studies [2, 3]. SA is variously used as an approach or tool for generating knowledge about actors (individuals or organizations), to understand their behaviours and interests, and for assessing their value to decision-making [4]. Stakeholder Analysis is a critical tool in clarifying the micro political economy of a policy area and can help identify interested parties that should be incorporated in the decision-making process, in addition to understanding the basis for their inclusion. Three key benefits to undertaking stakeholder analysis we can identify. By using a stakeholder analysis, one can facilitate inclusion of stakeholders that otherwise would be overlooked or marginalized. There is a descriptive and normative approach to the process that reveals power relationships that ensure values. The process can be a contribution to democracy with improvement of the decision making as well as bringing legitimacy to the process by incorporating a wide range of stakeholders' knowledge. It also helps to identify current/ future opportunities and threats in projects to improve policy design and implementation [5]. SA helps to find compatibility between policy objectives and stakeholder aspirations, and helps managers to choose between short-term and long-term policy objectives, or balance conflicting objectives such as conservation, development, equity and peace [6, 7]. These aspects make SA particularly relevant to Natural Resource Management (NRM) [8]. Though a PA may accrue a net gain for society, the benefits could go to a party that is not disadvantaged and compromises an already marginalized group [9]. These marginalized populations often depend on the natural resources, and it may be unadvisable to ignore their needs [8]. Hence, the need for dynamic stakeholders' interactions and partnerships for conservation has been stressed across recent literature [10]. SA can help to foresee socio-political obstacles to PAs and identify alliances, both existing and potential. Stakeholder analysis can be a powerful tool for nature protection researchers because the method allows a visible representation of both variations of power, as well as the different spatial scales in which the stakeholders operate [11]. Mushove and Vogel [12] used stakeholder analysis for forest reserve conservation management in Mozambique to better understand land-use disputes. Stakeholder identification and management (without categorization) uses methodologies that are robust and can be effective in environment that supports performance management and planning [13, 14]. Savage [15] and Mitchell [16] gave interesting definition of categories of stakeholders. According to them there are four generic types: supportive, mixed blessing, no-supportive, marginal. They develop an eight part stakeholder typology based on assessment of the strength of three attributes: power, legitimacy and urgency.

Comprehensive stakeholder identification, assessment and engagement that can be met in Cleland [17], who identifies stakeholders and their interests, measures these interests, and attempts to predict their future behaviour and its impact on the project and on the project team. In contrast to this Briner [18] focuses on communication as important part of stakeholder management. Fletcher et al. [19] describes stakeholder identification as a process for mapping stakeholders expectations based on value hierarchies and key performance areas (KPA). Frooman [20] gives an analysis of ways through which organizations can plan their stakeholder's management strategies, rather than only response strategies. Turner and Veil [21] use more holistic approach to stakeholder identification, which encompasses assessment of awareness, support and influence, all of which culminates in development of a stakeholder knowledge base. Lopez et al. [22] give a very detail analysis of stakeholders; the research goal was to describe how the functioning of the Park distributes its benefits and costs among local population, and to formulate strategies for the enrolment of stakeholders in decision making processes, by which the conservation goals could be reached. The focus of the research was on the issues of deforestation and commercial illegal logging. The high level of analysis was reached through usage of triangulation, which comprised of in-depth interviews (15% of local population), three different contingent valuation applications (targeted at visitor groups), a forest inventory study, and a cost-benefit analysis of management scenarios. Similar level of analysis was reached by Cho [23], who developed an interpretative planning model for a national park system of Korea. His triangulation consisted of in-depth interviews (use of SWAN framework – Stakeholder Wants and Needs Analysis) in combination with Resource Protection Criteria (RPC) and Park Management Criteria (PMC). Prell et al. [24] made a case study on Peak district National Park, in which they focused on the relations among stakeholders through application of stakeholder network analysis (more than 200 stakeholder groups identified). In the contrast to a situation with many stakeholder groups Suman et al. [25] did a case study on The Florida Keys National Marine Sanctuary, in which they had focused on in-depth scenario-analysis of participation of three key stakeholder groups. The following step in stakeholder analysis was done by Jennings et al. [26], who on a case study of the Lower Fitzroy and Port Curtis catchments where used the SA as a tool for capacity building. After performing face-to-face interviews and secondary research, the researches created "social maps" of all stakeholder groups, which were later used to build capacity of stakeholders for enrolment in decision making processes by a series of structured negotiation sessions. A similar conclusion was given by Christie [27], who (without the usage of SA) did a comparative study of four Marine Protected Areas in SE – Asia, and found that just by looking at biological elements of protected area without recognition of social demands of stakeholder groups - especially local people, the protected area management regime was in fact a failure. To this end the work of Renard et al. [28], which gives an overview of 6 SA applications in PA of the Caribbean region, states that for effective enrolment of stakeholders in decision making capacity building and project manager communication skills are essential. Stakeholder analysis is also a building block of the ecosystem approach of IUCN to management of natural resources on local level [29]. With this in mind, Brenner [30] performed a stakeholder analysis in a case study of the Great Smoky Mountains National Park. This research identified 29 stakeholder groups and focused on issue priorities and stakeholder power. The importance of SA in spatial planning was stressed by Enserink [31], who in his paper pointed out the necessity of usage of SA in the early stages of big infrastructure investments in Netherlands, where traditional reliance on secondary data about stakeholders has led to many public negative actions to big investments. He proposes a "Stakeholder quick scan", which is a combination of key informant interviews and focus groups.

Study Area - Nature Park "Medvednica"

Medvednica is a mountain north of Zagreb, on most of which surface the Nature Park Medvednica is located. The area of the NP today is 17,938 ha and the highest peak is Sljeme (1033 m). Medvednica is 42 km long and extends from the east-west direction (namely, northeast - southwest); the surface of the mountain is mostly forested. In mid-1981 western part of mountain Medvednica, with area of 22 826 ha and between the Podsused and Kašine, was declared a nature park [32]. The natural phenomenon upon which the Park was established were well preserved natural forest phytocenoses, which span on about 65% of the area (By decree in 1998). Later on the Government of Croatia had founded the Public agency "Park Prirode Medvednica", which is responsible for the management of the park. Today the agency employs 17 people.

Adoption of the Act was preceded by an expert research and elaboration of State Institute for Nature Protection. According to the Law on Nature Protection [33], the nature park category includes the vast natural or part of the cultivated area with a distinct aesthetic, ecological, educational, cultural tourist and recreational values. Nature Protection Act states that the protection, regulation, promotion and use of National Park and Nature Park should be determined by a spatial plan, and that the plan should be approved by the Parliament of Croatia. In order to systematically protect natural values, especially the most important spatial objects of protection, a Spatial Planning Program of Croatia [34] was developed, which provides guidelines and orientation for making spatial planning laws for declared natural parks, including Medvednica. According to Law on Spatial Planning and Construction [35] the spatial plan for area of special characteristics has to be made for nature parks, and represents the fundamental management document, with which all other document have to be aligned with. The responsibility for the spatial plan of nature park Medvednica is with the Ministry of Environment, Spatial Planning and Construction, and the obligation for its creation lies at the Municipal Bureau of Planning of the city of Zagreb.

In 1989 the first draft spatial plan was prepared and sent to a public hearing with a Decision about making Spatial plan for areas of special-purpose Nature Park Medvednica [34] The plan developed by the Urban Institute of City of Zagreb in 1989 was not adopted. In 2005 the Department for Planning of City of Zagreb prepared and proposed a plan for renewed public debate. The holder of the plan was the Ministry of Environment and Physical Planning. Starting points for the draft of the spatial plan of Nature Park Medvednica (2005) were the Spatial Planning Strategy and Program of Spatial Planning of Croatia, the applicable regional plans and county-level cities and municipalities, and the general master plans and regional plans. Studies, surveys and elaborates were made for the Nature Park Medvednica regarding the creation of the spatial plan; although numerous, the largest part of them was obsolete. The Public Hearing pointed out some problems: the boundaries of the protected areas, the treatment of the particularly valuable areas in the nature park, traffic connections with Region Zagorje By building a Tunnel under Medvednica which needs to be connected to Zagreb area with so-called "Northern Tangents" ((Studies 2006 and 2009) Transportation and utility infrastructure) as well as with and the problem of locating the new cable car station at the top of the mountain. Tunnel through Medvednica was scheduled to be built as part of the Northern bypass of Zagreb that is provided in a length of 25 kilometres, and it should connect the highway to Varaždin and highways for the Krapina. City of Zagreb has signed a contract with the Faculty of Civil Engineering and ordered studies for the building of the northern bypass around Zagreb, which is related to the construction of the tunnel through Medvednica. This plan until now was not accepted and it is not being incorporated as such in the third draft of the plan. Environmental Committee of the Croatian Parliament at its eleventh session held on September 16th 2009 made a statement in which they changed the boundaries and reduced the area of the park to a smaller surface of 17,938 ha, the parliament voted positively and changed the boundaries. This was never presented to the public or putted on a public debate. This statement is based on "The specialized background to change the boundaries of the park Medvednica" made by the State Office for the Protection of Nature in July 2005. The proposal of the Ministry of Environment, Spatial Planning and Construction was to completely distinguish (without overlapping) Medvednica Park Spatial Plan from the City of Zagreb, which has been accepted and included in the statement. With the Law on Amendments to the Act to designate the western part of the Nature Park Medvednica [32] the new borders of the park with total area of 17 938 ha where established in 2009.

Afterwards boundary modifications, changes to regulations in the field of nature and environment protection were made. The results of environmental impact assessment study and reconstruction of the lifts to Sljeme where consequences of the public discussion, but were not accepted. Forest management in NP Medvednica is mostly in the hands of the state forests management company "Hrvatske Šume" Ltd. ("Croatian Forests"), while their activities are supervised by "Park prirode Medvednica" public institution. However, problems in the vast majority of cases occur in private forests, which are sometimes managed by their owners irrespectively of the legal obligations of private forest management, and there instances of illegal conversion of forest land into construction plots.

Pollution and wild litter depots are constant problems that occur within the park and as a consequence, these influences of the environment to the people who live near the park are present and constant. At the moment, there are four quarries in Medvednica. Currently active quarries are called Bizek and Jelene Vode. Remediation is being practiced and it is not allowed to further expand the existing or to create new quarries. The biggest problem with the quarry is currently the illegal exploitation of green slate and the creation of landfill waste in quarries that are not being repaired.

MATERIALS AND METODS

This research analyse the stakeholders and their participation and influence in the processes of the formulation of Nature Park Medvednica's spatial plan by using stakeholder analysis for their identification. The official stakeholders list for creation of the spatial plan was used as a starters point. All that was be undertaken to interpret the data through the framework of stakeholders analysis their mapping and the level of their participation. This is an applied research, which is descriptive – explanatory, has cross-sectional direction and Inductive approach. Unit of analysis are interest groups, or formal and informal groups, and unit of data gathering are individual stakeholders of the Medvednica's spatial planning process. The data used for this research are past and present documents and acts as well as meetings recordings analyses, reports and articles. The information that are gathered is data on spatial characteristics of Nature Park Medvednica; Spatial planning drafts and all background studies and maps; data on policy development of spatial planning in Nature Park Medvednica; A review of policies and site specific documents. The general data gathered is the review of the relevant literature, reports and of historical data.

Qualitative data

This part of the research is based on semi-structured in-depth interviews with stakeholders and their representatives as well as with identified key informants. The identified stakeholders list was used for assessing the stakeholder's participation trough the ladder of participation [36]. As a starter point for stakeholders' identification an official stakeholders list of the creators of the plan was used. The further identification of stakeholders was done by impact zoning [37], following the guidelines of Brown [38]. The additional development of stakeholder list was done via snowball technique and key informant in order to identify the excluded stakeholders. The analysis was performed through MAXQDA software package for qualitative research. In this study a Stakeholder's analysis was made in order to be able to assess their participation and in the same time identification of their interest areas was done to see if there is some overlapping. Every interviewed stakeholder had a chance to draw on a map its area of interest. The stakeholders and their interest areas identification trough spatial and physical mapping on Medvednica were compared to the once that are being taken in consideration for the analysis of the last version of the spatial plan, and changes of the borders.

Theoretical framework

The process of creation of a spatial plan in Croatia necessitates participation approach; however, the term participation can encompass anything ranging from a merely discarded obligation in the context of informing the public up to binding agreement on implementation. For this reason it is very important to analyse the level of participation of different stakeholders on the one side, and their motivations for the enrolment in the participation process on another.

The level of stakeholder's participation was assessed through the framework of "ladder of participation" [36], in which the author describes the level of participation in the decision making process through eight steps: Manipulation, Therapy, Informing, Consultation, Placation, Partnership, Delegated power and Citizen Control (Figure 1). The assessment is done in order to see the amount of citizen's power in determining the final decision. "Manipulation" and "Therapy" describe the levels of "non-participation" that are being used by some processes to substitute the genuine participation. With that people are participating like in this case trough public display only to be able to let the power holders to "educate" or "cure" them (Figure 4). "Informing" and "consultation" are used by the power holders to hear the citizens, but in reality their views won't be taken into consideration. If participation is limited only to these levels you cannot have a final product and does not give a chance for changing the status quo. We have taken into consideration classic model of public participation and deliberative democracy with Sherry Arnstein's ladder of public participation as well as taking into accounts a more recent scholarly framework by IAPP (IAP2) [39] public participation spectrum of public impact. As you move from left to right on this spectrum, the level of citizen involvement and impact increases. On the left, there is no or little citizen involvement and impact, and on the far right, citizens have complete control of the public participation process and outcomes (Figure 2). We can only asses these results through Arnstein's ladder because obviously these systems that we research can be described as deliberative democracy. The newest IAP2 spectrum for accessing the level of participation cannot be implied because it takes into consideration only the decision making processes that have public impact and influences at the direct decision making process. Even if we would do the assessment, we cannot go further than the first rug, and that is discountable. The first rug "Inform" is described as public providence with balance and objective information. With informing them in the same time you assist them in understanding problems, giving them alternatives and opportunities, or sometimes even solution. With the presented results from the research so far we cannot find evidence that proves any of those, besides just pure informing. Looking at the first ladder of participation and the latest one used in democratic systems compared to the others used before, we can conclude that the first one is more applicable to the current situation and to the process made in 2005. That can be described as lack of democracy, or is that going backwards? Some can say that we are reinventing the things that already existed in the past political structures. The respective level of participation is a reflection of stakeholders interest to participate, and also partly of its power. In order to assess the power relations of stakeholders in more detail, the "Power Tools" [40] of the International Institute for

Environment and Development are going to be used. These documents represent the conceptual framework and methodology guideline for the stakeholder analysis's section on power distribution and relations.

This research will try to find out whether stakeholders perceive the process of spatial plan formulation as a process which favours all of its participants in an equally favourable way. And did they manage thorough power and informal participation to accomplish their interests on Medvednica. Stakeholder's power can also be proved trough mapping their interest zones (Figure 3). Until now the results showed a succeeded reduction of those areas in order to accomplish their interest trough informal participation. With not implementing a proper participation people leave space for informal ways of participating and having a good political back up for it through their lobbying groups. Making a ski resort and many different touristic attraction places in the top of the mountain, where is the I zone of most strict protection and where no works and changes of the nature are allowed, as well as reducing a protected areas is one of the best ways to prove that.

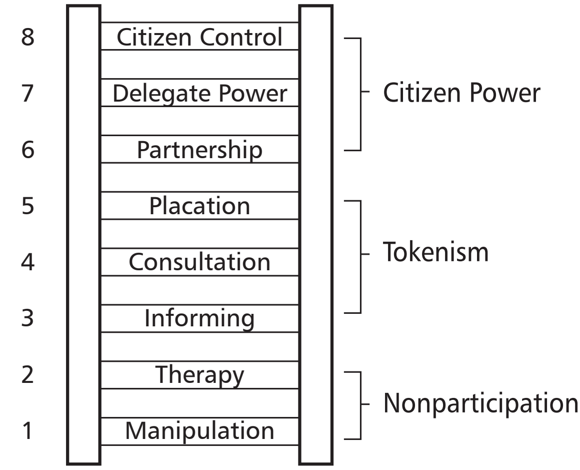

FIGURE 1
Sherry Arnstein [36] – Public Participation as 8 rungs on a ladder

Public Participation

Level of Citizen Involvement and Impact

Arnstein	Manipulation	Therapy	Informing	Consulting	Placation	Partnership	Delegat Power	Citizen Control
IAP2	Inform	Consult		Involve	Collaborate		Empower	
Public Participation Goal	To provide the Public with Balanced and Objective information To assist them in Understanding Problems, alternatives, Opportunities, and/or Solutions	To obtain public Feedback an Analysis, Alternatives, And/or decisions		To work directly With the public Throughout the process to Ensure that public concerns And aspirations Are consistently Understood and considered	To partner with The public in each aspect of The decision Including the Development of Alternatives and The identifications of the prefered solutions		To place final Decisionmaking in the hands of the public	

Spectrum adapted from International Assotiation of Public Participation (IAP2) parctitioner tools

FIGURE 2
Spectrum of public participation
- *Sherry Arnstein [36] – Public Participation as 8 rungs on a ladder*
- *IAP2 [39] – Public participation spectrum*

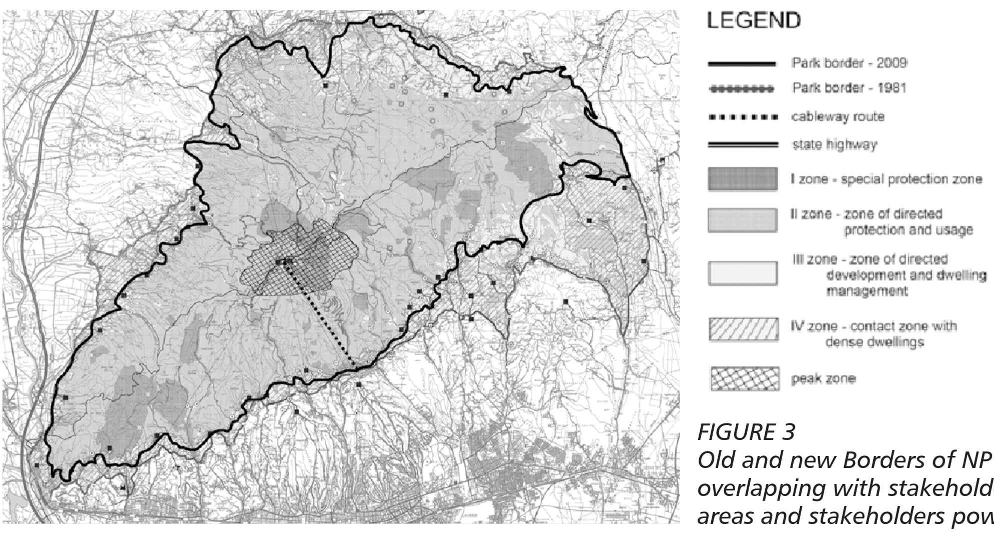

FIGURE 3
Old and new Borders of NP Medvednica overlapping with stakeholder's interest areas and stakeholders power mapping.

RESULTS

Nature Park Medvednica is trying to bring a spatial plan for more than 30 years. Historically and politically speaking they can be divided in 3 periods (Figure 4, 5, 7).

In the First period 1981-1991 during Former Republic of Yugoslavia the contractor of the plan was the City of Zagreb with the city committee for Spatial Planning, and communal matters. The implementing agency was the City of Zagreb's Urbanism bureau. 19 people were involved in designing of the plan, and they had consultation of 26 experts in different fields. 9 studies were conducted only for the purpose of that plan. Stakeholders meeting, pre meetings and consultations where made with 44 identified stakeholders. For citizen consultations a survey was made with the residents of Medvednica, and they were also consulted trough the public forum. Although many of the respondents were critical of the Former Yugoslavian Regime, this first attempt to bring the spatial plan had the longest list of participating stakeholders, the participation itself was most substantive, almost all stakeholders were taken into consideration, as their list was as almost as big as the list prepared within this research. Many stakeholders consultations and meetings where done in that time. The meetings where constituted of all stakeholders sitting at the same table and bringing decisions into place. The Former Yugoslav time maybe was considered as non-participatory but this study showed that was the most participatory of all the tree time periods researched, including post war transition period as well as the pre EU accession period.

Second Period 2002-2008 Post War and Transition period; the coordinator was Ministry for Environmental protection, spatial planning and construction and the minister itself was the main leader. The conductor was City of Zagreb, Bureau for spatial planning. They have consulted and recognised 21 stakeholders and 23 people were part of the executive crew that made the plan. They only consulted 5 experts and 8 studies were made in that purpose. Public forum consisted out of public presentations and discussion of the implementing agency of the plan and the stakeholders, who came on voluntarily basis, were present there as well. After that there was a 30 day notice in which unsatisfied stakeholders can submit a complaint, which might or might not be accepted. The notice about the public forum was sent to all the media and everyone who felt like they were affected by the plan could come and be part of the forum. The Spatial plan was presented for the public on 28th of September 2005. A public forum initiated discussions of the spatial plan of the NP Medvednica. The panel was constituted from a considerable number of stakeholders; including members of different sections of public administration, concerned citizens, various environmental NGOs and residents of mountaineers and municipalities directly affected by the changes in the new spatial plan. The discussion had very turbulent flow in which people sought changes in the plan and had a very aggressive stand towards the presented situation and respective state's agencies. Many of them had felt that they were deprived of their wealth, because due to prior media information, their real estate within the borders of Nature Park was expected to have drastic fall in prices. There has been great interest in the new regulation, which was directly related to the Sljeme ski resort (Ski resort is managed by the city company "Sljeme - Medvednica"). With the plan Medvednica should be divided into four zones. Construction is allowed in the fourth zone, which is the marginal zone of the park, where there are already buildings; the first zone marks the upper part of Nature Park; where any construction is prohibited, and were strict regulations of nature preservation apply. The ski resort mostly falls into the first zone but no significant changes were made for it, was the official explanation, except that is being actually built in the first zone; the whole complex of ski resorts (in today's state) entered the draft of the spatial plan. The regional plan also included a new cable car that goes on the north side of Medvednica, and against which there were passionate comments expressed by the environmental NGOs representatives. Also, the spatial plan is regulating and reducing the traffic on the top part of Medvednica and brings regulation (prohibition) for any kind of construction in the first zone. Ministry of Culture which is responsible for the nature protection and the Ministry of Environmental Protection, Physical Planning and Construction, which is the holder of the Spatial Plan process, has initiated the adoption of the amendment for changing the nature park boundaries, followed by a spatial plan proposal within the scope of the new boundaries. State Bureau for Nature Protection has received the task to create the technical base for the adopted Law on amendments to change Medvednica Nature Park borders, the proposed expansion of the park on the eastern slopes of Medvednica. The professional background proposed reduction of 3 365 ha and an increase of 5 712 ha and with that the total area supposed to be 25 173 ha. That proposal for increasing the borders was rejected and on 13.02.2009 was finally adopted by the Parliament with the changes of the Law Amendment for western part of Medvednica designation [41]. This time the proposal was accepted with decreased area by 4888 ha. The final proposal of the area of Medvednica with 22 826 ha was replaced by 17 938 ha.

In the third Period 2009-2012 the Pre EU accession period the one who ordered and coordinated the spatial plan was Ministry for Environmental protection, spatial planning and construction and the minister itself was the main leader. The conductor was City of Zagreb, Bureau for spatial planning. In this period 26 stakeholders are officially part of the stakeholders list. From them only 9 are being consulted at the "pre meeting", but not all of them at the same time and on the same table. The rest of them (17 stakeholders) were not being consulted but they will be invited to the public forum. The public forum still has not taken place and the plan is still in procedure.

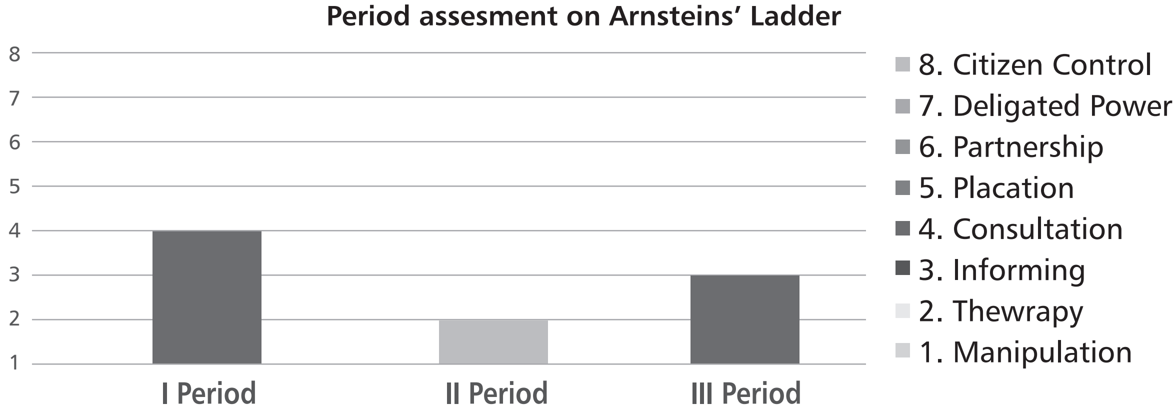

FIGURE 4
Period's assessment on [36] ladder

We can clearly see that in the first period they have gone the most high on the rug of the ladder of participation with Consulting, in the second period we can say that they have come as far as the Therapy rug, but in the third period there is a slight improvement as far as the informing rug comes.

In this tree period comparison we can see that numbers of stakeholders were much bigger in Former Yugoslav times with 44 of them, in the second period there were 21, and in the third period slightly more with 26. The same goes with the experts involved, they were 26 in the first period, 5 in the second and 17 in the third. Nine studies were made in the first period, 8 in the second and only 2 in the third. The only thing that is clear is the smallest number of people involved in the creation in the first period. If we see that in the third period there is the biggest number of people involved in the creation, we can conclude that is not the clearest formula for good achievements, as there should have been an increase in the studies made and stakeholders and experts involved.

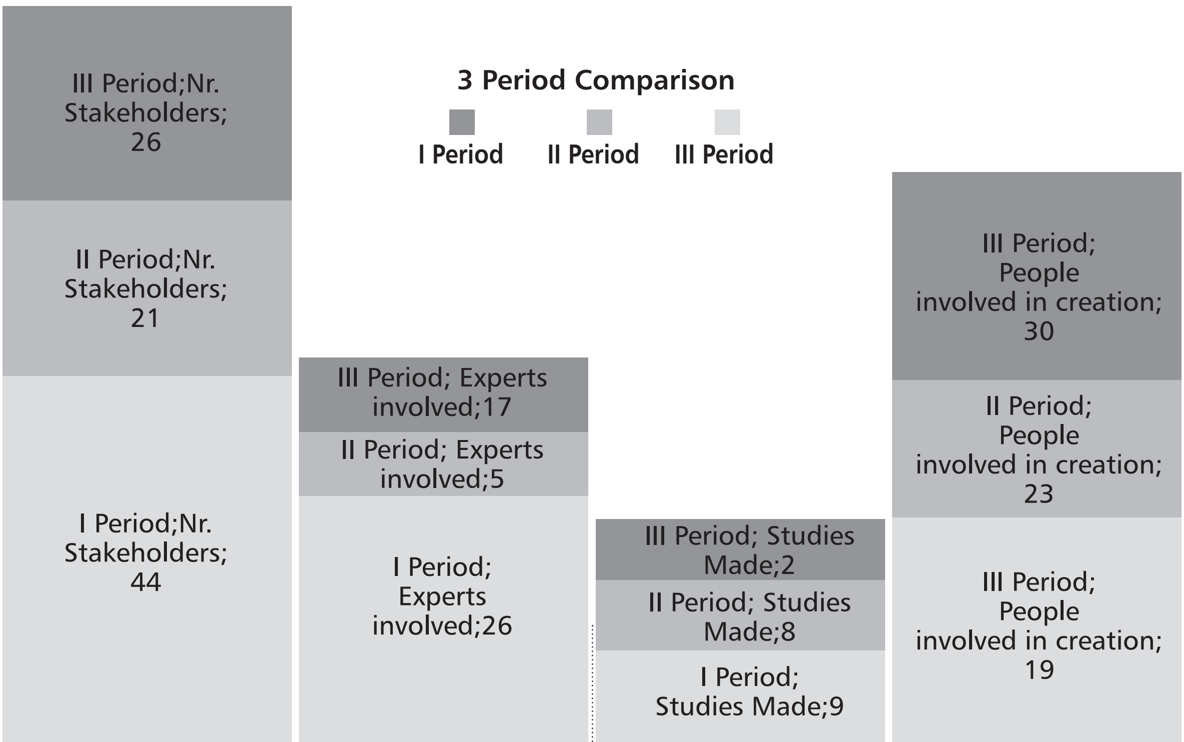

FIGURE 5
3 Period comparison

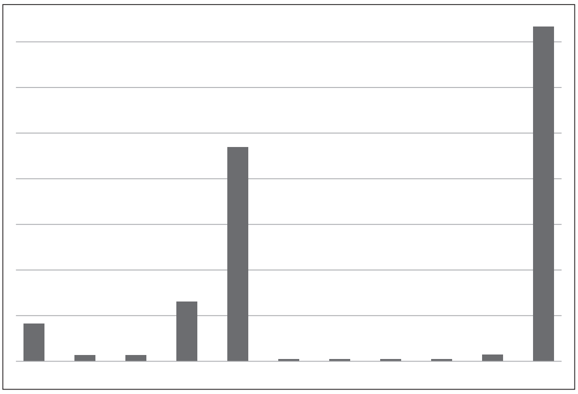

FIGURE 6
Number of complaints made by citizens on the public forum in 2005

In 2005, 733 complain were submitted by stakeholders, of those only 81 "accepted" and 473 are being "rejected" (Figure 6). 12 were "Partially accepted" and 14 were "already incorporated in the plan". On 131 of the complaints were answered with "it is not part of the plan". The answer "It is repeating itself" got 1 complaint, "no replay" got 2 complaints and "it is about changes of the border not about the spatial plan" got 1 complain. There were even 3 answers "it is not a complaint" and 15 of them were replied with "it is not being revived". If some citizens' complaints were anonymous or the address is not correctly written or is unknown, the complaint was automatically rejected. All of the rejected complaints got the same generic answer, without substantive explanation why their specific request wasn't accepted.

In Figure 7, it can be seen that only in the first period most of the indicators for participation were followed true with experts meetings, public forum, stakeholder's meetings and survey, and in the second and the third period just half of them where completed; the experts meetings (pre-meetings and public forum).

DISSCUSION AND CONCLUSIONS

Nature Park Medvednica is trying to bring a spatial plan for more than 30 years. Historically and politically speaking they can be divided in 3 periods. NP Medvednica was Founded 1981 and in 2012 there is still an on-going third process of creation of the spatial plan (This research is being made in the period of 2010-2012 and it is still on-going as part of a PhD thesis). For all three processes it can be said that there is the same outcome no matter what the political state is, no spatial plan came out of them. What can that be dependent of? Is it the cultural background, the specific norms and values or something else? The bureaucracy leading the process indifferently, without a motive to enhance their efforts as well as the interested sides influencing the decision making in order to be able to accomplish their goals? There is not presence of consultations with public participants in any kind, besides the public forums. In which category we can place the public forums and occasional consultation with few of the stakeholders which are not even a real stakeholders according the definition's but part of the Spatial Plan constructors by default taken into account since they are parts of the state administration. In order to have citizens and stakeholders participation some changes should be made in the following legislations:

- The provisions of Article 137 Paragraph 2 and Article 142 paragraphs 3 and 4, Environmental Protection Act ("Official Gazette", No. 110/2007 Regulation on public participation and public concerned in environmental matters ("Official Gazette" No. 64/08);
- Article 29a. Paragraph 2. Law on Spatial Planning ("Official Gazette" no. 30/94 and 68/98), Regulation on public consultation within the making of spatial plans (NN 101/98).

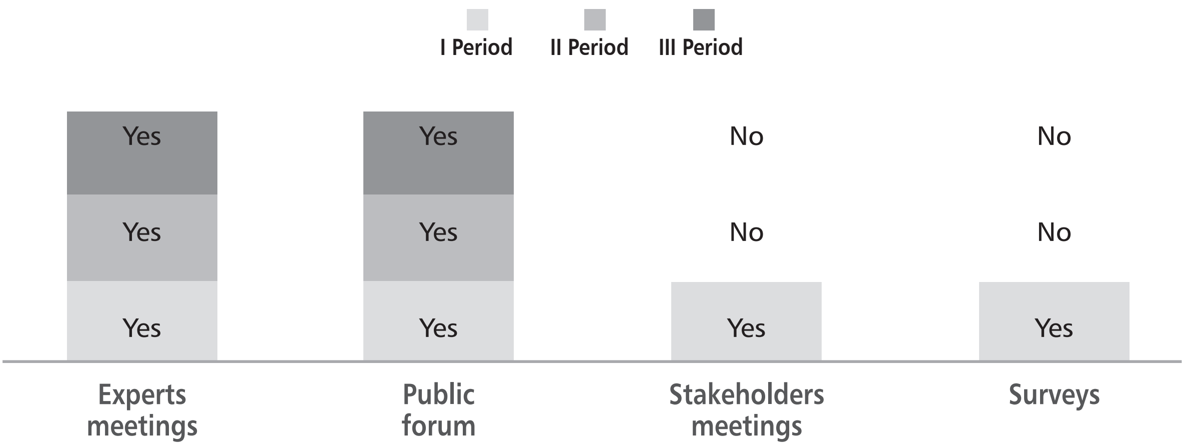

FIGURE 7
Way of Participating

The model that comes in the final phase of this research will bring some directions that can help in making the changes of that legislation. If the new models would be directly implied we will see whether some of the stakeholders opinions where true. There is always a possibility that if you apply a proper participation than you can see the right results from it. Almost all respondents working in public administration refer that they respect the guidelines from those regulations. Obviously they do not reach satisfactory levels of participation. Citizen's involvement should be made in the whole process from the beginning of the making of the plan by educating them and making focus groups in taking on their opinion of the suggestions and educating them in order to avoid their personal gains involvement in the spatial planning. With making the process more transparent and participatory you leave small space for political and personal accomplishment, lobbying of separate stakeholders and informal participation. The research showed that all the tolls already existing in Europe or wider are not necessary applicable in this different cultural and political environments in which other norms and ethical values apply. Many of the members of the implementing agency think that public forum is more than enough for stakeholders and citizens participation, since it is not in the culture of people to participate at such events; so within this setting, there is no need for enhanced participation. Representatives of stake-holding groups think that is necessary to make the changes and involve the stakeholders and citizens in a "proper way" in decision making, and there are the comments on the bureaucratic structure that they are not motivated enough to practice proper participations with the same financial support they receive. Croatia is one of the countries who signed the Aarhus Convention [42]. Three articles of the Aarhus Convention are concerning the public participation in environmental protection- Article 6 is about decision making in certain issues, Article 7 deals with public participation in decision-making on environmental issues, specifically on the participation in making of plans, programs and policies related to the environment and Article 8 is about participation during preparation of laws, legislations and legally binding normative instruments [43]. Awareness of environmental protection in Croatia must be converted into a clear, comprehensive and long-term concept, particularly because of the next years' accession to the European Union (EU). Strengthening the social capital, and better public education and information allows high level participation in decision making. This step, of course, should cause changes in the organizational as well as in the legislation forms. Therefore, the natural resources management requires an integrated and multidisciplinary approach. Building up social capital is one of the pre-requisites for a high-level participation in management of natural resources, which could be done by strengthening education and awareness of citizens on participation in decision making. All of this can be achieved by adequate implementation of the Aarhus Convention. Croatia has a long practice in the area of carrying out EIAs and involving the public in the process, since this is an area that has been regulated since 1984 [44]. This research showed that participation is not something new or an innovation in this part of the world, as in administrative practice in Croatia it already existed in Former Yugoslavian times (the first process in 1989). Research results have shown clear indications of discrimination against those requirements by state officials that are considered as "provocative" or made "for purely political reasons." The easiest way is not to give answer to them or just simply disqualify them as such. It should be noted that the most common requests for environmental information relating to information is about land use. The intensity of public participation depends on specific issues, and how the media informed and placed information's on the topic. In Medvednica's case that was conducted with a really strong intensity and rebel on the public forum due to the previous media articles. With that an area is left for manipulation of certain interest groups, and the changes to the final impact on the outcome of the public forum, which is how we can describe in some manners the unofficial participation. The interest for public debates usually is not great, since there aren't many written comments afterward and there is a small number of participants present at those forums. But after the 2005 public forum in Medvednica's case there were 733 complaints made and many people were present, so with that we can see that if stakeholders recognise their interest, they actually want to be involved in the process. It is believed that the cause of abstinence is former authoritarian political culture that, despite a relatively high degree of interest in politics, it is installed in the people principles that they do not have any influence on policy and decision making processes. This makes it difficult to motivate people in participating actively. Such attitude can be countered with enhancement of the information systems of publically available data and appropriate education and consultation of people through focus groups and seminars. What is necessary is a consistent and strategic approach to decision making, good legislative process when converting decisions into binding regulations and, finally, to encourage public participation in the entire process to make sure that these decisions can take a hold in everyday society. It is necessary to identify all relevant stakeholders, in each sector, at all levels and clearly distinguish their responsibilities. Whenever possible, the forums should involve all stakeholders (including citizens), NGOs and people from relevant professional background as well as the broad science community.

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Original scientific paper

Perception of Villagers from Ali Koch and Rastani Towards Forest Management Performed by the PE "Macedonian Forests"

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Background and purpose: *This paper describes the perception of the local population from two villages Ali Koch and Rastani regarding the forest management of the Public Enterprise (PE) Macedonian Forests.*

Materials and methods: *For the purpose of this research a multistage cluster sampling had been applied, where municipalities of Radovis and Veles were randomly selected from all municipalities in the country. These chosen municipalities were divided into areas (settlements), where each settlement represents a different cluster. Settlements were further divided into smaller areas - houses that are located closer or further to the forest. All households near the forests were approached and survey of 93 interviews was done.*

Results and conclusion: *Results showed that perceptions of the villagers from both villages in the Republic are almost the same. According to the obtained results perception of the local population towards management of the PE Macedonian Forests is not very satisfying, because most of them think that the enterprise activities are mostly focused on harvesting. Results provide information that can be helpful for the managers to improve the management of the enterprise, which can lead towards better perception of the forestry in the Republic.*

Keywords: *local perception, forest management, PE Macedonian Forests*

INTRODUCTION

Through the history different environmental, economical and social factors have been influencing public perception toward forest and forestry. Each of them has been influencing public perception in a different way, resulting with a permanent change on the public perception through the time. In order to manage forest in accordance with the society needs and to have efficient forest policy and legislation, it's very important to be aware and take into account the public perception of the forest [1].

Effective forest management requires both detailed knowledge of the resources and the involvement of the local forest users, who are often the most knowledgeable about the resources [2].

Commonly cited definitions for the term sustainable forest management generally include or imply the following elements: the continued existence and use of forest to meet human physical, economic, and social needs, the desire to preserve the health of forest ecosystems in perpetuity; and the ethical choice of preserving options for future generations while meeting the needs of the present. The concept of sustainability incorporates the knowledge that forests play a major role in sustaining human health and welfare. They contribute to the long term viability of watersheds, communities and economies. Sustainability depends on citizens and stakeholders adopting stewardship and individual responsibility as tenets by which to live and moving from conflicts to collaboration [3].

Attempts at forest management partnerships between local people and government employees are becoming more and more common. Establishing sustainable forest management schemes which promote the better integration and empowerment of local people requires an improved understanding and assimilation of local users' perceptions and use classifications of the forest [2].

Many local communities, including a significant number of indigenous groups, live in and around forest areas. They are primary users of forest products and they often create their own, locally adapted and accepted rules for how to use the forest part of what is often referred to as local institutions. Support for increased local access to and control of forest resources for these groups, thus legitimizing their role as responsible forest managers, has proved to be a constructive strategy to achieve sustainable forest management [4].

Accuracy and assessment of public perception for the management of public forest represent one of the basic problems. Public perception, as well the responses of the affected and interested members play an important role in creation and preparation of forest legislation and management plans. Public debates and research can be used as a mean to fulfil these obligations, but often there might be heard only people motivated by strong emotions [5].

Total forest area in Republic of Macedonia is about 906.635 ha or 35% of the total surface of the country, from which 90.1% is state and 9.9% private forests [6].

Considering the fact that country is facing a long transition period with aspiration toward EU entrance, forestry sector have been experiencing many changes.

Until the adaption of the Forest law from 1997 (Official gazette of Republic of Macedonia, no. 47/97) forest management have been performed by 30 independent companies. Nowadays the management of state forests is performed by Public enterprise Macedonian Forests (PEMF) which was established by the decision of the government on 15th December 1997 (Official gazette of Republic of Macedonia, no. 65/97). The enterprise begun to operate on 1st July 1998, as a legal successor of those 30 independent companies organized in one head and 30 branch offices with centralized budget and decision-making [7].

The new organizational structure did not involve new approaches related to forest management, especially involvement of local population. Traditional way of management is still prevailing with high percentage of the revenues coming only from production of fuel wood, neglecting ecological and social aspects of the forests. Perception of the villagers, citizens towards forest management has never been analyzed and this study will be a basis for further and deeper investigations related to this topic.

Thus, the main goal of the paper is to describe the perception of the local population from two villages in the Republic related to the forest management performed by PEMF.

In order to achieve the main goal the study will have the following objectives:

- expose perception of the villagers towards present condition of the forests and forest management;
- determinate villagers' perception of main causes which have negative effects on the forest quality;
- present perception of villagers about illegal activities of the employees in the PEMF;
- providing ideas for improvement of the current situation.

Hence, the main research question in this paper is "Which is the perception of the local population towards forest management of PEMF?"

CONCEPTUAL FRAMEWORK

Forestry is nowadays a knowledge-based industry but this message has still not reached the general public. Modern forest products industry uses the latest technology to grow, manage, harvest and process its renewable resource. Nevertheless, negative perceptions persist about forestry, forest products and the forest products industry [8].

The management of forest resources has always been important to many aspects of human society. The most prominent of these resources in terms of human consumption is wood. It is incredibly versatile, having been used for cooking and/or heating fuel, structural timbers for homes, and as pulp for paper production. Fortunately, as computer technology has improved, so have the means of conveying information to the general public about forest practices. Maps detailing management areas and the practices within can now be quickly and easily created to inform interested or concerned parties. In this way, the general public can be included in the management process to an extent, and a more favourable perception of forest practices can begin to be created [9].

The perceptions of forestry vary widely throughout the world based on social, ecological, and economical influences. In the United States and Europe, the perceptions of forestry are very different. Many of these perceptions are not based on facts but rather what society implies based on the media, personal experiences, or biased information [10].

In the Nordic countries of Europe including Denmark, Finland, Iceland, Norway, and Sweden forestry receives very strong support. The majority of Europeans consider Nordic forestry to be a benchmark for the rest of Europe and rate the natural resource management in the north as more sustainable than any other region in Europe [10].

Central European countries including Germany, Austria, and Switzerland accepts forestry positively. In a study asking central Europeans about what they thought about their forests? The answers were affirming. Perceptions of forestry in Central Europe are generally positive [10].

Eastern Europe consists of many countries that were occupied by the former Soviet Union (Russia, Ukraine Belarus, Lithuania, and Latvia). Since the collapse of the Soviet Union in the early 1990s, these countries have had an interest restructuring their forests. "While the rest of Europe is steadily progressing towards sustainable forest management, Eastern European countries are facing many challenges in better managing forest products following the restitution of land from the State to their previous owners" [11].

The public opinions of forestry within the countries of Eastern Europe are consistent around sustainable management and providing for a greener future. The greatest problem with these countries is their lack of ability to enforce environmental laws and regulations [11].

The public perceptions of forestry in the United States are generally misinformed. A large majority of the public relies on mainstream media sources for their information on subjects that they are not personally interested or professionally involved in. Many people do not realize that the mainstream media is not always correct, factual, and unbiased. This results in many misconceptions of forestry that are occurring in the United States [12].

METHODOLOGY

The research has been performed in villages Ali Koch and Rastani located at two different municipalities in Republic of Macedonia. Ali Koch by its geographical coordinates of 41°40'43.77" North and 22° 25' 44.46" East is situated in Radovis, while Rastani is located in Veles municipality with geographical coordinates of 41°43'25.44" North and 21°42'45.17" East.

For the purpose of this paper multistage cluster sampling method has been applied. Two municipalities in the Republic of Macedonia were selected by SRS (Sample Random Sampling). Using this method an equal chances were given to every municipality to be chosen. Municipalities that have been chosen were divided into areas (settlements), where each settlement represents a different cluster. So, in Radovis municipality there were 33 clusters, while in Veles 28. Randomly was selected one cluster in each municipality and selected clusters were Ali Koch and Rastani. Clusters were further divided into two parts-houses near the forests and the forest road is passing nearby and houses farther from the forests. In the first part of the clusters or houses near the forest and the forest road is passing nearby were determined 93 households or 46 in Ali Koch from 328 houses in total and 47 in Rastani from 286 in total. All of them (93 households) were approached and were part of the study.

The major study tools included a survey conducted by interviewers using a semi-structured questionnaire for individual interviews (households). The questionnaire contains twelve questions, to that first few questions are about age, gender, work and place of living of the respondents while rest other questions are relating on perception of the local population toward managements activities of PEMF.

The survey was undertaken during August-September 2011 using trained and experienced interviewers.

Answers from respondents during the survey were entered into excel so later were processed and statistically analysed.

RESULTS

The description of the main results is in accordance with the main research question drawn from the literature review.

According to the first question 87% of respondents that participated in this survey are people that have permanent residence in the villages, while 13% of them are temporary settled, so they only stay during the vacations and holidays (Figure 1).

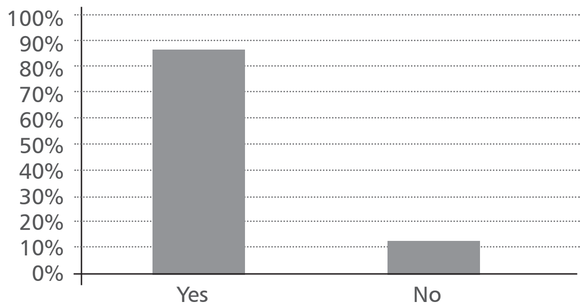

FIGURE 1
Question 1: Is this your place of living?

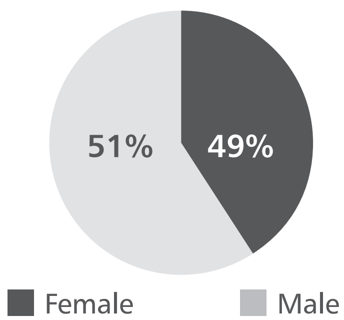

FIGURE2
Question 2: What gender are you?

More than a half of respondents or 59% are male population and the rest of 41% are female population (Figure 2).

The age structure of respondents was divided into 4 categories. First category includes all respondents younger than 20 years, the second is between 21 to 40, the third class is from 41 to 60 and in the fourth class are respondents older than 61. As it can be concluded from the Figure 3 the biggest share (42%) have respondents from 41 to 60 years and respondents over 61 have 31%. It means that about 73% of respondents belong to the category over 40 years. Only 17% belong to the category from 21 to 40 and 10% of respondents goes to age class of beyond 20.

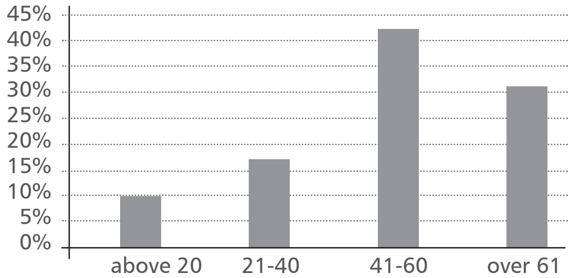

FIGURE 3
Question 3: How old are you?

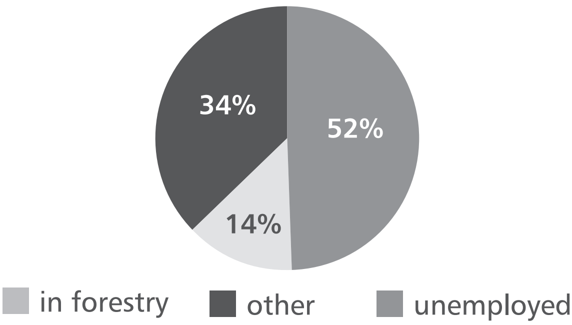

FIGURE 4
Question 4: Where do you work?

Results show that more than a half or 52% of respondents are unemployed or pensioners, while 34% are employed in other activities. The rest of 14% work in the forestry sector (Figure 4).

According to the obtained responses perception of the local population towards the current situation on the forests in their surrounding, can be concluded that 31% think that the forest is in crisis, while 22% of them think that situation is normal but with a tendency of deterioration. About 17% of the respondents think that forest is in a quite bad situation while only 16% of them think that current situation of the forest is normal with tendency of improvements. Other 14% don't have any comments about the current situation of the forest (Figure 5).

FIGURE 5
Question 5: How do you evaluate current situation of the forest in the municipality?

The question number six was focused on activities that negatively influence on the quality of the forest. This perception varies greatly among respondents. Illegal logging was pointed out as a significant reason that can cause great damages on the forest quality and it was set up on the first place with 25%, then follows inefficient management of the PEMF with 21%. About 18% of the respondents think that illegal activities are problem that should be solved, while 13% think that lack of commitment of the employees in their work is causing damage. Only 9% of the respondents don't have any comment, while 4% stated that other reasons are causing the damage of the forest (Figure 6).

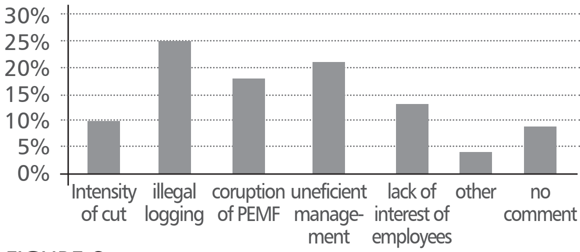

FIGURE 6
Question 6: According to you what do you think is the biggest problems that cause damage of the forest?

Answers on the question where respondents give opinion about the current techniques applied in forest management provide significant information about the perception of the villagers towards PEMF and their way of managing forests, because as it was stressed in the beginning 90% of the forests are managed by them. Management of the forest from the PEMF according to 40% of respondents is not very satisfying, while 25% perceive the management of the enterprise as very bad. Only 24% think that the management of the PEMF is good, while 11% of the respondents' state that this company is practising a very good management activities (Figure 7).

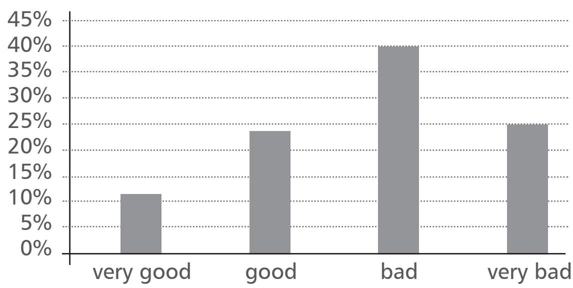

FIGURE 7
Question 7: How do you evaluate the work of the PEMF?

There are no significant differences among responds of villagers regarding the harvesting activities of the PEMF. More than a half of them or 54% of respondents think that harvesting dominates in their management activities while 46% stated the opposite (Figure 8).

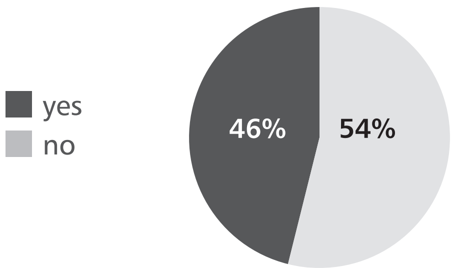

FIGURE 8
Question 8: Do you think PEMF only cut forest?

According to the results gained from the question related to the afforestation activities we can clearly conclude that 68% of respondents think that PEMF applies afforestation, while 32% of them don't agree (Figure 9).

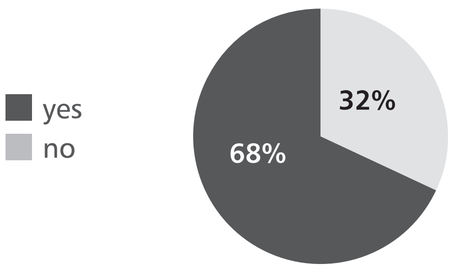

FIGURE 9
Question 9: Do you think that PEMF do afforestation?

The question number 10 was focused on illegal activities of the employees from the PEMF and respondents needed to indicate at which management stage illegal activities are mostly involved. More than a half of them (54%) stated that some or almost all of the employees (all management stages) are involved in "illegal" activities. About 13% of the respondents said that people employed in administration are the most involved, while 12% of them consider that forest guardians are the most involved. The forest engineers are mentioned from 10% of respondents and technicians with 7%. Only 6% of respondents think that people who are involved in illegal activities are not mentioned in the possible answers (Figure 10).

In order to find out the perception toward the presence of the employees of PEMF in the forests doing their daily activities respondents were asked how often they meet the employees in forests. This question gives the answer to the selected methodology because clusters were divided into houses located near the forests where the forest road is passing nearby. Answers were divided in 4 groups, and according to the obtained responses 39% of respondents rarely meet, while 34% of them never meet some of the employees in the forests. Only 15% of the respondents often meet employees

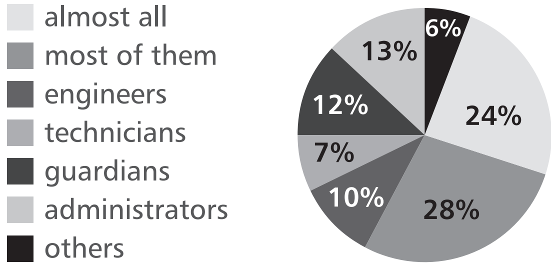

FIGURE 10
Question 10: At which management stage employees in PEMF are involved in illegal activities?

from the PEMF in the forests, while 12% stated that they meet them very often (Figure 11).

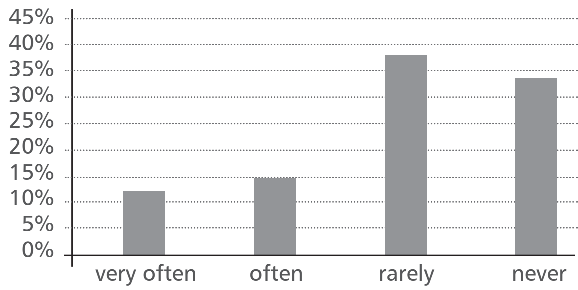

FIGURE 11
Question 11: How often you have meet employee of the PEMF in the forest in the last 2 years?

The last question was open where the respondents got the opportunity to provide information on which measurements or activities should be taken by PEMF in order to improve the current situation.

According to the cognition of the villagers forest management can be ameliorated in many ways. Enlarged control over illegal logging was pointed out by 24% of the respondents. About 16% argued that employment of professionals in this enterprise can be also one of the measures that can improve the present situation. Only 14% stated that afforestation, as one of the most beneficial activities, can also modify the current situation. Particular attention should be paid on reduction of illegal activities among the employees in PEMF according to 13%, and the same percentage of respondent's state that they don't have any idea how to alter the current situation. Sustainable forest management can help in solving this problem for 6%, while 4% of them see involvement of EU measurements of protection as a possible solution. Diminishing the political influence and power on the management of the PEMF is important for 3% of the respondents, while 2% of them stated that fire protection and communication with customers should ameliorate the current situation. Privatization, removal of the forest

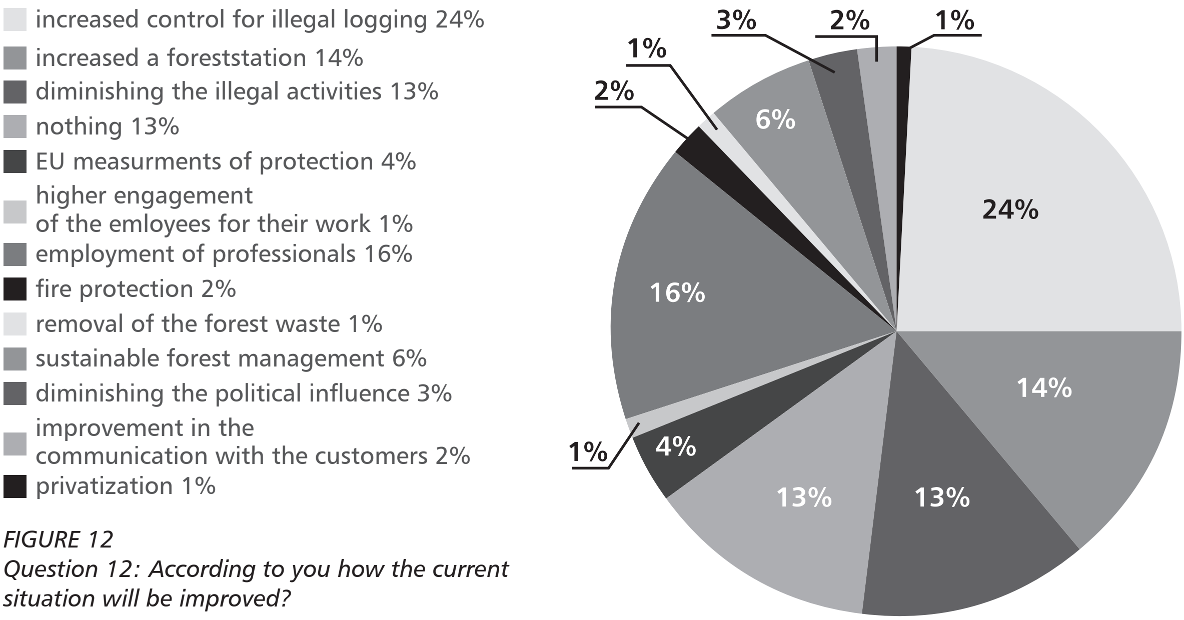

FIGURE 12
Question 12: According to you how the current situation will be improved?

waste and larger engagement of the employees on their work are placed at the lowest position according to the 1% of the respondents (Figure 12).

DISSCUSION AND CONCLUSION

Bearing in mind that forests are national wealth and public good, thus management of the forest is one of the most important things in forestry sector in each country worldwide. Hence, knowing the perception of the local population especially on those who live near forest will give us the information and indicators about the forest management and what should be done, changed and improved in this field.

Perception of the respondents concerning management of two different branches of PEMF from both villages is almost the same, taking into account that they occupy different territories of the Republic. According to the obtained results by the local population we might conclude that the company does not give an image of a well-managed company. Most of the villagers had evaluated the conditions of the forest as rather unsatisfactory with tendency for deterioration. This perception qualifies the PEMF as a company that should try to make changes in their everyday activities. The illegal logging and illegal activities were indicated as main reasons for the current situation of the PEMF.

Regarding the harvesting and afforestation performed by the enterprise among respondents there is a different perception. Around 46% of respondents think that the enterprise is focused only on harvesting activities.. Thus in future enterprise should also focus on development of the social and ecological functions of the forest. When it comes to activities associated with the afforestation 68% of the respondents think that PEMF are focused on afforestation. This attitude of respondents can be explained by the fact that there is an existence of an action named "Tree day" established by NGO in 2008 in the Republic of Macedonia. Supported by the Government this action had been performed for two times per a year from 2008 until today, including the whole territory of the country and planting from 2 to 5 million seedlings.

The perception of the villagers towards involvement in illegal activities only complements the unsatisfactory image that forestry sector already has. Existence of illegal activities among all management stages of employees is pointed out from respondents, even though there are differences at the perception about the stage where it is applied. Initiations of strict measures and penalties, motivation or increasing salaries' of employees are just some of the many opportunities to reduce or completely eradicate illegal activities in this enterprise.

Respondents had the opportunity to elaborate their opinion on measurements and activities that need to be taken in order to improve the current situation. Again the problem with illegal activities was pointed out as the main issue that should be approached very seriously working on its` diminishing.

One of the most interesting and significant issues raised by the villagers was the qualification structure of the employees within the enterprise. According to their perception this enterprise has a shortage of professionals as a result of the political influence in the management of the company. Sustainable forest management, communication with customers, EU protection measures are just few of the many ideas presented by respondents as strategic activities which need to be set on a priority list of the PE, if it wants to improve the perception of the local population.

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Preliminary communication

Digital Photogrammetry – State of the Art and Potential for Application in Forest Management in Croatia

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Abstract

Background and purpose: The main goal of this paper is to inform forestry community about the latest developments in digital photogrammetry, as well as to present its possible application in forest management. For this purpose, the current state of technological development of the main tools of digital photogrammetry (digital aerophotogrammetric cameras and digital photogrammetric workstations) has been presented. Furthermore, two adjusted methods of manual digital photogrammetry for application in forest management, namely: method for strata delineation (i.e. creation of forest management division), and method for measuring stand structure elements have been developed and presented here.

Material and methods: Research was carried out on the selected part of multi-aged, privately owned forest of ''Donja Kupčina - Pisarovina'' management unit which includes 6 compartments and 24 subcompartments and covers total area of 480 ha. After conducted aerial survey of research area, acquired digital images were processed, and digital terrain model and digital elevation model were derived. Digital aerial images of ground sample distance of 10 cm, topographical maps, digital terrain model and digital elevation model, as well as the digital photogrammetric workstations with appropriate software (PHOTOMOD, Global Mapper) were used for developing methods for strata delineation and stand structure elements estimation. Developments of both methods were carried out in the stereomodel of colour infrared digital aerial images in PHOTOMOD StereoDraw module. Additional data processing was conducted in ArcGIS 9.1. (for strata delineation) and in Global Mapper (for stand structure elements estimation) software.

Discussion and conclusions: This research has showed that PHOTOMOD Lite and Global Mapper software packages in combination with the used materials (digital aerial images, digital elevation model) and digital photogrammetric workstation completely satisfy the needs for strata delineation and stand structure measurements. The PHOTOMOD software enables simple creation of projects of digital images, easy manipulation of multiple digital images, and many other features that facilitate photogrammetric measurement and photo-interpretation, but its free version PHOTOMOD Lite has limited capabilities in terms of number of images and quantity of vector data that can be processed. If digital images of high spatial resolution are used (e.g. 30 cm or better), as was the case in this research, stereo-effect experienced by the operator and the quality of photo-interpretation are very good. That enables clear determination of vegetation types and as well as single tree species, more accurate pinpointing of tree tops and more accurate delineation of tree crowns. As long as automatic procedures are not available, digital photogrammetry has to rely on manual methods. Allometric relation between variables measured with photogrammetric method and desired variables need to be developed. An attempt to address this issue, at least in part, is made within the ongoing project 'Application of digital photogrammetry in practical forest management'.

Keywords: digital photogrammetric workstation, digital aerial images, strata delineation, stand structure elements

INTRODUCTION

In order to achieve faster, simpler and cheaper ways of collecting spatial data, remote sensing methods have been increasingly used in many disciplines, including forestry [1, 2].

Like in Europe and worldwide, a significant amount of research on possibilities of applying the remote sensing methods were also conducted in Croatia, especially photogrammetry in forestry practice, pioneered in the 1950s by professor Tomašegović [3-7]. From that time until today many research results were published, e.g. on application of aerial photographs in forest mapping and stand delineation [8-13], estimation of stand structure elements [10, 14-23] as well as possibilities for forest damage assessment using colour infrared aerial photographs [24-30]. Most of these studies were carried out with photogrammetric measurement and photointerpretation of the classical analogue aerial photographs with analogue stereo instruments. Only recently a smaller number of studies were carried out using digital image analysis [22, 23].

Despite all conducted studies, photogrammetry has not reached a significant level of practical application in Croatian forestry yet. Among the numerous reasons, the main were: high costs of aerial photographs and of equipment, demanding office work that requires classical photogrammetric methods, lack of photogrammetric trained staff, distrust in new methods, technologies and obtained results which haven't often satisfied all the needs of forestry practice [31, 32].

In the meantime, during 1980s and 1990s, the development of computer technology had also had a big influence on the evolution of remote sensing methods. Thus, in the last thirty years photogrammetry has developed from analogue, over analytical to digital photogrammetry [33] (Figure 1). During this development period, analogue aerial photographs as well as analogue or analytical stereo instruments were replaced by digital aerial images and by digital photogrammetric workstations [34, 35].

By the development of digital photogrammetry, primarily as a result of improvement in digital aerophotogrammetric cameras (DACs) that can capture digital images of high spatial, radiometric and spectral resolution, as well as by digital photogrammetric workstations (DPWs), the question of possible application of photogrammetry in practical forestry was reopened [32].

Therefore, the main goal of this paper is to inform forestry community about the latest developments in digital photogrammetry, as well as to present its possible application in forest management. For this purpose, the current state of technological development of the main tools of digital photogrammetry (DACs and DPWs) has been presented. Furthermore, methodology for application of digital aerial images and digital photogrammetric workstation in forest management have been developed and presented here.

DIGITAL PHOTOGRAMMETRY

Digital (softcopy) photogrammetry can be defined as the newest development phase of photogrammetry which includes the use of digital images captured by DACs or scanned analogue images as well as the use of DPWs in order to perform photogrammetric processing and to obtain photogrammetric products.

Simplified schematic workflow (Figure 2) shows DACs and DPWs as the main tools in digital photogrammetry.

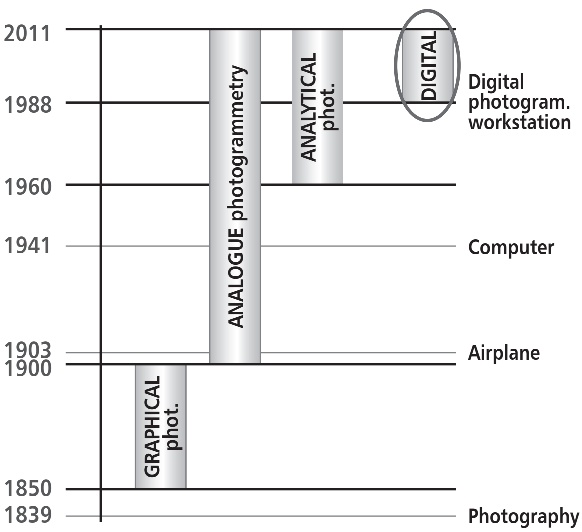


FIGURE 1
Phases of photogrammetric development, as a result of technological innovations (source [36])

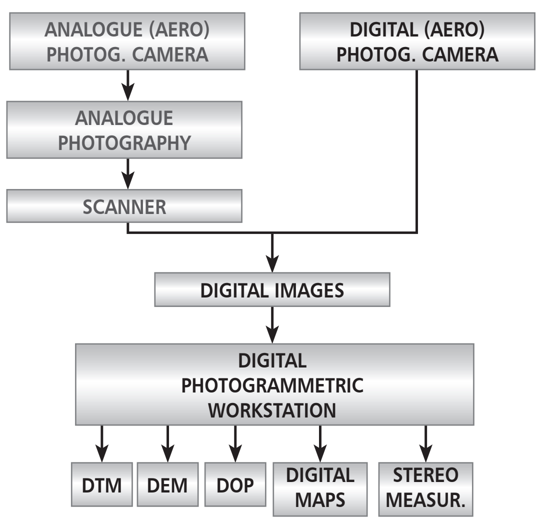


FIGURE 2
The simplified schematic workflow in digital photogrammetry

Digital aerophotogrammetric cameras (DACs)

Although the term *digital photogrammetry* has been in use for a long time, namely when scanners were used to obtain digital image from analogue photographs, only with the appearance of digital cameras we can talk of fully digital photogrammetry. The first commercial solutions of DACs (ADS40 and DMC) were presented at the ISPRS *(International Society for Photogrammetry and Remote Sensing)* congress in 2000 in Amsterdam [37-39].

The appearance of DACs which, by its characteristics, could replace the existing analogue technology meant a big change for photogrammetry. During a single aerial survey, the majority of digital cameras simultaneously record panchromatic, red, blue, green and infrared part of electromagnetic spectrum. With the help of GPS (Global Positioning System) and IMU (Inertial Measurement Unit), it is possible to get oriented images right after airplane landing. Then the images are directly loaded into DPWs for further processing. The additional benefits of using DACs are that there are no longer needs for films, photolab developing and scanning. In this way, a whole phase of photogrammetric work process disappeared, resulting in time and costs savings [37, 38, 40-43].

An additional advantage, compared to the traditional film workflow, is the absence of noise introduced during the scanning process as a result of film grain, dust particles, scanner glass imperfections, etc. Furthermore, digital images have improved radiometric properties of the image which enables much more information to be extracted, especially from shadowed areas of the image. Digital images also outperformed the analogue ones in terms of spatial resolution. This led to the improved stereoscopic view and better possibility for interpretation from stereomodel derived from digital images. Electronic forward motion compensation device enables recording of high spatial resolution images at great flying speed, so the time interval between two recordings can be shorter than one second. Due to the properties of DACs, aerial recordings can be made under relatively low light conditions. This increased the length of the season suitable for recording, as well as extended daily time appropriate for aerial photo flight sessions [37, 40, 42-45].

A digital camera, in its main parts, is almost identical to the analogue one. The basic difference is in the media for light registration and the process of creating images. In analogue cameras the media is a film and the image is created photographically, i.e. by chemical reaction of light and film. In digital cameras, the film is replaced by an electronic photosensitive sensor which could be CCD (Charge Coupled Device) or CMOS (Complementary Metal Oxide Semiconductor) [38, 41, 43].

According to the sensor size, i.e. the size of the resulting images, Petrie and Walker [43] differentiate digital cameras to:

- small format - up to 16 megapixels,
- medium format - from 16 up to 50 megapixels,
- large format - more than 50 megapixels.

Despite the increased appearance of small and medium format DACs, large format DACs still have the largest application and role in aerophotogrammetric surveys.

Finally, it is necessary to mention that the development of digital cameras is very dynamic and further technological advances can be expected.

Digital photogrammetric workstations (DPWs)

The first digital photogrammetric workstation Kern DSP1 was presented at the XVI ISPRS congress held in Kyoto in 1988. The DPW was defined as ''a hardware and software connection to derive photogrammetric products from digital imagery''. The advances in computer technology in the 1990s had great influence on the DPWs evolution and their expansion at the market. At the end of the same decade many photogrammetric companies and research institutions were using DPWs which gradually took domination over the analytical plotters [46, 47].

There are two main differences between DPWs and analytical plotters. The first and probably the most important is the input data (image type) which they use. DPWs use digital images, while analytical stereoinstruments use slides of analogue photographs. Besides aerial images, some of modern DPWs can process satellite or LiDAR images. The second important difference is the possibility of DPWs for partial or total automatization of photogrammetric processing [47, 48].

As any other ordinary computer, the DPW also consists of hardware and software. The main characteristic of DPW is a powerful hardware which implies powerful and fast processor (CPU), large memory (RAM) and large storage units. A part of the hardware which makes DPW significantly different from normal computer is the stereo viewing system consisted of graphic card, high resolution stereo monitor as well as a monitor suitable stereo glasses. Today the most widely used stereo viewing system is the one comprised of monitor with active polarization display and stereo glasses with polarization filters [36, 46, 47, 49, 50].

The most important part of DPW is its software. Generally, photogrammetric tasks which can be performed using DPW are the following: basic photogrammetric functions (image orientation, aerial triangulation, image block adjustment), mono or stereo vectorization, more or less automated creation of digital terrain model (DTM) and digital elevation model (DEM), digital orthophoto, digital map, etc. [51-53].

FIGURE 3
The digital photogrammetric workstation PHOTOMOD

Short overview of past application of digital photogrammetry in forestry

The initial development of digital photogrammetry in the 1990s had also encouraged foresters to start research on the possibility of its application in forestry. Based on a review of past research in application of digital photogrammetry in forest management, Benko and Balenović [54] differ:

- *manual methods* of photogrammetric measurement and visual interpretation (photo-interpretation) of digital aerial images using DPW [34],
- *automated methods* of photogrammetric measurement and interpretation of digital aerial images using a computer or DPW [55-63].

We found considerably more publications describing studies that make use of automated methods than those using manual methods (as can be seen from the above example). Manual methods are more labour intensive, i.e. they require much greater effort and knowledge of the interpreters, while in automated methods most of the work is performed by the computer. Thereby, time saving is achieved with automated methods. Also, by using automated methods, the influence of interpreter's subjectivity is eliminated [64]. However, despite these advantages, automated methods cannot reach manual methods in terms of accuracy yet, e.g. in determining tree species and in the estimation of stand structure elements in mixed stands. Therefore, the practical application of the automated methods is still problematic. Taking into consideration all things mentioned above, as well as constant technological advancement of DPWs and photogrammetric software, new research of the application of both automatic and manual methods of digital photogrammetry in practical forest management is necessary [54].

In the following section we will present two adjusted methods of manual digital photogrammetry for application in forest management in Croatia, namely: *method for strata delineation* (i.e. creation of forest management division), and *method for measuring stand structure elements.*

MATERIALS AND METHODS

Method for strata delineation and method for measuring stand structure elements, described here include the use of digital aerial images, digital terrain model (DTM) and digital elevation model (DEM), as well as the use of DPW with appropriate software. Typical software used with DPW includes software for photogrammetric processing of remote sensing data and geographic information system (GIS).

Research area

Research was carried out on the selected part of multi-aged, privately owned forest of ''Donja Kupčina - Pisarovina'' management unit (M.U.). Selected part includes 6 compartments and 24 subcompartments and covers total area of 480 ha (Figure 4). The dominant tree species: Sessile oak (*Quercus petraea* L.), Common beech (*Fagus sylvatica* L.), *Hornbeam (Carpinus betulus* L.), Black alder (*Alnus glutinosa* (L.) Gaertn.) and poplars (*Populus* sp.) form 4 main management classes (Sessile oak, Common beech, Hornbeam and Poplars) of the M.U.

Aerial survey and derivation of DTM and DEM

The colour infrared digital images were surveyed in July 2009 at a flight attitude of 1400 m above ground level and with approximate scale of 1:1000 by Vexcel UltracamX digital camera (Vexcel Imaging GmbH, Graz, Austria). Focal distance of camera lenses was 100.5 mm, while radiometric resolution was 12 bit. Forward overlap (endlap) of images was 60%, while lateral (sidelap) was 30%. In total, 23 images were acquired along two flight lines. Spatial resolution, i.e. ground sample distance (GSD) of acquired images was 10 cm.

After the aerial survey, digital aerial images were processed by the *Office Processing Center* (OPC) software package that comes with the camera. Raw data (RAW files) of digital images were transformed into raster files in TIFF format with JPEG compression (quality level of 100%) representing the final output data. The average size of images was about 197 MB. Aerial surveys of research area, as well as DTM and DEM derivation were performed by Geofoto Ltd, Zagreb.

Data for derivation of DTM (Figure 5a) of research area were collected by photogrammetric mapping of stereopars of digital aerial images on DPW Imagestation using *Feature Collection*, *Automatic Elevation* and *DTM Collection* modules (version 6.0). DTM data

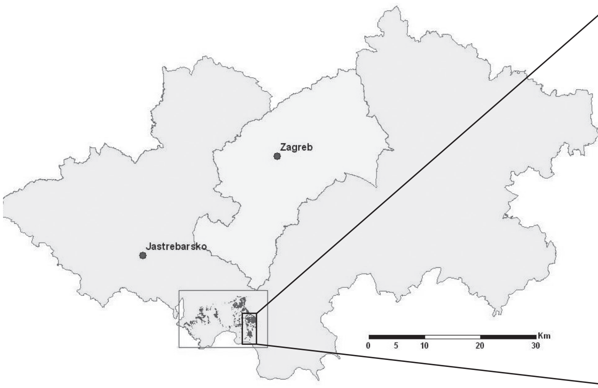


FIGURE 4 Left: Location of the ''Donja Kupčina – Pisarovina'' M.U. in Zagreb County. Right: Selected research area (compartments 16 to 21).

were controlled using visual methods of *Bentley Microstation* (version 08.05) and *Terrasolid Terra Modeler* software packages (version 6.1). Also, for detecting suspicion and illogical data during Triangulated Irregular Network derivation, 'filter errors' option was used. DEM (Figure 5b) was derived by interpolation of DTM data using *Terrasolid Terra Modeler* software (version 6.1). Output of DEM derivation was ASCII files of XYZ format and size of interpolated grid, i.e. distance between points was 25 m. DTM and DEM were derived according to rules for products specification of The State Geodetic Administration [65].

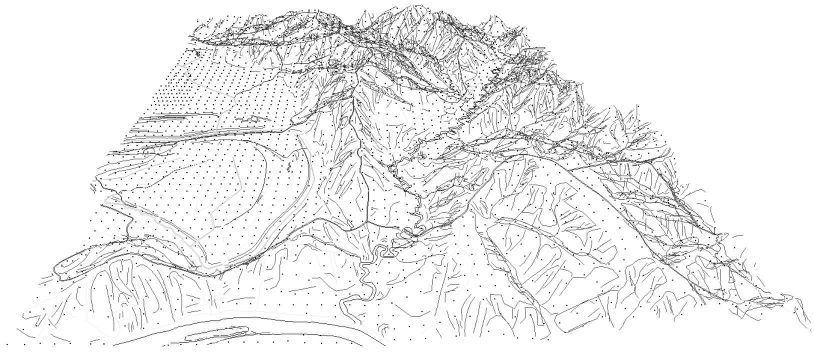


FIGURE 5a Digital terrain model (DTM).

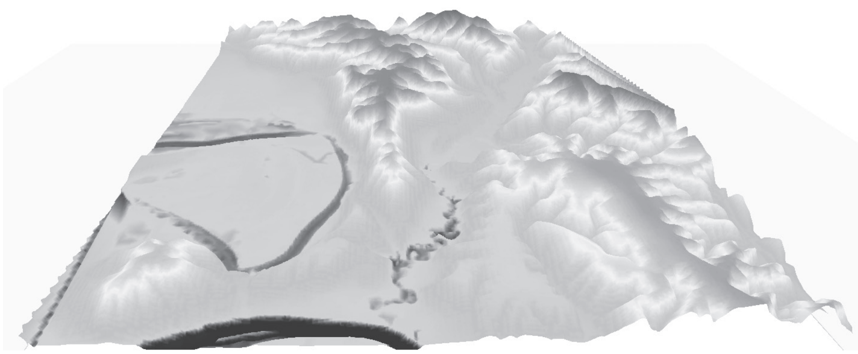


FIGURE 5b Digital elevation model (DEM) of research area. Both DTM and DEM are shown in 3D view of Global Mapper.

PHOTOMOD and Global Mapper software

There are many software for photogrammetric processing, as well as GIS software present at the market. We used free version of photogrammetric software PHOTOMOD Lite 4.4 [66]. Also, we used GIS software Global Mapper v11.01 [67], which came preinstalled with our DPW (Figure 3), as well as ArcGIS 9.1 software. However, other similar GIS software could also have been used instead.

In order to execute small photogrammetric projects PHOTOMOD Lite, a free version of PHOTOMOD digital photogrammetric system package, is appropriate. The Lite version has all features as full version of PHOTOMOD, but it can handle only limited number of images, vector objects, TIN nodes, break lines etc. For example, within one created project, the Lite version supports up to 10 digital aerial images in the central projection and extraction of vector objects up to 1000 points, allowing the performance of various photogrammetric tasks (vector objects collection, orthomosaics, DTMs and vector maps creation) [66]. However, in our case this was sufficient.

For application of the methods presented below two modules of PHOTOMOD Lite software were used:

- *PHOTOMOD Montage Desktop* - the core module of the digital photogrammetric system used to create and manage projects and operate different PHOTOMOD modules for further photogrammetric processing [68],
- *PHOTOMOD StereoDraw* - module for 3D feature extraction, i.e. creating, editing and measuring 3D vector objects in stereomode [69].

Before photo-interpretation and photogrammetric measurement, i.e. strata delineation and stand structure elements measurement on DPW, certain preparatory work was necessary.

In order to perform photogrammetric processing in PHOTOMOD it was necessary to first create the project. First step of the project creation is *block forming* when digital images are added to the project, followed by positioning (rotation) of images and the whole block. Then follows *aerial triangulation* of the project, which includes defining camera parameters, and the interior orientation of the aerial images. The exterior image orientation is carried out during the third step – *block adjustment*. *Block processing* is the last step in project formation when one of modules (StereoDraw, StereoVector, DTM) for further processing can be chosen [68]. Before creating or editing vector objects in the StereoDraw module, it is necessary to create the code table in which each object is defined and described by a code name, code number, shape (point, polyline, polygone), colour, symbol and additional attributes.

Method of strata delineation

Delineation of strata in forest, unless performed automatically by a computer, is in general subjective and depends on the experience of the person doing delineation. Typically, in forest delineation in the field a forester walks through the chosen part of forest and marks on the map distinctive points and lines where parts of forest stands differ. In manual delineation using photogrammetric method the procedure is similar. The photo-interpreter marks differences on the image between different parts of the forest. In both cases delineation has to be performed by a trained person, preferably familiar with forest on which she/he is working. In most cases, as is in our case, in delineation by photo-interpretation it is necessary to acquire a photo-interpretation key. Therefore several field surveys with temporary field plots were performed with the aim to train the photo-interpreter. It is difficult to set a strict written set of rules for photo-interpretation, particularly in diverse forests such as ours, so since photo-interpretation was performed by only one person we decided not to make a written photo-interpretation key. We used the approach where photo interpreter was first “trained” at the smaller part of the forest area, in order to perform photo-interpretation tasks on the remaining area.

Development of method of strata delineation for creating forest management division was carried out on the selected part of ‘’Donja Kupčina - Pisarovina’’ M.U. using photo-interpretation in the stereomodel of colour infrared (CIR) digital aerial images in StereoDraw module.

Before the delineation it is necessary to define classification categories. In Croatia different categories and subcategories of forests and forest land are defined by Regulations for Forest Management [70, 71]. In our case, through preliminary review of existing digital aerial images of the research area and photo-interpretation training with field surveys we identified four main categories divided into total of 19 subcategories (Table 1).

Strata are delineated on the basis of observable differences on digital images, according to predefined categories: crown size and tree height (cover), tree species mixture, canopy closure and tree species (Figure 6).

After delineation, vectorized polygon objects were loaded in ArcGIS 9.1 software for further processing (adjustment with cadastral data). Topographical maps and digital orthophoto were used as background layer in GIS software for easier orientation.

If strata delineation is performed for privately owned forests, then ‘overlapping’ of delineated strata with cadastral register data of private forests must be done, in particular overlapping and adjustment with polygons of cadastral particles which are in cadastre

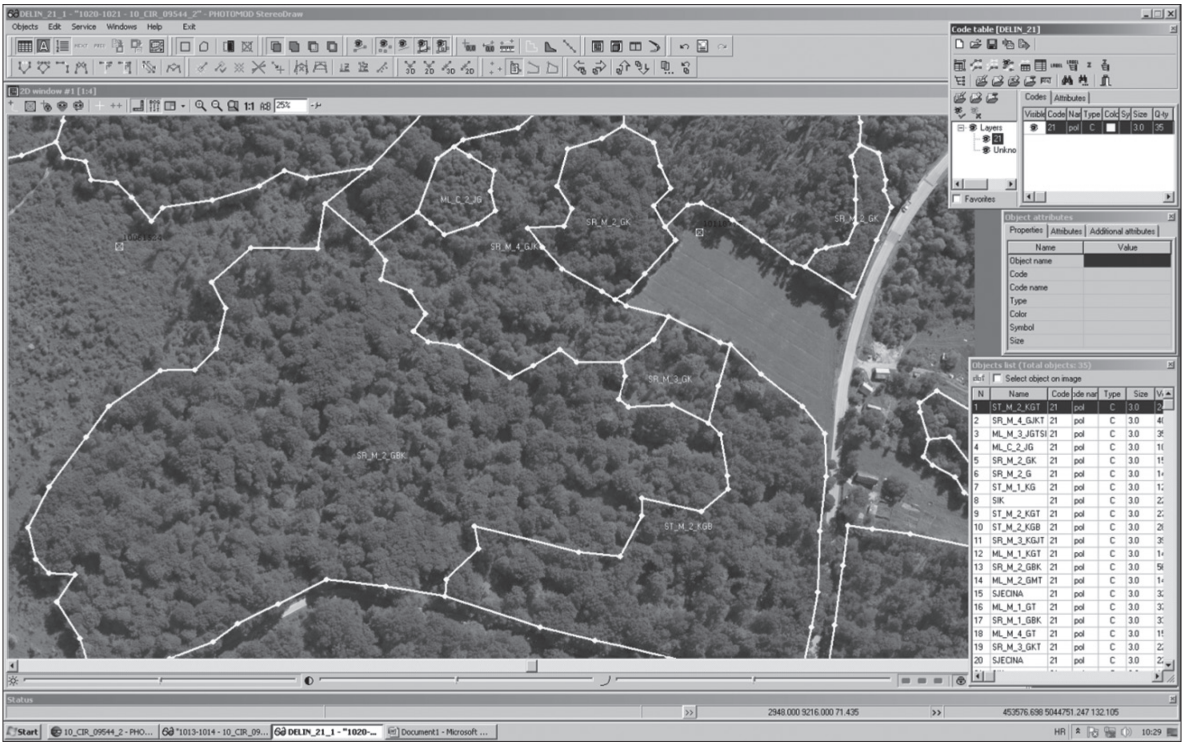


TABLE 1
Categories for forest and forest land classification for photo-interpretation of digital aerial images

Category	Subcategory	Subcategory code
Cover	High forest – Young	HF-Y
	High forest - Middle-Aged	HF-MA
	High forest – Old	HF-O
	Harvested Area	HA
	Degraded (shrub)	DEG
	Land In Succession	SUC
	Land Without Vegetation	WV
Mixture	Pure	P
	Mixed	M
	Not applicable	NA
Canopy closure	Complete (91-100%)	1
	Incomplete (76-90%)	2
	Rare (50-75%)	3
	Broken (< 50%)	4
	Not applicable	NA
Main tree species	*Quercus petraea*	QP
	Fagus sylvatica	FS
	Carpinus betulus	CB
	Alnus glutinosa	AG
	Populus sp.	POP
	Other	OTH
	Not applicable	NA

FIGURE 6
An example of strata delineated on digital aerial images of GSD 10 cm shown in 2D window of StereoDraw module at mitigation of 25 %

registered as privately owned. In our case, delineated strata were corrected (adjusted) with cadastral data in order to delete strata or its parts which in cadastral is not registered as privately owned forests.

Finally, grouping of strata into management classes and then into subcompartments is conducted according to: (I) categories (Table 1) which are assigned to each strata during delineation (cover, mixture, canopy closure, main tree species), (II) insight into the spatial distribution of delineated strata inside the compartment, and (III) with respect to rules of the Regulation on forest management [70, 71].

Method for photogrammetric measurement of stand structure elements

Development of method for photogrammetric measurements of stand structure elements was carried out in the stereomodel of CIR digital aerial images in StereoDraw module. Additional data processing was performed in Global Mapper software and OpenOffice spreadsheet calculator. An overall procedure of photogrammetric measurement of stand structure elements at one circular sample plot is described in the following example (Figures 7 to 9).

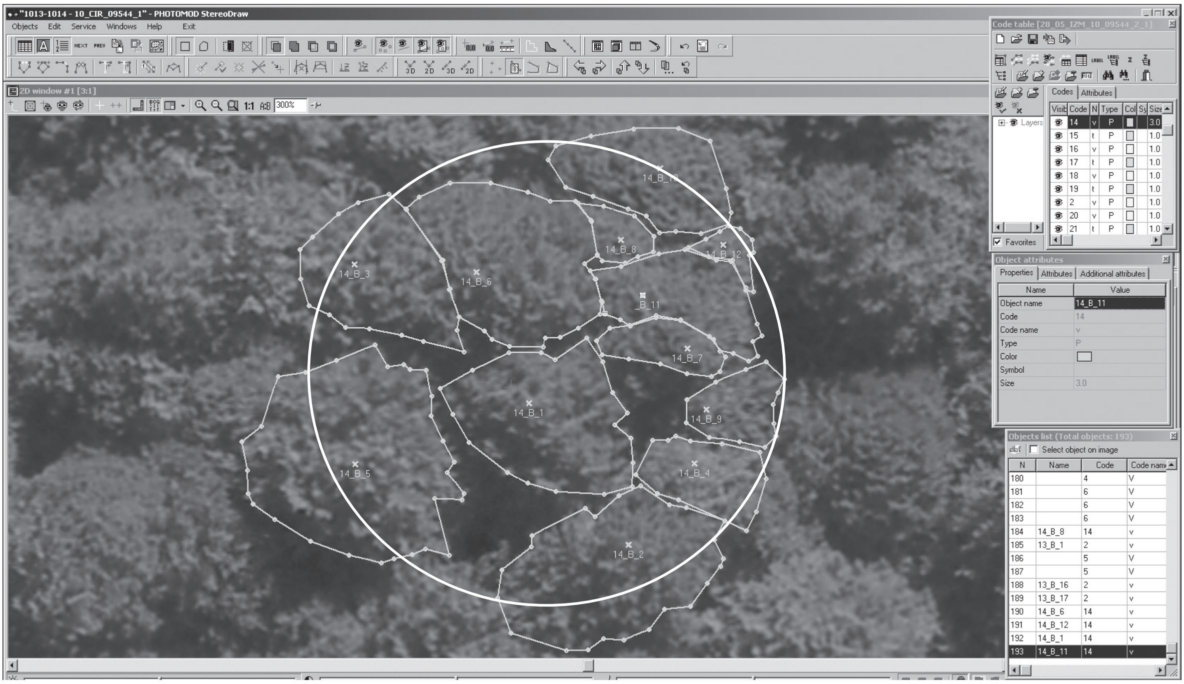


FIGURE 7
An example of a photogrammetric measurement of stand structure elements shown in model of CIR digital aerial images of GSD 10 cm in 2D window of StereoDraw module at magnification of 300 %.

Determination of tree species and crown top, as well as crown delineation were performed for each tree on the plot (Figure 7).

Tree species were recognized by a photogrammetry expert that had previously underwent training on plots with trees of known species. Species determination was performed on stereomodel of CIR digital aerial images by visual interpretation based on the general appearance of tree crowns (form, structure and crown texture) and crown colour.

The crown top of each tree, with its top falling inside circular plot, was determined and marked by placing stereo-marker on it and creating a 3D point object with *x, y, z* coordinates (where z is height in meters above sea level). Each point, representing single tree top, was labelled with a unique code (e.g. 14_B_1 – plot number, tree species (beech), tree number).

Finally, the crown area of each tree on the plot was manually delineated and represented by a polygon object. Data collected with StereoDraw module were recorded and stored in .DXF file format.

Data from .DXF files were then loaded as "trees" layer into Global Mapper software (Figure 8) using preloaded DEM as background layer and a reference for calculating tree height.

In order to calculate tree height (*h*) and crown area (*CA*) the following steps were performed:

- Selecting "trees" layer and choosing command "*Export Vector Data* $\longrightarrow$ *Export CSV*" we exported elevation coordinate of tree tops (h_T) into .CSV format (Figure 9) which we could process with spreadsheet calculator (OpenOffice).
- In order to obtained the elevation of the tree's "bottom" (h_B; i.e. elevation of orthogonal projection of tree top point) from the associated tree top points and DEM we used "*Apply Elevations from Terrain Layers to Selected Points*" command, and then we exported data into CSV file.
- The height (*h*) of each tree on the plot is calculated as $h = h_T - h_B$.
- Polygons representing tree crowns were selected and command "*Display Feature Measurements*" was used to show and subsequently export in CSV format the areas of each polygon representing orthogonal projection of tree crown area (*CA*).

In such a presented way, the obtained data are ready for further processing, i.e. for importing into the appropriate database and for calculation of necessary stand structure elements (*h, dbh, g, v, N, G, V*).

The diameter at breast height (*dbh*) of each tree in the plot could be calculated if appropriate regression models for *dbh* estimation exist. In such cases, as independent variables the regression models usually use crown area (*CA*) or crown diameter (*D*) in case of univariate models, or any combination of *CA*, tree height (*h*), number of trees per hectare (*N*) in case of multivariate models.

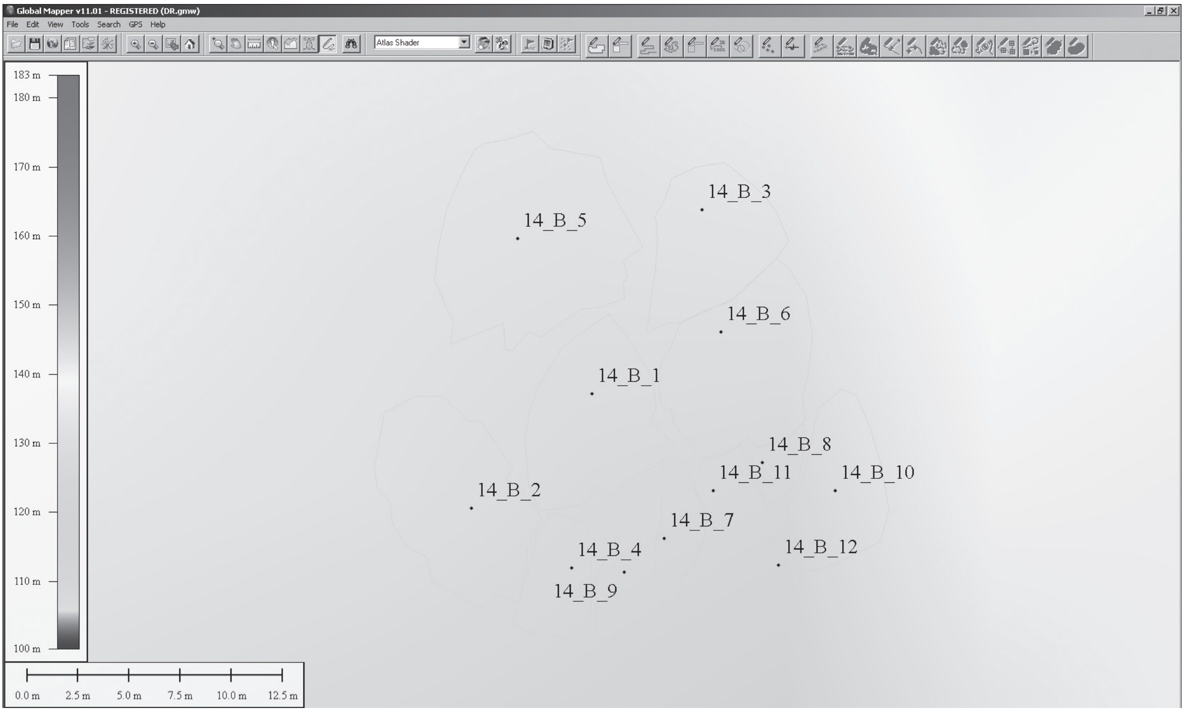
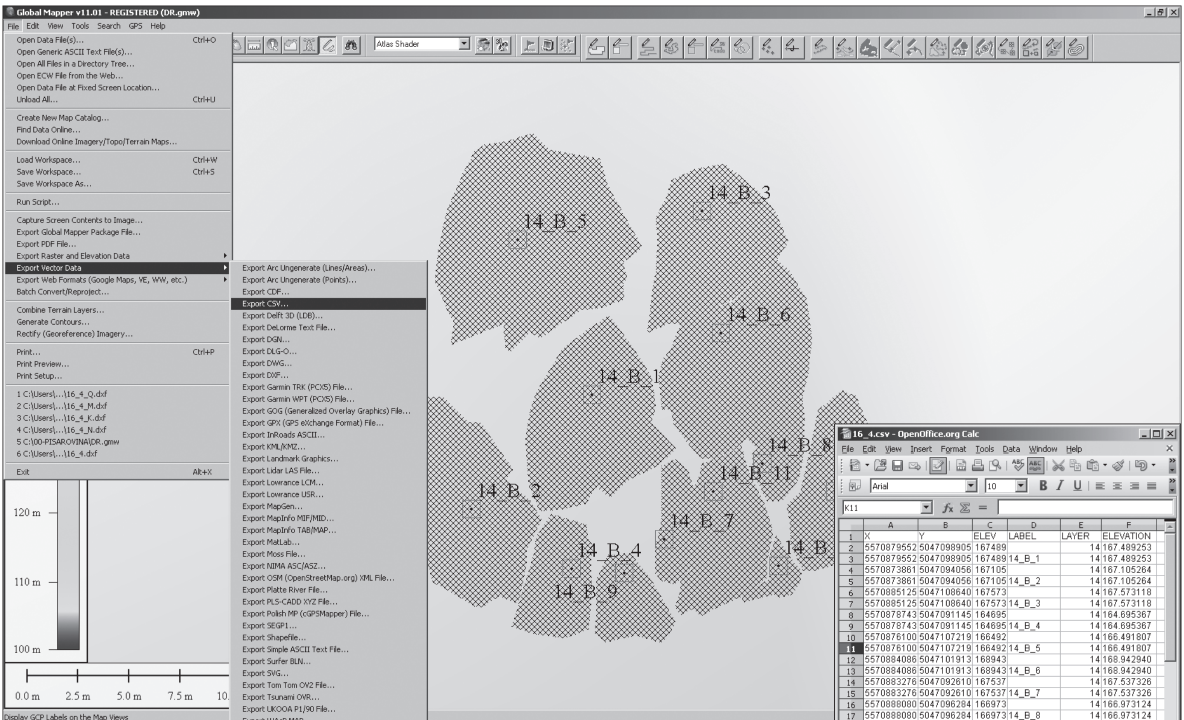
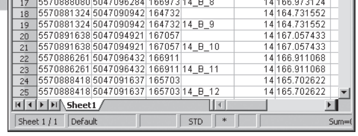


FIGURE 8
Objects collected in the StereoDraw module and loaded in the Global Mapper software for further processing





	A	B	C	D	E	F
1	X	Y	ELEV	LABEL	LAYER	ELEVATION
2	5570879552	5047098905	167489		14	167.489253
3	5570879552	5047098905	167489	14_B_1	14	167.489253
4	5570873861	5047094056	167105		14	167.105264
5	5570873861	5047094056	167105	14_B_2	14	167.105264
6	5570885125	5047108640	167573		14	167.573118
7	5570885125	5047108640	167573	14_B_3	14	167.573118
8	5570878743	5047091145	164695		14	164.695367
9	5570878743	5047091145	164695	14_B_4	14	164.695367
10	5570876100	5047107219	166492		14	166.491807
11	5570876100	5047107219	166492	14_B_5	14	166.491807
12	5570884086	5047101913	168943		14	168.942940
13	5570884086	5047101913	168943	14_B_6	14	168.942940
14	5570883276	5047092610	167537		14	167.537326
15	5570883276	5047092610	167537	14_B_7	14	167.537326
16	5570888080	5047096284	166973		14	166.973124
17	5570888080	5047096284	166973	14_B_8	14	166.973124
18	5570881324	5047090942	164732		14	164.731552
19	5570881324	5047090942	164732	14_B_9	14	164.731552
20	5570891638	5047094921	167057		14	167.057433
21	5570891638	5047094921	167057	14_B_10	14	167.057433
22	5570886261	5047096432	166911		14	166.911068
23	5570886261	5047096432	166911	14_B_11	14	166.911068
24	5570888418	5047091637	165703		14	165.702622
25	5570888418	5047091637	165703	14_B_12	14	165.702622

FIGURE 9
*Left: An example of exporting altitudes of the tree tops in the CSV format (*Export Vector Data → Export CSV*).*
Right: The corresponding exported data collected in OpenOffice.

DISCUSSION AND CONCLUSIONS

Development of digital photogrammetry, application of which has been mentioned earlier, has made it one of the most important methods of collecting spatial data in many disciplines (geodesy, geography, geology etc.). Since the remote sensing methods have not yet reached wider practical application in Croatian forestry, focus of our work was development of methodology for potential application of digital photogrammetry in forest management, in particular on tasks of creating management division and measuring stand structure elements.

According to previous research [34], some of major limitations in application of digital photogrammetry in forestry, were non user-friendly software and insufficient hardware performances then existing DPWs. In addition, photogrammetric images were acquired in lower spatial resolution than today. However, at present, due to constant development of computer performances, as well as increased image availability a significant advancement in photogrammetric software has occurred.

The software presented and used in this paper (PHOTOMOD Lite and Global Mapper) in combination with the used DPW are designed in 'user friendly' manner so that relatively low level of photogrammetry and GIS expertise is needed in order to completely satisfy the needs for strata delineation and stand structure measurements. The PHOTOMOD software enables simple creation of projects of digital images, easy manipulation of multiple digital images, and many other features that facilitate photogrammetric measurement and photo-interpretation, but its free version PHOTOMOD Lite has limited capabilities in terms of number of images and quantity of vector data that can be processed. However, since our work was focused on the method and not for real forest management purpose, the capabilities of the used software were sufficient.

If digital images of high spatial resolution are used (e.g. 30 cm or better), as was the case in this research (GSD 10 cm), stereo-effect experienced by the operator and the quality of photo-interpretation are very good. That enables clear determination of vegetation types and as well as single tree species, more accurate pinpointing of tree tops and more accurate delineation of tree crowns. Since all tasks of delineation and measurement are performed on computer, and data are already integrated into GIS environment, necessary are only minor corrections of delineated strata (e.g. according to cadastral data) followed by grouping of delineated strata into forest compartments and subcompartments. In contrast, with classical method, all data collected in the field have to be typed in computer, or at best downloaded from several field computers to the mainframe, checked and processed. Furthermore, field data on delineation of stands (e.g. notes from paper maps, or point from field computers) have to be translated in the GIS environment.

Recent research examine differences in work effort needed to perform typical tasks in forest management planning. Balenović [72] compared the work-time and costs for stand mapping and tree measurement in forest inventory with photogrammetric and classical forestry methods. From his results can be seen that photogrammetric method (conducted on digital images of GSD 30 cm), requires 52,5% less work-time in total, namely 7% more for forestry engineer, but 67% less work-time for technicians and workers. It is also noteworthy that photogrammetry method required approx. 47% of work-time to be used in the field (manly forestry technician and worker) while classical method required almost 95% of time for field work. This is important information in terms of productivity which, primarily for classical method, decreases as weather conditions or terrain configuration deteriorates.

Another advantage of digital photogrammetry is that overall photogrammetric measurement and photo-interpretation in (permanently) recorded in digital form. This allows easy control at any point in time (unlike the control of the field measurement) and possibility for reprocessing the data in future (e.g. testing of some future automated method for tree species recognition, crown delineation etc.).

Nevertheless, photogrammetric method has some obstacles which have to be resolved before its full application in everyday forest management would be possible. Most common problems related with photogrammetric method are additional costs caused by acquiring DPWs, photogrammetric software and most important digital images. However, these are digital-technology related problems that are becoming less pronounced as technology advances and increases availability of DPWs and digital photogrammetric images. More important problem, that will require solving before photogrammetric method would become generally accepted, is development of procedures and software solutions capable of automatic, or at least semi-automatic, image processing for delineation of both forest strata and individual trees. It can be assumed that these challenges, related to pattern recognition, might be addressed in foreseeable future. However, other issues, like accurate tree species recognition, or tree measurements with automatic methods, will probably be more difficult to resolve.

As long as automatic procedures are not available, digital photogrammetry has to rely on manual methods. But even manual method could find its application in forest management planning as was shown earlier [72].

One of the most important tasks in current photogrammetric research is, aside from above mentioned issues, research of allometric relations and models that would link desired variables (dbh, tree basal area or tree volume) with variables measured in photogrammetry (tree crown diameter or area, tree height). Those relations vary with tree species, management history, site index, etc. If photogrammetric method is to be used as an alternative method, that provides equal or better results in comparison to the classical method, those models would have to be developed and tested. An attempt to address this issue, at least in part, is made within the ongoing project 'Application of digital photogrammetry in practical forest management'.

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Review paper

Reducing Emissions from Deforestaton and Forest Degradation (REDD+) – What is Behind the Idea and What is the Role of UN-REDD and Forest Carbon Partnership Facility (FCPF)?

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<u>Background and purpose:</u> Although greenhouse gases related with the Land Use, Land Use Changes and the Forestry (LULUCF) represent approximately 15-20% of all greenhouse gases emissions to the atmosphere, afforestation/reforestation projects of Kyoto protocol related Clean Development Mechanism (CDM) represents only 0.75% of all CDM projects. All these facts prompted re-negotiation of climate change policy to include Reducing Emissions of Deforestation and forest Degradation (REDD+) in compliance carbon trading in the Post-Kyoto protocol. To help implementing the REDD in developing countries, two main multilateral readiness programs were established, the UN one (UN-REDD+), and the Forest Carbon Partnership Facility (FCPF), which was created by the World Bank. This paper describes the main idea behind REDD+ mechanism, the roles of UN-REDD and FCPF in creating REDD+ national policies and what are the challenges and main obstacles in successful implementation of REDD+.

<u>Material and methods:</u> Review of the existing literature like reports and publications related to REDD+ in general, as well as related with UN-REDD and FCPF roles in REDD+ implementation in sub- national, national and supra-national policies.

<u>Discussion and conclusion:</u> For successful implementation of REDD+ it is necessary to deal with the problems of governance (weak institution, corruption, lack of transparency and participation) that are common present in most of the tropical countries involved in REDD+. The implementation of an effective REDD+ mechanism will need an improved capacity building and law enforcement. The analysis of UN-REDD and FCPF program reveals large overlapping, especially in current phase of capacity building. At present, it seems that UN-REDD maintains a more social oriented approach, while FCPF focuses more on carbon sequestration projects.

<u>Keywords:</u> Climate change, deforestation, REDD+, UN-REDD, FCPF, tropical countries

INTRODUCTION

To cope with the climate change, and to limit the future increase of global temperature below 2°C [1], it is necessary to dramatically reduce the emissions of greenhouse gases to the atmosphere, particularly the anthropogenic carbon dioxide (CO_2).

At the global level emissions of greenhouse gases (GHGs) related with Land Use, Land use change and Forestry represent about 15-20% of global CO_2 emissions [2], so forestry is third sector after energy (25.9%) and industry (19.4%) regarding contribution of GHGs emissions to the atmosphere [1]. Although deforestation and forest degradation are one of the biggest sources of emissions of greenhouse gases and preservation of the forest is very important in fighting the climate change, there has not been any significant improvement there. Certified Emission Reductions (CER; i.e. "carbon credits") coming from forestry projects are potentially available through projects of Clean Development Mechanism (CDM) under the United Nations Framework Convention on Climate Change (UNFCCC) Kyoto protocol. However, such projects are limited only to Afforestation and Reforestation projects (A/R) [3]. Because of their complexity, high transaction costs and uncertainty out of 4200 CDM projects, only 32 (0.75%) are A/R project [4].

All these facts prompted re-negotiation of climate change policy to include REDD+ in compliance carbon trading in the near future, by recognizing tropical forests as the valuable assets and this way increase the prospect for sustainable management and protection of forests. On 9th Conference of the Parties (COP) in Milan in the year 2003, the first two years process of Reducing Emissions of Deforestation (RED) mechanism was initiated [5]. On COP 11th in Montreal the Papua New Guinea and Costa Rica's governments requested that "agenda related with Reducing Emissions of Deforestation in developing countries approaches to stimulate actions" The negotiations started on 13th section of Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC) in Bali in 2007 where second D was added and Reducing Emissions of Deforestation and forest Degradation (REDD) was defined. Since this activity the discussion about REDD had evolved until REDD+ was created on the COP 14th in Poznan, Poland in 2008 [6]. In addition, in REDD+ forest conservation, sustainable forest management and carbon stock enhancement were included [7] (Box 1).

Box 1

Situation on the carbon credit market

Many mechanisms were created in goal to reduce the emissions of greenhouse gases, and to mitigate the global climate change. Some of these mechanisms that are actual on the markets are Payment for Environmental Services (PES), including carbon credits markets, where there are two different systems of markets; 1) Compliance (regulated) Emissions Trading Schemes (ETS): like Clean Development Mechanism (CDM), Joint Implementation (JI), EU ETS; and 2) Voluntary carbon market schemes that are beyond regulations, for ex. Voluntary Carbon Standards (VCS), Plan Vivo, Climate, Community and Biodiversity Alliance (CCBA) and Carbon Fix. In compliance schemes regarding forestry carbon projects only CDM A/R (Clean Development Mechanism Afforestation/Reforestation) projects are valid for now, and in voluntary markets forestry projects that include A/R, REDD (Reducing Emissions from Deforestation and forest Degradation) and SFM (Sustainable Forest Management) can be certified for carbon offsets [23].

MATERIALS AND METHODS

Materials and methods we used for this article were analysis and review of existing literature like reports and publications related to REDD+ in general, as well as related with UN-REDD and FCPF roles in REDD+ implementation in sub- national, national and supranational policies. After the analysis and review of the literature we answered to the questions related with REDD+; like what is the main idea behind REDD+, what is role of UN-REDD and FCPF and why they were established, and what are the main similarities and differences between these two programmes.

What is the main idea behind REDD+?

According to the Stern Review, reducing deforestation is the "single largest opportunity for cost-effective and immediate reductions of carbon emissions" [8]. The added + in REDD signifies that the role of conservation, sustainable management of forest and enhancement of carbon stock in developing countries are recognised and included. The idea of REDD+ is that not only financial help would be given to stop deforestation and degradation, but also to conserve and to increase forest carbon stocks through sustainable forest management, through tree planting and rehabilitation of forest land [9]. Like this, the countries with sustainable forest management, that are already protecting their forest can also profit from the REDD financial benefits.

Many developed countries see REDD+ as an attractive option in gain part of their reduction targets through investing in REDD+ projects, while for developing countries REDD+ represents an additional income and a source for supporting and financing sustainable forest management and this way reduce the poverty [7]. Market based REDD+ would be only available in countries that fully implemented forest governance reforms. Suitable policies on forest tenure, use and management rights, and also benefit-sharing mechanism would be mandatory before the issue of carbon credits [10]. These measures should provide successful implementation of REDD+ in developing countries.

If the post Kyoto agreement fails to act against the deforestation and degradation, the future of the forest, especially tropical ones will be in high risk, together with climate change mitigation. So the next agreement should provide financial incentives for countries rich with forests, and provide Payment for Environmental Services (PES) directly to the local people [11].

UN-REDD and FCPF – What is their role?

To help implement the REDD+ in the sub-national and national programs, if it will be the part of the after-Kyoto protocol, two main multilateral readiness programs were established, UN-REDD+ and Forest Carbon Partnership Facility (FCPF). The aim of both of these two programs is to prepare the countries for REDD+ implementation, so they appear overlapping, but they maintain some remarkable differences (Box 2).

UN-REDD was established by collaboration of three UN agencies, UNEP, UNDP and FAO. UN-REDD is a multi-donor trust that provides funding with an aim in significantly reducing global emissions from deforestation and forest degradation in developing countries. Initially nine tropical countries from Africa, Asia and Latin America were chosen like pilot countries for UN-REDD Programme, which supports the capacity building of national governments to be ready to prepare and implement national REDD strategies, of course with involvement of all stakeholders [12] (Figure 1).

Box 2

Other REDD+ related multilateral funds

Forest Peoples Programme (FPP) is an international organisation that operates in tropical countries and it tries to make better connection between policy makers and forest people. Through capacity building, advocacy and practical projects FPP supports forest people to deal directly with the outside factors that shape their lives [24]. Forest Peoples Programme supports the rights of peoples who live in forests and depend on them for their livelihoods. They base their work on subjects as environmental governance, climate and forests, legal and human rights and responsible finance.

Congo Basin Forest Fund (CBFF) was launched in June 2008 with a grant of £100 million from the governments of the UK and Norway to develop the capacity of the people and institutions of the Congo Basin to preserve and manage their forests [25]. It accepts proposals from NGOs and governments to develop projects related with sustainable management of the forest, included projects elated with climate change mitigation.

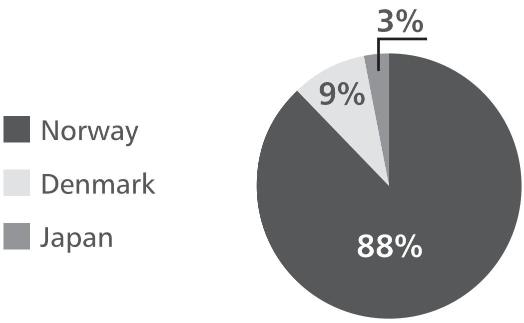

FIGURE 1
Donors by countries for UN-REDD program (in total 97.67 USD mn, according to: http://www.climatefundsupdate.org/listing/un-redd-programme)

The other program, The Forest Carbon Partnership Facility (FCPF) is a World Bank program that was created to help and assist developing countries in tropics to reduce emissions of deforestation and forest degradation. This program has two main objectives, like UN-REDD it has objective of capacity building for REDD+ readiness, and the second aim is to test a program regarding incentive payments in some pilot countries [13] (Figure 2).

The main differences and similarities between these two programmes

Behind the idea of FCPF and UN REDD mechanism is a support of activities regarding REDD+ and to

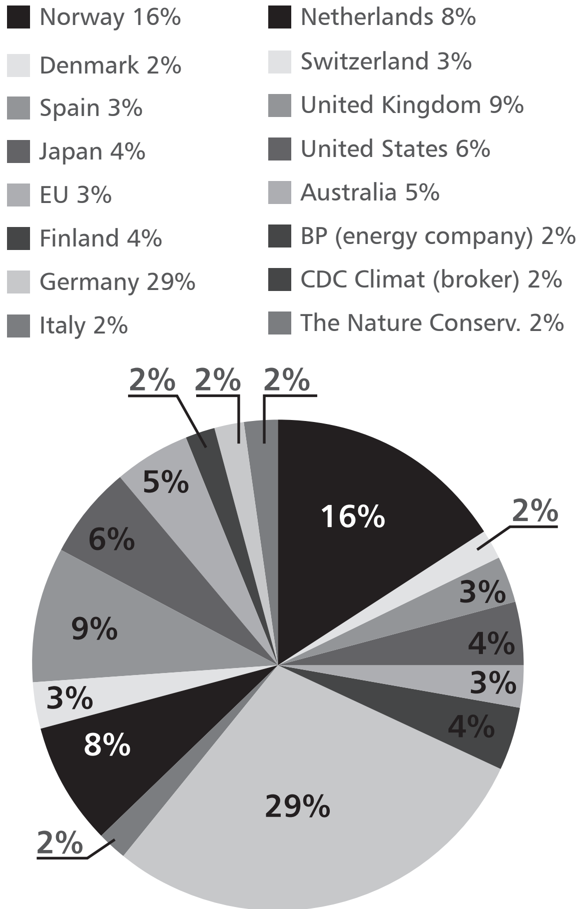

FIGURE 2
Donors by countries and organisations for FCPF program (in total 320.57 USD mn, according to: http://www.climatefundsupdate.org/listing/forest-carbon-partnership-facility)

help developing countries in reducing their emissions from deforestation and forest degradation. Also the idea behind both mechanisms is to work on multilateral basis with donors and REDD+ countries and that the REDD+ is an efficient way to mitigate the climate change [14]. Also both institutions work closely with UNFCCC, to support implementation of UNFCCC decisions. One of the main differences is that UN- REDD is seeking consensus and raising awareness of importance to include REDD+ into compliance market [15] while FCPF provides practical insights and knowledge generated from the FCPF's pilot implementations and carbon finance experiences to all interested entities [16]. Also there is a difference regarding decisions which countries can enter in REDD+ scheme like pilot countries, and a difference regarding the number of countries involved in the pilot scheme.

While UN-REDD is purely capacity building programme, for FCPF readiness is just the first part of their project, later they would focus more on Carbon Fund projects [17]. Indeed UN-REDD focuses on capacity building regarding readiness, while FCPF uses readiness only like first step to the carbon funding. Also there is a different view between these two initiatives, while UN-REDD, like a part of UN, is a non-profit organisation, FCPF like a part of World Bank is an investor oriented programme (Table 1).

TABLE 1
The main similarities and differences [17]

	UN-REDD	FCPF
Activites supported	• Country Programs • Global Program	• The Readiness • Mechanism • Carbon Finance Mechanism
Conditions and eligibility requirements	1. Request for quick start action 2. Existing collaboration with UN partners in related areas for rapid progress 3. Emission reduction potential	REDD countries are selected based on their submission of a Readiness Plan Idea Note (R-PIN) and in accordance with the following criteria. 1. Relevance of the country in the REDD context 2. Quality of the Readiness Plan Idea Note 3. Geographic and biome balance
Consultations with non-government stakeholders	Indigenous Peoples (IPs) and Civil Society (CSOs) are represented on the 19 seats of the Policy Board of the UN-REDD Program by the seat for Indigenous Peoples (IPs) and the seat for Civil Society (CSOs). In addition, there are 29 observers at Policy Board.	The country-led Readiness process will include an intensive stakeholder consultation process designed to: 1. Inform relevant stakeholders 2. Identify affected stakeholders 3. Involve key national and international scientific and political stakeholders
Uptake and projects supported	Partnerships with 29 countries in total, 13 of which have received funding allocations for National Programmes, as of May 2011	37 countries have signed an participant agreement and 17 of these have received an assessment of their R-PP proposals.

DISCUSSIONS AND CONCLUSION

Some of the main challenges regarding implementation of REDD+ on national level is related with the tropical countries political background. How most of the tropical countries with significant forest resources have problems of weak institutions, corruption, weak enforcement of laws and lack of transparency to create a credible REDD+ scheme there is a need of capacity building, law enforcement and strengthening of the governance [18]. REDD+ mitigation mechanism should have a credible system for Measuring, Reporting and Verifying (MRV) changes in carbon forest stock, which each country should set its own [7]. To properly develop and implement REDD+ mechanism there is still a need to resolve many challenges. The most important challenges are: a) Monitoring, reporting and verification for national inventory purposes, b) Capacity building, law enforcement and governance strengthening, including land tenure and c) Minimizing the perverse incentives [19]. There is also a need for high quality of national baseline and greenhouse inventories, for clear data about land use and land use changes, especially regarding degradation and deforestation, in aim to establish baselines.

The analysis of UN-REDD and FCPF programs reveals how they are largely overlapping especially in the current phase of building capacity. They have common donors, strategies and some countries benefit of both. Anyway the UN-REDD seems to maintain a more social oriented approach while the presence of carbon fund suggest a natural financial approach by the World Bank. The presence of these two initiatives seems to be related strongly to the need of both the institutions to be included in REDD+.

Both the programs have been challenged from different point of view but especially in the involvement of indigenous people and local community. Forest and European Union Resource Network (FERN) published a report where they reveal how the initiative was launched with a top-down approach without any consultation with civil society or organisation [20]. FERN in its document "Cutting corners" [21] concludes that FCPF process has been rushed "with little or no consultations with indigenous people, local communities or civil society organisations, and failed to meet the Bank's own standards". Respond to these critics were the series of regional consultations organised by World Bank, but anyway FCPF is still largely criticized by different NGOs for the poor involvement of people. Also there were critics related with UN-REDD Framework Document [22], related with its social approach. All these critics have to be taken in consideration by both sides to facilitate the implementation of REDD+.

REDD+ shouldn't be seen only as a tool to reduce GHGs emission, but also as a tool to preserve the forest and their biodiversity, and as a tool to provide and increase the sustainable income to the people living from the forest that are sometimes amongst the world's poorest people, for instance by Payment for Environmental Services (PES), So the goal of the REDD+ is to act like a mechanism that would help prior to decrease CO_2 emissions and global poverty and at the same time save and improve the biodiversity and ecosystems services.

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Review paper

The Silviculture of Black Locust (*Robinia pseudoacacia* L.) in Hungary: a Review

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Abstract

Background and purpose: *Black locust (*Robinia pseudoacacia *L.) was the first forest tree species introduced and acclimated from North America to Europe at the beginning of the 17th century. Although native of North America, black locust is now naturalized and widely planted throughout the world from temperate to subtropical areas. In Hungary, this species has played a role of great importance in the forest management, covering approximately 23% of the forested area and providing about 19% of the annual timber output of the country. Due to the increasing interest in black locust growing in many countries, this study has been compiled with the aim of giving a summary on the basis of research and improvement connected with the species over the past decades.*

Material and methods: *Black locust forests in Hungary have been established on good as well as on medium and poor quality sites. Establishment of black locust stands producing timber of good quality is possible only on sites with adequate moisture and well-aerated and preferably light soils, rich in nutrients and humus. Black locust forests on medium and poor quality sites are utilized for the production of fuel wood, fodder, poles and props, as well as for honey production, soil protection and environmental improvement.*

Results and conclusion: *Hungary has got much experience in black locust growing, as it has been grown for more than 250 years in the country. It is a fast growing, nitrogen fixing, site tolerant, excellent coppicing species with frequent and abundant seed production and relatively high yielding potential. It has a durable and high quality wood, which is used for many purposes. Being aware of the importance of black locust, forest research in Hungary has been engaged in resolving various problems of black locust management for a long time, and a lot of research results have already been implemented in the practice.*

Keywords: *black locust (*Robinia pseudoacaia *L.), clone selection, stand establishment, tending operations and yield; dendromass production, diseases*

INTRODUCTION

Black locust was introduced in Hungary between 1710 and 1720. The first large black locust forests were established at the beginning of the 18th century on the Great Hungarian Plain stabilizing the wind-blown sandy soil. In the country, black locust occupied 37.000 ha in 1885, 109.000 ha in 1911, 186.000 ha in 1938 and 415.000 ha in 2009. At present, it is the most widely planted species in Hungary, covering 23% of the country's total forest area. One-third of these stands are high forests and two-third of them are of coppice origin. In the 1960s, Hungary had more black locust forests than the rest of European countries together [1-3].

Black locust forests in Hungary have been established on good as well as on medium and poor quality sites. Establishment of black locust stands producing timber of good quality is possible only on sites with adequate moisture and well-aerated and preferably light soils, rich in nutrients and humus. Black locust forests on medium and poor quality sites are utilized for the production of fuel wood, fodder, poles and props, as well as for honey production, soil protection and environmental improvement [54].

The most important black locust growing regions in Hungary are located in the south and south-west Transdanubia (hill-ridges of Vas-Zala county, hill-ridges Somogy county), the plain between the rivers Danube and Tisza (Central Hungary) and north-east Hungary (Nyírség region) (Figure1).

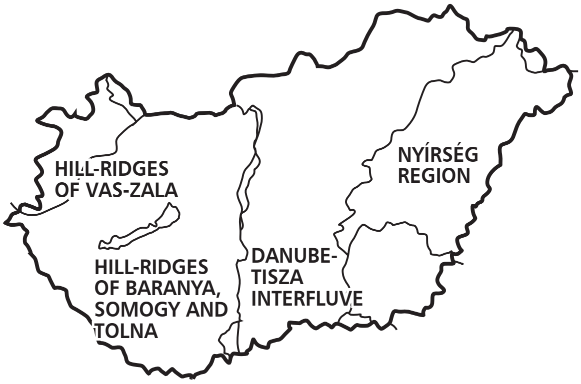

FIGURE 1
*The main growing regions of black locust (*Robinia pseudoacacia *L.) stands in Hungary*

BLACK LOCUST SILVICULTURE

Geographic distribution and variability as well as physiological attributes of black locust

Within the genus *Robinia* the species *R. pseudoacacia* L. black or common locust, and some of its varieties (shipmast locust - *var. pyramidalis*), and spineless locust are promised for forest tree breeding. Other varieties are rewarding with respect to breeding for honey prduction: early flowering (*var. praecox*), late flowering (*var. galiana*) and continuously flowering (*var. semperflorens Car.*), in addition two late flowering and abundantly nectarine spcies, *R. luxurians* (rich locust) and *R. viscosa* (sticky locust); and hybrids of the latter two species with black locust.

The species is indigenous to the eastern and central part of USA between latitudes 43° and 35°N. In its natural range tree types of black locust are distinguished by shape:

- *Pinnata* (feathered) type: the stem is straight. It occurs along the northern edge of the species' area at the elevation of about 800 m with *Picea rubra* and *Acer saccarinum*.
- *Palmata* (palm-like) type: the main part of the stem is crooked and not clearly visible in the crown. Its natural area is in the medium elevations of the Appalachians.
- *Spreading type:* it seems to be unsuitable for selection. It occurs at the low elevations of the Appalachians, and in the southern part of the natural area.

Physiological attributes of black locust are the followings:

- rapid growth rate, out-competes weeds,
- indeterminate growth habit,
- nodulated roots, fixes atmospheric N_2,
- high density wood,
- good pulping qualities,
- highly resistant to fungi, pests,
- tolerates low fertility sites,
- resistant to drought stress,
- resistant to air pollutants,
- resistant to low temperatures,
- resistant to high temperatures,
- very high net photosynthetic rates,
- high light demand,
- high leaf area accretion rate,
- high transpiration rate,
- rapid leaf position adjustment to changes in light intensity,
- small leaflets minimalize self-shading,
- vigorous sprouting of root cuttings,
- very plastic root system: strong tap and dense fibrous upper roots,
- flowers at early age,
- produces abundant seed crops,
- high seed viability and longevity,
- seeds easily cleaned, stored, sown,
- seeds germinate rapidly,
- easily micropropagated,
- high leaf protein,
- much genetic variation.

Clone and cultivar selection

In Hungary, the main goals of the first black locust breeding programme (in the 1960's) were to select new clones and cultivars providing good quality and volume of industrial wood. Superior tree groups have been identified in some seed grown stands. Graft material was taken from the plus trees and planted in test plots at Gödöllő (experimental station of FRI). *Mono-* and *multiclonal cultivars* were developed and a seed orchard was established from the selections. The Hungarian Forest Research Institute coordinated this research programme. With respect to the volume expected at felling age, the *'Jászkiséri', 'Kiscsalai', 'Nyírségi', 'Üllo˝i'* and *'Szajki'* cultivars proved to be the best [1, 2, 5].

In Hungary, the range of sites optimal for black locust growing is rather limited. Therefore, black locust growing is often exercised on sub-optimal sites. Possibilities for black locust growing are highly influenced by climatic conditions and extremes (temperature and precipitation, water supply and unfavourable soil conditions). In the lowlands, which are the most suitable regions for black locust growing, the annual precipitation is not more than 500–550 mm, most of which is outside the growing season. Thus drought is a frequent phenomenon in the summer period coupled with very high atmospheric temperatures (30–35°C). Relative air humidity in July is usually between 20–50 %. Due to the filling up of basin-like lowlands in Hungary, site conditions show a mosaic pattern, which changes even over small distances causing widely differentiated growth potential for black locust plantations. For this reason, there are no large, contiguous lands of homogenous site quality for black locust, and their growth and productivity may be very different across a large field. Therefore, the main aim of *our new selection work* is to find and improve black locust clones and cultivars, which perform good shape, provide good-quality wood material for industrial purposes, and which are able to tolerate the changing ecological conditions as well. As a result of our new selection programme 12 black locust clones (*'KH 56A 2/5', 'KH 56A 2/6', 'MB 12D', 'MB 17D 4/1', 'CST 61A 3/1', 'MB 15A 2/3', 'MB 17D 3/10', 'PV 201E 2/1','PV 201E 2/3', 'PV 201E 2/4', 'PV 35 B/2',and 'PV 233 A/2'*) have been recommended [6-9, 10].

Propagation

In Hungary, black locust plants are commonly multiplied by two methods: by seed and by root cuttings. Growing trees from *seed* is a relatively simple method for reliably producing seedlings on a large scale under a variety of circumstances. There are two state approved seed production stand-regions meeting the requirements for black locust seeds (one in the plain between the rivers Danube and Tisza and the other in the Nyírség region) [11]. Seeds are collected by sieving the top 20 cm of soil beneath the selected seed-producing stands. As the seeds of black locust used to remain dormant in the soil for several years, the age of seeds within the lots collected in this way is very variable. This is the reason of viability and germination are so variable. Therefore, before sowing, an accurate seed test is necessary. Seed production for sowing and scarification is carried out by the agency responsible for collecting the seed. It is advisable to treat the seeds against fungi, and this is done in a small concrete mixer. 200–250 thousand seedlings of 40–90 cm high and 5–12 mm in base diameter are raised on one hectare. Mechanization of the method is easy and the production costs are relatively low.

Propagation from *root cuttings* is suitable for reproduction of superior individuals or varieties (cultivars). By applying this method, superior traits of the selected trees can be preserved in the clones. Production of plants in this way demands more care than raising seedlings from seeds. For this propagation method, root pieces cut into 8–10 cm or chopped to 3–5 cm in length are used. Plant spacing in the rows should be 5–8 cm .

Almost 25 new cultivars or selected clones were micro-propagated during the last few years in the Micro-propagation Laboratory of Research Institute for Fruit growing and Ornamentals, Érd in collaboration with the Hungarian Forest Research Institute. *Plant tissue culture methods* provide us with new means to speed up vegetative propagation of recently selected clones and give us the opportunity to establish new clone trials and a seed orchard with them [7, 8, 12].

Stand establishment, forest tending and yield

Climate, hydrology and soil types are the factors that determine the site type, and this in turn determines the choice of tree species. The water regime of the soil is also highly influenced by the texture of the soil, whether it is humus, coarse sand, loam or clay. Black locust – because of its high requirement for both water and aeration in the soil – cannot be grown even on any soil composed of humus, coarse sand or clay if the rooting depth is very shallow.

Black locust requires well-drained soils with adequate moisture until the associated nitrogen-fixing *Rhizobium* bacteria are able to thrive. That is why soil preparation (total or partial) to improve aeration and the water regime of the soil and tilling of the inter-row space may become necessary.

Black locust afforestation and artificial regeneration may utilise seedlings. The most popular spacing for black locust in Hungary is 2.4 m by 0.7 to 1.0 m, requiring at least 4000 seedlings/ha. Black locust stands are often regenerated by coppice (from root suckers) as well. In young stands of coppice origin, a cleaning operation should be carried out to adjust spacing when the stands are 3–6 years old and should reduce stocking to less than 5000 stems/ha [10, 13].

The black locust is a fast-growing tree species, which, up to the age of 10–15 years, is able to close canopy openings caused by tending operations quickly, but the closure is much slower in later years. Height growth peaks within the first five years, while diameter growth culminates in the first decade. The peak of current annual increment is at about the age of 20, whereas that of the mean annual increment is at about the age of 35–40 years.

To find the right cleaning and thinning intensity, the so-called growing space index is a good method. This index expresses the mean distance between trees (in a triangular pattern) as a percentage of mean height after cleaning and thinning. The mean value of the index for black locust stands should be 23–24 %. Pruning of crop trees should also be carried out. After finishing selective thinning, stems must be free of branches up to a height of 4–6 m.

The objective of tending is to produce a high proportion of good quality saw-logs from stands of yield class I and II; some saw-logs and a high proportion of poles and props from stands of yield class III and IV; and poles, props and other small-dimension industrial wood from other yield stands [14-16].

TABLE 1
Tending regimes for high and coppice common black locust stands (Yield table: source [17])

Operation	Age (yr)	Height (m)	Basal area (m^2/ha)	DBH (cm)	Density (stems/ha)	Growing space (m^2)	Volume cut (m^3/ha)
Yield Class I							
Cleaning	5	8	7	6	2500	2.1	6
Cleaning	9	13	13	10	1700	2.6	20
Selective thinning	12	16	12	13	900	3.6	30
Selective thinning	18	20	17	19	600	4.4	35
Increment thinning	25	24	18	24	400	5.4	50
Harvest cutting	40	27	32	32	400	5.4	425
Yield Class II							
Cleaning	6	8	7	6	2500	2.1	5
Cleaning	10	12	13	10	1700	2.6	20
Selective thinning	15	16	14	14	900	3.6	35
Increment thinning	22	20	17	20	550	4.6	45
Harvest cutting	35-40	23	29	26	550	4.6	340
Yield Class III							
Cleaning	7	8	7	6	2700	2.5	4
Cleaning	12	12	14	10	1800	2.5	15
Selective thinning	17	15	16	14	1100	3.3	35
Increment thinning	22	18	17	17	700	4.1	40
Harvest cutting	30	20	26	22	700	4.1	270
Yield Class IV.							
Cleaning	8	8	8	6	3000	1.8	4
Cleaning	13	11	15	10	2000	2.4	15
Selective thinning	19	14	13	13	1000	3.4	35
Harvest cutting	30	17	25	18	1000	3.4	235
Yield Class V							
Cleaning	9	7	7	7	3000	1.8	4
Cleaning	15	10	9	9	1500	2.8	20
Harvest cutting	25	14	20	13	1500	2.8	155
Yield Class VI							
Cleaning	10	6	7	5	3500	1.6	-
Cleaning	15	8	8	7	2000	2.4	15
Harvest cutting	20	10	12	9	2000	2.4	70

On Table 1 the most important stand structure and yield factors of black locust main crops (height, basal area, DBH, stem number, growing space and volume cut) can be seen.

The yield and stand structure of black locust stands can be described by the following formulas and coefficients:

1. H= mean height of the main crop weighted by the basal area (m):
   $H\% = 123.12\ (1-e^{-0,070333A})^{1.111638}$
   where A = age of stand in years;
   H at the age of 20 = 100%

2. DBH = the diameter at breast height of the main crop (cm):
   $DBH = (69.9675 + 1.00625A)\ \frac{H}{100} (r = 0.8092)$

N = number of stems per hectare of the main crop:
$N = e^{9.81801-1.15147 \times \ln DBH}$ (r = 0.9421)

According to our yield table [17] the volume of main crop varies between 80 and 280 m^3/ha in function of yield classes at the age of 30 years, which is the average rotation age for black locust stands in Hungary. The black locust stands of Yield Class I-II have a rotation of 35-40 years and an annual incre-

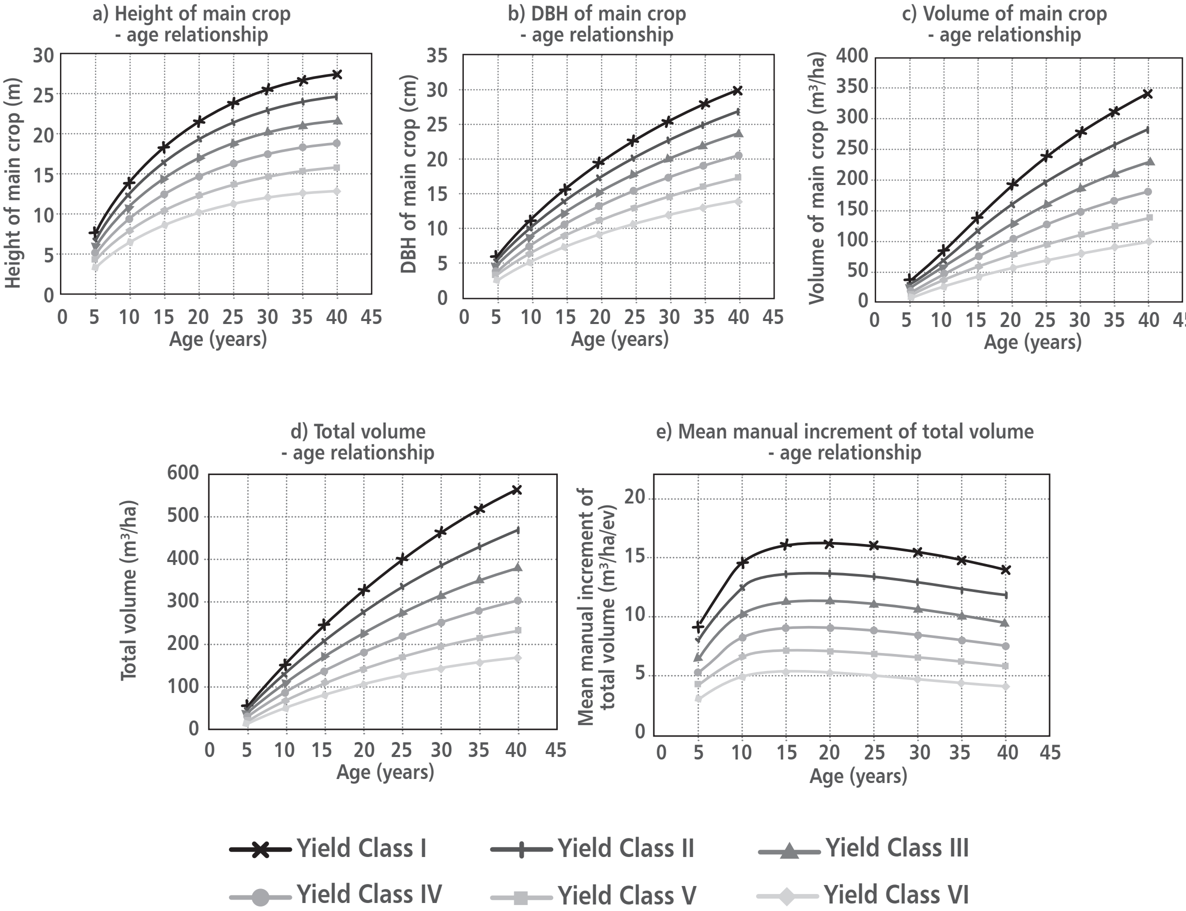

FIGURE 2
Black locust stand structure factors in function of age (Yield table: source [17])

ment of total volume of 12-14 m^3ha-1yr^{-1}. The stands of Yield Class III-IV have a rotation of 30 years and an annual increment of 8-9 $m^3ha^{-1}yr^{-1}$. Finally, the poorest stands (Yield Class V-VI) have a rotation of 20-25 years and an annual increment of 4-6 $m^3ha^{-1}yr^{-1}$ (Figure 2). In first generation coppice stands, growing stock, increment and health are similar to those in high forests.

Black locust short rotation forestry

More and more agricultural land is being taken out of use for food crops, some of which can be used for wood energy production plantations. Black locust is the very best tree species for this purpose, since it has excellent energy production properties, such as:

- vigorous growing potential in juvenile phase,
- excellent coppicing ability,
- high density of the wood,
- high dry matter production,
- favourable combustibility of the wood,
- relatively fast drying,
- easy harvesting and wood processing.

In the last decade several energy producing plantations have been established in Hungary. In these experiments, several spacing treatments were tested and the common black locust as well as its cultivars were compared.

In Helvécia (central Hungary, sand-soil region) an energy plantation was established using common black locust and its cultivars. The various spacings of the common black locust were: 1.5x0.3 m, 1.5x0.5 m and 1.5x1.0 m.

Results concerning the trial with cultivars and common black locust at the age of 3, 5 and 7 are provided in Table 2 and focused on the differences in the values of the mean annual increment of oven - dry stem dendromass in Figure 3. At the age of 5, the highest increment value was produced by the cultivar *'Üllői'* (8.0 to ha^{-1} yr^{-1}), followed by 'Jászkiséri' (7.4 to ha^{-1} yr^{-1}) and the common black locust (6.7 to ha^{-1} yr^{1}). At the age of 7, the order was the following: *'Üllői'* cultivar (9.7 to ha^{-1} yr^{-1}), common black locust (8.4 to ha^{-1} yr^{-1}) and *'Jászkiséri'* cultivar (7.6 to ha-1 yr^{-1}).

TABLE 2
Evaluation of a short-rotation plantation with black locust cultivars on the base of plot averages (Helvécia 80/A); Stem number = 6666 per ha, H=height, DBH= diameter at the breast height (1.3 m).

Cultivars	Age (yr)	Mean		Oven-dry stem dendromass (to ha^{-1})	Mean annual in-crement of oven-dry stem dendromass (to ha^{-1} yr^{-1})
		H (m)	DBH (cm)		
'Üllői'	3	4.1	3.1	8.9	3.0
	5	6.2	4.9	40.1	8.0
	7	9.3	6.4	68.1	9.7
'Jászkiséri'	3	3.6	2.9	7.1	2.4
	5	6.1	4.7	37.1	7.4
	7	8.8	6.2	53.2	7.6
'Nyírségi'	3	3.1	2.7	7.2	2.4
	5	5.3	4.2	28.4	5.7
	7	7.6	5.1	46.2	6.7
'Kiscsalai'	3	3.9	3.2	12.5	4.2
	5	6.1	4.6	31.1	6.2
	7	8.4	5.9	49.7	7.1
Common black locust	3	3.7	3.1	10.9	3.6
	5	6.1	4.7	33.5	6.7
	7	8.2	5.5	59.1	8.4

The data from the Table 2 and the Figure 3 indicate that it is not reasonable to harvest the plantations in the first three years, as the mean annual increment of oven-dry sterm dendromass at the age of 5 and 7 is 1.5-3 times higher than it was at age of 3. This result is important as it is known that too early harvesting may also increase the population of biotic pests [18] .

According to the significance test at α = 5% level, significant differences were found in the mean annual increment of oven - dry stem dendromass ($F=40.991>F_{0,05}=3.422$, $SD_{5\%} = 0.69$ m^3 ha^{-1} yr^{-1}). To compare the concerning yields produced by the black locust clones and the common black locust, it is no worth using expensive black locust clonal material for setting up short rotation plantation.

Black locust energy forests can also be established by coppicing. Advantages of energy forests of coppice origin are that the cost of establishment is low compared to that of soil preparation, plantation and cultivation. From the developed root system of the previous stand, a large dendromass can be produced within a short time period. Disadvantages of these forests are that the area distribution of trees in coppice stands is not as uniform as in plantations optimized for energy production. In coppice stands the quantity of the produced dendromass is lower and the length of growing time is highly influenced by the uneven distribution of stems.

The first peak of the annual increment in volume of black locust energy forests established from sprouts falls between the age of 3 and 5 years. Then, the annual increment declines and a new peak occurs between age of 9 and 12 years. A further maximum is expected later on, at about 15 years because of an even higher degree of mortality. Approximately one-third of the stems are lost at age 7 and 8. By the 12-13 years, the stem numbers decreased to less than 50 %.

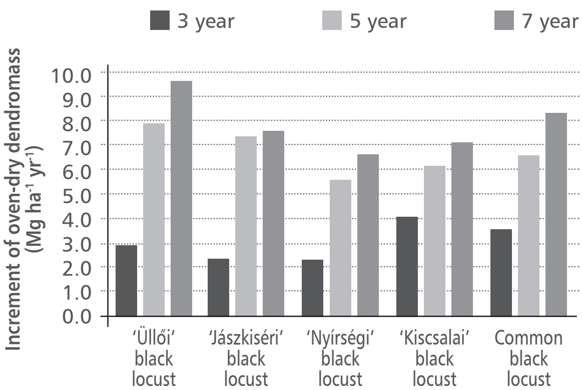

FIGURE 3
Mean annual increment of oven-dry stem dendromass of black locust cultivars and common black locust at different ages

The experiences from both the planted and the coppiced energy plantations and other stands indicate that it is not reasonable to harvest in the first three years, as the yield in oven-dry weight in the fifth year is 2-3 times higher than it is in the fourth year. Harvesting too early may also increase the population of biotic pests [18-20].

Diseases, insects, and other damaging agents of black locust

Regarding the abiotic damages, frost damage can be considered as the most important factor (early and late frosts, hard winter frosts). Black locust is seems to be good disease and pest resistant. However in the ultimate time more and more potential pests have appeared in the European black locust forests. Several fungi infects black locust, specially the seeds and seedlings, for example *Alternaria tenuis* (NEES) or *Fusarium oxysporum* (SCHLECHTENDAHL). In case of biotic damages we have to mention the damages caused by pests; such as Black bean aphid (*Aphis fabae* SCOPOLI).

Black locust scale (*Parthenoclanium corni* BOUCHÉ), Black locust leafminor (*Phyllonorycter robiniella* CLEMENS), or Cotton bollworm (*Helicoverpa armigera* HÜBNER). Game damage can also cause relative high shortfall in the annual increment. Main part of game damage is caused by rabbit and deer. Rabbits are peeling off the bark of young trees, deer and roe deer like browsing the fresh shoots and buds.

CONCLUSIONS

Black locust was the first forest tree species introduced from North America to Europe. Hungary has got much experience in black locust growing, as it has been grown for more than 250 years in the country. Being aware of the importance of black locust, forest research in Hungary has been engaged in resolving various problems of black locust management for a long time, and a lot of research results have already been implemented in the practice.

In the future there are two bigger regions, where the fast spread of black locust can be expected. In Europe the Mediterranean countries (Italy, Greece, Spain and Turkey), while in Asia China and Korea may become the most prominent black locust growers.

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Professional paper

Calculation of Economic Rotation Period for Even-Aged Stand in Croatia

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Abstract

Background and purpose: Even-aged forests prevail in Croatia's forestry. Rotation period is based mostly on natural parameters. In practice, rotation period is given by Croatian Rulebook of forest management. Cutting age is determined based on inventory data and many other stand characteristics. Rotation period is a planned time and it always has to be unique for particular tree species, and cutting age is the age of a stand at the moment of the final cut. The aim of the paper is to compare rotation period based on economic parameters and rotation period determined by using forest inventory data.

*Material and methods: Owing to absence of long term stand calculation data, research object was taken from Forest Management Handbook (1995). Mean annual increment (MAI) and current annual increment (CAI) provided fundamental data for calculations. The research was conducted at one hectare Common Beech (*Fagus sylvatica *L.) stand. Assortment structure and value of timber was estimated by the present cutting value method calculated by using Croatian forests Ltd. Price list for the year 2008. Labor costs in forest exploitation were also taken into account.*

Results and conclusion: In order to achieve cost-effective management of common beech stands, it is necessary to adjust current optimal rotation period. Optimal rotation period should be based on management goals as the main factors. So far the most common criterion adopted in Croatian forestry has been the rotation of maximum sustained yield or maximum Mean annual increment. The presented results indicate that common forest management practice should be changed in order to achieve cost-effective management of beech stands in the future.

*Keywords: forest economics, economic rotation period, even-aged forests, common beech (*Fagus sylvatica *L.)*

INTRODUCTION

One of the fundamental questions in forest economics is when is the best time to harvest a forest stand. Forest rotation period is a question of economic goal and an essential basis of long-term planning in forestry all together, but also in individual units of administration and management such as forest management areas, forest industry and forestry [1]. Rotation period represents the number of years which have passed between the establishment of the stand and its final harvesting at the end of regeneration period.

After achieving the management goal the cutting of all trees in the same area occurs and stand regeneration begins. The optimal rotation refers to optimal time for final harvesting (clear-cutting).

The main issue in optimal rotation is choosing the optimal time for final harvesting, followed by reforestation and another even-aged stand. In economics, these kinds of decisions in general should be made based on the forest owner's optimization behavior. Therefore, forest owner should first specify the target (or actually choose among three alternative targets): (1) maximum sustained yield, (2) forest rent or (3) land rent that a forest owner tries to maximize [2].

The debate on the appropriate criteria for determining the optimal forest rotation is a long-lasting one [3-5]. The most common criteria [6] adopted in forestry is the rotation when stand achieves maximum sustained yield or maximum mean annual increment.

The minimal rotation period for even-aged stands is prescribed by the Rulebook of forest management [7]. For protective forests and forests with special purpose rotation is usually based on physiological maturity of the trees. In uneven aged forests cutting age for forest trees is based on tree diameter and cutting maturity, i.e. the optimal diameter of the tree; when the tree is mature enough to be harvested. Cutting maturity means that the age when net present value of forest is maximized whereas value may include timber and non-timber values. This statement refers to mature timber, and not to old growth and thinning [8]. The volume of wood to be cut should take into account the demand of the market, but also the capacity of the forest, whereas there is a need to take into account production capabilities, along with maintaining or increasing forest stock [9]. Determining economically the most advantageous rotation period is an investment problem as well as a forest (management) inventory problem associated with particular land use [10].

Economic rotation of forest stand is achieved when the maximum income is reached, i.e., when the most valuable timber stocks are produced. Increase in the value of growing stock is more stable than the increment value. Maximum growth value occurs after the maximum of the timber value increment. Age of economic maturity can be determined by using the tangent drawn from the origin of coordinate system on the curve value of growing stock or determine the age where the highest possible income would be achieved by calculation.

In even-aged forests economic maturity results in a very long rotation, especially for those tree species whose price increases proportionately with age. In case of Pedunculate oak (*Quercus robur* L.) forest the value increases in correlation with the cube of diameter at breast height [11]. As the diameter of elite trees increases, the value increases as well or remains constant. This means that Pedunculate oak trees should not be cut as long as they are healthy and their value is constantly increasing.

In order to ensure sustainable income from a forest there is a need to find the answer to how, where and when timber should be cut in a forest and how the stand would be regenerated. Sustainable yield will be acchieved if the forest has not been cut more than its annual growth increment.

In this paper we are analyzing whether it is possible to determine economic rotation for even-aged forest based on natural and economical parameters. Comparison between the rotation period used in Croatian forestry practice and economic rotation period was made.

MATERIAL AND METHODS

Common beech (*Fagus sylvatica* L.) is the most common tree species in Croatia, spreading over 744 796 ha. It takes the highest proportion in the Croatian growing stock (36%) [12].

Beech forests are classified according to the management of forest types for the economic production of quality logs (veneer logs, peeling logs and sawing) and wood for chemical processing. Even-aged management system always gives better round wood than the selective one.

Because of the long production (and rotation) period product prices are affected by inflation. Prices of timber assortments and labor price are not equal throughout the production period (100 years in this case) and it is difficult to calculate them precisely. Due to various limitations of long term calculation the assumption of constant prices for products, silvicultural and administrative costs have been used. In calculation, inflation will be zero. Thus, the average costs and prices for goods and services will be constant over time.

The subjects of the research are 14 common beech stands size of one hectare, one per decade. Research stands are on first site quality-class managed with even-aged management system. The data source was Forest Management Handbook from which data on development of growing stock, current annual increment (CAI) and mean annual increment (MAI) from stand establishment until the end of the rotation (Table 1) were taken.

Yield tables are used for comparison of real growing stock status in a real forest under normal conditions. The calculation is made on the basis of an established tariff sequence obtained from double-entry tree volume tables and a height curve. Diameters at breast height were measured by total callipering. In the even-aged stands that are allocated for felling in the following ten years, all trees were measured.

TABLE 1
Stand characteristics (CAI- Current Annual Increment, MAI- Mean Annual Increment) [13]

Age	Stand volume (m^3/ha)	Current annual increment (m^3/ha/year)	Mean annual increment (m^3/ha/year)
20	100	12.0	5.5
30	185	13.0	7.7
40	254	13.3	9.0
50	310	13.9	9.9
60	367	13.1	10.5
70	419	12.4	10.9
80	469	11.6	11.1
90	516	10.5	11.1
100	557	9.4	11.1
110	591	8.6	10.9
120	618	7.8	10.7
130	637	6.7	10.5
140	646	6.6	10.2
150	654		10.0

For more accurate estimation of wood value data for wood above 3 cm was used. By using the CAI and MAI data (natural indicators) minimum rotation period is determined. Minimum rotation period was defined when the CAI and MAI were equal. In this case it is at the age of 85 years. Rotation period should not be shorter than prescribed, but it is allowed, in particular circumstances, to make the final cut before planned rotation period is reached. In Croatia prescribed rotation period for even-aged Common beech stands is 100 years.

Even though determined minimum rotation period is 85 years, stand will be cut much later. The reason for that lies in the fact that other forest services apart from timber are important too, as well as increased value of timber if the cutting is postponed.

The present cutting value method

The economic value of forest can be calculated from the selling prices of the timber assortments. In this method of determining the economic value, forest is considered as a final product that can be cut and sold immediately. Consequently, this method is often recognized in literature [11] as value of forest stand which is cut and sold at any age. To determine the value of the stand based on the amount of its assortments it is necessary to take prices of assortments. Content of assortments must be multiplied by current price. Obtained result is the market value of the stand. This value is very low for young stands and it grows with age of the stand.

Economic rotation period

Economic rotation period is achieved when the maximum profit is reached (maximum forest rent), i.e. when the stand produces the most valuable timber stocks. Increment of growing stock value is more stable than growing stock volume. Maximum growth of value occurs after the maximum growing stock increment volume. According to the equation by the [9, 11, 14] forest rent (r) is:

$$r = \frac{Au + \sum D - (c + u \cdot v)}{u} \tag{1}$$

Where is: (Au) growing stock value in u-year stand, ($\sum D$) sum of values from thinning, (c) silvicultural cost, (v) the administrative cost per unit area, (u) forest size in hectares.

The formula gives the annual forest rent per unit area, assuming sustainable forest management. Silvicultural and administrative costs culminate at the same time as the forest rent.

RESULTS

To estimate current value of forest stands the method of the present cut value is used. Using data of growing stock with assortment tables and price lists, classification by age and worth is made. The estimated economic value of the existing growing stock and economic value of assortments harvested in thinning is presented in Table 2.

Stand value grows continuously over time. Thinning values start decreasing after the age of 60. This is due to the positive selection (as one of the causes), where we cut the low value trees after the half of the rotation period. The best quality trees wait for the end of rotation period to be cut.

By using the equation (1) net value is calculated for the period between age 20 and age 150. The stand and thinning volume was estimated by present cutting value method (using assortment tables and stumpage price from Croatian forest ltd. for year 2008). Silvicultural costs are calculated by Labor Price List [15] of Croatian Forests Ltd. Administrative costs (v) were estimated at 25% of total silvicultural (biological reproduction) costs [16]. Net value is a result of forest rent, which is generated through sales of timber assortments [17].

TABLE 2
Forest coverage in Croatia (source [8])

Age	Growing stock (m^3)	Stand Value (EUR)	Thinning Value (EUR)	Silvicultural costs (EUR/ha)	Administrative costs (EUR/ha)	Net Value (EUR)
20	100.00	1882.88	610.52	248.63	62.16	2182.61
30	185.00	3483.33	1064.05	433.33	108.33	4005.72
40	254.00	4782.51	1449.82	590.43	147.61	5494.29
50	310.00	5836.93	1543.96	628.77	157.19	6594.93
60	367.00	6910.17	1487.47	565.07	141.27	7691.30
70	419.00	8167.94	1442.55	548.00	137.00	8925.48
80	469.00	9142.64	1345.08	510.98	127.74	9848.99
90	516.00	10058.85	1247.61	450.81	112.70	10742.94
100	557.00	10858.10	1169.63	422.64	105.66	11499.44
110	591.00	11608.81	1158.92	336.00	84.00	12347.73
120	618.00	12139.16	1158.92	336.00	84.00	12878.08
130	637.00	12512.37	1139.27	211.92	52.98	**13386.75**
140	646.00	12689.16	1139.27	393.64	98.41	13336.38
150	654.00	12846.30				

Economic rotation is the rotation period of time when the highest net value is realized. Net value increases since the establishment of the stand, and reaches its maximum at the age of 130 years. The most important factors affecting the net value are silvicultural costs, administration costs and economic value of assortments harvested in thinning.

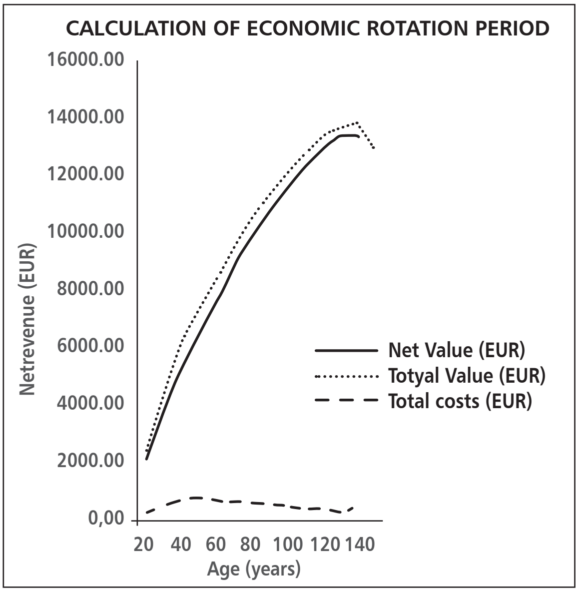

FIGURE 1
The highest net value

According to the calculation of the main parameters for value (stand value and thinning value) and forest management costs (silvicultural costs and administrative costs) from Table 2 and Figure 1, achieved economic rotation is highest at the age of 130 years with the amount of 13386.75 EUR net revenue.

CONCLUSIONS

Determining total value of forests, as well as values of certain functions is necessary for efficient management of natural resources and quality of decisions in forestry [11]. For valuation of forest stand according to various biological parameters different methods exist [18].

A rotation period starts with establishment of the forest stand and finishes after several decades, when most of the trees are harvested and regeneration of the forest stand is achieved. During the rotation period silvicultural activities generate forest management costs.

From the production point of view, the fact that both trees and forests can produce different goods and services at the same time is an advantage but poses also complex management problems.

For the research purpose timber production was the only management goal (non timber values were ignored). Thus, we have analyzed only one decision, the optimal economic rotation, by which forest owner can control profitability of timber production.

In order to achieve cost-effective management of beech stands, it is necessary to adjust the optimal rotation period. On beech stands in Croatia which are managed with even-aged management system the planned rotation of 100 years is applied. From economic point of view, this is not always acceptable and it is necessary sometimes to extend the rotation period by 30 years (as in this case), depending on the stand conditions. One of many reasons for cutting age not being much higher than 100 years is false beech heartwood affecting the quality of beech logs [19].

The optimal forest rotation is influenced by productivity (quality) of the land, the value of the timber produced, the harvesting costs, taxes and administration costs, forest interest rate and non-timber forest products and services. They vary widely in different circumstances. Timber prices and harvesting costs are most unpredictable variables due to the long production period in even-aged forests. Adding nonmonetary benefits derived from standing timber will lengthen the optimal rotation.

For more accurate calculation of rotation period it is necessary to carry out further research on different stands.

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