ACTA SILVATICA
&
LIGNARIA
HUNGARICA

Acta Silvatica & Lignaria Hungarica

An International Journal in Forest, Wood and Environmental Sciences

VOLUME 12, NR. 1
VOLUME 12, NR. 2
2016

UNIVERSITY OF WEST HUNGARY PRESS

ACTA SILVATICA ET LIGNARIA HUNGARICA
AN INTERNATIONAL JOURNAL IN FOREST, WOOD AND ENVIRONMENTAL SCIENCES
issued by the Forestry Commission of the Hungarian Academy of Sciences

The journal is financially supported by the
Hungarian Academy of Sciences (HAS),
Faculty of Forestry, University of West Hungary (FF-UWH),
Simonyi Karoly Faculty of Engineering, Wood Sciences and Applied Arts, University of West Hungary (SKF-UWH),
National Agricultural Research and Innovation Center, Forest Research Institute (NARIC-FRI),
Sopron Scientists' Society of the Hungarian Academy of Sciences (SSS).

HU ISSN 1786-691X (Print)
HU ISSN 1787-064X (Online)

Manuscripts and editorial correspondence should be addressed to
TAMÁS HOFMANN, ASLH EDITORIAL OFFICE
UNIVERSITY OF WEST HUNGARY, PF. 132, H-9401 SOPRON, HUNGARY

Phone: +36 99 518 122
Fax: +36 99 329 911
E-mail: aslh@nyme.hu
Information and electronic edition: http://aslh.nyme.hu

The journal is indexed in the CAB ABSTRACTS database of CAB International; by SCOPUS, Elsevier's Bibliographic Database, by EBSCOhost database and by De Gruyter Open Sp. z. o. o., Warsaw

Published by UNIVERSITY OF WEST HUNGARY PRESS,
BAJCSY-ZS. U. 4., H-9400 SOPRON, HUNGARY
Cover design by ANDREA KLAUSZ
Printed by LŐVÉR-PRINT KFT., SOPRON

ACTA SILVATICA ET LIGNARIA HUNGARICA

Vol. 12, Nr. 1

Contents

ACTA SILVATICA ET LIGNARIA HUNGARICA

Vol. 12, Nr. 2

Contents

ACTA SILVATICA ET LIGNARIA HUNGARICA

Vol. 12, Nr. 1

Tartalomjegyzék

Vol. 12, Nr. 2

DE GRUYTER OPEN DOI: 10.1515/aslh-2016-0002 Acta Silv. Lign. Hung., Vol. 12, Nr. 1 (2016) 9–22

Power of Forest Stakeholders in the Participatory Decision Making Process: A Case Study in Northern Italy

Alessandro PALETTO[a*] – Jessica BALEST[a] – Isabella DE MEO[b] – Grazia GIACOVELLI[a] – Gianluca GRILLI[c]

[a] Council for Agricultural Research and Economics – Forest Monitoring and Planning Research Unit (CREA-MPF), Italy
[b] Council for Agricultural Research and Economics – Agrobiology and Pedology Research Centre (CREA-ABP), Italy
[c] Department of Civil, Environmental and Mechanical Engineering, University of Trento, Italy

Abstract – In European countries, current forest use aims to enhance goods and services supplied by forest ecosystems, taking into account the multiple needs and interests of society through a participatory process. A successful participatory process requires a thorough analysis of stakeholders' perceptions and preferences. The aim of this paper is to investigate the differences between stakeholders' perceived influence and real power in forest management. A questionnaire survey was carried out among 51 forest stakeholders in a case study in the Italian Alps. Perceived influence was measured by asking stakeholders to rate on a 5-point scale the extent to which they can influence forest management issues. Real power was analyzed using social network analysis (SNA), investigating the relationships that stakeholders have with each other in the network. Real power was measured using a Freeman's degree centrality measure, which focuses on the direct ties coming in and out for each stakeholder. The results show that public administration is the category of stakeholders with the most power in all forest management issues, while the actors of the tourism sector are in a marginal position. In addition, the results of the study suggest that in many cases stakeholders have a distorted perception of their own power.

multi-objective forest management / influence / public participation / stakeholder analysis / social network analysis / Valle di Non (Italy).

Kivonat – Az erdőkhöz kapcsolódó érdekcsoportok érdekérvényesítő ereje részvételen alapuló döntéshozatali folyamatokban – Észak-olaszországi esettanulmány. Az európai országokban a jelenlegi erdőhasználat az erdei ökoszisztémákból származó termékek és szolgáltatások erősítését célozza meg megfelelve a részvételen alapuló folyamatokban megnyilvánuló sokrétű szükségleteknek és érdekeknek. A részvételen alapuló folyamatok sikere megkívánja az érdekeltek szemléletének és preferenciáinak részletekbe menő vizsgálatát. Jelen írás célja annak vizsgálata, hogy az érdekeltek észlelt és valós, erdőgazdálkodásra gyakorolt érdekérvényesítő képessége között milyen eltérések találhatók. Az olasz Alpokban 51 erdőkkel kapcsolatos érdekelt bevonásával kérdőíves felmérés készült. Az észlelt érdekérvényesítő képességet azon keresztül mérték, hogy az érdekeltektől azt kérték, hogy 5 fokozatú skálán jellemezzék, milyen mértékben képesek befolyásolni az erdőgazdálkodással kapcsolatos kérdésköröket. A valós érdekérvényesítő képességet a társadalmi kapcsolati háló elemzés módszerével vizsgálták, feltárva az érdekeltek egymás közötti kapcsolatait. A valós érdekérvényesítő

* Corresponding author: alessandro.paletto@entecra.it; p.za Nicolini 6, 38123 Villazzano di Trento, Italy

képesség mérése a Freeman fokszám központisággal történik, amely az egyes érdekeltek egymás közötti kapcsolatait veszi alapul. Az eredmények azt mutatják, hogy a közigazgatás csoportjába sorolható érdekeltek minden erdőgazdálkodást érintő kérdésben a legbefolyásosabbak, míg a turizmus szereplői a legkevésbé erősek. Továbbá a vizsgálat eredményei arra engednek következtetni, hogy sok esetben az érdekeltek torz képpel rendelkeznek a saját érdekérvényesítő képességükkel kapcsolatban.

többcélú erdőgazdálkodás / befolyás/ nyilvános részvételi folyamat / érdekelt elemzés / kapcsolati háló elemzés / Valle di Non (Italy)

1 INTRODUCTION

The participatory approach in the development of multi-objective forest management strategies has responded to the need to include multiple stakeholders and interests in the decision making process (Martins – Borges 2007, Pukkala 2002). This approach recognized that forest management should combine and synthesize multiple management objectives into a coherent set of practices (Appelstrand 2002). Moreover a participatory approach – involving local community in the decision-making process – is a way to increase social sustainability and an important tool to support sustainable forest management (Kangas et al. 2006, De Meo et al. 2011).

In the light of these considerations, it is evident that participatory forest management is a complex issue, where several stakeholders - who often have different interests and expectations (e.g. wood production, recreational activities, nature conservation) - are involved (Webler et al. 2001, Mendoza – Martins 2006). When both the number of stakeholders and the stakes are high, the participatory process is strongly influenced by the relationships, the coalitions of interests, and the balance of power among the participants. In this context, the analysis of stakeholders' power is relevant, in order to understand their role and the influence of individual stakeholders or coalitions in the decision process, and to guarantee transparency and fairness of the process itself (Paletto et al. 2012, Paletto et al. 2015). In particular, the analysis of power distribution among stakeholders is important in cases when the decision making process is influenced by a few powerful stakeholders, while a large number of stakeholders remain passive and without a real power.

The historical origins of the concept of power must be sought in Leviathan (1651) by Thomas Hobbes. The analysis made by Hobbes distinguishes the power of a person in i) natural power, which includes the abilities of the body and mind as intellect and strength, and ii) instrumental power, which derives from the acquired faculties and advantages of friends, money or reputation. Leviathan (1651) was the starting point for the development of subsequent theories of power such as those developed by Max Weber (1947) and Robert Dahl (1961). In current political science, power can be defined as "the probability that an actor within a social relationship will be in a position to carry out his own will despite resistance" (Weber 1947). Starting from this definition, power can be considered as the ability of an individual in a relationship to exert influence on another person, in order to obtain the expected outcomes (Simpson et al. 2014). In other words, the exercise of power implies that a stakeholder has power to the extent that he can use coercive, utilitarian or normative powers to impose its will in the relationship (Etzioni 1964). The possible strategies in order to influence a person can be direct or indirect: the first type is visible and unambiguous, while the second is less visible and more subtle. Weber's power definition was analyzed and re-elaborated by Dahl (1961) in his theory of community power. The fundamental principle of the theory is that society is pluralistic, where community interests are represented by means of open processes. In this pluralistic society, power is exercised by a specific actor, while other actors are prevented from doing what they would like to do. If power can be defined as the

potential to influence and as a basic force in social relationships (Keltner et al. 2003), then influence can be considered the exercise of power (Turner 2005). Social actors have a clear objective intent to influence the behavior of someone else to achieve their goals.

From a sociological perspective the concepts of power and influence have clear definitions, but in everyday reality they are closely inter-related. The interactions between individuals or groups are shaped by patterns of power and influence (Lasswell – Kaplan 1950). Power can be wielded through resources such as threats to use instruments for the purpose of causing damage, the control of tools that restrict the action of others, and all other elements that can hinder or be a detriment to others. The most common resources that power utilizes are strength, knowledge, prosperity, capital (material, immaterial and social), and organization. It is important not to confuse power with its resources, because resources alone do not necessarily translate into power.

Concerning influence, a person has influence on another when they are able to alter the other person's behavior through the application of pressure. It is a sort of mediate power that is able to modify the behavior of other actors without the need for orders or threats. On the other hand, this influence is a kind of social relationship that modifies the original behavior of someone through means such as communication, charisma, or persuasion (Nye 2008).

Another main issue when dealing with participatory forest management is to distinguish the levels of power and influence between stakeholders. Inter alia, it is important to analyze perceived influence that is defined as "the believed ability to affect other actors' behaviors or beliefs by effectively controlling resources (e.g. information, ability to make decisions, etc.) skillfully and willfully" (Weible 2005).

Starting from these considerations, the present research considers the "perceived influence" as the stakeholders strive to influence the decision making process, and power as the real capacity of stakeholders to influence the decision making process, which can be measured by objective methods. The main aim of the research is to define a useful method for comparing stakeholders' perceived influence and real power. The proposed method was applied in a case study in North Italy (Valle di Non, Trentino-Alto Adige region), characterized by multiple stakeholders' interests and high relevance of forest resources both from the economic and social point of view. Power was quantified through the analysis of stakeholders' relationships and networks (social network analysis), while information on perceived influence was collected through a questionnaire survey of forest stakeholders. Finally, results of perceived influence and real power were compared in order to highlight behaviors of the different stakeholders' categories. This type of analysis is useful because it can support the decision makers during the participatory process in order to include all the interests at stake in the final plan.

2 MATERIALS AND METHODS

2.1 Study area

The study area is the Valle di Non (*Figure 1*), in Trentino-Alto Adige Region (North-East of Italy). Valle di Non is a rural valley (596.7 km^2), with a well-developed agricultural industry (apple and grape production) and forestry sector. As an outcome of a territorial specialization process that occurred during the last thirty years, the Valle di Non is home to a relevant quota of apple production (5% of the European production). Urban centers of the Valle di Non, 38 small country communes, are surrounded by fields and farms lying between 400 and 1,200 m a.s.l. where the main product - apples - are cultivated. The labor force employed in the primary sector is around 20% of the total labor force of the valley. The forest area is around 350 km^2 (59% of total area) and the main forest types are Norway spruce (*Picea abies* (L.)

H. Karst.), Scots pine (*Pinus sylvestris* L.) and European larch (*Larix decidua* Mill.) dominant forests. Broadleaf forests, mainly European beech (*Fagus sylvatica* L.) forests, are concentrated in the low part of the valley. Considering the forest property, forest areas are mainly public and common forests (80%) managed by municipalities and self-organization of common forests called *Amministrazioni Separate per i beni di Uso Civico* (ASUC). Forest management is conducted according to Forest and Wildlife Service of Autonomous Province of Trento guidelines (Notaro et al. 2009). The remaining 20% of forests belong to small private owners (Grilli et al. 2014). The standing stock of the high forests in Valle di Non is about 4 million m^3 with an annual increment of 64,000 m^3 per year. The harvesting rate is approximately 55% of annual increment.

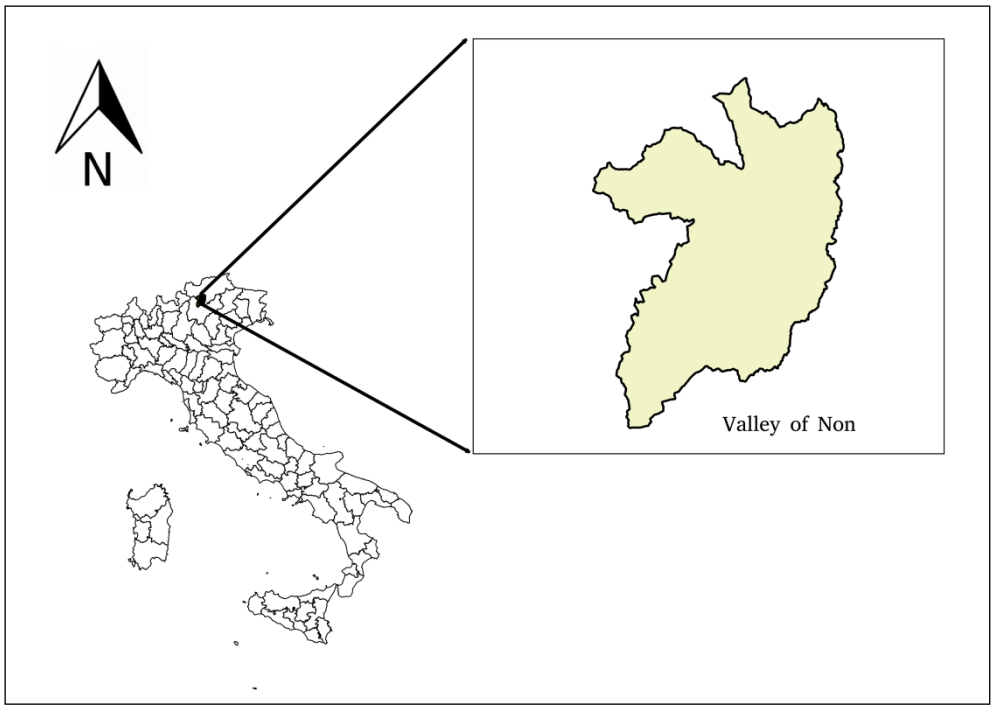


Figure 1. Location of the study area (Valle di Non) in Italy.

2.2 Three-stages methodology of research

The research framework was structured in three stages: (1) stakeholder analysis, (2) questionnaire survey, (3) statistical analysis and comparison of the data collected with the questionnaire.

The stakeholder analysis aims to identify, characterize, and classify the stakeholders in order to determine the extent of their future involvement in the decision making process (Grimble – Wellard 1997). All stakeholders - individuals, communities, social groups or institutions of any size, aggregation or level in society (Grimble – Chan 1995) - who affect and/or are affected by the policies, decisions, and actions of the system should be recognized.

In the present research, the stakeholder analysis was conducted through two steps. The first step was a brainstorming session between project researchers and local experts (forest managers and planners). A preliminary list of stakeholders was identified and then the sample was completed with a snowball sampling technique: names of other potential stakeholders are collected from the initial group. This sampling method is usually employed in the investigation of social networks and social dynamics (Noy 2008). At the end of the stakeholder analysis, 51 stakeholders were identified and classified in four main categories: 25 public administrations (municipalities, ASUC, Forest and Wildlife Service of Autonomous Province of Trento), 7 associations (alpine clubs, local hunting and environmental associations),

13 forest-wood chain actors (forest enterprises and sawmills), and 6 tourism sector actors (hotel keepers, agencies of tourism development).

During the second stage, a questionnaire survey was conducted among selected stakeholders through face-to-face interviews. The stakeholders, selected as representatives for each organization or association, were: mayors or council members of the municipalities, heads of the forest enterprises, sawmills and hotel operators, presidents of the associations and ASUC, and managers of the Forest and Wildlife Service of Autonomous Province of Trento. The questionnaire was aimed at assessing stakeholders' perceived influence and power in the participatory forest planning. The questionnaire included 17 closed-form questions and was subdivided in four thematic sections ("organization information", "personal information", "social and human capital", "forest management and local tradition"). Closed-form questions were used to analyze quantitatively the collected data. Moreover these questions are quick and easy to answer, and require little time investment. Being conscious of the limitations of closed questions, such as the impossibility of individual interpretation and in-depth response (May 1997, Paletto et al. 2013), time was left to the interviewees to discuss and express their opinions. A preliminary version of the questionnaire was prepared by the researchers previously involved in the stakeholder analysis and pre-tested with some local experts.

In the third stage of the research, the questions of the section "social and human capital" were processed and analyzed from the statistical point of view using XLStat 2012. Data analysis focused on the following aspects: (1) stakeholders' personal perception of their influence on the decision making process, (2) real power of stakeholders in terms of relational embeddedness, and (3) correlation between the two above mentioned aspects.

2.3 Perceived influence

The perceived influence of stakeholders on the forest management decision making process was assessed by the statements of the respondents. Stakeholders were asked to evaluate the influence of their organization in relation to six key-issues of forest planning and management. The key-issues were the following: (1) forest management for the production of timber, bio-energy and non-wood products (mushrooms and wild berries); (2) forest management for recreation, tourism and landscape purposes; (3) forest management for the protection against natural hazards (landslides, rockfalls, avalanches); (4) forest management to maintain and improve biodiversity and habitats; (5) environmental rehabilitation (quarries and landfills restoration), (6) management of wildlife (mainly ungulates such as red deer, roe deer and chamois). The six key-issues were chosen based on their importance in the multi-objective forest planning and the local guidelines of forest policy. The first issue focuses on the enhancement of the productive function of forests which includes both the wood production areas and the areas dedicated to non-wood products. The second issue includes the recreational areas, frequented by a large number of tourists, while the third considers the protective areas as defined by the third Ministerial Conference for the Protection of Forests in Europe (MCPFE). In the fourth issue protected areas, such as national and regional parks, nature reserves, and Natura 2000 sites are included. The fifth issue includes degraded areas such as quarries and landfills, while the last comprises the game reserves. Each of the six issues was scored using a 5-point Likert scale (from 0=no influence to 4=very high influence).

The data collected with the questionnaire were statistically processed and the main descriptive statistics (mean, median, standard deviation) were calculated. The aggregation of all key-issues was used as indicator for describing the perceived influence of the groups. In addition, the non-parametric statistical test of Kruskal-Wallis was applied in order to evidence differences between categories of stakeholders in relation to each single key-issue. The non-parametric statistical tests were chosen because the data distribution is not normal and the number of observations is low. All statistical tests were assessed at the $\alpha = 0.05$ level.

2.4 Power

The real power of stakeholders was assessed on the basis of the relational embeddedness, using the social network analysis (SNA) method. SNA is a formal theory to define and analyze the relationships that organizations or individuals (stakeholders in general) have with each other and it focuses on positions and structural patterns of actors (Wasserman – Faust 1994, Scott 2000). Analysis of social networks allows the opportunity to unpack the social factors and provides information about knowledge exchange. According to Weiss et al. (2012) and Mills et al. (2014) SNA can highlight which stakeholders are important for influencing policy or actions, or for facilitating information and knowledge transfer.

The main practical applications of SNA in the forest sector found in the international literature are summarized as follows: Tikkanen et al. (2003) studied the regional network of forest-related organizations in northern Finland, Harshaw and Tindall (2005) employed a social network approach to examine the role of social capital in the relationships between people and forested landscapes in Canada, Vennesland (2004) analyzed the importance of networks in forest-based rural economic development in Norway, while Paletto et al. (2012) applied SNA in a participatory landscape forest planning study in Italy.

In the present paper, SNA was applied to highlight power distribution among forest stakeholders. In particular, network centrality was used and quantified in order to analyze the role and position of stakeholders in the network. Network centrality considers sociocentric network data that provide information on relationships among all actors within a bounded social network (Freeman 1979, Marsden 2002). According to Freeman (1979), global centrality can be expressed through three types of centrality: degree centrality, closeness centrality, and betweenness centrality. In sociological terms, degree centrality represents the level of communication activity; betweenness centrality represents control of communication as the ability to restrict the communication of others, while closeness centrality represents independence (Mizruchi – Potts 1998). In addition, network centrality is a fundamental concept to account for actors' social status, power and satisfaction with group activities (Bavelas 1950, Leavitt 1951). Some research showed a positive relationship between centrality in the network and power (Brass 1984, Krackhardt 1990). Despite this, not all measures of centrality can be considered an appropriate indicator of an actor's real power (Mizruchi – Potts 1998). According to Freeman (1979), degree centrality was defined as the number of alters to whom an actor is directly tied and represents the ability to communicate directly with others (level of communication activity). Considering these theoretical assumptions, in this research the degree centrality was considered as a measure of the real power of individual stakeholders. Information useful to assess degree centrality was collected through the survey questionnaire. Specifically, two types of information were collected: (1) number and type of stakeholders with which the respondent has a professional relationship in the field of forest planning and management (six key-issues), (2) strength of relationships. It is important to emphasize that only collective stakeholders (institutions, organizations and associations) were considered in the analysis. The strength of relationships was evaluated distinguishing three types of ties according to strength: very weak, weak, strong. Strong ties are comprised of all of those types of relationships in which either the stakeholders are involved in an emotional manner, while weak ties are those relationships established by different stakeholders among which communication is sporadic and where emotional intensity is generally low (Granovetter 1973).

The graphic elaborations and the degree centrality values were realized with the software programs NetDraw and UCINET 6.0 (Borgatti et al. 2002).

The Freeman's formula used to calculate the degree centrality is the following:

$$Dc(n_i) = \sum_{k=1}^{n} a(n_i, n_k)(N-1)^{-1}$$

Where:

D_c = degree centrality

a_{ik} = arc between nodes (1 when there is a connection between n_i and n_k, 0 when there is not a connection between n_i and n_k).

The degree centrality calculated for each stakeholder was aggregated in categories of stakeholders (public administrations, associations, forest-wood chain actors and tourist sector actors).

3 RESULTS AND DISCUSSION

3.1 Perceived influence

The aggregate result (all key-issues together) for individual stakeholders' perceived influence shows that values are included in a range between 0 and 23. The highest values were recorded for the following stakeholders: Brèz municipality (P_i total=23), Forest and Wildlife Service of Autonomous Province of Trento (P_i total=20), Dambel municipality (P_i total=19), and the sawmill of Sarnonico municipality (P_i total=18).

Statistical results (mean, median and standard deviation) of perceived influence per category of stakeholders are reported in *Table 1*. The mean value was used as a synthetic indicator of perceived influence by category of stakeholders.

Public administrations perceive their level of influence as medium on four issues (wood production, forest recreation, hydrogeological protection and biodiversity conservation) and low and very low for wildlife management (P_i mean=1.08) and environmental rehabilitation (P_i mean=1.56). The total level of perceived influence of the public administrations taking into account all key-issues is 9.72.

Representatives of the associations declared a high and very high level of influence on two forest management issues: biodiversity conservation (P_i mean=2.50) and forest recreation (P_i mean=2.00), while for the other issues the level of influence is quite low. The high level of influence on the biodiversity conservation issue is mainly affected by the answers of hunting association representatives. This is reasonable because they contribute to the wildlife population census and to the provincial hunting plan. The total level of perceived influence of this category is equal to 8.43.

Actors of the tourism sector declared a low or very low level of influence for all forest management issues; according to these declarations the total level of perceived influence of this category of stakeholders is 2.67. It is interesting to highlight that their perceived influence is low (P_i mean=0.67) also on the valorization of tourism and recreation in forests. This scarce perceived influence is not surprising, since the decision making process in Valle di Non is mainly driven by public actors. Otherwise, it is important to underline that such a low score may be interpreted also as a scarce interest of these actors in natural resources management. In such a case, this result could be more worrisome, because tourism in Valle di Non is mainly nature-based and the tourism actors are expected to be the main drivers of tourism and recreational activities in forest.

Finally, the forest-wood chain actors declared a low level of influence on three forest management issues (wood production, forest recreation and biodiversity conservation) and a very low level of influence on the other three issues (protection against hazards, environmental rehabilitation and wildlife management). The highest level of influence is on wood production (P_i mean=1.62).

Table 1. Mean, median and standard deviation of perceived influence on six key-issues of forest management per categories of stakeholders.

Category of stakeholders	Wood production	Recreation in forest	Protection against hazards	Biodiversity conservation	Environmental rehabilitation	Wildlife management
All stakeholders (n=51)						
Mean	1.51	1.51	1.19	1.65	1.16	0.86
Median	1	2	1	2	1	0
St.dev.	1.31	1.36	1.21	1.42	1.22	1.28
Public administrations (n=25)						
Mean	2.00	1.92	1.57	1.96	1.56	1.08
Median	2	2	2	2	1	0
St.dev.	1.10	1.32	1.27	1.30	1.26	1.47
Associations (n=7)						
Mean	0.67	2.00	1.50	2.50	1.29	1.43
Median	0	3	2	4	1	1
St.dev.	1.21	1.90	1.38	1.97	1.60	1.51
Tourism sector actors (n=6)						
Mean	0.17	0.67	0.33	0.67	0.67	0.20
Median	0	1	0	1	1	0
St.dev.	0.41	0.82	0.52	0.82	0.82	0.45
Forest-wood chain actors (n=13)						
Mean	1.62	0.92	0.77	1.15	0.54	0.38
Median	1	1	0	1	0	0
St.dev.	1.45	1.04	1.01	1.28	0.78	0.65

The non-parametric test of Kruskal-Wallis shows statically significant differences between categories only for the perceived influence related to wood production (K observed value = 13.415, K critical value = 7.815, p-value = 0.004). For this key-issue, the influence of public administrations and forest-wood chain actors is significantly higher than the other categories of stakeholders, while the non-parametric test of Kruskal-Wallis shows no significant statistical differences for the other five key issues.

3.2 Power

SNA results are reported in *Table 2* and *Figure 2*. As reported in *Table 2* (which shows the degree centrality values for all stakeholders in the network), Forest and Wildlife Service of the Autonomous Province of Trento are individual stakeholders with the highest values of degree centrality (D_c=137), followed by two municipalities (Malosco municipality D_c=78 and Brèz municipality D_c=87) and an ASUC (D_c=63). A high number of stakeholders have values of degree centrality that are rather low (D_c lower than 20). In light of these differences, we can assert that the forest sector network in Valle di Non is a highly centralized network, where one stakeholder (Forest and Wildlife Service) plays a key role, both in terms of power and prestige. This assertion is supported by the difference in values of degree centrality between Forest and Wildlife Service of the Autonomous Province of Trento and all other stakeholders. In addition, during the face-to-face interviews some stakeholders highlighted that the Autonomous Province of Trento is the key actor as regards all decisions on land planning and management in urban and rural areas. The centralized network presents the main advantage of rapidity and ease in decision-making, and the possibility for administrators to manage the forests of the valley with a unique and homogenous management approach. Conversely, this centralized network presents the main disadvantage in the risk of low participation in decision-making and of a de-empowerment of the other stakeholders in the area.

Besides, *Figure 2* shows that within stakeholders' categories there is a different distribution of power. In particular, it is important to highlight the marginal role of tourism sector actors: 3 hotel keepers have no ties with any other actor in the network and the other tourism sector actors are all in marginal positions, confirming the result derived from the perceived influence analysis. Instead, the forest-wood sector actors are in "key positions" in the network, in particular three sawmills (sawmill Sarnonico D_c=54, one of the two sawmills of Clès D_c=36, sawmill Drès D_c=35) and two forest enterprises (forest enterprise Darmine di Taio D_c=38, forest enterprise Livo D_c=36).

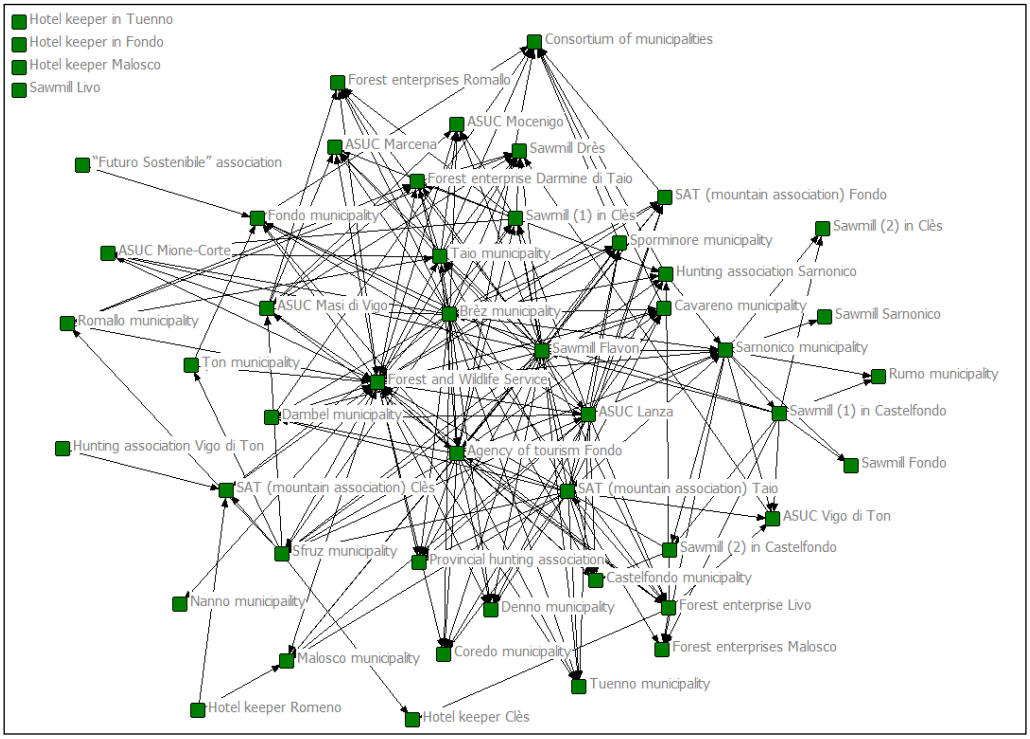


Figure 2. Social Network Analysis (SNA) of the forest sector stakeholders in Valle di Non.

To better understand real power distribution, it is important to make a distinction between indegree and outdegree centrality for the interpretation of the values in *Tables 2* and *Table 3*. The indegree centrality of a stakeholder depends on the number of incoming links, while the outdegree centrality sets the stakeholders in hierarchical centrality because it considers the outcoming links.

Table 3 shows the main statistics, considering the four categories of stakeholders.

Those actors who show elevated values of outdegree centrality occupy a central hierarchical position in the network, and are therefore able to directly reach a high number of actors. Nevertheless, this position does not ensure clear-cut prestige since the acknowledgment of the other actors (indegree centrality) is required.

Public administrations is the category with a greater concentration of power and this fact is mainly explained by the values of in-degree centrality, that for public administrations shows a mean value of 17.32, while for the forest-wood chain actors and the associations is equal to 7.08 and 8.29 respectively.

Conversely, the outdegree centrality values are higher for the latter two categories of stakeholders (forest-wood chain actors mean OD_c=16.92, associations mean OD_c=18.86) than for public administrations (mean OD_c=10.44). This result can be interpreted as a unidirectional flow of requests for technical advice or financial support from the various stakeholders towards public administrations.

Table 2. Indegree, outdegree and degree centrality values per each stakeholder

Stakeholder	Outdegree	Indegree	Degree
Hotel keeper in Tuenno	0	0	0
Hotel keeper in Fondo	0	0	0
Tuenno municipality	3	15	18
Taio municipality	15	18	33
Forest and Wildlife Service	78	59	137
Sawmill Fondo	0	6	6
Fondo municipality	3	20	23
Castelfondo municipality	2	18	20
Sawmill (1) in Castelfondo	26	3	29
Sawmill (2) in Castelfondo	6	6	12
Cavareno municipality	3	15	18
Consortium of municipalities	0	3	3
Sawmill Sarnonico	36	18	54
Sarnonico municipality	3	0	3
“Futuro Sostenibile” association	6	14	20
Hunting association Sarnonico	3	15	18
Denno municipality	0	12	12
Forest enterprises Malosco	3	15	18
Malosco municipality	72	6	78
Sawmill Flavon	3	6	9
Sawmill (1) in Clès	21	15	36
Rumo municipality	0	5	5
Sawmill (2) in Clès	0	6	6
Sawmill Drès	9	26	35
ASUC Vigo di Ton	3	12	15
Forest enterprise Darmine di Taio	18	20	38
ASUC Masi di Vigo	21	11	32
Hunting association Vigo di Ton	3	0	3
Hotel keeper Romeno	6	0	6
Hotel keeper Malosco	0	0	0
Sawmill Livo	0	0	0
Hotel keeper Clès	0	5	5
Provincial hunting association	0	15	15
Ton municipality	6	6	12
SAT (mountain association) Fondo	6	15	21
Romallo municipality	12	9	21
SAT (mountain association) Taio	23	6	29
Forest enterprise Livo	21	15	36
Brèz municipality	81	6	87
Forest enterprises Romallo	1	17	18
ASUC Marcena	1	17	18
ASUC Mocenigo	1	17	18
ASUC Mione-Corte	1	17	18
ASUC Lanza	54	9	63
SAT (mountain association) Clès	3	12	15
Agency of tourism Fondo	40	10	50
Sfruz municipality	18	15	33
Sporminore municipality	5	15	20
Dambel municipality	6	15	21
Coredo municipality	0	15	15
Nanno municipality	3	15	18

Table 3. Mean values of indegree and outdegree centrality per category of stakeholders

Category of stakeholder	Indegree	Outdegree
Public administrations (n=25)	17.32	10.44
Actors of forest-wood chain (n=13)	7.08	16.92
Associations/NGO (n=7)	8.29	18.86
Actors of tourism sector (n=6)	2.00	2.00

3.3 Correlation between perceived influence and power

The correlation between perceived influence and real power is analyzed to investigate if there is a correspondence or a deviation between these policy issues, and to understand reasons for different trends. The Spearman correlation between the perceived influence and the values of indegree, outdegree, and degree centrality are reported in *Table 4*. Results show a statistically significant correlation between the perceived influence and the values of indegree centrality ($r = 0.562$) and degree centrality ($r = 0.388$). For the fact that the degree centrality is the sum of indegree and outdegree, it is important to focus on the differences between these two indicators. The correlation between indegree centrality and perceived influence is relatively high because indegree can be considered a good indicator of the prestige and prominence of a stakeholder. A stakeholder is considered prestigious and prominent, if he is particularly visible to the other stakeholder in the network and the number of his ties in the network is high. Stakeholders in a prominent position in the network have a greater ease of influencing the choices of others stakeholders. This can be considered an indirect form of power.

Table 4. Spearman correlation between perceived influence and indegree centrality, outdegree centrality and degree centrality

Parameters	Indegree centrality vs. perceived influence	Outdegree centrality vs. perceived influence	Degree centrality vs. perceived influence
r	0.562	0.189	0.388
p-value	<0.0001	0.183	0.005
α	0.05	0.05	0.05

The Spearman correlation between the perceived influence and the indicators of real power shows that some stakeholders have a distorted perception of their own power. A limited number of stakeholders have a perceived influence higher than the real power, and in this group fall some hotel keepers and associations. Instead, the key actor of the network - the Forest and Wildlife Service of the Autonomous Province of Trento - declares a level of influence far below its real power. A similar situation is reported for some municipalities such as Malosco municipality ($P_i = 0$, $D_c = 78$), Brèz municipality ($P_i = 8$, $D_c = 87$) and an ASUC (ASUC Lanza $P_i = 8$, $D_c = 63$). The first interpretation for these differences is tied to a distorted perception of the reality: there are actors who overestimate their influence in the society they are living in and actors who, on the contrary, underestimate their power. Another interpretation for these differences could be of strategic nature: those actors who hold positions of power in the society say that they are not conscious of their role of prominence.

4 CONCLUSIONS

Over the last few decades, scientific literature concerning the techniques and methods for collection and analysis of social preferences in natural resources management has experienced a rapid growth (Trakolis 2001, Tarrant – Cordell 2002, Kumar – Kant 2007, Rodríguez-

Carreras et al. 2013, De Meo et al. 2013, Paletto et al. 2013). Despite this growth of interest, the analysis of the relationship between the power of social actors and decisions taken during the management process remains a little-studied field. The present work tries to contribute to the scientific debate in this field, focusing on the issue of relations between the real power of actors and their perceived influence.

In this framework, it is relevant to highlight that perceptions shape behaviors more than real power. In fact, if actors perceive a centralized structure of influence in the decision making process, most stakeholders would prefer to have relationships with the actor with more (perceived) influence. On the other hand, if there is a decentralized structure of (perceived) influence, actors recognize interdependence among stakeholders and would be more available to cooperate in a participatory process for obtaining their goals (Bobbio 2006, Elster 1998). Perceived influence could be more explicative than real power in understanding decision-making behaviors (Pruitt – Thomas 2007).

Results of the present research demonstrate that analysis of the differences between perceived influence and real power could give decision makers information useful for understanding the stakeholders' behavior, to search for opportune integrations between actors, and to choose suitable methods to give everyone due consideration.

Moreover, results show that single stakeholders and categories of stakeholders could have a rather distorted perception of influence on decisions, and a clear vision of power distribution is not foreseen.

This kind of information, combined with other qualitative and quantitative information provided by SNA, can improve the participatory process and reduce possible distortions of information among the decision makers. What is clear from the Valle di Non case study is the centralized structure of the decision making process. A few of the actors have a high level of power and a dual role in being an intermediary for particular interests and, concomitantly, remain the decisional center.

The authors want to evidence that in order to better manage a situation of conflicting interests and trade-offs between stakeholders' objectives, the network should be as inclusive as possible. In particular, in the Valle di Non case study, a deeper involvement of the tourism sector actors could play an important role in conservation strategies, since tourism is known to have an important role in this field (Bookbinder et al. 1998, Gössling 1999). On the other hand, greater power for the forest wood chain actors could create decisions towards a more intense timber harvesting scenario. In any case, an inclusive network society stimulates the debate around natural resources, allowing for increased awareness about other stakeholders' interests and facilitating shared decisions.

Concerning the adopted methodology, survey questionnaires and social network analysis have the advantage of being simple and require a limited number of data. Limits of the method could be related to the typical disadvantages of face-to-face interviews such as: a higher need for personnel involvement, the necessity of interviewer training, higher costs of data collection, some stakeholders' unavailability to be interviewed, and incomplete answers to some questions.

Finally, it is of course necessary to point out that relations between real power and perceived influence and, in general, studies concerning relations between social network and forest management, are influenced by a combination of factors and deeply rooted in the local context. For this reason, case-study surveys offer ideas and insights that could be used to improve this field of research.

In particular, future steps of this research must be focused on alternative measures of real power through other indicators and the comparison between these indicators and SNA data.

Acknowledgements: this work is a part of the For.Net "Social capital and social network analysis as tools to support the forest planning and management" project, co-funded by CARITRO (Cassa di Risparmio di Trento e Rovereto) Foundation.

REFERENCES

APPELSTRAND, M. (2002): Participation and societal values: the challenge for lawmakers and policy practitioners. Forest Policy and Economics 4: 281–290.

BAVELAS, A. (1950): Communication patterns in task oriented groups. Journal of the Acoustical Society of America 22: 271–282.

BOBBIO, L. (2006): Dilemmi della democrazia partecipativa. Democrazia e diritto 4: 11–28.

BOOKBINDER, M.P. – DINERSTEIN, E. – RIJAL, A. – CAULEY, H. (1998): Ecotourism's Support of Biodiversity Conservation. Conservation Biology 12(6): 1399–1404.

BORGATTI, S.P. – EVERETT, M.G. – FREEMAN L.C. (2002): Ucinet 6 for Windows: Software for Social Network Analysis. Harvard, MA: Analytic Technologies.

BRASS, D.J. (1984): Being in the right place: a structural analysis of individual influence in an organization. Administrative Science Quarterly 29: 518–539.

DAHL, R.A. (1961): Who governs? Democracy and power in an American city. Yale University Press, New Haven.

DE MEO I. – CANTIANI, M.G. – FERRETTI, F. – PALETTO A. (2011): Stakeholders' perception as support for forest landscape planning. International Journal of Ecology 1: 1–8.

DE MEO, I. – FERRETTI, F. – FRATTEGGIANI, M. – LORA, C. – PALETTO A. (2013): Public participation GIS to support a bottom-up approach in forest landscape planning. iForest 6: 347–352.

ELSTER, J. (1998): Deliberative democracy. Cambridge University Press, Cambridge.

ETZIONI, A. (1964): Modern organizations. Prentice-Hall, Englewood Cliffs.

FREEMAN, L.C. (1979): Centrality in social networks: conceptual clarification. Social Networks 1: 215–239.

GÖSSLING, S. (1999): Ecotourism: a means to safeguard biodiversity and ecosystem functions? Ecological Economics 29: 303–320.

GRANOVETTER, M. (1973): The strength of weak ties. American Journal of Sociology 6: 1360–1380.

GRILLI, G. – PALETTO, A. – DE MEO, I. (2014): Economic Valuation of Forest Recreation in an Alpine valley. Baltic Forestry 20(1): 167–175.

GRIMBLE, R. – WELLARD, K. (1997): Stakeholder methodologies in natural resource management: a review of principles, contexts, experiences and opportunities. Agricultural Systems 55(2): 173–193.

GRIMBLE, R. – CHAN, M.K. (1995): Stakeholder analysis for natural resource management in developing countries. Natural Resources Forum 19(2): 113–124.

HARSHAW, H.W. – TINDALL D.B. (2005): Social structure, identities, and values: a network approach to understanding people's relationships to forests. Journal of Leisure Research 37(4): 426–449.

HOBBES, T. (1651): Leviathan. Green Dragon, St. Paul's Churchyard.

KANGAS, A. – LAUKKANEN, S. – KANGAS, J. (2006): Social choice theory and its applications in sustainable forest management - a review. Forest Policy and Economics 9: 77–92.

KELTNER, D. – GRUENFELD D.H. – ANDERSON C. (2003): Power, approach, and inhibition. Psychological Review 110: 265–284.

KRACKHARDT, D. (1990): Assessing the political landscape: structure, cognition, and power in organizations. Administrative Science Quarterly 35: 342–369.

KUMAR, S. – KANT, S. (2007): Exploded logit modeling of stakeholder' preferences for multiple forest values. Forest Policy and Economics 9: 516–526.

LASSWELL, H.D. – KAPLAN, A. (1950): Power and society: a framework for political inquiry. Yale University Press, New Haven.

LEAVITT, H.J. (1951): Some effects of certain communication patterns on group performance. Journal of Abnormal and Social Psychology 46: 38–50.

MAY, T. (1997): Social Research: Issues, Methods and Process. Open University Press, Buckingham.

MARSDEN, P.V. (2002): Egocentric and sociocentric measures of network centrality. Social Networks 24: 407–422.

MARTINS, H. – BORGES, J.G. (2007): Addressing collaborative planning methods and tools in forest management. Forest ecology and management 248(1): 107–118.

MENDOZA, G. A. – MARTINS, H. (2006): Multi-criteria decision analysis in natural resource management: a critical review of methods and new modelling paradigms. Forest ecology and management 230 (1): 1–22.

MILLS, M. – ÁLVAREZ-ROMERO, J.G. – VANCE-BORLAND, K. – COHEN, P. – PRESSEY, R.L. – GUERRERO, A.M. – ERNSTSON, H. (2014): Linking regional planning and local action: Towards using social network analysis in systematic conservation planning. Biological Conservation 169: 6–13.

MIZRUCHI, M.A. – POTTS, B.B. (1998): Centrality and power revisited: actor success in group decision making. Social Networks 20: 353–387.

NOTARO, S. – PALETTO, A. – RAFFAELLI, R. (2009): Economic Impact of Forest Damage in an Alpine Environment. Acta Silvatica & Lignaria Hungarica 5: 131–143.

NOY, C. (2008): Sampling knowledge: the hermeneutics of snowball sampling in qualitative research. International Journal of Social Research Methodology 11 (4): 327–344.

NYE, J. S. (2008): The powers to lead. Oxford University Press, New York.

PALETTO, A. – FERRETTI, F. – DE MEO, I. (2012): The role of social networks in forest landscape planning. Forest Policy and Economics 15: 132–139.

PALETTO, A. – DE MEO, I. – CANTIANI M.G. – MAINO F. (2013): Social Perceptions and Forest Management Strategies in an Italian Alpine Community. Mountain Research and Development 33(2): 152–160.

PALETTO, A. – HAMUNEN, K. – DE MEO, I. (2015): The social network analysis to support the stakeholder analysis in participatory forest planning. Society & Natural Resources 10: 1108–1125.

PRUITT, B. – THOMAS, P. (2007): Democratic dialogue – A handbook for practitioners. UNDP, New York.

PUKKALA, T. (2002). Multi-objective forest planning. Kluwer academic publishers, Dordrecht.

RODRÍGUEZ-CARRERAS, R. – ÚBEDA, X. – OUTEIRO, L. – ASPERÓ, F. (2013): Perceptions of social and environmental changes in a Mediterranean forest during the last 100 years: The Gavarres Massif. Journal of Environmental Management 138: 75–86.

SCOTT, J. (2000): Social network analysis: A handbook. Newbury Park: Sage.

SIMPSON, J.A – FARRELL, A.K. – ORIÑA, M.M. – ROTHMAN, A.J. (2014): Power and Social Influence in Relationships In: Mikulincer, M. – Shaver P.R. (eds.): APA Handbook of Personality and Social Psychology. American Psychological Association, Washington. 393–420.

TARRANT, M.A. – CORDELL, H.K. (2002): Environmental Assessment. Amenity Values of Public and Private Forests: Examining the Value-Attitude Relationship. Environmental Management 30(5): 692–703.

TIKKANEN, J. – LESKINEN, L. – LESKINEN, P. (2003): Forestry organization network in northern Finland. Scandinavian Journal of Forest Research 18: 547–559.

TRAKOLIS, D. (2001): Local people's perceptions of planning and management issues in Prespes Lakes National Park, Greece. Journal of Environmental Management 61: 227–241.

TURNER, J.C. (2005): Explaining the nature of power: A three-process theory. European Journal of Social Psychology 35(1): 1–22.

VENNESLAND, B. (2004): Social capital and networks in forest-based rural economic development. Scandinavian Journal of Forest Research 19(5): 82–89.

WASSERMAN, S. – FAUST, K. (1994): Social network analysis. Cambridge: Cambridge University Press.

WEBER, M. (1947): The Theory of Social and Economic Organization. Oxford University Press, New York.

WEBLER, T. – TULER, S. – KRUEGER, R. (2001): What is a good public participation process? Five perspectives from the public. Environmental Management 27(3): 435–450.

WEIBLE, C. M. (2005): Beliefs and perceived influence in a natural resource conflict: An advocacy coalition approach to policy networks. Political Research Quarterly 58(3): 461–475.

WEISS, K. – HAMANN M. – KINNEY, M. – MARSH, H. (2012): Knowledge exchange and policy influence in a marine resource governance network. Global Environmental Change 22: 178–188.

DOI: 10.1515/aslh-2016-0003 Acta Silv. Lign. Hung., Vol. 12, Nr. 1 (2016) 23–33

Perceptions of Forest Owners and the General Public on the Role of Forests in Slovakia

Zuzana DOBSINSKA[a*] – Zuzana SARVASOVA[b,c]

[a] Department of Economics and Management of Forestry, Faculty of Forestry, Technical University in Zvolen, Zvolen, Slovak Republic
[b] Department of Forest Policy, Economics and Forest Management, National Forest Centre – Forest Research Institute in Zvolen, Zvolen, Slovak Republic
[c] Faculty of Forestry and Wood Sciences, Czech University of Life Sciences Prague, Prague, Czech Republic

Abstract – During the past decades, the awareness of environmental issues in forest management is increasing due to changes in environmental education. The perceptions of forests, sustainable management, and ecosystem services were studied through two surveys. The general public and forest owners were the two target groups. The questionnaires had similar questions, though two different methodological approaches were used – the CATI system, for general public opinion survey, and semi-structured questionnaires for forest owners. The second survey contained more detailed questions regarding forest properties. Combined answers from 1503 respondents from the general public and 150 forest owners were evaluated on the following topics: sustainable forestry, major ecosystem services, and perceptions of forests. The majority of the Slovakian public regards ecological values as the most important element, whereas forest owners prefer the economic purposes for the maintenance and enhancement of forests. Forest owners tend to visit their forests once per week, whereas the general public tend to visit only once per month. The main cause for this non-attendance in the general public was a lack of recreational time, followed by a disinterest in forests. The main purpose for visiting forests for both groups was recreation. Overall, it can be concluded that people are mostly satisfied with forest management in Slovakia. Forest owners are satisfied with their forest properties, and plan to keep them for their children. In the future, more attention should be focused on investigating the younger generation's perception of forests.

environmental education / forest functions / ecosystem services / forest management

Kivonat – Az erdőtulajdonosok és a közvélemény felfogása az erdők szerepéről Szlovákiában. Az elmúlt évtizedekben a környezet-tudatosság az erdőgazdálkodásban emelkedett, amelyben a környezeti nevelésnek is szerepe van. Az erdők, az erdőgazdálkodás és az ökoszisztéma szolgáltatásokkal kapcsolatos felfogást két felmérés vizsgálta. A két célcsoportot a közvélemény és az erdőtulajdonosok alkották. A kérdőívek hasonló kérdéseket tartalmaztak, bár két különböző módszertant alkalmaztak – az ún. CATI rendszert a közvélemény esetében és a félig strukturált interjúkat az erdőtulajdonosok esetében. Ez utóbbi részletes kérdéseket tartalmazott az erdőtulajdonra vonatkozóan. A közvéleménytől származó 1503, és az erdőtulajdonosoktól származó 150 válasz összesített elemzése az alábbi témakörökre vonatkozóan történt: tartamos erdőgazdálkodás, főbb ökoszisztéma szolgáltatások, és az erdőkkel kapcsolatos felfogás. A szlovákiai nagyközönség többsége az ökológiai értékeket tekinti az

* Corresponding author: zuzana.dobsinska@tuzvo.sk, SK-96053, ZVOLEN, T. G. Masaryka 24

erdők legfontosabb elemének, míg az erdőtulajdonosok az erdők fenntartását és fejlesztését szolgáló gazdasági célokat részesítik előnyben. Az erdőtulajdonosok az erdőket jellemzően hetente látogatják, a nagyközönség pedig havonta. Ez utóbbi okainak fontossági sorrendjében első helyen áll a kikapcsolódásra fordítható idő hiánya, amelyet az erdőkkel kapcsolatos érdektelenség követ. Mindkét csoport esetében az erdőlátogatás elsődleges oka a kikapcsolódás. Összességében megállapítható, hogy az emberek többnyire elégedettek a szlovákiai erdőgazdálkodással. Az erdőtulajdonosok meg vannak elégedve az erdőtulajdonukkal, és szándékaik szerint azt a gyerekeik számára hagyják örökül. A jövőben nagyobb figyelmet szükséges fordítani a fiatal generációk erdőfelfogásának vizsgálatára.

környezeti nevelés / erdők funkciói / ökoszisztéma szolgáltatások / erdőgazdálkodás

1 INTRODUCTION

The awareness of environmental issues in forest management is increasing due to changes in environmental education. According to the national strategy for environmental education adopted in 1996 (revised in 2006), the key factor in environmental education is education and training towards sustainable development. The so called "environmental minimum" contains the following topics: biodiversity maintenance, deforestation and soil erosion, rational use of natural resources, air, water and soil pollution, depletion of the ozone layer, acid rain, greenhouse effect, energy consumption, waste, urbanization, and population explosion (Izakovicova 2010). Forests are an essential component of the landscape and play an important role in environmental education.

Environmental education promotes positive attitudes, and is thus an important natural resource conservation tool. However, education strategies require urgent changes and innovative approaches to meet changing needs. In Slovakia, the persistent preference for teaching methods aimed at gaining verbal knowledge is still present, hindering the use of creative approaches. Pupils often gain theoretical knowledge without a complete understanding of the problems existing within their surrounding environment. They learn about global problems which are difficult to understand. The phenomena and processes occurring in the country are only studied in textbooks, without the possibility of monitoring these phenomena and processes directly.

Schools are an element in the process of change. Schools must promote active interaction among children, teachers, and parents. Future education strategies should start in the family, but must also be addressed in the classroom. Classic teaching approaches must be replaced by alternative methods which enable pupils to participate more actively, subsequently fostering the creativity of the pupil. The shift towards converting knowledge into conscious environmental behaviour is vital. It is necessary to examine people's fears and expectations for the future in order to understand how these perceptions of the future influence the way people behave, and how their current behaviour will influence the future (Hicks and Holden 1995).

Over the past few decades, significant changes have occurred in the views and demands on forests by society at large. This includes an increased level of environmental awareness and recreational interest in Slovakian society (Hajduchova – Sulek 2011). These changes also affect the public's perspective from the traditional role of forests as producers of raw materials. Simultaneously, the urge to re-orient societies towards increasingly "bio-based economies" results in a higher demand for raw material, not only for increasingly sophisticated products, but also for renewable energy (Rametsteiner et al. 2009).

Forests have acquired a new and more global meaning in modern society, going beyond their role as a productive and usable resource. For a growing portion of the population, forests represent a publicly-accessible space for recreation. At the same time, forests are increasingly identified as a natural environment. This new development reflects the needs and preferences of contemporary society, and the desire of an increasingly urban population for recreational

opportunities in natural surroundings. It also reflects public concern over the impending threats to the environment and biodiversity. The wish to preserve a forest is evident in the number of demands for limiting forest exploitation and protecting areas in a close-to-natural state. For many people, the protection of environments and landscapes has become a major criterion for judging the overall performance of forest management strategies (Schmithusen 2007). Currently, a clear need exists to further develop the dialogue between the forestry sector and the general public in order to establish mutually acceptable relations (Lichý 2013).

These changes must also be reflected in forestry education. Forest education is changing in response to shifting international, national, and local perceptions towards forests (Stead 2001), and is necessary to meet the ever-changing needs of society. These needs include a worldwide commitment to sustainable forest management (SFM) and ecosystem-oriented approaches. In agreement with a change of perspective in the management of environmental issues, the process requested for SFM comprehends participatory mechanisms to involve relevant stakeholders (Kangas et al. 2006, Kangas et al. 2010). Therefore, there is an increased need for foresters to have communication skills which would enable them to interact at all levels: from local communities to government and international levels. Foresters should face this new paradigm using a bottom-up approach, rather than the top-down system that has previously characterized forest governance throughout the world – particularly with regards to forestry planning and stakeholder involvement. The bottom-up approach presents a two-way information flow system that considers prior consultation with target groups about their needs, problems, and aspirations for effective forestry planning. On the contrary, the top-down approach is simply a one-way information delivery system that reinforces the hierarchical relationship between the forester and the target group. These changes are not easy to implement or accept, and will require training in social relations in order to meet the growing demand of the public towards forests and their use – especially when it comes to a forest's recreation function (Kumar – Kant 2005). Foresters will no longer be sole agents of information and advice in these situations. Various interest groups such as environmental NGOs, citizens' associations, and municipalities all have an interest in promoting forest use.

The meaning of sustainable forest management has developed from its primary focus on wood production to include a wide range of different combinations of forest uses, meeting economic needs and opportunities while addressing dynamically changing social and cultural values (Schmithusen – Seeland 2006). This introduces new stakeholders into the forest policy-making process. These stakeholders arrive with their own perceptions, values, attitudes, and interests regarding forests and the forest sector (Krott 2005).

For this study, two stakeholder groups were analysed. One group includes the general public while the other group represents forest owners. The aim of this study is to present the results from these two surveys regarding the awareness of the general public and forest owners about forests, sustainable forest management, and ecosystem services.

2 MATERIALS AND METHODS

The perceptions of forests, sustainable management, and ecosystem services were studied by two surveys. The general public and forest owners were the two target groups, and the questionnaires had similar questions. The questions in the surveys were prepared with input from several experts in the field, including academics as well as forestry practitioners. The questionnaire for the general public opinion survey contained 10 questions. The semi-structured questionnaire for forest owners contained 44 questions, including detailed questions regarding forest property. In total, answers from 1503 respondents (general public)

and 151 forest owners were evaluated on following topics: sustainable forestry, major ecosystem services, and the perception of forests.

General public survey

The survey was carried out by a professional agency using the computer-assisted telephone interviewing (CATI) method. CATI is a telephone surveying technique in which the interviewer follows a script provided by a software application. This involves a structured system of data collection by telephone that speeds up the collection and editing of data, permitting the interviewer to educate respondents on the importance of timely and accurate data. The software is capable of customising the flow of the questionnaire based on the answers provided, as well as information already known about the participant.

The results of the public survey include responses collected between January and February 2013. In total, 1503 citizens were contacted via telephone, providing valid responses until February 28th, 2013. The age and residence distribution is shown in the *Tables 1, 2,* and *3*.

Forest owners' questionnaire

The questionnaire for forest owners was sent via regular mail to 639 forest owners in June 2013. The target group was private forest owners – preferably members of forest owners associations from different regions of Slovakia. The sampling method represented convenience sampling, so it is therefore not a representative sample of all private forest owners in Slovakia. Therefore, the results must be interpreted with an appropriate level of caution. Respondents were selected using only one criterion defined by the research team: private forest ownership. Data collection was linked to ongoing research activities regarding private forest owners in Slovakia. The return rate was 23% (151) by November 10th, 2013. The age and residence distribution is shown in the *Table*s *3, 4 and 5*.

Table 1. Gender distribution of respondents

	General public	Forest owners
Male	777	137
Female	726	14

Table 2. Residence distribution of respondents

	General public	Forest owners
Urban	819	53
Rural	648	98

Table 3. Age distribution of respondents

	General public	Forest owners
18-24	126	0
25-39	385	6
40-54	483	28
55+	509	117

In this study, seven questions (Q) were selected and evaluated. The questions are presented with answers (A) in *Table 4*. Questions were evaluated separately according to their order. The first portion of the questionnaires contained general questions relevant to further sampling, including age, gender, education, and residence. Q22 and 23 were asked only in the questionnaire aimed at forest owners. The answers of both surveys were compared and are presented in figures. Q22 and 23 were evaluated for urban and rural areas because the questions were asked only in the forest owner questionnaire.

Table 4. Selected evaluated questions

General Public Survey Questionnaire		Forest Owners Survey Questionnaire	
Q 4	People have different opinions on why forests should be maintained and enhanced. Which of the listed options do you think should be the most important in Slovakia?	Q 16	Which of the following options explain the importance of owning a forest for you?
A	Economic purpose, ecological values, social aspects, other.	A	Economic purpose, ecological values, social aspects, other.
Q 2	How often do you visit a forest?	Q 18	How often do you visit the forest?
A	Once a week, once a month, never,	A	Once a week, once a month, never.
Q 3a	How do you spend your time in a forest? For what purpose do you go into a forest?	Q 19	How do you spend your time in the forest? For what purpose do you go into the forest?
A	Recreational, NWFP, other.	A	Recreational, NWFP, other
Q 3b	I do not go into a forest because:	Q 20	I do not go into forest because:
A	I don´t feel safe in a forest. I have no time. I am not interested in forests.	A	I don´t feel safe in the forest. I have no time. I am not interested in my forest.
Q8	People have different opinions on private forest management. In your opinion rate, as in school using a score from 1 to 5, how well do private forest owners and their associations take care of their forest property (with one being the best and five being the worst)?	Q 21	Rate how private forest owners and their associations take care of their forest properties.
A	1, 2, 3, 4, 5.	A	1, 2, 3, 4, 5.
		Q 22	What are your plans for your forest property in the future?
		A	Sell, lease, leave for children, expand, buy new forests, no plans, other.
		Q 23	How do you evaluate your forest property in terms of your expectations?
		A	Satisfied, not satisfied, don´t know.

3 RESULTS

An important factor influencing public perception of forests in Slovakia is the right to free access to forests guaranteed by the Forest Act. This implies that visitors are permitted to walk, ski, or cycle on another person's land, as long as landowners' and/or public peace is not disturbed, and fields or plantations are not damaged. In Q4 and Q16, the general public and

forest owners were asked about what the main purpose of forests should be. The majority of the public regards ecological values as the most important (1258 out of 1503), whereas forest owners prefer an economic purpose (83 out of 151).

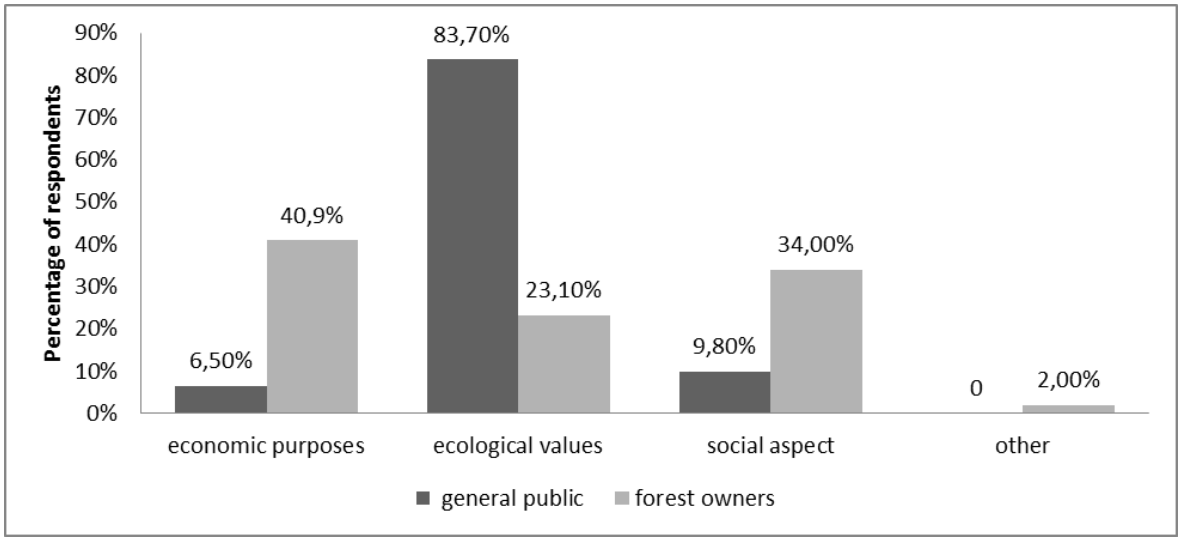


Figure 1. The purposes of maintaining and enhancing forests

The frequency of forest attendance is evaluated in *Figure 2*. The majority of the general public visits a forest once a month (63.41%, 541), whereas forest owners visit their forest weekly (74.17%, 112). Respondents who do not visit forests at all were mainly from the general public category (122), compared to only one forest owner.

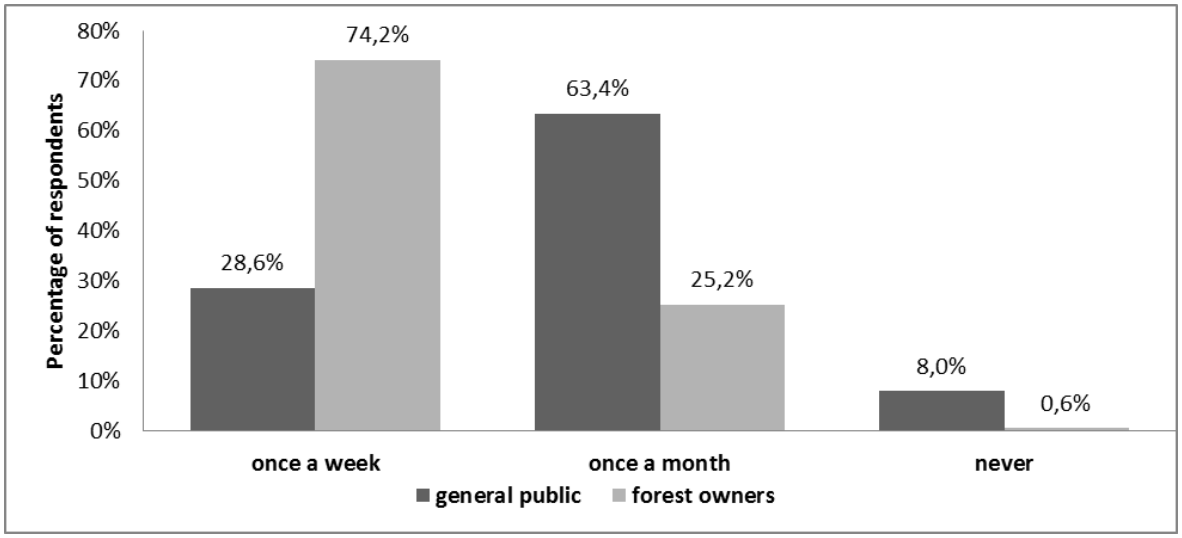


Figure 2. Frequency of forest attendance

The next question is built upon the previous one. When a respondent replied that they never visit forests, they were asked the reason why. The main reason for non-attendance was a lack of free time (68) followed by a lack of interest in forests (46). Only 6% of the general public does not feel safe in forests (*Figure 3*).

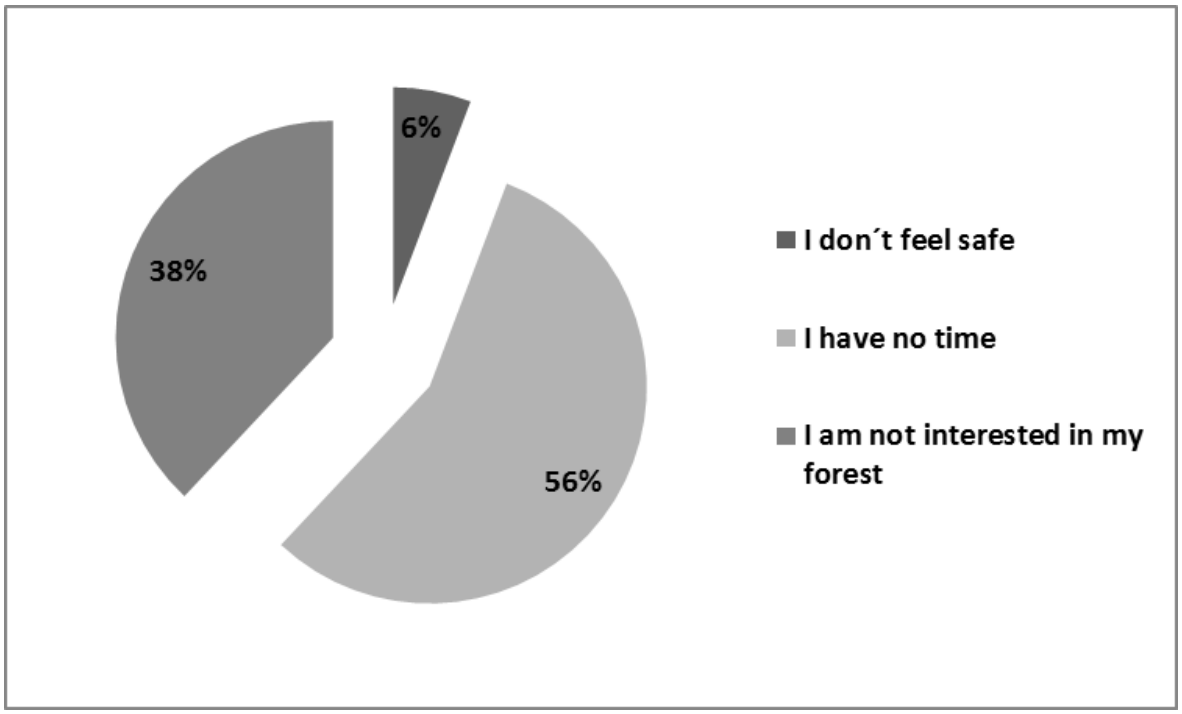


Figure 3. Reasons for not visiting a forest in the general public group

Forests provide a variety of ecosystem services. This question investigated the hierarchy of ecosystem services as perceived by the respondents. The primary purpose for visiting forests for both groups was recreation (79.87% of the public and 68.70% of forest owners), followed by non-wood forest products (*Figure 4*). The recreational category included the following activities: tourism, sport, rest, and hunting.

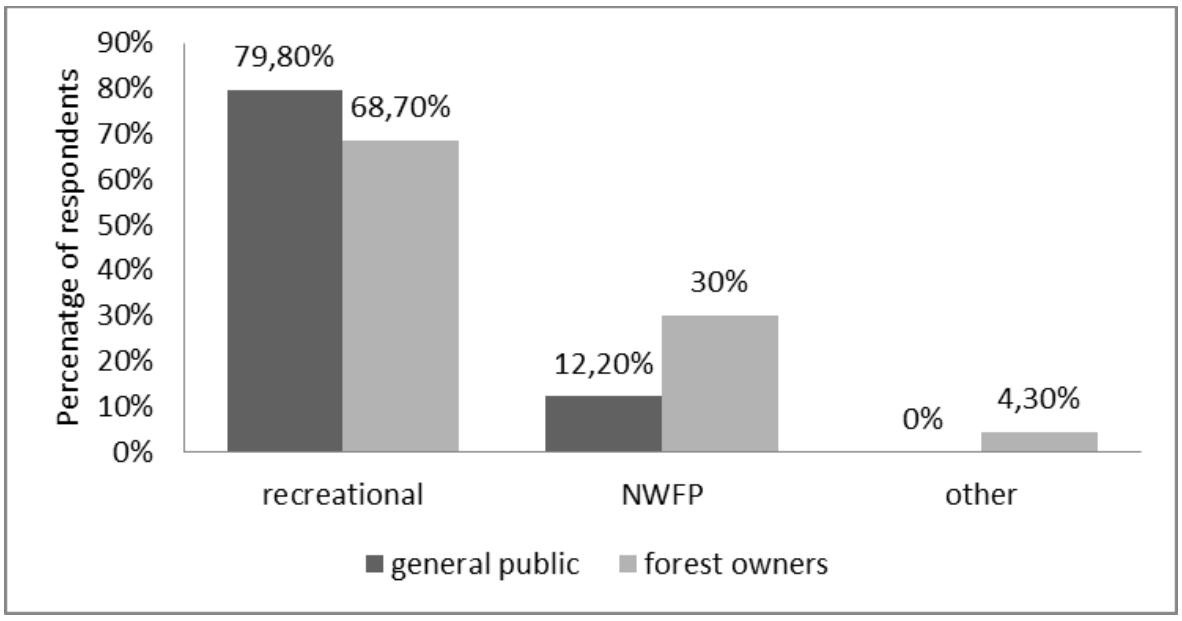


Figure 4. Main ecosystem services that forests should provide

In Q8/21, respondents could rate the forest management conducted by private forest owners. The grading scheme is the same as that of the Slovakian school system, where a score of 1 represents the best and a score of 5 represents the worst. Most of the general public rated the private forest owners with a score of 2 or 3. Most private forest owners marked their management with a score 2, followed by 1 and 3.

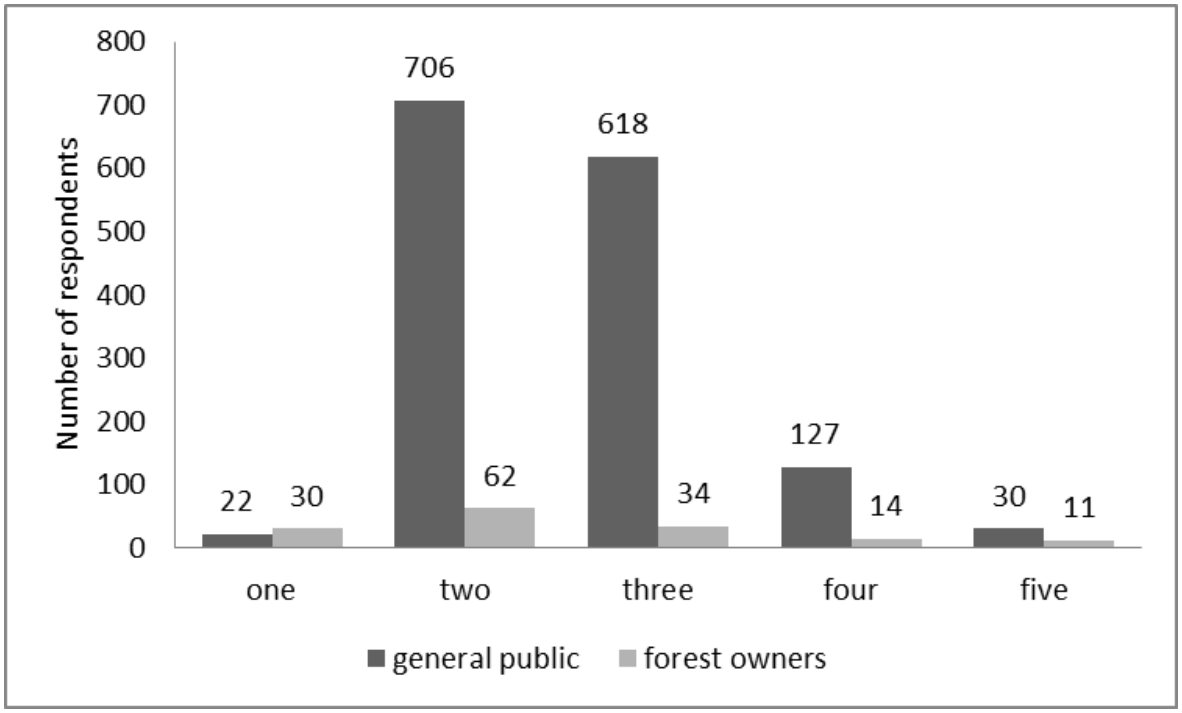


Figure 5. How are private forest owners managing their forests?

The two final questions were asked only in the forest owner questionnaire. The questions regarded the respondents' own forest properties. *Table 6* illustrates future forest property plans. The majority of forest owners intend to leave their property for their children.

Table 6. Future plans for forest properties

	Sell		Lease		Leave for children		Buy new forests		No plans		Other	
	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%
Urban areas	1	1.9	2	3.8	31	58.5	13	24.5	0	0	6	11.3
Rural areas	0	0	3	3.1	66	67.3	23	23.5	2	2	4	4.1

Most forest owners are satisfied with their property (*Table 7*). The ownership of forested land meets their expectations. In rural areas, owners are more satisfied with their property when compared to owners living in urban areas.

Table 7. Expectations of the owned forest property

	Satisfied		Discontent		Don´t know	
	Total	%	Total	%	Total	%
Urban areas	43	81.1	3	5.7	7	13.2
Rural areas	78	79.6	11	11.2	9	9.2

4 DISCUSSION

Regarding the validity of the research findings, it has to be stated that although the study includes a large sample of the general public population, the questionnaire may have included biases in the selection of respondents. The use of CATI for selection criteria aims at randomizing selection as much as possible, though it presents possible deficiencies (e.g. some people might not have been registered or included in the register). The survey conducted on forest owners is not representative as respondents were selected purposively, so the results must be approached with caution as they are unlikely to be representative of the whole country. However, these results provide valuable insight into the perceptions of forest owners.

The main purpose for visiting forests in Slovakia corresponds to similar research conducted in this area (Rametsteiner et al. 2009), which suggested that the European public places a higher value on forest conservation and the protective functions of forests rather than on forest utilisation aspects. This contrasts forest owners, whose main concern is the economic profit from their property. Public opinion on the productive functions of forests has been studied in many European countries. Previous studies conclude that the general public in typical forestry countries such as Sweden, Norway, or Austria seem to have a more sensitised, pragmatic, and balanced view of the productive functions of forests with regards to the interplay between humans and nature. The general public of eastern and southern Europe tends to view forest functions more from the amenity perspective. In the majority of countries, the public mentioned recreational, educational, and scientific purposes as positive forest functions, while extensive logging, hunting, and construction were generally regarded as negative forest-related activities (Rametsteiner et al. 2009). An overwhelming majority of people in central Europe, for example, link the economic function of forests mainly to the production of wood. In Finland, most private forest owners indicate that financial profit is still important, but they simultaneously classify the recreational uses and aesthetic experiences provided by their forests as almost equally important (Heino – Karvonen 2003).

When it comes to visiting forests, not many of the surveys carried out in Europe asked people how often they did this. In Germany a nationwide quantitative survey concerning forests and forestry was conducted in 2007. In it, 49% of the respondents stated enjoying a visit to a forest. In contrast, only 19% of the questioned German public stated that forests are not interesting for them (Kleinhückelkotten – Wipperman 2007). Of the respondents in Lithuania who had visited forests, 25% said that they visited at least 3-4 times per year (Mizaraite – Mizaras 2006).

With regard to forest attendance, the results in other European countries are similar to this Slovakian survey. In Germany, 77% of interviewees view the forest as a place for recreation and relaxation; 55% used the forests for recreational walks. Other activities included observing nature (42%), collecting herbs (20%), having barbeques and parties (17%), as well as jogging and 'Nordic walking' (17%) (Kleinhückelkotten – Wipperman 2007). A survey from the Czech Republic stated that the collection of non-wood forest products, such as mushrooms and different kinds of berries, had a high recreational value for visitors (Šišák 2006). The most popular forest activities among Swiss citizens were recreation and various types of sports, followed by the gathering of non-wood forest products (Seeland et. al 2007). Interestingly, in the study conducted by Rametsteiner et al. (2009), recreational purposes were not ranked as one of the top two most important benefits by European citizens. This contradicts previous studies, as well as the expectations of forest experts across Europe (Rametsteiner et al. 2009).

Ecosystem services tend to be more important for people living in central Europe (10.1% rank them as most important element) when compared to other regions. They are considered least important by people in north-western European countries (3.8%). A high variation in in

results can be found within individual countries. Approximately 16% of people in Slovakia rank ecosystem services as most important, followed by Finland (15.3%), and Slovenia (Rametsteiner et al. 2009).

With the development of new environmental education strategies in Slovakia, there is a need to conduct opinion surveys of young people as a target group. Research in other countries which has targeted young people has shown that perceptions, attitudes, and knowledge should represent key components in the preparation of programmes for community education, forest resource management, and conservation (Barrazza – Pineda, 2003).

5 CONCLUSIONS

Slovakia appears to contrast other countries in its inability to face the challenge of creating general acceptance for the forestry sector. In most developed countries, ecological values are becoming more prevalent among the general population, though they are not as evident among private forest owners. Results suggest that people are mostly satisfied with the management of forests in Slovakia. As the results of the public survey have indicated, the general public has expectations with regards to forests and forestry, expecting greater protection and management for ecosystem services (emphasising on ecological values before economic purpose), contrary to forest owners, who stress the economic function.

In the future, younger generations must work to improve their knowledge of forestry and forests. The implementation of educational programs prepared for schools that include elements of forest education support these findings.

In surveys that will take place in the coming years, changes in perceptions on ecosystem services and higher trust in foresters are expected.

Acknowledgements: This work was supported by the Slovak Research and Development Agency under contract No. APVV-0057-11, and the Czech Agency for Agricultural Research under contract No. QJ1220313. This publication was implemented as a result of: Centre of Excellence "Decision support in forest and country", ITMS: 26220120069, and supported by the Research & Development Operational Programme funded by the ERDF.

REFERENCES

BARRAZA, L. – PINEDA, J. (2003): How young people see forests in Mexico: a comparison of two rural communities, Unasylva 213(54): 10–17.

HAJDUCHOVA, I. – SULEK, R. (2011): Forests - key development factor of selected regions in Slovakia. In Resources of the Slovak Republic as a factor of development strategies in European and global space. Bratislava: Ekonóm.

HEINO, J. – KARVONEN, J. (2003): Forests – an integrated part of Finnish life. Unasylva 213(54): 3–9.

HICKS, D. – HOLDEN, C. (1995): Visions of the future: why we need to teach for tomorrow. London, Trentham Books.

IZAKOVICOVA, Z. (2010): Nové netradičné formy environmentálnej výchovy (New Untraditional Forms of Environmental Education). Geographia Cassovienensis 2: 22–26.

KANGAS, A. – LAUKKANEN, S. – KANGAS, J. (2006): Social choice theory and its applications in sustainable forest management—a review. Forest Policy and economics, 9(1): 77–92.

KANGAS, A. – SAARINEN, N. – SAARIKOSKI, H. – LESKINEN, L. A. – HUJALA, T. – TIKKANEN, J. (2010): Stakeholder perspectives about proper participation for Regional Forest Programmes in Finland. Forest Policy and Economics, 12(3): 213–222.

KLEINHÜCKELKOTTEN S. – WIPPERMANN C. (2007): Kommunikation für eine nachhaltige Waldwirtschaft in Deutschland [Communication for a Sustainable Forest Economy in Germany]. In: Berichtsband zum 39. Forstpolitikertreffen, Tschechische Landwirtschaftliche Universität in Prag, Fakultät für Forstwirtschaft und Umwelt, Prag (in German).

KROTT, M. (2005): Forest Policy Analysis. Springer, 323 p.

KUMAR, S. – KANT, S. (2005): Bureaucracy and new management paradigms: modelling foresters' perceptions regarding community-based forest management in India. Forest Policy and Economics 7: 651–669.

LICHÝ, J. (2013): Proposal of model of forest enterprise media communication. Lesnícky časopis - Forestry Journal, 59(4): 276–283, 2013, ref. 30, ISSN 0323 – 1046.

MIZARAITE, D. – MIZARAS, S. (2006): Afforestation of agriculture land as a tool of rural forestry development in Lithuania. In: Wall, S. (ed.). 2006. Small-scale forestry and rural development: the intersection of ecosystems, economics and society. Proceedings of the IUFRO 3.08 conference hosted by Galway-Mayo Institute of Technology, Galway, Ireland. Online http://www.fao.org/fileadmin/user_upload/rome2007/docs/Afforestation_agriculture_land_Lithuania.pdf.

RAMETSTEINER, E. – EICHLER, L. – BERG, J. (2009): Shaping forest communication in the European Union: public perceptions of forests and forestry. Final report. Online http://forestindustries.eu/sites/default/files/userfiles/1file/Shaping_forest_communication.pdf

SCHMITHUSEN, F. (2007): Multifunctional forestry practices as a land use strategy to meet increasing private and public demands in modern societies. Journal of Forest Science 53 (6): 290–298.

SCHMITHUSEN, F. – SEELAND, K. (2006): European Landscapes and Forest as Representation of Culture. In: Cultural Heritage and Sustainable Forest Management – The Role of Traditional Knowledge. Ministerial Conference on the Protection of Forests in Europe, Liaison Unit, Warsaw, 1: 217–224.

SEELAND, K. – KILCHLING, P. – HANSMANN, R. (2007): Urban consumers' attitudes towards non-wood forest products and services in Switzerland and an assessment of their market potential. Small-scale Forestry (6): 443–452.

SISAK, L. (2006): Importance of non-wood forest product collection and use for inhabitants in the Czech Republic. Journal of Forest Science 52(9): 417–426.

STEAD, J. (2001): Requirements of a forestry education from an ENGO perspective. In Meeting of Iinternational University Forestry Education Leaders. 4 December 2001. Vancouver, BC, Canada. University of British Columbia Faculty of Forestry/FAO.

DE GRUYTER OPEN DOI: 10.1515/aslh-2016-0004 Acta Silv. Lign. Hung., Vol. 12, Nr. 1 (2016) 35–45

Fostering Adaptation by Changing Landowners' Knowledge Framework – Responses to Extension Education in Northwest Washington State, USA

Kevin W. ZOBRIST [a*] – Lauren A. GRAND [a] – Mary A. ROZANCE [b]

[a] Extension Forestry, Washington State University, Everett, WA, USA
[b] Institute for Sustainable Solutions, Portland State University, Portland, OR, USA

Abstract – Landscape urbanization and fragmentation, spread of invasive pests, biodiversity loss, social value changes, and loss of manufacturing infrastructure are some of the changing ecological, economic and environmental framework conditions facing small-scale forest owners in northwest Washington State, USA. To successfully adapt to these changes, landowners' knowledge framework must change. Washington State University Extension has been offering comprehensive, multi-week training courses for small-scale forest owners. From 2008 – 2013, participants were surveyed at the conclusion of the training, one year following the training, and again at three years following the training. These follow-up surveys demonstrate a progression from knowledge change to behaviour (management) change and, ultimately, to condition change. Condition changes included increased wildlife diversity, decreased invasive species cover, and increased economic sustainability. The results demonstrate that changing a landowner's knowledge framework through education is a highly-effective approach for helping them successfully adapt to changing external framework conditions.

forestry / Extension / evaluation

Kivonat – Az alkalmazkodóképesség elősegítése a földtulajdonosok gondolkodási keretének megváltoztatásával – Észak-nyugat Washington Állam (USA) továbbképzéseinek eredményei. A tájkép beépülése és feldarabolódása, az özönállatok terjedése, a biodiverzitás csökkenése, a társadalmi értékek és a feldolgozási infrastruktúra átalakulása azok az ökológiai, gazdasági és környezeti keret-tényezők, amelyekkel a kisterületű erdőtulajdonosoknak szembe kell nézniük Washington Állam (USA) északnyugati részében. A változásokhoz történő sikeres alkalmazkodás érdekében a földtulajdonosok gondolkodási kereteinek is változni kell. A Washington Állami Egyetem továbbképzései átfogó, többhetes kurzusokat ajánlanak a kisterületű erdőtulajdonosok számára. 2008 és 2013 között a résztvevők felmérésben vettek részt közvetlenül a képzés lezárásakor, majd azt követően 1 és 3 év múlva. Ezek az után-követő felmérések bemutatják a megszerzett tudás átalakulását magatartássá, majd végső soron a peremfeltételek megváltozásává. Ez utóbbi magában foglalja az állatvilág változatosságának növekedését, az özönfajok csökkenését és a gazdasági fenntarthatóság növekedését. Az eredményeken keresztül látható, hogy a tulajdonosok gondolkodási kereteinek oktatással történő megváltoztatása kiemelkedően hatásos módja annak, hogy segítsük őket a változó külső keretfeltételekhez történő alkalmazkodásban.

erdőgazdálkodás / továbbképzés / értékelés

[*] Kevin W. Zobrist: kevin.zobrist@wsu.edu; 600 128th St SE Everett, WA, USA 98208.

1 INTRODUCTION

Small-scale forest owners in northwest Washington State, USA face a variety of changing ecological, economic, and social framework conditions. Expanding urbanization is resulting in the loss and fragmentation of the forest land base (Bradley et al. 2007). A changing regulatory framework, in response to concerns about water quality and salmon habitat, increases the complexity and decreases the profitability of forest management on small ownerships (Zobrist – Lippke 2003). Changing log markets and manufacturing infrastructure are resulting in changing management trends (e.g. Mason 2003). Other issues such as invasive species and available wildlife habitat are cited by landowners as additional areas of concern (Zobrist – Rozance in press (a)).

Changing landowners' knowledge framework through education can help them adapt to these changing conditions. Landowners identify education and technical assistance as preferred methods for helping them implement good forest management practices (Jones et al. 1995, Kilgore et al. 2007). This study examines whether a forest landowner education program effectively changes landowners' knowledge framework in a way that subsequently leads to behaviour and condition changes (i.e. adaptation to changing framework conditions).

2 BACKGROUND

Forest Stewardship Coached Planning is one of the flagship landowner education and outreach programs offered by Washington State University (WSU) Extension. The program is done in partnership with the Washington Department of Natural Resources (DNR), the United States Forest Service (USFS), and other state and local partners. The program is offered several times per year at different locations around the state, reaching thousands of family forest owners since its inception in 1992 (Baumgartner et al. 2007). Coached planning is typically seven to nine weeks in length and includes class sessions one evening per week, a Saturday field day, and a site visit to each participant's property by a state service forester, usually from the DNR.

Coached Planning is a comprehensive education course that covers a broad spectrum of topics including species identification, stand dynamics, soils, forest health, wildlife, invasive species, silviculture, regulations, water quality, forest inventory, wildfire, and special forest products. The course is focused on coaching landowners in the writing of their own forest stewardship plans (also called management plans) that encompass all of these topics and provide a roadmap for successful management and adaptation. The writing of stewardship plans, coupled with site visits from state service foresters, helps participants synthesize class information and apply it to their individual properties. Downing and Finley (2005) found that learning information that applies to an individual's personal situation is important to landowners. In Washington, management plans have additional benefits, as qualifying landowners can use their plans to meet eligibility requirements for cost share assistance, preferential property tax treatment, and forest certification (Zobrist 2011).

Washington's Forest Stewardship Coached Planning program, along with the corresponding technical assistance from DNR foresters, has been supported in part by the USFS Forest Stewardship Program, a nationwide initiative launched in 1991 to promote written stewardship plans for small-scale forest owners. In many states, funding from this program has been used to provide landowners with professionally-prepared plans. A few states, like Washington, offer the coaching option for landowners to self-prepare plans (Esseks – Moulton 2000).

In the period from 2008 – 2013, 12 coached planning classes were offered in various locations across four northwest Washington counties: King, Snohomish, Skagit, and Island. Two additional classes were offered online in a webinar format. This region, which includes most of the Seattle metropolitan area, has over 50,000 small forest landowners managing over 167,000 hectares of forest (Rogers – Cooke 2009). The total attendance for these classes was 507 people representing 333 families or organizations. Most attendees were family forest owners, but there were several attendees representing municipalities and non-profit organizations related to land stewardship.

3 METHODS

Evaluations were done at four different times: midway through the course, at the end of the course, one year after the course, and three years after the course. The evaluations midway through and at the end of the course collected feedback about the first and second halves of the class, respectively. These evaluations were done for each of the 14 classes, though data for one class in 2011 is missing and not included in this study. In addition to gathering feedback to improve future classes, the purpose of these evaluations was to assess short-term impacts of knowledge change due to the course. This was done as a retrospective pre-test (also called a then-test), coupled with a post-test, asking participants to rank their before and after knowledge of different course topic areas using a five-point Likert scale, with one being not knowledgeable and five being very knowledgeable. A two-sample t-test was used to test for significant differences between the results of the retrospective pre-test and the post-test.

A retrospective pre-test was chosen because of an expectation of a strong response-shift bias with a true pre-test. This bias is introduced when participants recalibrate their perception of their knowledge based on what they learned. This can result in an underestimate of gains, and in some cases the post-test scores may even be lower than the pre-test scores, as participants find there is much more they do not know about a topic than they realized before the education event. This phenomenon was observed when evaluating a past program, and program participants have commonly expressed things like "I did not know what I did not know."

The one-year and three-year post-class evaluations were done as mail surveys. One-year evaluations were done for 11 classes from 2008 through 2012. Three-year evaluations were done for five classes from 2008 through 2010. The survey method was roughly based on the Tailored Design Method proposed by Dillman (2007). A pre-notice was sent a few days in advance by email. The survey was then sent by mail along with a cover letter and postage-paid return envelope. A thank you and reminder letter was sent by mail, along with a new copy of the survey and a new postage-paid return envelope, two weeks after the first mailing. A second reminder letter was sent two weeks after the first reminder, also with a new copy of the survey and a new postage-paid return envelope. Thank you and reminder emails were also sent one week after the first survey mailing and one week after the first reminder letter mailing. Only those participants who agreed at the beginning of the course to participate in follow-up surveys and who provided a valid mailing address were surveyed. Only one survey was sent per household.

The focus of the one-year survey was on behaviour change due to taking the course. The survey included questions about whether participants used new knowledge from the course to complete a stewardship plan, implement stewardship practices, and/or share information with others. A chi-squared test was used to compare the behaviour change between those who completed a written stewardship plan and those who did not. The one-year survey also included questions about whether the course increased participants' enjoyment of their forest

land, their understanding of the ecological importance of their forest land, and their likelihood of utilizing the services of a professional forester if harvesting timber.

The focus of the three-year survey was on condition change. Participants were asked if they had a stewardship plan and, if so, how often they referred to it. Participants were asked if they observed increased wildlife use or decreased invasive species cover after implementing practices using knowledge gained from the course. Participants were asked if they used course knowledge and/or their stewardship plan to sell any timber or non-timber products, enrol in a cost share program, or enrol in a preferential property tax program. Participants were also asked if their comfort and confidence as landowners and their overall quality of life as landowners had improved due to taking the course.

4 RESULTS

4.1 Knowledge self-assessment results

Table 1 summarizes the mean self-assessment responses for topic knowledge before and after the course. Not every topic was covered in every class, and knowledge of how to write a stewardship plan was not surveyed before 2011, so some n values are noticeably lower than others. All topics showed a mean knowledge gain of at least 1 point (on a scale of 1 to 5), and all gains were significant at $\alpha = 0.01$. How to write a stewardship plan showed the greatest knowledge gain, followed by forest inventory and timber sale management. Native trees, wildlife, and invasive species showed the smallest gains, but these topics also had the highest levels of pre-class knowledge.

Table 1. Mean topic knowledge rating before and after the course, on a scale of 1 (not knowledgeable) to 5 (very knowledgeable)

	Before the course			After the course					
Topic	Mean	SD	n	Mean	SD	n	change	t	p
Native trees	2.64	1.15	257	3.89	0.81	255	1.25	14.23	<.001*
Wildlife	2.67	0.97	254	4.08	0.71	252	1.41	18.68	<.001*
Invasive species	2.40	1.05	200	3.97	0.73	201	1.57	17.38	<.001*
Forest taxes	1.98	1.11	170	3.56	0.93	168	1.59	14.16	<.001*
Stand dynamics	2.21	1.07	277	3.80	0.72	272	1.59	20.32	<.001*
Forest soils	1.89	0.97	289	3.52	0.74	283	1.63	21.49	<.001*
Silviculture	1.94	0.92	258	3.64	0.96	253	1.70	20.47	<.001*
Importance of plans	2.39	1.24	269	4.13	0.80	268	1.74	19.34	<.001*
Regulations	1.78	0.94	220	3.53	0.77	220	1.75	21.31	<.001*
Non-timber products	1.99	0.93	247	3.75	0.77	247	1.75	22.83	<.001*
Forest health	2.07	0.91	258	3.86	0.70	255	1.79	25.01	<.001*
Timber sale	1.44	0.81	108	3.36	0.86	107	1.93	16.89	<.001*
Forest inventory	1.88	0.94	120	3.82	0.74	119	1.94	17.73	<.001*
Plan writing	1.45	0.84	131	4.08	0.74	131	2.63	26.79	<.001*

* Significant at $\alpha = 0.01$

4.2 One-year follow-up results

The one-year follow-up surveys were sent to 234 households who agreed to participate and provided valid contact information (87.3% of 268 originally participating households). There were 209 responses (89.3% response rate). *Table 2* summarizes participant responses.

Approximately 65% completed a written plan, and over 90% used course knowledge to implement stewardship practices. Practices implemented are summarized in *Table 3* and *Table 4*. Wildlife habitat enhancement, invasive weed control, and fire risk reduction practices were applied to the greatest total area, and trail building was applied to the greatest total distance. Wildlife habitat enhancement, invasive species control, and tree planting were applied by the greatest number of respondents.

Table 2. Summary of participant responses in the one-year follow-up evaluation

	No	Yes	% yes
Completed a stewardship plan	71	131	64.9
Implemented practices using course knowledge	20	184	90.2
Shared course knowledge with others	8	199	96.1
Increased enjoyment of property	21	187	89.9
Increased understanding of ecological importance of property*	15	124	89.2
Increased likelihood of using a professional forester when harvesting timber**	9	92	91.1

*Asked of 2009 and later classes
**Asked of 2010 and later classes

Table 3. Stewardship practices applied within one year using course knowledge

Practice	Participants implementing	Area treated (ha)
Regeneration harvest	26	30.6
Commercial thin	7	63.5
Animal damage protection	44	101.1
Pre-Commercial thin	40	138.8
Pruning	64	137.3
Other vegetation control	87	159.8
Tree planting	92	162.8
Fire risk reduction	71	238.1
Invasive weed control	126	288.1
Wildlife habitat enhancement	100	491.2
Total		1811.8

Table 4. Kilometres of stewardship practices applied within one year of the course

Practice	Participants implementing	Distance treated (km)
Streamside habitat improvement	31	22.8
Road improvement	30	33.1
Trail building	63	84.3

Of those who completed a stewardship plan, 94% implemented stewardship practices using course knowledge compared to 86% of those who did not complete a stewardship plan (*Table 5*). The results of the chi-squared test indicate that this difference is significant at $\alpha = 0.10$, but just barely insignificant at $\alpha = 0.05$ ($\chi^2=3.81$; $p=0.051$).

Table 5. Comparison of practices implemented between those who did and did not complete plans

	Completed a plan	
	Yes	No
Implemented practices	122 (94%)	59 (86%)
Did not implement practices	8 (6%)	10 (14%)

Approximately 96% of respondents reported sharing course information with others in the year following the course. The total number of people that respondents reported sharing with was 2,212, which is an average of approximately 11 people per participant who shared. Approximately 90% of participants reported that the course resulted in a greater enjoyment of their property, a greater understanding of its ecological importance, and a greater likelihood of utilizing a professional forester if harvesting timber.

4.3 Three-year follow-up results

For the three-year follow-up surveys, surveys were sent to 123 households who agreed to participate and provided valid contact information (86.0% of 143 originally participating households). There were 101 responses (82.1% response rate). *Table 6* summarizes participant responses. The percent of respondents with completed plans increased to 85.9% at the three-year mark. Those who completed a plan reviewed it an average of 1.4 times per year. Over half of the participants observed increased wildlife use and decreased invasive species cover due to practices implemented using course knowledge. Almost all respondents reported that the course increased their comfort and confidence as a forest owner and decision maker, and that the combination of course impacts increased their overall quality of life.

Table 6. Summary of participant responses in the three-year follow-up evaluation

	No	Yes	% yes
Completed a stewardship plan	14	85	85.9
Increased wildlife use observed	37	49	57.0
Decreased invasive species cover	30	57	65.5
Sold products using course knowledge	69	17	19.8
Enrolled in a cost share program	65	12	15.6
Enrolled in preferential tax program	34	47	58.0
Increased comfort/confidence as forest owner	0	95	100
Increased quality of life	3	87	96.7

Over half of the respondents used their stewardship plan to enrol in a preferential property tax program for forestry. Those who did reduced their property tax liability by an average of $1,489 USD per year. Fewer than 20% of respondents reported using course knowledge to sell timber or non-timber products or enrol in a cost share program. Those who sold products generated a combined total of $516,243 USD in income. Those who enrolled in a cost share program received a combined total of $42,710 USD in cost share funds. When asked to rank their likelihood of converting their property to non-forest use before and after taking the course (highly unlikely, unlikely, neither likely nor unlikely, likely, very likely), 30.8% reported a lower likelihood, 3.3% reported an increased likelihood, and 65.9% reported no change. Of those who reported no change, all were either unlikely or highly unlikely.

5 DISCUSSION

5.1 Knowledge change

The results of this study suggest that education through the Forest Stewardship Coached Planning course successfully changes the knowledge framework of small-scale forest owners in northwest Washington State. Knowledge gains were significant across all 14 topics. The extent of these gains should be viewed with some caution. Although a retrospective pre-test can be used to counter response-shift bias, it introduces different biases that can result in overestimating the effect of a program, especially when measuring a socially-desirable outcome like knowledge gain (Hill – Betz 2005). Thus, these results should be viewed with an understanding that they represent participants' subjective views of how they have changed. Future studies may warrant different methods to reduce or better understand potential biases. The results of this study show that the greatest knowledge increase is in how to write a forest stewardship plan, which reflects the overall emphasis of the course. The one-year follow-up results show that participants share their new knowledge with an average of 11 people per person in the first year after taking the course, which represents a multiplying of the knowledge change. Further study to investigate the impact of this indirect influence of the course would be beneficial.

5.2 Behaviour change

The one-year evaluation results indicate a progression from knowledge change to behaviour change, with 90.2% of respondents reporting using knowledge gained from the course to implement stewardship practices on their property. This is higher than the 73% reported in a 14-year state-wide retrospective study of the program done by Baumgartner et al. (2007). However, that study asked the question differently, asking about practices that the landowner would not have done otherwise. This study asked in more general terms about practices implemented using course knowledge. There may have been practices that the landowner would still have done if not for the course, but that the practice was done differently through the application of course knowledge. Both cases indicate a behaviour change for the vast majority of participants.

This study found that plan completion rates, especially after three years, are higher than the 61% reported by Baumgartner et al. (2007). It is unknown why the 2008–2012 results are higher than those from 1992–2005. This could reflect improvements to the course, changes in instructors, or region-specific differences between northwest Washington and the rest of the state. Respondents in this study on average reviewed their plans at least once per year. This is similar to a study by Elwood et al. (2003) in the neighbouring state of Oregon that found that all participants used their plans at least annually. In contrast, the results of this study are quite different than a study in West Virginia that found that less than 20% of participants in a forest stewardship program referred to their plans regularly (Jennings – McGill 2005). The reason for this stark difference is unknown. In West Virginia, stewardship plans are written for landowners by professionals, whereas in this program the landowners write the plans themselves. This could indicate that self-prepared plans get greater use, or that management plans done in conjunction with education get more use. This is an area for future study.

The groups of respondents who did and did not complete a stewardship plan both had high rates of implantation of stewardship practices after one year (94% and 86%, respectively). The difference in practice implementation rate between the two groups is significant at $\alpha = 0.10$, but insignificant (albeit barely) at $\alpha = 0.05$. That both groups have implementation rates greater than 85% is perhaps more notable than any difference between them, though, especially since the finding of a higher rate of implementation for those who

completed plans does not establish a cause and effect relationship. These results suggests that the education and assistance aspects of the Coached Planning program drive behaviour change more than writing a stewardship plan. This calls into question whether the production of management plans is the best policy focus when it comes to landowner outreach and assistance, especially when plans are done by professionals and not coupled with landowner education. Further study is needed to understand the most effective drivers of change.

5.3 Condition change

The three-year evaluation results suggest a progression from knowledge and behaviour change to condition change. Over half of the respondents reported increased wildlife use and decreased invasive species cover on their property after implementing practices using knowledge gained from the course. The wildlife observations should be treated with some caution, as participants may simply be more aware or observant of wildlife use based on what they learned in the class. The decrease in invasive species cover, however, is likely to stem from practices implemented to control these species. This represents an important adaptation to one of the changing ecological framework conditions (the spread of invasive species) facing small-scale forest owners.

Unlike the one-year follow-up survey, the three-year survey did not ask respondents if they implemented specific practices like wildlife habitat improvement or invasive species control. Thus, these results do not connect specific practices with outcomes. As such, these results are not indicative of the effectiveness of specific practices, but rather are indicative of the impact of the program as a whole relative to these specific areas of interest.

Another adaptation seen in the three-year results is economic adaptation. Over half the participants used course knowledge to get their property enrolled in a preferential property tax program for forestry, saving $1,489 USD per year on average. Forest land that is taxed based on highest and best use rather than forestry use can be a significant impediment to economic sustainability (D'Amato et al. 2010). Forest landowners have cited property tax burdens as a key factor influencing them to parcel their property or sell it (Butler et al. 2010, Stone – Tyrrell 2012). Studies in the U.S. have found that many landowners are not aware of preferential property tax programs for forestry (Rathke – Baughman 1996, Williams et al. 2004, Fortney et al. 2011, Van Fleet et al. 2012). Education about these opportunities, coupled with education about how to write the management plan that is often required for enrolment, can play a significant role in getting landowners enrolled.

This study revealed another economic adaptation, which is using course knowledge to generate income from the sale of timber and non-timber forest products. Fewer participants (approximately 20%) pursued this compared to those pursuing preferential tax treatment. This is not unexpected, since generating income is not a high ownership value for landowners in northwest Washington (Zobrist – Rozance 2014). Nevertheless, these participants generated over a half a million USD of new income using course knowledge, which is important for economic sustainability and rural economic development.

5.4 Potential impact on forest conversion rates

Getting more landowners enrolled in preferential property tax programs may not achieve the policy goals of good land stewardship and reduced forest conversion. While landowners consistently claim that property taxes are one of their top concerns and a driving factor for parcelization and conversion (e.g. Butler et al. 2010, Stone – Tyrrell 2012), empirical results from studies of actual landowner behaviour are mixed. A 1999 study in the state of Tennessee found no difference in intention to change land use within ten years between those who were enrolled in a preferential property tax program and those who were not (Brockett – Gerhard

1999). While property taxes have been linked empirically to parcelization and conversion, these land use changes are inelastic relative to property taxes, such that lowering property taxes has a disproportionately small impact on slowing parcelization and conversion (Polyakov – Zhang 2007, Poudyal – Hodges 2009). Butler et al. (2010) observed that focus group participants, when unprompted, did not cite property taxes as a key problem nearly as much as they did after they were informed that the study was about tax policies. These studies suggest that, when it comes to conversion and parcelization choices, property taxes are not as great of an influence as landowner testimonials would indicate.

Almost all respondents in this study (89.9%) reported an increased understanding of the ecological importance of their property due to taking the course. This may be important, as Wadsworth (1999) found that landowners who believe their forest land has an impact on the larger landscape were less associated with an intention to sell or subdivide their property due to financial reasons. That study does not demonstrate cause and effect, though, so increasing ecological understanding does not necessarily lead to a lower likelihood of property sale or conversion. When asked directly to rank their likelihood of converting their land to development before and after the course, 30.8% reported a lower likelihood while 65.9% reported no change. Those who reported no change were already unlikely or very unlikely. This brings up another important issue, which is that participants self-selected into the Coached Planning program and thus may represent a biased sample that is more inherently concerned with ecosystem services and land preservation.

Almost all respondents reported greater enjoyment of their property; greater comfort and confidence as forest owners; and greater overall quality of life. These factors may lead to participants maintaining ownership of their property longer or taking additional steps to protect their forest land from development (e.g. conservation easements). Such outcomes are currently unknown, though, and offer opportunities for further study.

6 CONCLUSIONS

Overall, this study suggests that education is a successful strategy for changing landowners' knowledge framework in a way that fosters adaptation to a variety of changing conditions. This study finds that the Forest Stewardship Coached Planning program in northwest Washington State, USA, significantly increases landowner knowledge across 14 topic areas. This leads to subsequent behaviour change, which ultimately results in condition changes that represent successful economic and ecological adaptations that improve landowner quality of life. The Forest Stewardship Coached planning program, which combines classroom and field-based education with stewardship plan writing and direct technical assistance, appears to be a highly effective landowner education and outreach model. Education and assistance may be more important factors than management plan writing when it comes to behaviour change, and there are opportunities for further study to explore this as well as gain a better understanding of cause and effect relationships when assessing the impacts of education and outreach programs.

REFERENCES

BAUMGARTNER, D.M. – COHN, P.J. – GROTTA, A. – PERLEBERG, A. – HANLEY, D.P. – BERGSTROM, A. – GIBBS, S. (2007): Forest Stewardship Coached Planning in Washington State. Rural Technology Initiative Working Paper 8. University of Washington College of Forest Resources, Seattle, WA, USA. 14 p.
Online: http://www.ruraltech.org/pubs/working/08/working_paper_08.pdf.

BRADLEY, G. – ERICKSON, A. – ROBBINS, A. – SMITH, G. – MALONE, L. – ROGERS, L. – CONNER, M. (2007): Forest Land Conversion in Washington State. Future of Washington's Forest and Forest Industries Study 4. University of Washington College of Forest Resources, Seattle.
Online: http://www.ruraltech.org/projects/fwaf/final_report/pdfs/05_study4_landconv.pdf.

BROCKETT, C.D. – GERHARD, L. (1999): NIPF tax incentives: Do they make a difference? J. For. 97 (4): 16–21.

BUTLER, B.J. – HEWES, J.H. – CATANZARO, P. – GREENE, J.L. – KILGORE, M.A. – KITTREDGE, D.B. – LANGER, J. – MA, Z. – REUBEN, A. – TYRRELL, M. (2010): Effects of federal, state, and local tax policies on family forest owners. Family Forest Research Center Technical Report. 74 p.

D'AMATO, A.W. – CATANZARO, P.F. – DAMERY, D.T. – KITTREDGE, D.B. – FERRARE, K.A. 2010. Are family forest owners facing future in which forest management is not enough? J. For. 108 (1): 32–38.

DILLMAN, D.A. (2007): Mail and Internet Surveys – The Tailored Design Method. John Wiley & Sons, Inc., Hoboken, NJ. 523 p.

DOWNING, A.K. – FINLEY, J.C. (2005): Private Forest Landowners; What They Want in an Educational Program. Journal of Extension 43 (1).
Online: http://www.joe.org/joe/2005february/rb4.php.

ELWOOD, N.E. – HANSEN, E.N. – OESTER, P. (2003): Management plans and Oregon's NIPF owners: A survey of attitudes and practices. Western Journal of Applied Forestry 18 (2): 127–132.

ESSEKS, J.D. – MOULTON, R.J. (2000): Evaluating the Forest Stewardship Program through a National Survey of Participating Forest Land Owners. Center for Governmental Studies, Northern Illinois University.

FORTNEY, J. – ARANO, K.G. – JACOBSON, M. (2011): An evaluation of West Virginia's managed timberland tax incentive program. Forest Policy and Economics 13 (1): 69–78.

HILL, L.G. – BETZ, D.L. (2005): Revisiting the retrospective pretest. American Journal of Evaluation 26 (4): 501–517.

JENNINGS, B.M. – MCGILL, D.W. (2005): Evaluating the effectiveness of the Forest Stewardship Program in West Virginia: Ten-year assessment. Northern Journal of Applied Forestry 22 (4): 236–242.

JONES, S.B. – LULOFF, A.B. – FINLEY, J.C. (1995): Another Look at NIPF's: Facing our Myths. J. For 93 (9): 41–44.

KILGORE, M.A. – GREENE, J.L. – JACOBSON, M.G. – STRAKA, T.J. – DANIELS, S.E. (2007): The influence of financial incentive programs in promoting sustainable forestry on the nation's family forests. J. For 105 (4): 184–191.

MASON, L. (2003): After decades of Douglas-fir plantations, is it time for forest landowners to consider planting alder and cedar? Rural Technology Initiative Fact Sheet 22. University of Washington College of Forest Resources, Seattle, WA, USA.
Online: http://www.ruraltech.org/pubs/fact_sheets/fs022/fs_22.pdf

POLYAKOV, M. – ZHANG, D. (2008): Property tax policy and land-use change. Land Economics. 84 (3): 396–408.

POUDYAL, N.C. – HODGES, D.G. (2009): Property taxes and rural land values: Their effect on private forest land ownership structure in Texas. Land Use Policy 26: 1100–1105.

RATHKE, D.M. – BAUGHMAN, M.J. (1996): Influencing nonindustrial private forest management through the property tax system. Northern Journal of Applied Forestry 13 (1): 30–36.

ROGERS, L.W. – COOKE, A.G. (2009): The 2007 Washington State Forest Landowners Database. University of Washington College of Forest Resources, Seattle, WA, USA. Online: http://www.ruraltech.org/projects/wrl/fldb/pdf/The_2007_Washington_State_forest_land_Database.pdf

STONE, R.S. – TYRRELL, M.L. (2012): Motivations for Family forest land Parcelization in the Catskill/Delaware Watersheds of New York. J. For. 110 (5): 267–274.

VAN FLEET, T.E. – KITTREDGE, D.B. – BUTLER, B.J. – CATANZARO, P.F. (2012): Reimagining family forest conservation: Estimating landowner awareness and their preparedness to act with the conservation awareness index. J. For. 110 (4): 207–215.

WADSWORTH, B. (1990): Factors Affecting forest land Conversion and the Feasibility of Cooperative Land Management Efforts at King County's Urban/Rural Interface. M. Sci. Thesis. University of Washington, Seattle.

WILLIAMS, E.D. – GOTTFRIED, R.R. – BROCKETT, C.D. – Evans, J.P. (2004): An integrated analysis of the effectiveness of Tennessee's Forest Greenbelt Program. Landscape Urban Plan. 69: 287–297.

ZOBRIST, K. – LIPPKE, B.R. (2003): Case studies examining the economic impacts of new forest practices regulations on NIPF landowners. In Teeter, L. – Cashore, B. – Zhang, D. (eds.): Forest policy for private forestry: Global and regional challenges. CABI Publishing, Wallingford, UK. 203–210.

ZOBRIST, K.W. (2011): Your Forest Stewardship Plan. Fact Sheet FS060E, Washington State University Extension, Pullman, WA, USA.
Online: https://pubs.wsu.edu/ItemDetail.aspx?ProductID=15445

ZOBRIST, K.W. – ROZANCE, M.A. (2014): Ownership values of small forest landowners in Northwest Washington, USA. In: Proceedings of the IUFRO Joint Conference of 3.08 & 6.08 "Future Directions of Small-scale and Community-based Forestry." Japan. September 2013. 199–207.

ZOBRIST, K.W. – ROZANCE, M.A. (2015): Forest Landowner Education Interests and Delivery Preferences: A Retrospective Look at Survey Results and Actual Participation. Journal of Extension 53 (5).

DE GRUYTER OPEN DOI: 10.1515/aslh-2016-0005 Acta Silv. Lign. Hung., Vol. 12, Nr. 1 (2016) 47–53

Natural Resource Enterprises: Payments to Landowners for Ecosystem Services from Forests and their Management in the United States of America (U.S.)

Walter Daryl JONES*

Department of Wildlife, Fisheries, and Aquaculture, Mississippi State University Extension Service

Abstract – Mississippi landowners were found to diversify incomes from forests through fee-access outdoor recreation, including hunting, angling, wildlife watching, and other nature-based activities (Jones et al. 2005). The Natural Resource Enterprises (NRE) Program at Mississippi State University educates private landowners, resource agencies, and local communities about recreational enterprises, conservation, and integration of these activities with sustainable forestry through educational workshops. Since 2005, the NRE Program has organized and conducted over 75 landowner workshops in 11 U.S. states and Sweden and trained in excess of 4,000 participants in outdoor recreational business development and associated conservation practices. Survey results revealed that our programming has initiated over 1,000 new outdoor recreational businesses on an estimated 1.2 million hectares of forest and agricultural lands, generating over $14 million in incomes while fostering natural resource conservation on family farms in the U.S. NRE development on rural lands benefits landowners and local communities through promoting payments for ecosystem services supported by sustainable forests.

sustainability / forest management / landowners

Kivonat – Ökoturisztikai vállalkozások: Díjfizetés a földtulajdonosok számára az erdőből és az erdőgazdálkodásból származó ökoszisztéma szolgáltatásokért az Amerikai Egyesült Államokban (USA). Mississippi földtulajdonosok díjfizetős természetközeli kikapcsolódási lehetőségekkel, például vadászattal, horgászattal, vadvilág megfigyeléssel és más természethez kapcsolódó szolgáltatásokkal diverzifikálták bevételeiket (Jones et al. 2005). A Mississippi Állami Egyetemen működő Ökoturisztikai Vállalkozások Program (ÖVP) műhelybeszélgetéseken keresztül tart képzéseket földtulajdonosok, ügynökségek és a helyi közösségek képviselői számára az ökoturisztikai vállalkozások, a természetvédelem és ezek erdőgazdálkodással történő integrálása témakörében. 2005 óta az ÖVP 75 műhelybeszélgetést szervezett meg és hajtott végre az USA 11 államában és Svédországban, és 4000-ret meghaladó résztvevőt képzett az ökoturisztikai fejlesztés és a kapcsolódó természetvédelmi tevékenységek témakörében. Felmérési eredmények felfedték, hogy a program révén 1000 új ökoturisztikai vállalkozás indult el 1,2 millió hektárra becsült erdő és mezőgazdasági területen, 14 millió USD bevételt generálva, miközben a természeti erőforrások védelmét is elősegítette az USA családi agrárvállalkozásaiban. Az ÖVP fejlesztés a vidéki térségekben a tartamos erdőgazdálkodás ökoszisztéma szolgáltatásaiért történő díjfizetések ösztönzésével a földtulajdonosok és a helyi közösségek számára is hasznot hajt.

tartamosság / erdőgazdálkodás / földtulajdonosok

* daryl.jones@msstate.edu; Box 9690, Mississippi State University, MS 39762, USA

INTRODUCTION

Ecosystem services can be defined as the direct and indirect contributions of ecosystems to human well-being (Economics of Ecosystems and Biodiversity 2010). These services support human survival and life qualities in a number of ways. Ecosystem services can be categorized in four primary types, including provisioning, regulating, habitat, and cultural services. Provisioning services are products from ecosystems, such as food, water, wood, fiber, genetic, and medicinal attributes. While regulating services are benefits to society from ecosystems including climate regulation, natural hazard regulation (i.e., coastal zone protection from hurricanes and typhoons resulting from coastal wetlands, water quality and quantity attributes from watersheds, waste management, and environmental benefits to agriculture (pest control and pollination)). Habitat services refer to wildlife and fisheries habitats within ecosystems that enhance biodiversity of species and genetic variability among individual species. Lastly, cultural services are societal benefits derived from healthy ecosystems, such as spiritual and religious enrichment, scholarly enrichment, outdoor recreation, and aesthetic values of the environment. Natural resource conservation, stewardship, and wise-use land management practices can provide these ecosystem services to society, particularly when commercial and private landowners are given economic incentives to manage lands in environmentally friendly ways.

Outdoor recreation, including recreational hunting, angling, wildlife watching, and ecotourism is one avenue that incentivizes natural resource conservation and sustainable land-use practices on private lands in the U.S. while providing ecosystems services benefitting society at large. Demand for quality outdoor recreation is popular throughout the world. U.S. citizens (87.5 million) spent over $145 billion (U.S. dollars) on wildlife-related recreation in 2011 (U.S. Department of the Interior 2011). Past research found that revenues collected in 1998 from fee-access hunting on private lands in Mississippi ranged from $2,964 to $5,254 on average per landowner who offered access to property or $7.50 – $14.28/ha, depending upon the region of the state evaluated. Net revenues averaged from $1,539 to $3,244 per landowner who provided hunting access or $3.95 to $9.66/ha (Jones et al. 2005). During 2005–2008, outdoor recreation increased Mississippi rural property values by 52% or $1,615/ha and those tracts that were leased for recreational hunting averaged over $61/ha (Brashier 2014). Property characteristics that statistically influenced sales prices of rural tracts were hectares comprised of diverse land covers dominated by forested and agricultural lands. Expenditures for outdoors recreation (hunting, angling, wildlife watching, horse trail riding, and other nature-based outdoor activities) were estimated at $2.7 billion in economic returns to the State of Mississippi in 2008 (Henderson et al. 2010). Despite the economic and environmental benefits of fee-access outdoor recreation, only 10–14% of Mississippi private landowners participated in these businesses on their properties, primarily due to concerns in accident liability and perceived incompatibility with traditional forestry and agricultural land uses (Jones et al. 2005). Similar trends in revenues and land values associated with fee-access wildlife and fisheries recreation have been documented in other southern U.S. states (Richardson et al. 1992, Richardson et al. 1996).

Marginal lands, such as agricultural field borders, wetlands and wetland forests, and forested riparian corridors along watersheds, are often difficult to farm or manage for timber production due to flooding problems or regulatory restrictions (National Research Council 1992). However, these properties are ideal for conserving wildlife and fisheries habitats and can be readily enrolled in fee-access recreational businesses and governmental cost-share assistance programs. Revenues from fee-access recreation on private lands were substantially greater on forested and managed agricultural lands, particularly bottomland hardwood forests and forested riparian buffers along watersheds. This finding reveals that private landowners

can generate income from conservation and restoration of lands that were marginal for forestry, agriculture, or development (Jones et al. 2005, Jones et al. 2008). Additionally, these lands provided ecosystem services that benefit local and regional communities. This study also revealed that fee-access recreation and associated wildlife habitat conservation often times promoted by governmental cost-share assistance programs were compatible with agriculture and forestry, thereby providing incentives to landowners to diversify natural resource enterprises on their properties that encourage land and water conservation.

Natural resource enterprises may include diverse outdoor activities, wildlife-related recreation, and associated amenities such as hunting, angling, wildlife watching, agritainment or farm tours, horse trail riding, and rural bed and breakfast accommodations. Establishing these types of enterprises on family forests and farms provide multiple benefits and ecosystem services that include the diversification of income streams for rural families, land ownership retention, conservation and stewardship of the land, improved watershed integrity, high quality habitats for wildlife and fish, reduced regulatory measures for environmental protection (state and federal wetland regulatory protection programs), and sustainable rural development (Jones et al. 2005, Jones et al. 2008).

NATURAL RESOURCE ENTERPRISES PROGRAM

The Natural Resource Enterprises Program (NRE) (www.naturalresources.msstate.edu) was established in the Department of Wildlife, Fisheries, and Aquaculture and Cooperative Extension Service at Mississippi State University to educate rural landowners in the U.S. about fee-access recreational business development, wildlife and fish habitat management on farm and forest lands, and compatible land-use practices. Historically in the U.S., educational materials for natural resource enterprise development, though available, have been difficult to locate. As a result, landowners may not be aware of training opportunities and resources available. Working with program partners, we have developed educational workshops, demonstrations, and resources to inform landowners, agency professionals, and community leaders about enterprise opportunities, wildlife habitat management, and sustainable land uses on private lands. The NRE Program partners with federal resource agencies and state land-grant universities, farm bureaus and agricultural trade organizations, U.S. state agencies, non-governmental organizations, and private-sector firms. Partners are actively trained in NRE and land management approaches and participate in workshops. Through these partnerships, we offer on-the-ground educational demonstrations and workshops to assist private landowners in outdoor recreational business development and conservation practices on their lands to enhance natural resources, including wildlife and fish and their associated habitats.

WORKSHOP PROGRAMMING

NRE workshops provide participants with the opportunity to learn from and interact with resource and agency professionals and existing operators of successful outdoor recreational businesses. We conduct workshops on properties that are currently in forestry or agricultural production and that also support a fee-access outdoor recreational enterprise.

During workshops, participants are given learning experiences including instructional lectures from resource professionals and field tours on properties with a fee-access recreational business. During lecture sessions, speakers from universities, resource agencies, and organizations discuss topics, such as revenue potential from outdoor recreational

enterprises, business planning and management, legal considerations and liability reduction, governmental cost-share assistance, and habitat management considerations on the farm.

Attendees tour properties hosting events during afternoon sessions to observe enterprise operations and wildlife and fisheries habitats management integrated with forestry and farming practices. Each workshop attendee receives educational materials about enterprise operations, business management and marketing, liability reduction, wildlife and fisheries habitat management, cost-share assistance programs, and other topics pertinent to establishing and managing an enterprise.

PARTICIPATION

Workshops have been well received by past landowner, resource agency, and community leader participants. From 2005 to 2014, the NRE Program and partners have conducted over 70 landowner workshops and demonstrations in 11 U.S. states, including Alabama, Arkansas, Indiana, Louisiana, Michigan, Minnesota, Mississippi, Oregon, South Carolina, Tennessee, and Texas. Attendance at these events has been exceptional with over 4,500 participants, including an estimated 4,000 landowners with landholdings located in 16 U.S. states. The program participated in a conference and series of workshops sponsored by Lunds University (Dr. Marie Appelstrand) and the Swedish Forest Agency in 2009 to promote fee-access outdoor recreational enterprises within local communities in central Sweden.

To evaluate impacts from workshops, participants were mailed a comprehensive survey entitled Natural Resource Enterprises Landowner Survey that requested information about land-use practices, NRE businesses and conservation that have been implemented on farms since respondents attended a workshop, and additional information required to manage their properties. The Dillman method of survey design and administration was used in construction and mailing of the questionnaire to workshop participants (Dillman 1991). In June 2013 and 2014, questionnaires were mailed to past NRE workshop participants attending events from 2011 to 2014. Respondents to questionnaires were pooled with respondents from a survey mailing conducted in 2011 to participants of workshops from 2008–2010. The survey was divided between sections with questions related to landownership, cost-share assistance program participation, types of NRE's initiated on private lands and revenues collected from new business start-ups, informational needs on land management, and respondent demographics.

RESULTS

Survey response rate was 34%, yielding an N size of 514 landowners (pooled from an estimated 30 workshops) who owned lands in 16 U.S. states. Respondents reported that they frequently utilized the NRE website (www.naturalresources.msstate.edu) to acquire information about wildlife management on their properties, business resources for establishing an NRE business, and to learn about upcoming training events. Other methods preferred by respondents for learning about NRE establishment in addition to attending workshops were watching videos (75% viewed or were interested) and using a resource binder of educational materials provided to attendees at events (65% of respondents). Resource materials sought by respondents were those about wildlife management (82%), timber management (80%), legal issues surrounding NRE operations (76%), wildlife supplemental plantings (74%), agritainment enterprises (63%), fee hunting (62%), and NRE business planning (62%).

Most workshop attendees were landowners (91%) and had the following land uses on their properties: agriculture (78%), forestry (63%), personal recreation on property (61%), fee-access recreational businesses (22%), and vegetable and mushroom production for sale (18%). In terms of landownership, respondents (n=462) owned 220 hectares on average. Land covers on properties owned were primarily forested (mean = 148 hectares/respondent), followed by agriculture (mean = 79 hectares) and other lands such as fallow fields and wetlands (mean = 41 hectares). Agricultural lands ranged from row crops (mean = 79 hectares), pasture (mean = 26 hectares), and aquaculture ponds (mean = 5 hectares). Forested lands were dominated by planted pines and bottomland hardwood forests, 74 hectares and 59 hectares on average, respectively. Mixed pine hardwood forests averaged 44 hectares, followed by upland hardwoods (mean = 39 hectares), natural pine (mean = 20 hectares) and recently harvested cutover tracts averaged 14 hectares. Other lands owned by respondents consisted of wetlands and flooded fields (averaged 10 hectares), food plots for wildlife, roads, and rights of way (each cover type averaged 8 hectares), and fishing ponds (mean = 3 hectares).

Conservation practices were implemented by respondents (n=328) on an aggregate 5,856 hectares representing on average about 50 hectares per farm. Diverse practices were reported by respondents on their properties and included mowing (56%), wildlife plantings (50%), herbicide application (43%), land disking (34%), use of prescribed fire (30%), and forest management (29%). In terms of conservation practices information requested, respondents reported wildlife plantings, herbicide application, pond management, forest thinning, and prescribed burning were the subjects most sought. Over one-half of respondents reported that they had requested assistance from university extension staffs, agency biologists, or other land management experts to implement conservation and land management practices on their properties.

Nearly one-half of respondents reported that they had lands enrolled in U.S. Farm Bill conservation cost-share assistance programs. On average, these landowners collected $7,146 (U.S. dollars) in annual contract payments, accounting for payments in excess of $1.25 million. Conservation Reserve Program was the most popular cost-share assistance program participated in with 97 landowners reporting enrollments of 82 hectares on average per farm. Wetlands Reserve Program had 29 farmers participating who averaged 57 hectares enrolled on average, followed by Wildlife Habitat Incentives Program with 52 participants who averaged 19 hectares enrolled and Environmental Quality Incentives Program with 49 landowners who averaged 15 hectares enrolled per farm.

One hundred and sixty-four respondents (30%) reported initiating an NRE business on their lands between 2011–2013 with 46 landowners establishing hunting leases, 40 fee-hunting operations, and 30 landowners starting fishing or agritainment operations. On average, landowners committed 329 hectares of their forests and farm lands to outdoor recreational businesses per farm, totaling over 54,000 hectares across all U.S. respondents. In terms of hunting species featured on lands, white-tailed deer (n=101) and wild turkey (n=62) were the most popular game species reported, followed by squirrel species, waterfowl, mourning dove, and rabbit. Landowners initiating NRE businesses collected on average $13,851 per farm, totaling nearly $2.3 million in aggregate cash flow from NRE's initiated (*Table 1*). Inferring these averages to the total number of landowners attending past workshops, an upper limit of new NRE business start-ups would equal 1,050 new NRE's established on an estimated 1.2 million hectares of forest and agricultural lands in the U.S., accounting for an aggregate cash flow of $14.5 million U.S. dollars. Overall, respondents (69%) reported that revenues met their income expectations. When asked reasons why landowners initiated these businesses, most reported income potential from NRE operations, land conservation management, recreational potential on their lands, improving wildlife and fish on their property, and for personal hobby and enjoyment.

Lastly, most respondents did not have a business plan for their NRE and needed help in drafting such a document. To meet this need, we have initiated more advanced workshop formats to train landowners in drafting business plans to better guide their actions in starting new NRE ventures. Respondents reported that their business clients consisted of adult hunters, families, and out-of-town guests who learned about their outdoor excursions offered through word of mouth. When respondents were asked how they would prefer to learn about NRE business and land management opportunities in the future, most favored attending workshops. The majority of respondents were male (63%), older than 56 years of age, over 90% Caucasian, college graduates, and slightly more than half lived on the property reported in the survey.

Table 1: Expected income of landowner respondents from natural resource enterprises developed on their properties in the U.S. from 2008–2013.

Expected income from enterprise development	Number of responses (N=164)	Percentage (%) of total responses
$0 – $1,000	76	45
$1,000 – $10,000	47	29
$10,001 – $25,000	17	10
$25,001 – $50,000	13	8
$50,001 – $75,000	6	4
$75,001 – $100,000	1	1
$125,001 – $150,000	1	1
Over $150,000	3	2

CONCLUSION

Past research has shown that private landowners earn additional revenues from their properties through fee-access outdoor recreational businesses. As a result, we have developed workshops to educate private landowners, state and federal resource agency staffs, and elected and nonelected community leaders about fee-access outdoors recreational enterprise development and integrated conservation practices on rural properties. Survey findings revealed that workshop participants have become more knowledgeable about and had implemented successful natural resource enterprises and associated land conservation management on rural properties located in U.S. states. Landowners earned income from these businesses and earnings met landowner expectations. Consequently, natural resource conservation practices conducted on private lands and associated with NRE development enhanced environmental protection on these working properties and thus, provided viable ecosystem services to rural communities in the U.S.

In terms of providing outreach programming in the U.S., multi-state stakeholder collaboration among land-grant universities, state and federal resource agencies, conservation and agricultural trade organizations, and private-sector groups has been vital to designing and implementing educational programming to attract and educate forest landowners and agricultural producers. Outreach programming promoting fee-access recreation and conservation on privately-owned U.S. lands can benefit landowners and local communities through sustainable economic development, environmental conservation, and land

stewardship and retention. It is believed that this hands-on approach of participatory teaching, marketing, and information dissemination through workshop programming is effective at delivering quality land management training to landowners in rural America who oftentimes have difficulty in acquiring knowledge and skills. In this fashion, we can assist landowners in rural landscapes to diversify family incomes on their lands while enhancing land and water conservation, thereby strengthening local economies and providing ecosystem services and quality outdoor recreation on the U.S. land base that might not otherwise be provided if incentives were not present.

REFERENCES

DILLMAN, Don A. (1991): The Design and Administration of Mail Surveys. Annual Review of Sociology 17: 225–249

BRASHIER, J. The contribution of outdoor recreation on rural property sales in Mississippi. Retrieved from ProQuest Dissertation and Theses. (Accession Order No. [12007]).

Economics of Ecosystems and Biodiversity - TEEB. (2010): The Economics of Ecosystems and Biodiversity Ecological and Economic Foundations. Edited by Pushpam Kumar. Earthscan, London and Washington

HENDERSON, J. – GRADO, S. – MUNN, I. – JONES, W. (2010): Economic impacts of wildlife- and fisheries-associated recreation on the Mississippi economy: an input-output analysis. Forest and Wildlife Research Center, Research Bulletin FO398, Mississippi State University. 21 p.

JONES, W. – JONES, J. – MUNN, I. – GRADO, S. (2005): Wildlife enterprises on Mississippi private lands. Proceedings of the 58th Annual Conference of the Southeastern Association of Fish and Wildlife Agencies, 58: 344–355.

JONES, W. – RING, J. – JONES, J. – WATSON, K. – PARVIN, D. – MUNN, I. (2008): Land valuation increases from recreational opportunity: a study of Mississippi rural land sales. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies. 60: 49–53.

NATIONAL RESEARCH COUNCIL (1992): Restoration of Aquatic Ecosystems. Commission on Geosciences, Environment, and Resources, National Academy Press, Washington, D.C. 552 p.

RICHARDSON, C. – YARROW, G. – SMATHERS, W. (1992): Economic impact of hunting on rural communities in South Carolina. Clemson Univ. Coop. Ext. Serv. Publ. 26 p.

RICHARDSON, C. – YARROW, G. – SMATHERS, W. (1996): Economic impacts of hunting on rural communities. Quality Whitetail. 3(2): 5–8.

U.S. Department of Interior, U.S. Fish and Wildlife Service and U.S. Department of Commerce, U.S. Census Bureau. (2011): National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. Washington, D.C.: U.S. Government Printing Office.

DE GRUYTER OPEN DOI: 10.1515/aslh-2016-0006 Acta Silv. Lign. Hung., Vol. 12, Nr. 1 (2016) 55–73

Development and Possibilities for Close-to-Nature Forest Resource Management in Hungary

Béla LETT[a*] – János GÁL[a] – Magdolna STARK[a] – Norbert FRANK[b]

[a] Institute of Forest Resource Management and Rural Development, Faculty of Forestry, University of West Hungary, Sopron, Hungary
[b] Institute of Silviculture and Forest Protection, Faculty of Forestry, University of West Hungary, Sopron, Hungary

Abstract – Legal regulations of the activities of forest managers were fundamentally changed by the legislature of the past decade, and little is known about the actual change in forest management practices. Based on the data collected by the State Forest Service, this study investigates the changes of the past 15 years and presents the influencing factors, primarily the species and sectorial characteristics and differences

In the study both the area of final cuts and regenerations are presented by modes, sectors and species. The main factors influencing forest resource management are site (which can be modified by climate change) and the corresponding species or stand type. Based on these possibilities, close-to-nature forest management can be evaluated on a more realistic basis. The sum and average values for the whole country are too general; the country consists of sectors with different forest resource management properties.

forest resource management / final cutting methods / regeneration methods

Kivonat – A természetközeli erdővagyon-gazdálkodás fejlődése és lehetőségei. Az elmúlt évtized jogi előírásai és igazgatási eljárása alapvetően megváltoztatták az erdőgazdálkodók tevékenységének szabályozását, amely a gyakorlatot is módosítja, *ennek* mértékéről azonban nem sokat tudunk. A tanulmány az Erdészeti Igazgatóság által gyűjtött és közzétett adatok alapján mintegy 15 év változását vizsgálja és bemutatja a ható tényezőket, elsősorban a regionális és a szektorális sajátosságokat és különbségeket.

A véghasználat területét és fatérfogatát használati módonként, régiónként, szektoronként és fafajonként mutatjuk be, az erdőfelújításokat (első kivitel és befejezett erdősítés) felújítási módonként, régiónként, szektoronként és fafajonként szemléltetjük. A (klímaváltozással módosuló) termőhely, az annak megfelelő fafaj bizonyul az erdővagyon-gazdálkodást meghatározó legfontosabb tényezőnek, így a természetközeli erdővagyon-gazdálkodás lehetőségeit is reálisabban ítélhetjük meg (amely a további változások megtervezésénél és előírásánál hasznot jelenthet). Az országos összesen és az átlagok magyarázó ereje nagyon kicsi, az ország teljesen máshogy működő erdővagyon-gazdálkodású régiókból áll, kívánatos a regionális erdővagyon-gazdálkodási programok készítése.

erdővagyon-gazdálkodás / fahasználati eljárások / erdőfelújítási módok

* Corresponding author: lettb@emk.nyme.hu; H-9400 SOPRON, Bajcsy-Zs. u. 4., Hungary

1 INTRODUCTION

The law LIV of 1996 regarding forests put forest management on new foundations in the period after the change of the political system. This period was closed by the law XXXVII of 2009, also a forest law, which introduced a new attitude towards ecological sustainability of forest management.

Several studies were published about close-to-nature forest management (Solymos 2000), siviculture (Frank 2012), about the change of the structure of forest resources (Lett – Stark 2013), and about regional forest management (Lett – Stark 2014).

The initiative called „Past and Future" started as a consultation among forestry professionals on close-to-nature forest management, which then resulted in a series of publications. It started with the publication of the presentations of the Őrség Forestry Days, which deals mainly with the selection system in small forest properties in the Vend area (Lett et al. 2009). The publication was a success; it had a positive effect on the opinion of experts and the next publication „Past and Future II: from clearcut to selection system" dealt with the experience of scientists, educators, and administrators in separate chapters. The study also raised questions and listed possible failures in connection with intruducing the selection system (Lett et al. 2010). The topic became even more interesting as the new Forestry Law (Law XXXVII of 2009) made the introdutction of the selection system compulsory in an increasing proportion after every 10 year period in the state forests.

The gathered experience was discussed on the 2nd Meeting of Forestry Economists and the studies were published in a publication "Past and Future III – The selection system from the viewpoit of forest managers" (Lett – Schiberna 2012)

The publication "Past and Future IV – Sustainability, close-to-nature management, control by the society" was compiled based on the presentations of another conference (Forest forum in Kőszeg) (Gyöngyössy 2012).

Theoretical questions of the new method are discussed in Schiberna et al. (2012); the practical economic investigations were summarized by Csépányi (2013). The investigations of the cost-benefit relations in transformation and selection systems (Marosi – Juhász 2012, 2014) also contributed to the general economic understanding of these systems.

The forestry law of 1996, with its ministerial decrees and regulations, completely changed the regulation of activities of forest managers, which then modified the everyday practice. Little is known about the scope of this change; therefore, we decided to make a preliminary analysis based on the data of the year 2000.

To characterize forest resource management, we present the change of utilizations and regeneration modes in the first decade of the 21st century (2000–2009/2010 and 2008/2009).

We consider year 2000 as a base so that changes can be made visible.

The combinations of utilization and regeneration modes are directly related to forest resource management concepts and are the distinctive characteristics of slivicultural regimes. This study puts emphasis on factors influencing silviculture, among which site and tree species combinations are of paramount importance. Due to the significant differenes between state and private forests with regards to these factors, the prospects of close-to-nature forest management are also different in these sectors.

2 MATERIALS AND METHODS

The study is based on the primary analysis of data published annually by Forestry Authority (ÁESZ; MGSZH; Forestry Directorate of NÉBIH): Report on afforestations and utilizations in the years 2000–2010.

When analyzing forest resource management, combinations of timber utilization and regeneration modes are investigated. Forestry Authority prepared two lists about utilization–regeneration mode combinations in this period because of the changes in the legal regulation. Comparisions and data analysis were conducted with due regards to these differences.

As the basis for comparision, the year 2000 has been chosen, which is far enough from 1996 to allow time for the new regulations to take effect, and also far enough from 2009 to have a sufficient dataset to be analyzed. Of course some years bring random elements, but there are insufficient periods for calculating averages about the new forest resource management regulations, and the appearance and registration of first plantings also changes.

In this study the differences between public (state and community) and private ownership forms are also analyzed.

3 PRODUCTION, PROTECTED AND NATURA 2000 FORESTS

Because of the change in legal environment, we investigated the forest assets management in the new primary function categories.

The area of final cuttings in the production forests is double that of the protected and Natura 2000 forests (and nearly half of this area is black locust). Forest resource management (and its elements) is strongly influenced by the utilization of exploitable stands on protected and Natura 2000 areas in the next 10–20 years; the limiting regulations of their regeneration and the encouragements for species changes. One fifth of the allowable cut is black locust and poplar on the protected and Natura 2000 areas, which is another long term problem. A similar question is the role of conifers (spruce – lowland and barren lands, present situation and future vision); conifers on protected and Nature 2000 areas make up half of the area on production areas for the same species.

Because of the large difference in species proportions, the area and volume relations also show big differences among production and protected forests as shown in *Table 1*.

With the Natura 2000 designations (and with their interpretation by the authorities) the area of forest with non-production functions has practically doubled, and the proportion of stands with native species on protected/Natura2000 areas is higher than on production areas.

Besides the stock variables of forest management (forest area – FA, growing stock – GS) special attention is also given to the flow elements (area of cuttings – AC, volume of cuttings – VC). The allowable cut (final cuttings) is presented by the area and volume of stands designated for cutting in the next decade.

Another important question of Hungarian forest resource management is to what extent the allowable cut on protected and Natura2000 areas can be utilized.

Beech evokes strong emotions especially from nature conservationists and partly also from the general public. However, it is only important in smaller regions because its share in the forest cover and in the standing timber volume is low on national level. Because of the overwhelming proportion of the protection function in beech forests, the only way to make use of their timber yield is to apply close-to-nature silivicultural methods that are suitable for the protection goals.

Table 1. Forest area and growing stock in 2010, as well as area and volume of final cutting 2000–2010 by species in production, protected and Natura 2000 forests in Hungary

Species	Forest area (FA)		Area of final cutting (AC)		Growing stock (GS)		Volume of final cutting (VC)	
	Production (10^3 ha)	Protected Natura (10^3 ha)	Production (10^3 ha)	Protected Natura (10^3 ha)	Production (10^6 m^3)	Protected Natura (10^6 m^3)	Production (10^3 ha)	Protected Natura (10^3 ha)
1 Beech	22.0	88.0	2.5	6.1	8.0	31.4	1.3	3.1
2 Oak	166.2	222.0	10.0	19.0	32.1	52.0	3.5	6.5
3 Turkey oak	102.2	104.1	12.1	11.5	22.1	23.1	3.8	3.6
4 Other hardw.	80.4	120.3	8.6	10.7	13.8	22.7	2.1	2.8
5 LRHW (1+2+3+4)	***370.8***	***534.4***	***33.2***	***47.3***	***76.0***	***129.2***	***12.9***	***19.2***
6 Black locust	376.6	70.3	74.7	7.2	39.6	8.5	11.8	2.6
7 Hybrid popl.	93.1	30.7	31.8	10.0	10.9	5.0	5.0	2.1
8 Bl.l.+Hyb.popl (6+7)	*469.7*	*101.0*	*106.5*	*17.2*	*50.5*	*13.5*	*16.8*	*4.7*
9 Poplars	46.3	27.2	8.1	4.7	6.6	5.9	1.9	1.6
10 Other softw.	43.8	56.0	6.6	8.2	9.4	13.8	1.9	1.3
11 Conifers	141.5	71.4	14.8	6.5	34.0	20.1	4.0	2.1
12 Softw.+con. (9+10+11)	*231.6*	*154.6*	*29.5*	*19.4*	*50.0*	*39.8*	*7.8*	*5.0*
13 Non LRHW (8+12)	***701.3***	***255.6***	***136.0***	***36.6***	***100.5***	***53.3***	***24.6***	***9.7***
Total (5+12)	**1,072.1**	**789.9**	**169.3**	**84.0**	**176.5**	**182.5**	**35.2**	**25.5**

Legend: LRHW= long rotation hardwood Source of data MgSzH

In the cases of black locust and hybrid poplar, more than 100 thousand hectares are under protection or Natura2000. Of course these forests are not the subject of protection, but they fall within protection zones. However, protection measures also affect them. These two species make up a considerable share in harvest volume and, thus, they also have a great financial impact on the forestry sector. It is difficult to measure how far they fall from close-to-nature state, and it is even more difficult to find ways through which close-to-nature silvicultural methods could be introduced in these plantations without the plantations losing their profitability. The attitude of nature protection is basically condemnatory and the problems can be handled on a very long time frame.

The proportion of coniferous stands has considerably diminished.Their state of health is critical; it is possible and necessary to replace these stands with other species.

There is a critical situation in the groups of oak, Turkey oak and other hardwoods where the proportion of production forests exceeds one-third and approaches one-half.

4 FINAL CUTTING AND REGENERATION MODES

4.1 Area and volume of final cuttings by sector and cutting modes

The combinations of final cutting and regeneration modes characterize forest resource management. Firstly, the data on final cuttings (and those of regeneration, which are nearly identical) is presented. Dataset is classified by sector (state and private) and modes of cut (clearcut and regeneration cut).

At the flow data and especially at the area of final cuts *(Table 2)*, but also at volume *(Table 3)* the possibilities of private forestry are considerable, particularly in black locust and hybrid poplar stands.

Table 2. Area of final cuttings 2000 – 2010 (ha)

Sector	Clear-cut	Regen. cut	Shelt. cut	Final cut total	(Sel. cut)	(Stock maint.)	Unr. cut	Oth.	Total	Clear cut %
2000										
State + community	8,211	3,465	–	11,676	*	*	108		11,785	69.7
Private	8,823	534	–	9,358	*	*	35		9,392	93.9
Total	**17,034**	**3,999**	**–**	**21,034**	*****	*****	**144**		**21,177**	**80.4**
(%)	**80.4**	**18.9**	**–**	**99.3**	*****	*****	**0.7**		**100**	
2010										
State + community	7,780	3,342	241	11,363	*	*	449		11,812	65.9
Private	9,356	792	41	10,188	*	*	48		10,236	91.4
Total	**17,216**	**4,134**	**285**	**21,635**	*****	*****	**499**		**22,134**	**77.8**
(%)	**77.8**	**18.7**	**1.3**	**97.7**	*****	*****	**2.3**		**100.0**	

∗ Authorities do not assign area for regeneration obligation. Source of data MgSzH

Table 3. Volume of final cuttings by modes of cut and sectors 2000 – 2010 (10^3 m^3)

Sector	Clear-cut	Regen. cut	Shelt. cut	Final cut total	(Sel. cut)	(Stock maint.)	Unr. cut	Oth.	Total	Clear cut %
2000										
State + community	2,017	1,252	–	3,269	–	–	322	39	3,630	55.6
Private	1,627	125	–	1,752	–	–	104	22	1,878	86.6
Total	**3,644**	**1,377**	**–**	**5,021**	–	–	**426**	**61**	**5,508**	**66.2**
(%)	*66.1*	*25.0*	**–**	*91.1*	–	–	*7.8*	*1.1*	***100***	
2010										
State + community	1,801	1,209	95	3,107	41	1	456	31	3,635	49.5
Private	1,813	2,370	12	2,062	4	5	99	18	2,187	82.9
Total	**3,629**	**1,447**	**107**	**5,184**	**45**	**6**	**556**	**49**	**5,841**	**62.1**
(%)	*62*	*24.8*	*1.8*	*88.8*	*0.8*	*0.1*	*9.5*	*0.8*	*100*	

Source of data MgSzH

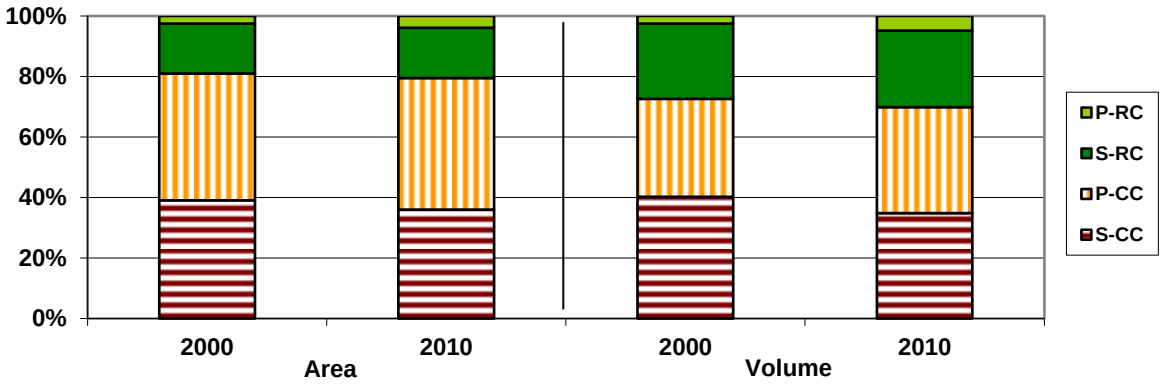
Cutting modes in 2010 were extended with modes which were not present in the statistics in 2000 (shelterwood cut, selection cut, growing stock maintaining cut). In the statistics of 2010, the new elements of utilization, the volume of which is minimal, appeared. Shelterwood cut generates obligation for regeneration; for selection cut and growing stock maintaining cut – the volume of which is negligible – the authorities do not assign obligation for regeneration.

The basic consequence is the change of proportion of clearcuts which is similar in terms of area and volume, but is different in magnitude (because of the already mentioned difference in specific volume). Regeneration cuts did not increase considerably in volume or in proportion; shelterwood cut, selection cut, and growing stock maintaining cuts just appeared recently and are in the phase of planning. The numbers of utilization (and consequently those of regeneration) show a steadiness typical for sustainable management and we cannot expect a sudden change in volume because of the strong determination.

4.2 Volume of final cuttings 2000–2010

Comparing the data from 2000 and 2010, no considerable shift in area, volume, proportions, or sectors can be observed, but a little change is noticeable from clearcut to regeneration cut (regeneration cut also increased in private sector). Clearcut is still determining in private forestry. *Figure 1* shows the proportions, their differences, and change in time.

The difference between the sectors in final cut – regeneration modes is considerable because of the stable difference in the forest resource of the state and private sector; changing this is a slow process determined by many other factors.



Legend: S-CC = State, clearcut; P-CC = Private, clearcut;
S-RC = State, regen. cut; P-RC = Private, regen. cut

Figure 1: Distribution of final cuts by modes and sectors 2000–2010 (Source of data MgSzH)

4.3 Volume of final cutting by species and sectors

In 2000 the statistics of final cuts by species provided the volumes as total, not divided by clearcuts and regeneration cuts, so the table was completely different. The data in *Table 4* show the differences between the sectors by species.

Table 4. Volume of final cuts by species and sectors 2010

Species	Clearcut		Regen. cut		Shelterw. cut		Total final cut	
Total	(10^3 m^3)	(%)	(10^3 m^3)	(%)	(10^3 m^3)	(%)	(10^3 m^3)	(%)
1 Beech	22.4	0.4	428.6	8.3	49.4	1.0	500.3	14.7
2 Oak	344.7	5.9	392.2	6.7	23.0	0.4	760.0	13.3
3 Turkey oak	209.2	3.6	463.6	7.9	14.6	0.3	687.4	3.0
4 Hornbeam	71.5	1.2	78.6	1.3	6.9	0.1	157.0	2.4
5 Other hardwoods	101.2	1.7	20.5	0.4	4.4	–	126.2	43.0
6 LRHW (1+2+3+4+5)	749.0	14.4	1,353.5	26.1	98.3	1.9	2,230.9	25.6
7 Black locust	1,317.4	22.6	6.3	0.1	1.3	–	1,325.0	15.5
8 Hybrid poplar	805.8	13.8	0	–	–	–	805.9	41.1
9 Black l.+ hyb.popl.	2,123.2	41.0	6.3	0.1	1.3	–	2,130.9	2.4
10 Poplar	124.8	2.1	2.0	0	0.2	–	127.0	0.6
11 Willow	31.6	0.5	–	–	–	–	31.6	2.8
12 Other softwood	123.4	2.1	20.3	0.3	2.4	0.1	146.1	10.0
13 Conifers	477.2	8.2	34.9	0.6	5.6	0.1	517.7	15.9
14 Other sw and con. (10+11+12+13)	757.0	14.6	57.2	1.1	8.2	0.2	822.4	57.0
15 Non LRHW (9+14)	2,880.2	55.6	63.5	1.2	9.5	0.2	2,953.3	14.7
Total (10^3 m^3)	**3,629.2**		**1,447.0**		**107.9**		**5,184.1**	
(%)		**70.0**		**27.9**		**2.1**		**100**

Legend: LRHW= long rotation hardwood Source of data MgSzH

Table 4 continued. Volume of final cuttings by species 2010

Species	Clearcut		Regen. cut		Shelterw. cut		Total final cut	
State	(10^3 m^3)	(%)	(10^3 m^3)	(%)	(10^3 m^3)	(%)	(10^3 m^3)	(%)
1 Beech	16.1	0.5	368.6	11.9	47.1	1.5	431.8	13.9
2 Oak	274.4	8.8	336.3	10.8	20.5	0.7	631.3	20.3
3 Turkey oak	164.8	5.3	378.5	12.2	13.3	0.4	556.6	17.9
4 Hornbeam	46.8	1.5	57.2	1.8	5.2	0.2	109.2	3.5
5 Other hardwoods	68.0	2.2	17.2	0.6	4.0	0.1	89.2	2.9
6 LRHW (1+2+3+4+5)	570.	18.4	1,157.8	37.3	90.1	2.9	1,818.1	58.5
(%)	*31.4*		*63.7*		*4.9*		*100*	
7 Black locust	410.8	13.2	2.0	0.1	0.3	–	413.1	13.3
8 Hybrid poplar	323.5	10.4	–	–	–	–	323.5	10.4
9 Black l.+ hyb.popl.	*734.3*	*23.6*	*2.0*	*0.1*	*0.3*		*736.6*	*23.7*
10 Poplar	67.8	2.2	1.8	0.0	0.2	0.0	69.8	2.2
11 Willow	18.5	0.6	–	–	–	–	18.5	0.6
12 Other softwood	42.3	1.4	19.7	0.6	2.4	0.1	64.4	2.1
13 Conifers	368.3	12.4	28.5	0.9	2.4	0.1	399.1	12.8
14 Other sw and con.	*496.9*	*16.0*	*50.0*	*1.5*	*5.0*	*0.2*	*551.8*	*17.8*
15 Non LRHW (9+14)	1,231.2	39.6	52.0	1.6	5.3	0.2	1,288.4	41.5
(%)	*95.6*		*4.0*		*0.4*		*100*	
Total (10^3 m^3)	**1,801.3**		**1,209.8**		**95.4**		**3,106.5**	**100**
(%)		***58.0***		***38.9***		***3.1***	***100***	
Private								
1 Beech	6.3	0.3	59.9	2.7	2.3	0.1	68.5	3.3
2 Oak	70.3	3.2	55.7	2.5	2.4	0.1	128.4	6.2
3 Turkey oak	43.4	2.0	85.0	3.9	1.2	0.1	129.6	6.3
4 Hornbeam	24.6	1.1	21.4	1.0	1.5	0.1	47.5	2.3
5 Other hardwoods	33.1	1.5	3.3	0.2	0.2	–	36.6	1.8
6 LRHW (1+2+3+4+5)	177.7	8.6	225.3	10.9	7.6	0.4	410.6	19.9
(%)	43.3		54.9		1.8		100	
7 Black locust	901.3	43.7	4.3	10.1	0.9	–	906.5	44.0
8 Hybrid poplar	477.6	23.1	–	–	–	–	477.6	23.1
9 Black l.+ hyb.popl.	*1,378.9*	*66.9*	*4.3*	*10.1*	*0.9*	*–*	*1,384.1*	*67.1*
10 Poplar	56.6	2.6	0.3	–	–	–	56.9	2.8
11 Willow	12.9	0.6	–	–	–	–	12.9	0.6
12 Other softwood	80.2	3.7	0.6	–	0.1	–	80.8	3.9
13 Conifers	107.0	6.9	6.5	0.3	3.2	0.1	116.7	5.7
14 Other sw and con.	*256.7*	*12.4*	*7.4*	*0.3*	*3.3*	*0.1*	*267.3*	*13.0*
15 Non LRHW (9+14)	1,635.6	79.3	11.7	0.6	4.2	0.2	1,651.4	80.1
(%)	99.0		0.7		0.3		100	
Total (10^3 m^3)	**1,813.4**		**236.9**		**11.7**		**2,062.0**	
(%)		**87.9**		**11.5**		**0.6**	**100**	

Legend: LRHW= long rotation hardwood Source of data MgSzH

The proportion of clear cut in state and private forests are nearly similar in area and volume, but the species distribution and, therefore, the management conditions are substantially different. In private forestry, the role of black locust is vast and the role of hybrid poplars is also important.

The majority of final cuttings in state forestry consist of broadleaved hardwood stands (58.5%). In these stands clearcut does not reach one third of the area (in the case of beech not even 5%), while in other species this proportion is 95%.

In private forestry the share of broadleaved hardwoods is only one fifth, and black locust (44%) and hybrid poplar (23%) are in majority. With other species clearcut is nearly 99%, while in the case of broadleaved hardwoods the situation is similar to that in state forests.

Using clearcut or regeneration cut depends mainly on species, but other factors and stand characteristics can also influence the decision.

Behind the differences in final cutting – regeneration modes between sectors *(Figure 2)* are the differences in species, so the differentiation is for the long run. In the species composition of regeneration cuts, the difference is much smaller (beech is important in state forests) and in clearcut, oak is important in state forests.

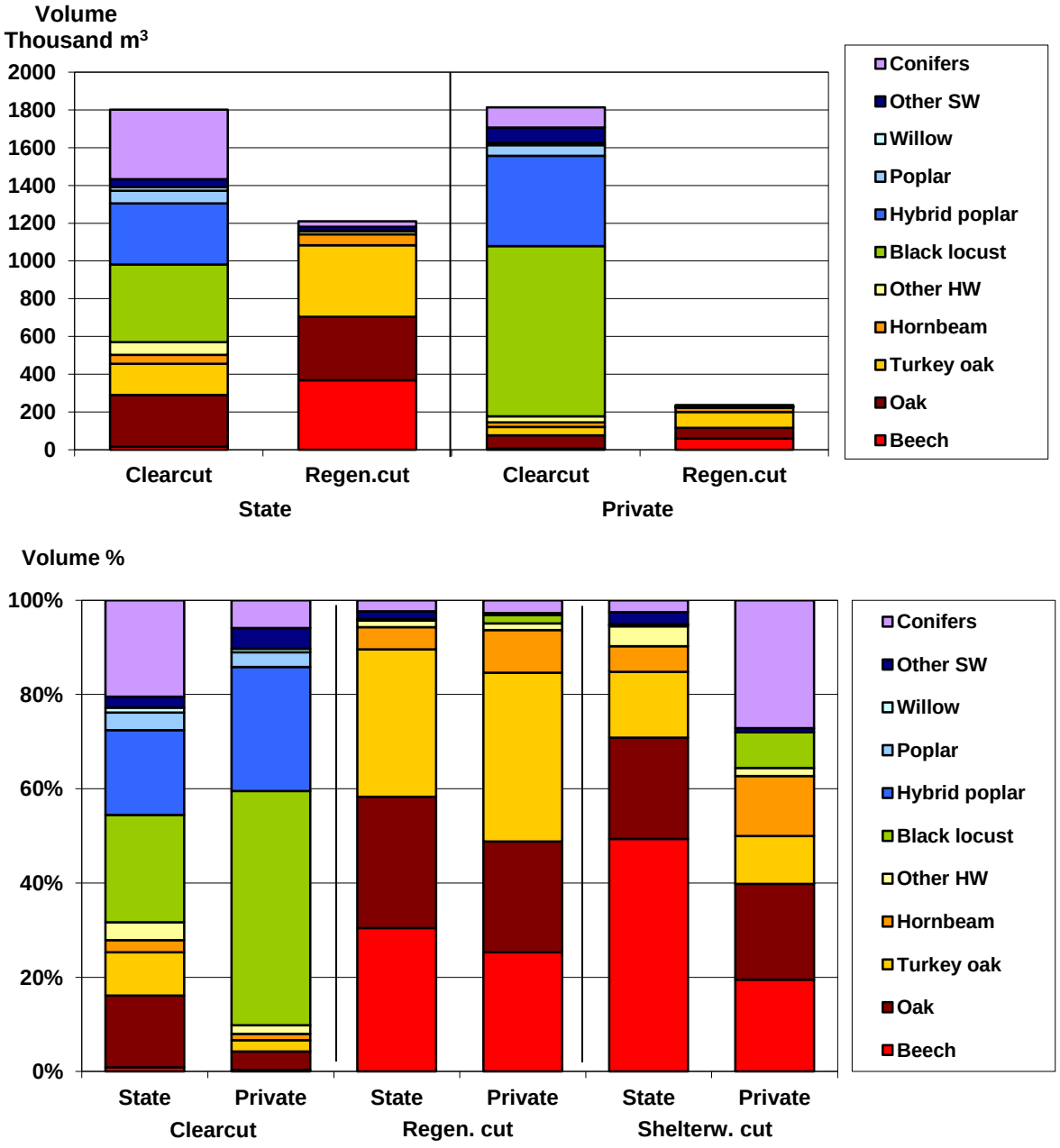


Figure 2. Comparison of state and private forest resource management (Source of data MgSzH)

Based on the data in *Table 4 and Figure 3*, the following statements can be made:

- proportion of regeneration cuts in turkey oak is higher than in oak (similarly to beech) in both sectors
- regeneration cuts are negligible in short rotation stands and no increase is expected

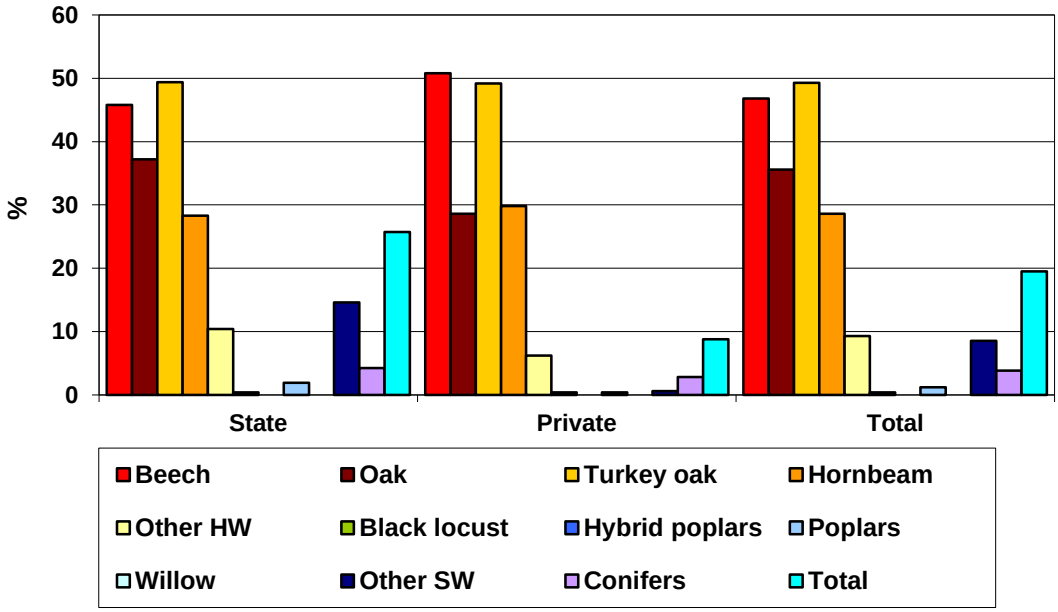


Figure 3: Proportions of regeneration cuts (2010) (Source of data MgSzH)

Annual final cuttings have stabilized, the changes do not have a tendency, the increase of conifers is steady, and a decrease is expected with hybrid poplars *(Figure 4)*

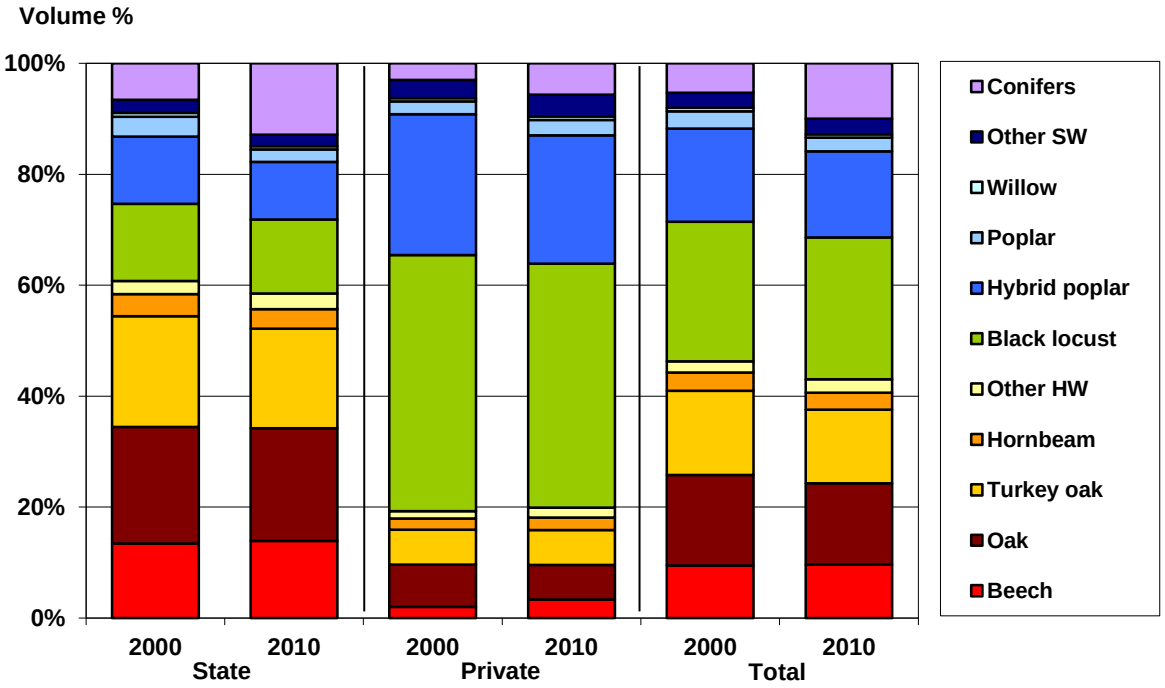


Figure 4. Change of final cutting by species (2000–2010) (Source of data MgSzH)

According to proportion of final cut, species groups with good separation can be observed *(Table 5)* and rotation age is an important influencing factor:

- below 55%, conifers because of the age structure
- between 55–70%, native stands with high rotation age (but also other softwood in the state forest category)
- final cut proportion is over 70% in the case of short rotation age
- with some species the final cut proportion is lower in the state forest than in private forest, the rotation age is higher,
- there is no substantial change in time because of the stable species structure, only slow change is to be expected,
- the final cut proportion is two-thirds in the state forest, and about three-quarters in the private forest

Table 5. Proportion of final cut volume within total timber removal in 2000 and in 2010 (%)

Species	State		Private		Total	
	2000	2010	2000	2010	2000	2010
Beech	70.1	53.7	62.1	58.1	69.4	54.6
Oak	69.7	69.7	67.5	65.9	69.3	69.0
Turkey oak	76.0	72.7	57.8	75.1	75.9	73.2
Hornbeam	47.3	54.0	56.8	66.2	49.1	57.2
Other HW	53.8	54.2	66.3	68.5	56.3	57.5
Black locust	79.9	78.3	87.1	82.9	84.4	81.4
Hybrid poplar	78.2	81.4	79.3	82.7	78.8	82.2
Poplar	60.4	73.9	71.1	75.7	76.6	74.1
Willow	47.1	70.3	61.1	79.6	60.7	74.2
Other SW	51.5	47.6	68.8	78.1	57.7	60.9
Conifers	33.6	58.7	26.2	51.2	31.8	56.9
Total	66.1	66.1	74.7	76.4	68.9	69.8

Source of data MgSzH

5 PERFORMANCE AND CHANGE OF COMPOSITION OF REFORESTATION

5.1 Mode and performance of reforestation (2000–2009)

The forest resource management of the 2000's was determined by financing along similar principles, but with different practices: funds for supporting forest resource and normative financing of regeneration. The effects if its termination in 2008 will be detectable only after several years have passed.

The proportion of regeneration cut has not reached one-fifth in the state-owned forests, and within this artificial regeneration there is more regeneration than natural seed origin in clearcuts. In private forestry, natural regeneration can be applied only to some species, but black locust coppice regeneration reduces artificial regeneration, thus reducing costs for the forest manager (*Table 6, Figure 5*).

In the forest resource management of the state-owned forest, use of regeneration cut has exceeded one-quarter (we will get back to this when species distribution is discussed). There is still more artificial regeneration in regeneration cuts (with its high costs) than seed origin in clearcuts.

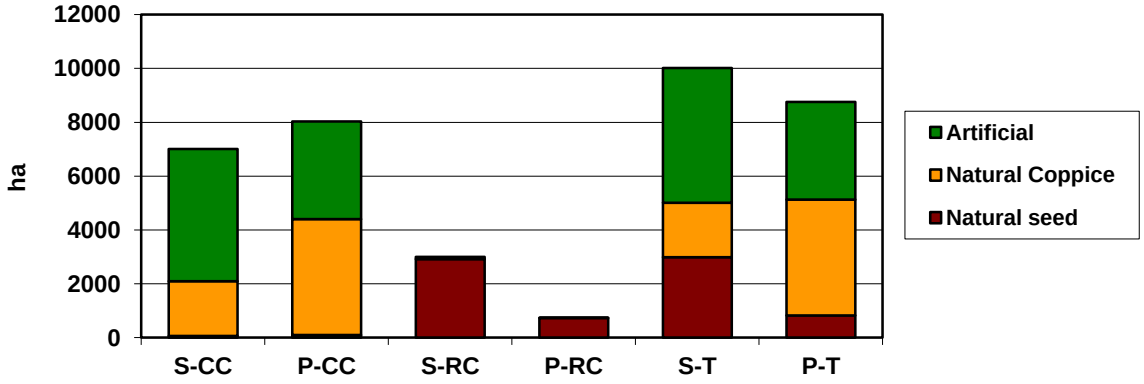
The first plantings in 2000 and the completed reforestations in 2008/2009 can be compared; regeneration cuts slightly decreased, artificial regenerations and coppice regenerations increased at the expense of natural seed regeneration.

In the vegetation year 2008/2009, there is no considerable change in the area and proportions of regeneration cuts, perhaps the natural seed regeneration increased in private forestry.

Table 6. Regeneration – First planting (2009) (ha)

Mode of regeneration	**State**			**Private**			**Total**		
	CC	**RC**	**Total**	**CC**	**RC**	**Total**	**CC**	**RC**	**Total**
Natural seed	63	2,920	2,984	95	726	821	158	3,646	3,804
Natural Coppice	2,027	–	2,027	4,309	–	4,308	6,336	–	6,336
Artificial	4,916	83	4,999	3,624	7	3,631	8,540	90	8,630
Total	**7,007**	**3,003**	**10,010**	**8,028**	**733**	**8,761**	**15,034**	**3,736**	**18,770**
Additional plant.	1,939	918	2,857	677	45	722	2,630	964	3,594

Legend: CC = clearcut; RC = regeneration cut; Source of data MgSzH



Legend: S-CC = State – clearcut; P-CC = Private – clearcut; S-RC = State – regeneration cut; P-RC = Private – regeneration cut; S-T = State – total; P- T = Private – total

Figure 5. Final cuttings – reforestation first planting by sector (2009)

Annual replacements of plants are attached to the first plantings, though there are no data available on the distribution of species or on the mode of regeneration.

We will investigate the data of the afforestation for the last year in more detail. The combination of clearcut and natural regeneration from seed hardly occurs, and artificial regeneration and regeneration is also rare (regeneration cut and coppice regeneration does not occur at all). There are considerable differences between state and private management in terms of cutting and regeneration modes:

The proportion of natural regeneration from seeds does not reach 20% proportion and is mainly concentrated in state forests. One-third of the regenerations are done naturally, but from coppice (the distribution of the coppice regenerations by age and species needs a separate investigation because of the still existing old stands).

Nearly half of the regenerations are artificial regeneration after clearcut.

There is a considerable difference between sectors in regeneration after clearcut. In the case of state forests, two-thirds are regenerated artificially, while in private forests the proportion of natural coppice is higher. In the case of regeneration cuts, natural seed regeneration is dominant.

5.2 Comparison of regenerations by species and sector

The previous chapter presented the relation of utilization and regeneration and the differences in sectors. These sectorial differences can be explained by the difference of species of regeneration. Clearcut is dominant in private forestry (and within this, mainly black locust and less hybrid poplar) and regeneration cut is marginal. On the species level, there is little difference between sectors in the utilization and regeneration modes. *(Table 7 and Figure 6)*

Table 7. Regeneration and first planting by species (2010) (ha)

Species	Clearcut		Regeneration cut		Total	
	State	Private	State	Private	State	Private
Beech	75	13	945	191	1,020	204
Oak	1,571	660	970	260	2,541	920
Turkey oak – other hw.	755	286	1,053	281	1,808	567
LRHW	**2,401**	**959**	**2,968**	**732**	**5,369**	**1,691**
Black locust	2,065	4,748	–	–	2,065	4,748
Hybrid poplar	681	1,306	1	–	682	1,306
Other softwood	1,231	889		–	1,232	889
Conifers	629	127	34	1	663	128
Non LRHW	**4,606**	**7,070**	**35**	**1**	**4,641**	**7,071**
Total	**7,007**	**8,029**	**3,003**	**733**	**10,010**	**8,762**

Legend: LRHW= long rotation hardwood Source of data MgSzH

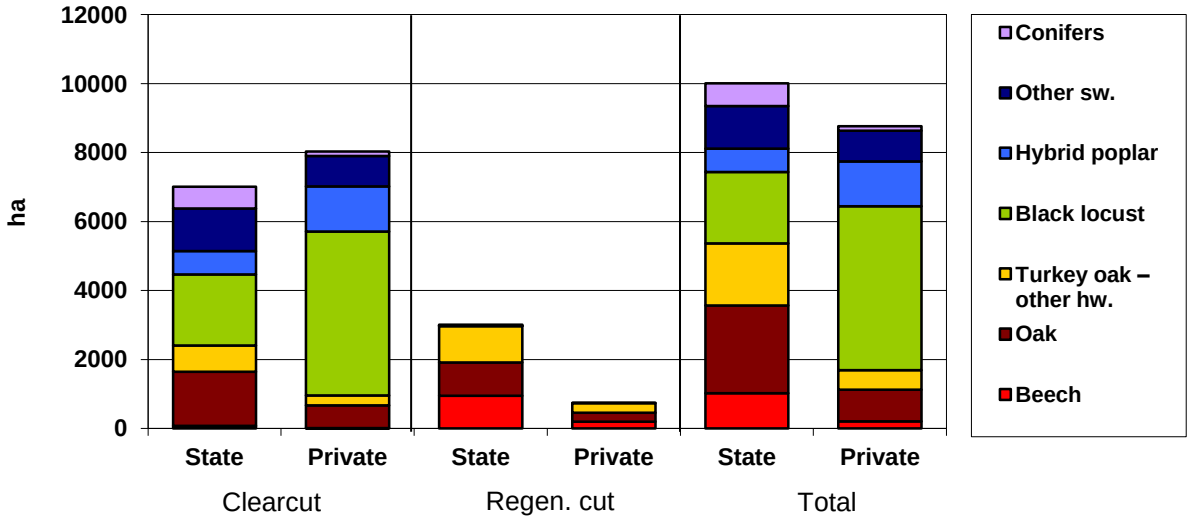


Figure 6. First planting of regenerations by species (2010) (Source of data MgSzH)

5.3 Change of regeneration modes and performance

Taking into consideration the two dates of finished regenerations and first plantings (2000, 2010), four series of data can be used to investigate an approximate time period of fifteen years. The distribution of regeneration cut – clearcut comes from final cuttings, and to these three regeneration modes can be assigned: natural regeneration from seeds, and coppice, and artificial regeneration. The distribution of cutting modes (clearcut and regeneration cut) and regeneration modes (natural seed, natural coppice, artificial) by sectors is presented in *Table 8* and *Figure 7.* The species composition and its change show the difference between management in the sectors.

Table 8. Change regeneration mode and performance

Final cut and regeneration mode	State (ha)				Private (ha)			
	2000		2010		2000		2010	
	Finished	First plant.	–	First plant.	Finished	First plant.	Finished	First plant.
Regen. cut								
NRS	1,701	2,729	2,515	2,920	287	487	516	726
NRC	–	1	–	–	3	3	–	–
NR	1,701	2,730	2,515	2,920	290	490	516	726
AA	550	389	130	83	21	40	5	7
Total	***2,251***	***3,119***	***2,645***	***3,003***	***311***	***530***	***521***	***733***
Clearcut								
NRS	204	95	36	63	76	71	29	95
NRC	2,755	2,268	2,373	2,373	4,273	4,204	4,668	4,309
NR	2,959	2,363	2,409	2,436	4,349	7,275	4,697	4,404
AA	6,197	5,814	5,664	4,916	3,542	3,836	3,645	3,624
Total	***9,156***	***8,177***	***8,073***	***9,788***	***7,891***	***8,111***	***8,312***	***8,028***
Total	**11,407**	**11,296**	**10,718**	**12,791**	**8,202**	**8,641**	**8,863**	**8,761**
T-NR	*4,660*	*5,093*	*4,924*	*5,356*	*4,639*	*4,765*	*3,213*	*5,129*
T-AR	*6,747*	*6,203*	*5,794*	*4,999*	*3,563*	*3,876*	*3,650*	*3,631*

Total

Final cut and regeneration mode	Area (ha)				Proportion (%)			
	2000		2010		2000		2010	
	Finished	First plant.	Finished	First plant.	Finished	First plant.	Finished	First plant.
Regen. cut								
NRS	1,988	3,216	3,030	3,647	10.1	16.1	15.4	19.3
NRC	3	4	–	–	–	0	–	–
NR	1,991				10.1	16.1	15.4	19.3
AA	571	429	135	90	2.9	2.2	0.7	0.5
Total	***2,562***	***3,649***	***3,166***	***3,737***	***13.1***	***18.3***	***16.1***	***19.8***
Clearcut								
NRS	280	166	65	159	1.4	0.8	0.3	0.8
NRC	7,028	9,472	7,091	6,412	35.8	47.5	36.1	33.9
NR	2,308	9,638	7,156	6,571	37.2	48.3	36.4	44.7
AA	9,739	9,650	9,345	8,597	49.7	48.4	47.5	45.5
Total	***17,047***	***16,288***	***16,500***	***15,168***	***86.9***	***81.7***	***83.9***	***80.2***
Total	**19,609**	**19,937**	**19,666**	**18,905**	**100**	**100**	**100**	**100**
T-NR	*9,299*	*9,858*	*10,186*	*10,217*	*47.4*	*49.5*	*51.8*	*54.0*
T-AR	*10,310*	*10,079*	*9,480*	*8,688*	*52.6*	*50.5*	*48.2*	*46.0*

Legend: NRS – Natural regeneration seed
NRC – Natural regeneration coppice
NR – Natural regeneration
AA – Artificial afforestation
T-NR – Total natural regeneration
T-AR – Total artificial regeneration

Source of data MgSzH

CC = Clearcut; RC = Regeneration cut
NS = Natural seed; NC= Natural coppice; AA = artificial afforestation

Figure 7. Change of mode and performance of regeneration in state and private sector (Source of data MgSzH)

5.4. Change of species composition in regeneration

The difference between modes of cut and regeneration method combinations is primarily defined by the species conditions (and site differences determining these conditions, *Table 9*, *Figure 8*).

With the species black locust, poplar, and conifers clearcut is dominant as the final cutting mode, and as regeneration, natural coppice is typical for black locust; otherwise, artificial regeneration with plants is usual. Different proportions of regeneration cuts (natural regeneration with seeds) by species can be mentioned with broadleaved hardwoods with a long rotation age, where the difference between sectors is smaller and the change is more evident in the first plantings (thus appearing in planning).

Table 9. Change in species structure of regeneration

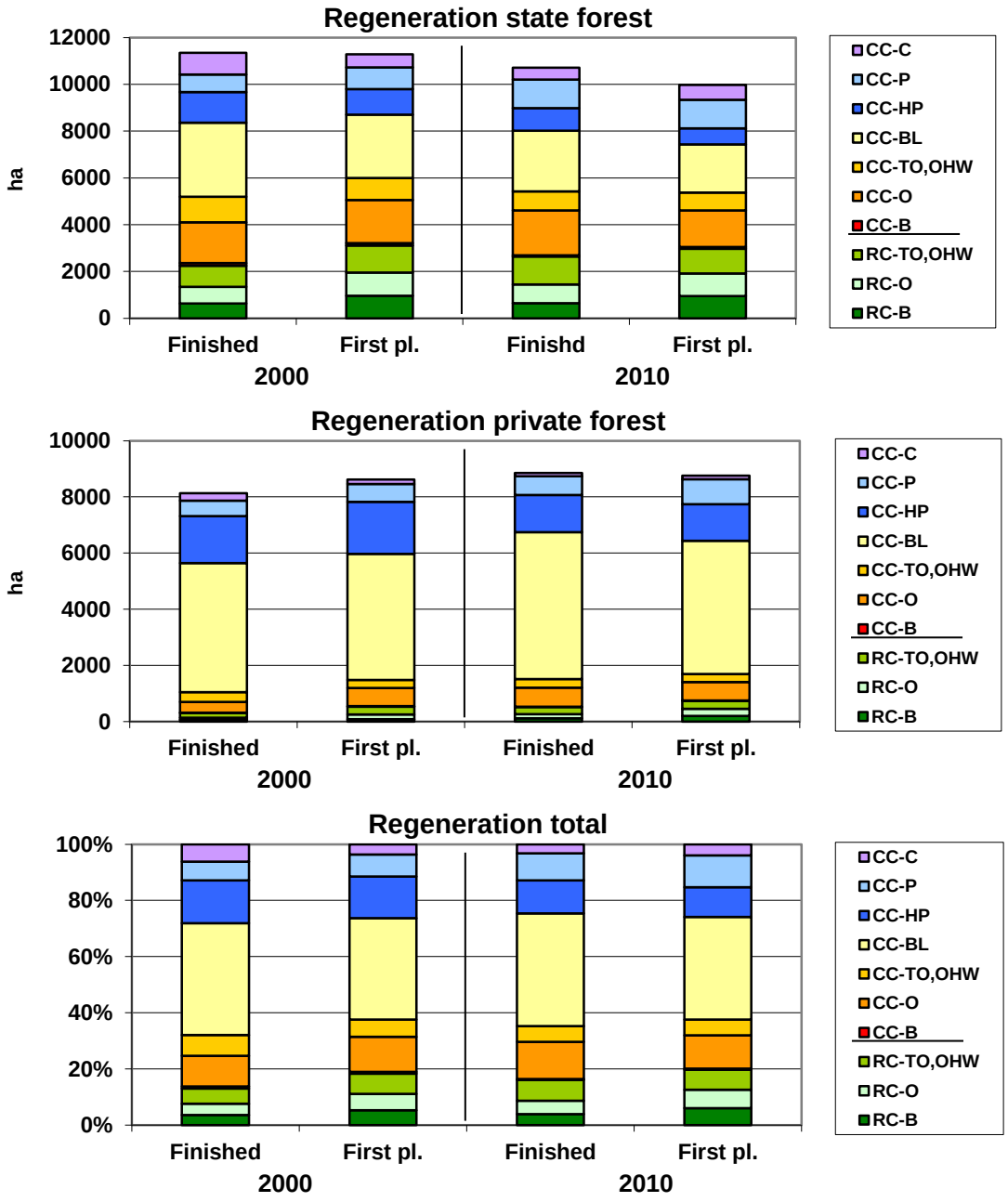
Species	State (ha)				Private (ha)			
	2000		2010		2000		2010	
	Finished	First plant.	Finished	First plant.	Finished	First plant.	Finished	First plant.
Regen. cut								
Beech	628	955	642	945	60	84	110	191
Oak	714	995	797	970	77	169	145	260
Turkey oak - OHW	897	1,156	1,199	1,053	163	270	262	281
LRHW	2,239	3,106	2,638	2,968	300	523	517	732
Total	***2,251***	***3,119***	***2,645***	***3,003***	***311***	***530***	***521***	***778***
Clearcut								
Beech	120	109	56	75	14	21	10	13
Oak	1,736	1,841	1,919	1,571	381	643	677	660
Turkey oak - OHW	1,104	937	811	754	349	293	303	286
LRHW	2,960	2,877	2,786	2,400	744	957	990	959
Black locust	3,156	2,706	2,589	2,065	4,600	4,495	5,241	4,748
Hybrid poplar	1,312	1,099	973	681	1,674	1,851	1,320	1,306
Poplar	759	924	1,224	1,231	545	634	666	889
Conifers	927	564	502	628	268	156	123	127
Total	***9,156***	***8,177***	***8,073***	***7,007***	***7,891***	***8,111***	***8,342***	***8,705***
Total	**11,407**	**11,296**	**10,718**	**10,010**	**8,202**	**8,641**	**8,863**	**9,483**

Total

Species	Area (ha)				Proportion (%)			
	2000		2010		2000		2010	
	Finished	First plant.	Finished	First plant.	Finished	First plant.	Finished	First plant.
Regen. cut								
Beech	688	1,039	753	1,137	3.5	5.2	3.8	6.0
Oak	791	1,164	942	1,231	4.0	5.8	4.8	6.5
Turkey oak - OHW	1,060	1,426	1,462	1,335	5.4	7.2	7.4	7.1
HVFK	2,539	3,629	3,157	3,703	12.9	18.2	16.0	19.6
Total	***2,562***	***3,649***	***3,166***	***3,737***	***13.1***	***18.3***	***16.1***	***19.8***
Clearcut								
Beech	134	130	65	88	0.7	0.7	0.3	0.5
Oak	2,117	2,484	2,596	2,243	10.8	12.5	13.2	11.9
Turkey oak - OHW	1,453	1,220	1,115	1,045	7.4	6.1	5.7	5.5
LRHW	3,704	3,834	3,776	3,376	18.9	19.2	18.9	17.9
Black locust	7,756	7,201	7,883	6,901	39.6	36.1	40.1	36.5
Hybrid poplar	2,986	2,950	2,323	2,007	15.2	14.8	11.8	10.6
Poplar	1,304	1,558	1,891	2,127	6.7	7.8	9.6	11.3
Conifers	1,195	720	626	754	6.1	3.	3.1	4.0
Total	***17,047***	***16,288***	***16,500***	***15,168***	***86.9***	***81.7***	***83.9***	***80.2***
Total	19,609	19,937	19,666	18,905	100	100	100	100
Total hardwood	6,243	7,463	6,933	7,079				

Legend: OHW = other hardwoods
LRHW = hardwoods with long rotation age

Source of data MgSzH



CC = clearcut; RC = Regen. cut
B=beech; O=oak; TO=turkey oak; OHW=other hardwood;
BL=black locust; HP=Hybrid poplar; P=poplar; F C=conifers

Figure 8. Change of species structure in regenerations (Source of data MgSzH)

6 SUMMARY

The modification of forest management regulations changes the practice of forest management fundamentally. The changes in legal regulation, including the ratification of the forest law in 1996, facilitated the increase of protected areas, which was followed by the designation of NATURA 2000 sites by the middle of 2000s. This process was coupled with a considerable social pressure represented by NGOs to widen protection functions of forests and to apply close-to-nature silviculture. As a result, forest management had to face increasing restrictions on forest operations limiting available technology, the time frame of fellings, and also the allowable cut.

Also, within the forestry community the idea and the new possibilities of close-to-nature methods found supporters. In regions where protection measures prohibited timber harvest completely using clear cut or short period regeneration cuttings, close-to-nature silviculture provided the only way to utilize timber yield. In other cases, forest regeneration with natural regeneration methods resulted in cost reduction.

This process reached another milestone in 2010, when a completely new forestry law was ratified introducing a classification of forests according to their natural state, a more – but not perfectly – accurate regulation of the selection system and other silvicultural methods, and also measures for the state forests on the application of these redefined methods.

This analysis attempted to describe the above process by quantifying the changes with statistical data on timber harvest and forest regeneration in the period of 2000–2010. Findings of this article reveal that:

- Forest resource management cannot apply universal concepts for the whole country; smaller regions should be designated with regulations suitable for the local specific conditions.
- Changes in the application of new silvicultural methods require long period of time
  - Any large-scale changes in silvicultural methods first shall appear in forest management plans, which have a 10 year cycle. Changes in forestry practice can, therefore, be only gradual.
  - New or rarely used silvicultural methods are often handicapped by initial skepticism and resistence. Research, field experiments, active dissemination of information, and participatory processes are prerequisites for successful introduction of new methods, all of which is time consuming.
- First signs of changes could be observed in broadleaved hardwood forests with long rotation age, where natural forest regeneration started to increase.
- Beech tends to be suitable for natural regeneration and selection systems, as these methods have the highest share in beech stands.
- Black locust and hybrid poplars are plantations, and close-to-nature silvicultural methods cannot be applied in these stands without losing their goals of production and their profitability.
- Black locust and hybrid poplars have a large share in forest areas, which limits the propagation of close-to-nature silvicultural methods.
- Forest characteristics, especially species distribution in the private and the public (state and community) sector are significantly different, which is reflected in the application of close-to-nature silvicultural methods.
- Within the same species categories, private and public sectors show minor differences. In the case of beech, private forestry shows higher (but still low) level of clearcuts, while in the case of oak and turkey oak, close-to-nature silviculture is more common in the private sector than in the state sector.

The application of close-to-nature silvicultural methods has obstacles that can be traced in the statistical analysis in this article. However, there are other important factors that are influencing, mostly hindering the process:

- The technical background of forestry, especially living traditions of forestry technology is lacking in actively applied close-to-nature methods. Even forest planning is challenged by the task of how to incorporate uneven-aged forests in the present planning protocol. (Frank 2014)
- Wild game damage is reported to be the most important (semi-)natural limiting factor of natural regeneration. Even though wild game management is experiencing a slow decline in terms of trophy quality and financial stability (Schiberna–Szalai, 2015), its lobbying ability is preventing it from fundamental changes.

- The needs of society are usually a basis for arguments in discussions on the development of forestry practice. However, the public perception of nature is significantly different from what is advocated by environmental NGOs as the need of the society. Public opinion is mostly against clearcuts, and less sensitive about delicate differences of regeneration methods or silvicultural operations. (Kapócs-Horváth et al. 2012; Schiberna – Stark 2011, Folcz – Schiberna 2012)
- Lessons learned from afforestation programs suggest that private forest owners prefer easy and simple silvilcultural methods, as well as short rotation periods. Consequently, plantation forestry is more suitable for their short term economic goals and is also more suitable for their long term visions (Andrasevits – Schiberna 2005). Afforestations take place mostly in regions where site conditions also make these plantations the best choice.
- Rural development programs also showed that private forest owners are capable of applying more advanced silvicultural methods if they are coupled with subsidies. So the progress of close-to-nature forest management to a great extent depends on targeted forest policy measures.

To have a more realistic view of close-to-nature forest assets management, the possibility to investigate primary functions and regions in addition to looking at differences in sectors exists.

Controlling intentions along facts and knowing the pace and segments of changes would be an advantage when planning future measures.

REFERENCES

ANDRÁSEVITS Z. – SCHIBERNA E. (2005): Magánerdő-gazdálkodás az agrárvállalkozásokban. [Private forestry in agrar enterprises] Gazdálkodás 49(2) : 28–37. (in Hungarian)

CSÉPÁNYI P. (2013): Az örökerdő elvek szerinti és a hagyományos bükkgazdálkodás ökonómiai elemzése és összehasonlítása. [Economic analysis and comparison of beech forest management in traditional and continuous cover management regimes] In: Erdészettudományi közlemények 3(1) : 111–124. (in Hungarian)

FOLCZ Á. – SCHIBERNA E (2012): A magyar fogyasztói társadalom erdőkkel kapcsolatos igényei és annak környezetgazdasági hatásai. [Requirements of the Hungarian consumer society towards forests and their effects on the environmental economy] In: Lett B. – Schiberna E. – Horváth S. – Puskás L. – Stark M. (eds.): Mészáros Károly Emlékülés, Nyugat-magyarországi Egyetem Kiadó, 2012. pp. 17–29. (ISBN:978-963-334-058-5) (in Hungarian)

FRANK N. (2012): A szálaló és átalakító üzemmód erdőművelési kérdései. [Sylvicultural issues of the transformation and continuous management system] In: Lett B. – Schiberna E. (eds.): Múlt és jövő III. A folyamatos erdőborítás gazdálkodói szemmel. Nyugat-magyarországi Egyetem Kiadó, Sopron. (ISBN:978-963-334-085-1) : 6–12. (in Hungarian)

FRANK N. – VEPERDI G. – SCHIBERNA E. – GÁL J. (2014): Erdőnevelési modelltáblák: múlt és jövő. [Forest tending models: past and present] In: Bidló A. – Horváth A. – Szűcs P. (eds.): IV. Kari Tudományos Konferencia: Konferencia kiadvány (ISBN:978-963-359-033-1) : 20–23. (in Hungarian)

GYÖNGYÖSSY P. (Ed.) (2012): Múlt és jövő IV. Tartamosság, természetszerűség, társadalmi kontroll. [Past and future IV. Sustainability, close-to-nature management, control by the society] Nyugat-magyarországi Egyetem Kiadó, Sopron (ISBN 978-963-334-081-3) : 244 p. (in Hungarian)

KAPÓCS-HORVÁTH ZS. – HÉJJ B. – LETT B. – STARK M. – SCHIBERNA E. (2012): A társadalom erdőkkel kapcsolatos véleményének vizsgálata. [Investigating the opinion of the society about forests] In: Lett B. – Schiberna E. (eds.): Múlt és jövő III.: A folyamatos erdőborítás gazdálkodói szemmel, Nyugat-magyarországi Egyetem Kiadó, Sopron. (ISBN:978-963-334-085-1) : 84–92. (in Hungarian)

LETT B. – NAGY I. – PUSKÁS L. – STARK M. – HORVÁTH S. – HORVÁTH T. (eds.) (2009): Múlt és jövő. Kisparaszti szálalás a Vendvidéken. [Past and future: Small scale continuous cover forestry in the Vend area in Hungary] Soproni Felsőoktatási Alapítvány, Sopron. (ISBN 978-963-06-7086-9) : 222 p. (in Hungarian)

LETT B. – NAGY I. – PUSKÁS L. – STARK M. – HORVÁTH S. – HORVÁTH T. (eds.) (2010): Múlt és jövő II. „Tarvágásból szálalásba". A folyamatos erdőborítás üzemmódjainak bevezetése, gyakorlata. [Past and future II. „From clearcut to selection system".Introduction and practice of the management regimes of continuous cover forestry.] Szabó Vendel EV. (ISBN 978-963-06-9392-9) 206 p. (in Hungarian)

LETT B. – SCHIBERNA E. (eds.) (2012): Múlt és jövő III. A folyamatos erdőborítás gazdálkodói szemmel. Természetközeli erdőgazdálkodási módszerek tapasztalatai. [Past and future III. The selection system from the viewpoit of forest managers. Experiences of close-to-nature forest management practices.] Nyugat-magyarországi Egyetem Kiadó, Sopron (ISBN 978-963-334-085-1) : 104 p. (in Hungarian)

LETT B. – STARK M. (2013): Az erdővagyon-gazdálkodás szerkezetének változása (2000–2009/2010) [Change of the structure of forest resources management (2000-2009/2010)] In: Lett et al. (eds.) Mészáros Károly Emlékülés. 2013. június 18. Nyugat-magyarországi Egyetem Kiadó, Sopron (ISBN 978-963-334-058-5) : 63–85 (in Hungarian)

Lett B. – Schiberna E. – Stark M. – Horváth S. – Szabó Zs. (Eds) (2013): Mészáros Károly Emlékülés. 2013. június 18. Nyugat-magyarországi Egyetem Kiadó, Sopron (ISBN 978-963-334-058-5) : 154 p.

LETT B. – STARK M. (2014): A természetközeli erdővagyon-gazdálkodás regionális sajátosságai. [regional specifics od close-to-nature forest management] Előadás kézirat. Mészáros Károly Emlékülés – IV. Erdész-ökonómus Találkozó, Sopron, 2014. június 13. (in Hungarian)

MAROSI GY. – JUHÁSZ I. (2014): Az átalakító és a szálaló üzemmódok költség – hozam viszonyai. [Cost-benefit relations in transformation and continuous cover management regimes] Előadás kézirat. Mészáros Károly Emlékülés – IV. Erdész-ökonómus Találkozó, Sopron, 2014. június 13. (in Hungarian)

SCHIBERNA E. – LETT B. – JUHÁSZ I. (2012): A folyamatos erdőborítás ökonómiai értékelésének elvi kérdései. [Theoretical question of the economic valuation of continuous cover forestry] In: Erdészettudományi közlemények 2(1) : 7–19. (in Hungarian)

SCHIBERNA E. – STARK M. (2011): Erdőpedagógia az erdészeti felsőoktatásban. [Forest pedagogy in forestry higher education] In: Kováts-Németh Mária (ed.): Együtt a környezetért, Palatia Nyomda és Kiadó Kft. (ISBN:978-963-7692-35-2) : 203–220. (in Hungarian)

SCHIBERNA E. – SZALAI Á. (2015): A vadgazdálkodási ágazat gazdasági elemzése – Nemzeti kincsünk marad-e a gímszarvas? [Economic Analysis of Wild Game Management Sector in Hungary – Red Deer as National Heritage endangered] In: Lett B. –Schiberna E. – Jáger L. – Stark M. – Horváth S. (eds.): Tanulmánykötet Mészáros Károly tiszteletére. Nyugat-magyarországi Egyetem Kiadó, Sopron: (ISBN:978-963-334-242-8) : 73–81. (in Hungarian)

SOLYMOS R. (2000): Erdőfelújítás és -nevelés a természetközeli erdőgazdálkodásban. [Forest regeneration and tending in close-to-nature forest management] Mezőgazdasági Szaktudás Kiadó, Budapest: 286 p. (in Hungarian)

1996. évi LIV. törvény az erdőről és az erdő védelméről [Law No. LIV of 1996 on forests and their protection]

2009. évi XXXVII. törvény az erdőről, az erdővédelméről és az erdőgazdálkodásról [Law No. XXXVII of 2009 on forests, on the protection and management of forests]

275/2004. (X. 8.) Korm. rendelet az európai közösségi jelentőségű természetvédelmi rendeltetésű területekről (Natura2000) [Decree No. 275 of 2004 (X. 8.) of the Government on nature conservation areas of European Community importance]

SOURCE OF DATA

MgSzH Erdészeti Igazgatóság (2000; 2009; 2010): Beszámoló az erdősítésekről és a fakitermelésekről [Report on afforestations and cuttings] (in Hungarian)

DE GRUYTER OPEN DOI: 10.1515/aslh-2016-0007 Acta Silv. Lign. Hung., Vol. 12, Nr. 1 (2016) 75–88

Readiness of Forest Officers for Adaptations in Forest Management Planning

Christoph HARTEBRODT* – Julia SCHMITT

Department of Forest Economics, Forest Research Institute Baden-Württemberg, Freiburg, Germany

Abstract – Under the framework of a society that enhances the demand for different kinds of ecosystem services, "Forest Management Planning" (FMP) has changed notably over the last decades. As a consequence of budget constraints and the fact that the present forest planning system of the State Forest Administration of Baden-Württemberg has been in operation since 2000, this system has to be developed further. Since the group of forest officers at the county level is the largest user group, it was decided to start a participatory process in order to derive the most relevant requirements of that group. A survey within the board of managing directors followed. In order to gain an insight into the requirements and preferences we used the pairwise comparison method. The paper highlights the preference structure in respect to (1) the goals of FMP, (2) target groups, (3) the FMP process, (4) tasks, (5) and the outputs of FMP. It can be shown that the average percipience of FMP of forest officers tends to be more traditional and internal than proactive and stakeholder-oriented. The pairwise comparison approach has been proven successful as a means to get insight in the preference structures.

integrated planning / internal participation / readiness for change / plurality of opinions

Kivonat – Az erdészeti szakszemélyzet alkalmazkodási készsége az erdőtervezés folyamatában. Azon társadalmi keretek között, amelyek a különböző ökoszisztéma szolgáltatások keresletét erősítették, az erdőtervezés észrevehetően megváltozott az utóbbi évtizedekben. A költségvetési korlátok, valamint az a tény, hogy a Baden-Württemberg tartomány jelenlegi állami erdőtervezési rendszere 2000 óta van érvényben, szükségessé teszik a továbbfejlesztését. Mivel az erdőtervek legfőbb felhasználója az erdészeti szakszemélyzet, ezért a részvételükre alapozott folyamat indult el a legfontosabb elvárásaik feltárására. Ezt egy döntéshozói felmérés követte. Annak érdekében, hogy az elvárások és preferenciák köréről belső információk álljanak rendelkezésre, a páronkénti összehasonlítás módszerét alkalmazták. A cikk rávilágít a preferenciák rendszerére (1) az erdőtervezés céljai (2) a célcsoportok, (3) az erdőtervezési folyamat, (4) a feladatok, (5) az erdőtervezés kimenetei tekintetében. Kimutatható, hogy az erdészeti szakszemélyzet erdőtervezéssel kapcsolatos átlagosnak mondható szemlélete jellemzően tradicionális és befelé forduló, és kevésbé proaktív és érdekelt-irányultságú. A páronkénti összehasonlítás sikeres módszernek bizonyult a preferencia szerkezet feltárására.

integrált tervezés / részvételi folyamat / változtatási hajlandóság / vélemények sokszínűsége

* Corresponding author: christoph.hartebrodt@forst.bwl.de; Wonnhaldestraße 4, D-79100 FREIBURG

INTRODUCTION

The role of Forest Management Planning (FMP) has changed notably over the last decades. Until the late seventies FMP was mostly seen as an internal, mostly technical procedure, primarily focusing on the productive function of forests. Especially under the framework conditions of a densely populated county with, on average, a highly educated population, the role of forests has changed more and more towards a supplier of various ecosystem services. Except for all kinds of timber processing industries and an initially small, but increasing, number of private timber consumers, the societal interests are concentrated mainly in the recreational and environmental functions of forests. Together with this shift in interests the demand for participatory processes has grown larger. Whenever the use of instruments that are related to sustainable development is foreseen, participation is a standard step during the development, implementation, and mostly during the use of the respective instrument (e. g. sustainability reporting (GRI 2103) and the Agenda 21 processes (Heinrichs 2007, Feindt – Newig 2005). There are substantial findings which suggest that planning procedures are seen as good opportunities for communication with and participation of various kinds of stakeholder groups (Sheppard 2005, Joint FAO/ECE/ILO Committee 2000, cited in Beck 2011).

It is not only the external participation, however, that contributes to the success of FMP systems. As these systems are used by a potentially maximum share of members in almost every forest institution, the acceptance of the FPM and other instruments in place can be seen as a key success factor for their application. A means to achieve a sufficient level of acceptance is the involvement of users in the development process (Hartebrodt 2009). Consecutively, not only external participation has to be considered, but also internal participatory processes have to become part of the revision of existing instruments.

The change of societal requirements resulted, at least in Germany, in an increasing dispute between forest owners and/or administrations and stakeholder groups. In particular, environmentalists tend to be generally sceptical and mistrusting towards timber harvesting or at least towards a higher share of conventional management practices. Owners and forest practitioners highlight the increasing demand for all kinds of wood-based raw materials and underline the important role of forest utilisation in a bio-based economy. The willingness to adopt new requirements in the management practice differs widely despite the fact that a relevant part of these requirements rests on the present legal framework, for instances the European Framework Directive on ‘Flora, Fauna, Habitat’ (European Commission 1992). This directive leads (among other things) indirectly to the upcoming idea of implementing the so-called integrated management plans, which cover both the management of forest production and the management of ecological issues (European Commission 2013).

AIM OF THE STUDY

The purpose of the study was two-fold. First, the objective was to develop a deep and detailed insight into the preferences and requirements of different internal user groups of FMP. The pattern of the preferences was foreseen to be used as a set of decisive criteria for the ongoing revision process of the FMP system. Of special interest was the question whether forest practitioners are ready for an integration of external requirements in FMP and the involvement of stakeholder groups in the FMP process.

Second, it was of interest, if, and to what extent, elements of a decision support system and the related participatory processes are suited in the context of such kind of revision process. Furthermore, it was planned to analyse the consistency of the results in various substrata, the ability of the process to provide additional information about the hetero- or homogeneity of the opinions and the acceptance of the decision process.

CASE STUDY

We used the revision process of the FMP-system of the State Forest Administration of Baden-Württemberg (SFA-BW) as a case study. SFA-BW is organised as a so-called joint forest administration responsible for all types of forest owners (state-owned, communal and private). The state forest service manages the state forest, is responsible for assistance and (technical) support of other forest owners, as well as for the distribution of financial allowances. The state forest administration is essentially responsible for the "planning, preparation, organisation, management and supervision of all kinds of forest management activities" (LWaldG 2012: §47 (1) [translation by the author]) in communal forests. Communal authorities can decide whether to take over this responsibility or not; however, as the state service is free of charge, most communal bodies do not choose to do so. Part of this 'service-package' is the process of the FMP, which takes place every 10 years. The FMP is carried out by one department of the middle administrational level. As most communal bodies make use of the state service, there is, consequently, generally one FMP process in place. The revision of this process is used as a case-model for the present study.

Before a final decision about the general structure of the revised FMP process could be made, the board of managers decided first that the needs and requirements of the main user group, which is the forest staff at the county level, should be studied in a way that is able to produce reliable, trustworthy, and presentable results. The main areas of interests (later on dimensions) were objectives (1) and tasks (2) of FMP, as well as tools and products (3) provided by FMP. The CEO defined the need that a clear prioritisation should be undertaken in respect to all dimensions. During the process the decision was made to identify the most important user groups (4) and relevant process steps (5) of FMP as well. During the workshops, information needs were additionally gathered. These results are not included in this paper. It has to be mentioned that there are two FMP-traditions (the western and eastern part of Baden-Württemberg). After a mid-term presentation of the results gathered from amongst representatives of the county level, it was decided to involve the departments of top- and middle-level management and those of the state forest research institute.

METHODS AND DATA

Methods

Workshop with Representatives of the County Level

The results concerning the opinion of the members of the county level were collected during two workshops (WS 1 and WS 2) in December, 2013. In order to determine whether there is a notable difference within the state of Baden-Württemberg, one WS was carried out in the western and one in the eastern part of the state. One had, however, also the option of attending either WS. The WS-procedure in dimensions (which are discussed later in the paper) was as follows: Based on a proposed list of items in each dimension the participants developed a final list and discussed it in terms of their present use and its frequency at the county level. This in-depth discussion was documented on posters and remained visible during the final evaluation session as background information for the participants.

For the final evaluation of the priority of each item we used the pairwise comparison approach (comp. Saaty 2008), which is regarded as suitable for prioritisation of intangible factors. Based on an Excel solution it was possible to transfer the lists of items into a (hard copy) questionnaire, which was filled out by the participants at the final evaluation session. *Figure 1a* depicts a completed questionnaire in the dimension 'objectives' (Ziele).

Figure 1a

Ziele

	+	=	+	
Gesetzl. Auftrag Nachhaltigkeitssicherung	X			Zentrale Datenhaltung öffentl. Wald
Betriebssteuerung Betriebsleitung Land		X		Zentrale Datenhaltung öffentl. Wald
Betriebssteuerung Betriebsteile UFB	X			Zentrale Datenhaltung öffentl. Wald
Gesetzl. Auftrag Nachhaltigkeitssicherung	X			Kundenzufriedenheit
Betriebssteuerung Betriebsleitung Land			X	Kundenzufriedenheit
Betriebssteuerung Betriebsteile UFB		X		Kundenzufriedenheit
Zentrale Datenhaltung öffentl. Wald			X	Kundenzufriedenheit
Einheitliche Datenstruktur			X	Kundenzufriedenheit
Gesetzl. Auftrag Nachhaltigkeitssicherung		X		Klärung Eigentümer Zielsetzung
Betriebssteuerung Betriebsleitung Land			X	Klärung Eigentümer Zielsetzung
Betriebssteuerung Betriebsteile UFB		X		Klärung Eigentümer Zielsetzung
Zentrale Datenhaltung öffentl. Wald			X	Klärung Eigentümer Zielsetzung
Einheitliche Datenstruktur			X	Klärung Eigentümer Zielsetzung
Kundenzufriedenheit		X		Klärung Eigentümer Zielsetzung
Fortbildung		X		Klärung Eigentümer Zielsetzung
Gesetzl. Auftrag Nachhaltigkeitssicherung	X			Fortbildung
Betriebssteuerung Betriebsleitung Land		X		Fortbildung
Betriebssteuerung Betriebsteile UFB		X		Fortbildung
Zentrale Datenhaltung öffentl. Wald			X	Fortbildung
Einheitliche Datenstruktur		X		Fortbildung
Kundenzufriedenheit		X		Fortbildung
Gesetzl. Auftrag Nachhaltigkeitssicherung	X			Einheitliche Datenstruktur
Betriebssteuerung Betriebsleitung Land		X		Einheitliche Datenstruktur
Betriebssteuerung Betriebsteile UFB	X			Einheitliche Datenstruktur
Zentrale Datenhaltung öffentl. Wald		X		Einheitliche Datenstruktur
Gesetzl. Auftrag Nachhaltigkeitssicherung	X			Betriebssteuerung Betriebsteile UFB
Betriebssteuerung Betriebsleitung Land		X		Betriebssteuerung Betriebsteile UFB
Gesetzl. Auftrag Nachhaltigkeitssicherung	X			Betriebssteuerung Betriebsleitung Land

Figure 1b

0=weniger wichtig(Zeilenkriterium < Spaltenkriterium) 1= gleichgewichtig (Zeilenkriterium = Spaltenkriterium) 2= wichtiger (Zeilenkriterium > Spaltenkriterium)	Gesetzl. Auftrag Nachhaltigkeitssicherung	Betriebssteuerung Betriebsleitung Land	Betriebssteuerung Betriebsteile UFB	Zentrale Datenhaltung öffentl. Wald	Einheitliche Datenstruktur	Kundenzufriedenheit	Fortbildung	Klärung Eigentümer Zielsetzung	**Gewichtungswerte (?)**	**Gewichtungsprozent**
Gesetzl. Auftrag Nachhaltigkeitssicherung		2	2	2	2	2	2	1	13	23
Betriebssteuerung Betriebsleitung Land	0		1	1	1	0	1	0	4	7
Betriebssteuerung Betriebsteile UFB	0	1		2	2	1	1	1	8	14
Zentrale Datenhaltung öffentl. Wald	0	1	0		1	0	0	0	2	4
Einheitliche Datenstruktur	0	1	0	1		0	1	0	3	5
Kundenzufriedenheit	0	2	1	2	2		1	1	9	16
Fortbildung	0	1	1	2	1	1		0	6	11
Klärung Eigentümer Zielsetzung	1	2	1	2	2	1	2		11	20
Summe									**56**	**100**

Figure 1. Questionnaire used for the complete pairwise comparison and its conversion in percental preferences

The pairwise comparison was transformed into a percentage by using a matrix that transforms the individual comparisons into a percental preference (Niklas 2002). This is executed in a way that in the case that the preferred item listed in the rows is more important than the column, a code 2 is used; code 1 is applied if equal importance (=) is seen and 0, when the item (row) is valuated as being less important. The sum of the codes related to the individual item (row) is used to derive the importance in percentages of the respective item by dividing by the total sum of codes. *Figure 1b* shows the transformation of the questionnaire shown in *Figure 1a*. The average value for the individual group (WS 1, WS 2, Departments = Dept.) was calculated as a mean-value of the individual questionnaires.

To use these preferences for interpretation it has to be taken into account that the maximum of the percental preference is related to the number of items evaluated. The respective formula is: $100/ (N_{Items}/2)$. Thus the maximum is limited to the twofold rate of the average priority; the minimum preference value is zero (*see also Figure 2*).

Surveys in the Top- and Middle-Level Management and Research Institute

It was to be expected that in management the evaluation forms would be prepared by a member of the staff, but would have to then be authorized by the head of the department. The use of the questionnaires for a complete pairwise comparison is comparatively time-consuming and does not immediately lead to the percental results, which could be approved easily by the heads of department. Consecutively, a different questionnaire was used in which the individual items had to be evaluated using a four point (forced) Likert scale (+ + = important, + = somewhat important, – = somewhat unimportant, – – = unimportant). In order to receive comparable results in terms of a percental evaluation, Likert values were used. The coding in the evaluation matrix was as follows: 2 was given if the Likert value of the row was higher than the value of the item in columns, 1 in case of equal preference and 0 when the row-Likert value indicated less importance (*Figure 2*).

Items	Likert Value (row)	Item 1	Item 2	Item 3	Item 4	Item 5	**Sum**	**Percental preference**
Likert Value (column)		+	– –	–	+ +	+		
Item 1	+		2	2	0	1	5	25
Item 2	– –	0		0	0	0	0	0
Item 3	–	0	2		0	0	2	10
Item 4	+ +	2	2	2		2	8	40
Item 5	+	1	2	2	0		5	25
Sum							**20**	

Figure 2. Conversion of Likert scale evaluation into percental preferences

Data

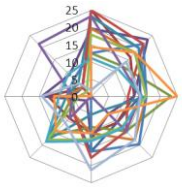
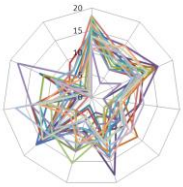
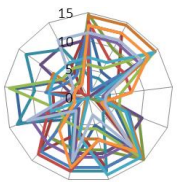
We received 13 completed questionnaires in WS 1 and 22 in WS 2. These were questionnaires in which the complete version of the pairwise comparison was performed. Except for the dimension "Tasks", where we received 14 questionnaires, we had 13 from the various departments of SFA-BW Here the Likert scale version was used.

RESULTS

Objectives of FMP

The results show – generally speaking – that the traditional objectives of FMP such as assurance of sustainability and the use of operative management are ranked best from almost all groups. The objectives related to potentially new objectives or external use of FMP (*subsequently generally written in italics*) show normally a clearly lower preference in percentages (*Table 1*).

Table 1. Objectives of FMP

FMP as a means for:	Mean WS 1***	CV WS 1	Mean WS 2	CV WS 2	Mean Dept.	CV Dept.
Maximum preference in percentages	25.0		18.2		16.7	
- assessment of sustainability as a responsibility of the public administration	17.6	0.39	14.4	0.15	11.0	0.31
- operative management on local level	15.8	0.25	12.5	0.19	9.9	0.36
- operative management on board level	10.5	0.58	10.1	0.24	12.2	0.23
- ensuring customer / user satisfaction**	12.0	0.46	10.3	0.33	5.3	0.55
- provision of a standardised data structure	7.9	0.54	8.2	0.33	10.3	0.27
- clarification of strategic forest management goals	17.3	0.22	*	*	7.9	0.58
- vocational training	12.7	0.35	8.1	0.43	3.1	0.83
- centralised data storage on state level	6.2	0.85	6.6	0.37	9.3	0.37
- assessment of sustainability for individual forest enterprises / associations	*	*	11.6	0.31	6.8	0.69
- *evaluation and management of ecosystem services*	*	*	*8.4*	*0.53*	*7.2*	*0.61*
- *external quality control*	*	*	*6.9*	*0.61*	*6.3*	*0.64*
- *enhancement of transparency for stakeholder groups*	*	*	*3.0*	*0.94*	*5.3*	*0.66*
- *provision of a framework for participatory processes*	*	*	*	*	*5.3*	*0.70*
Pattern of heterogeneity						

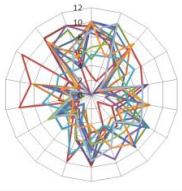
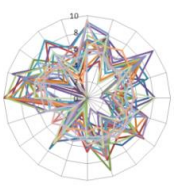
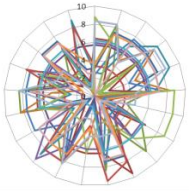
* Not proposed, discussed and evaluated in the respective workshop. This is a clear indication of lower importance. It leads, however, to a slight average increase of the preference values in WS 1.
** Satisfaction in terms of satisfaction with the whole organisation and their offers.
*** One item not matching this dimension was removed from the list.

The coefficients of variation (CV) show mostly a lower or medium level with regard to the traditional objectives. However, even the CV provides only an overview of the variations of the preference patterns of the individual respondent. Based on the percental preference, net-graphs give an insight into the homo- or heterogeneity related to the individual dimension and respondent (*See graphs at the bottom of tables 1-5*). Despite the fact that individual differences are given, it can be stated that there is a lower heterogeneity at the county level in comparison to the evaluation of the departments.

Tasks of FMP

It has to be mentioned again that the traditional tasks such as the control of the realisation of forest management plans are in the front. With regard to new requirements, the medium preference of the "integration of Natura 2000 management planning" task indicates that this aspect has gained importance in the last few years. There is strong evidence that the (already existing) use of external stakeholder groups (e.g. based on the Act on Information about Environment) is not seen as a preferred task of the FMP at the county level, whereas these functions are evaluated on average with more or less equal importance by the various departments. The heterogeneity on the county level (WS 1 and WS 2) was limited, however it was very significant at the department level. *(Table 2).*

Table 2. Tasks of FMP

	Mean WS 1	CV WS 1	Mean WS 2	CV WS 2	Mean Dept.	CV Dept.
Maximum percental preference	10.5		11.8		9.5	
Control of FM-Plans realisation	7.7	30.4	6.5	14.1	5.7	41.7
Planning of ranger districts	8.1	30.1	6.4	26.7	5.1	45.9
Data base for GIS Applications	7.3	24.3	5.8	30.0	6.4	32.6
Planning on stand level	7.0	40.0	7.1	17.8	5.2	42.9
Inventory of basic forest data at stand level	6.8	31.8	4.9	39.3	6.2	27.0
Proliferation of detailed data for individual stands	6.4	37.8	6.1	23.9	5.1	52.6
Integration of Natura 2000 management planning	5.4	40.7	4.6	25.2	6.2	32.8
Harmonisation of conflicting goals	*5.7*	*31.9*	*4.5*	*39.9*	*5.0*	*51.6*
Database for reporting	4.5	36.7	4.8	36.7	5.9	42.2
Database for financial planning	6.2	34.5	5.1	31.3	3.7	68.6
Control of silvicultural standards	6.1	24.7	4.5	30.6	4.1	56.9
Database for in depth analysis of special cases	4.6	48.4	4.4	37.9	5.3	48.6
Silvicultural training	6.3	32.4	4.4	28.4	2.3	97.1
Vocational training	5.0	44.0	3.5	38.1	3.1	70.4
Provision of information for forest certification(FSC/PEFC)	*3.6*	*69.2*	*2.0*	*66.6*	*5.3*	*47.7*
Integrated (environmental. managerial planning) at stand level	*	*	*5.2*	*36.8*	*4.8*	*38.2*
Process development	3.6	35.8	3.0	54.3	3.1	78.6
Database for Sustainability Balanced Scorecard	*3.3*	*74.5*	*	*	*5.1*	*47.4*
Database for proliferation of information based on the act on information about environment	*2.4*	*129.0*	*	*	*5.0*	*43.5*
Forest monitoring	*	*	*	*	4.3	59.1
Information on areas suitable for compensation for environmental relevant impacts	*	*	*	*	*2.9*	*98.2*
Pattern of heterogeneity						

* Not evaluated. Due to the lower share of non-evaluated items there is no relevant impact on the average preference pattern of the other items.

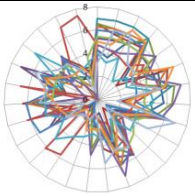
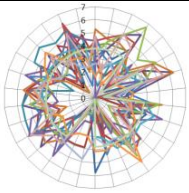
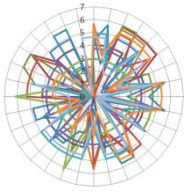
Tools and Products of FMP

The high preference for traditional outputs of FMP is even stronger at the county level when the question for tools and products is raised. The highest percental ranking receives the total felling budget, stand register, and planning information on stand level. The evaluation of the departments' questionnaire shows a more evenly structured preference pattern. As in the other dimensions examined, the role of new products meets on average wide scepticism amongst the representatives of the county level, but the normally high CV indicates that a smaller part of the group has a different view on these externally used products. With regard to the preference pattern of the individual evaluator, it can be shown that we have here a tremendous heterogeneity in all groups. The requirements seem to vary significantly among different regions or under a different thematic scope of the departments *(Table 3).*

Table 3 (part 1). Tools and Products of FMP

	Mean WS 1	CV WS 1	Mean WS 2	CV WS 2	Mean Dept.	CV Dept.
Maximum percental preference	6.9		6.9		6.3	
Total felling budget	5.5	0.19	4.5	0.24	4.1	0.34
Resuming of silvicultural measures	4.9	0.23	4.5	0.20	4.1	0.34
Forest GIS	4.7	0.31	4.5	0.22	4.2	0.30
Stand register	5.5	0.17	3.5	0.43	4.0	0.36
Management plans for individual stands	5.4	0.26	4.0	0.36	3.6	0.47
Digital maps	5.3	0.22	3.4	0.36	4.3	0.26
Digital stand information	3.4	0.33	4.1	0.22	4.3	0.21
Resuming of activities in areas under different kinds of treatment (planting. pruning. harvesting ...)	5.2	0.22	3.2	0.42	2.7	0.49
Traditional (hardcopy) maps	5.3	0.21	3.0	0.47	2.7	0.54
Permanent comparability between plan and completion on stand level	4.1	0.43	4.3	0.17	2.6	0.51
Plan for individual ranger districts	4.7	0.31	3.6	0.39	2.3	0.70
Standard reports	3.3	0.46	4.4	0.18	2.9	0.54
Digital cadastral information	2.9	0.47	3.5	0.34	4.0	0.26
Information about structure and spatial affiliation of land parcels	3.4	0.49	3.8	0.24	3.2	0.40
Maps about specialised questions	3.6	0.37	3.8	0.23	3.0	0.44
Management summary for decision-makers	4.1	0.38	3.4	0.30	2.7	0.58
Special analysis	2.6	0.64	3.7	0.22	3.4	0.32
Mapping of forest habitat types	*2.5*	*0.70*	*3.5*	*0.42*	*3.4*	*0.36*
Strategic management planning on enterprise level	4.2	0.31	2.1	0.53	2.9	0.56
Provision of time series	2.4	0.45	2.7	0.47	3.3	0.42
Felling plan structured by timber-assortments	3.8	0.43	1.5	0.62	2.9	0.66
Operations analysis	2.9	0.39	2.6	0.44	2.6	0.87

Table 3 (part 2). Tools and Products of FMP

	Mean WS 1	CV WS 1	Mean WS 2	CV WS 2	Mean Dept.	CV Dept.
Management contract between owner and manager	0.0	0.00	4.7	0.24	3.2	0.54
Experts' opinion for the management of the elapsed period	2.3	0.43	2.8	0.33	2.2	0.64
Specialised analysis for different zones	0.0	0.00	3.4	0.32	3.5	0.55
Forest statistical report	1.8	0.44	2.0	0.82	2.8	0.47
List of individual stand matching special criteria	0.0	0.00	3.5	0.30	2.3	0.65
Digital information for external stakeholders and partners	*1.7*	*0.89*	*1.5*	*0.94*	*2.3*	*0.78*
Digital GIS information for external stakeholders and partners	*1.8*	*1.02*	*1.4*	*0.96*	*2.3*	*0.78*
Map of Natura 2000 areas	*	*	*	*	*3.5*	*0.22*
Description of present state of stand level	*	*	*	*	3.0	0.56
Dynamic maps which depict changes over time during a planning period.	*	*	*	*	1.8	0.70
Pattern of heterogeneity						

* Not assessed at the county level.

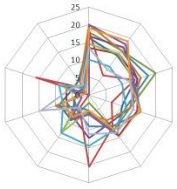
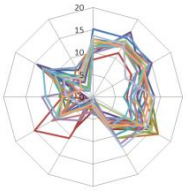
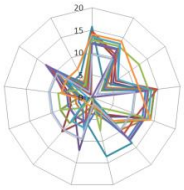
Users of FMP

The analysis of the preferred user groups shows a clear result. There is a wide consensus that the state FMP system should be suited for a wide range of forest users. Except for the private forest owners, which are not favoured by the departments, all ownership types and managers of different levels show a distinct and greater importance. The comparatively low CV related to the forests users indicate a low heterogeneity, which is additionally supported by the patterns of heterogeneity *(Table 4).*

Process Steps

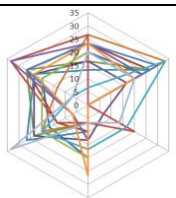
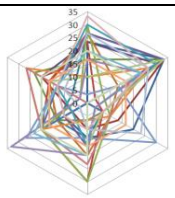
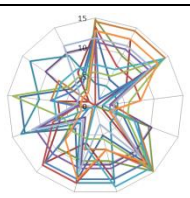
It can be stated that there are two process steps which are ranked best in all groups. These are the joint inspection of the individual stands and a discussion about the core objectives to be executed during the next ten-year planning period. The potential role of the FMP as a platform for participatory processes was only assessed at the department level and was not seen as playing an important part of the FMP process. However, as it is normal for new aspects, it showed a high CV, indicating different opinions at the department level.

Table 4. User groups of FMP

	Mean WS 1	CV WS 1	Mean WS 2	CV WS 2	Mean Dept.	CV Dept.
Maximum percental preference	20.0		16.7		15.3	
Owners and managers of state forest land	14.2	0.18	11.5	0.13	13.2	0.12
Owners and managers of communal forest land	16.8	0.19	13.8	0.09	11.5	0.21
Owners and managers of private forest land	14.3	0.25	12.4	0.16	5.5	0.65
Managers on board level (state forest)	12.2	0.13	10.7	0.21	12.8	0.11
Managers on local level (including forest rangers)	12.4	0.19	12.8	0.18	11.7	0.32
Other administrations	*7.8*	*0.38*	*7.6*	*0.37*	*9.0*	*0.37*
Hunters	*2.5*	*0.60*	*2.1*	*0.51*	*3.2*	*1.15*
NGOs	*5.2*	*0.79*	*3.2*	*0.80*	*5.8*	*0.56*
Citizens	*8.0*	*0.65*	*7.1*	*0.51*	*5.6*	*0.48*
Timber consumers	*6.6*	*0.59*	*5.9*	*0.44*	*4.3*	*0.68*
Forest associations	*	*	*8.5*	*0.43*	*5.2*	*0.45*
Certifiers	*	*	*4.4*	*0.46*	*9.1*	*0.32*
Adjacent forest owners	*	*	*	*	*3.3*	*0.66*
Pattern of heterogeneity						

* Not assessed in the respective WS.

Table 5: Importance of process-steps in the FMP-process

	Mean WS 1	CV WS 1	Mean WS 2	CV WS 2	Mean Dept.	CV Dept.
Maximum percental preference	40.0		40.0		33.3	
Joint inspections (district ranger and a member of FMP organisation)	23.1	0.38	24.4	0.38	19.5	0.43
Discussion about a set of objectives	20.0	0.28	20.3	0.43	23.3	0.22
Debriefing	17.7	0.46	16.3	0.44	16.9	0.50
Negotiations during FMP process	13.1	0.48	14.9	0.54	19.2	0.45
Participative processes with external stakeholders	*	*	*	*	*11.9*	*0.89*
Mid-term meeting	4.4	1.69	9.4	0.82	10.0	0.97
Pattern of heterogeneity						

DISCUSSION

Objectives

The results give a clear indication that traditional goals of FMP are still absolutely predominant. FMP as a means to control the forest enterprise at the local level or to ensure the legal obligation to manage forests in a sustainable manner are emphasised homogenously at the county level and at the department level. The results from the two workshops at the county level show a wide overlap, hence we can conclude that the underlying hypothesis that no relevant regional differences exist was proven successfully. However, it is evident that some differences remain as well. The clarification of the set of goals of the individual owner is much more important at the county level and the same applies for the satisfaction of most communal users of FMP. Still, this applies for the internal use of FMP as well. All 'new' objectives are on average of lower priority; at the local level the results indicate that there is tremendous scepticism towards integration of such kind of objectives when designing a new FMP processes. The reasons behind this attitude were not assessed during the process; however, the novelty of these requirements may play a substantial role. It has to be pointed out that a higher CV indicates that there is a smaller share of county representatives, who displayed a different opinion. The awareness seems to differ notably at the local level, which corresponds with the wide variety of framework conditions reaching from condensed urban areas to rural landscapes. One should expect that these 'new objectives' are of much higher relevance on the upper management levels. Despite the fact that the average evaluation shows a higher ranking at the department level than in the counties, it has to be stated that there is no common evaluation of these new potential objectives at the department level either.

Tasks of FMP

Firstly, it has to be mentioned that the plurality of opinions is mostly higher when individual tasks of FMP are analysed. We found a lower CV (<0.40) for roughly only 50% of the tasks, which indicates that there is a broader consensus about the importance of the individual task; only five tasks could be identified, which are seen as being of greater relevance in all groups. With regard to the operative tasks of FMP, analysis shows that the requirements of the local level are completely different from those of the departments. County members voted definitely for tasks, which are in context to silvicultural activities on the stand and district level, whereas the departments showed a higher affinity to external functions of FMP such as certification, the controlling of strategic goals in the Sustainability Balanced Scorecard e.g. Here we identify a notable difference between the requirements of the different management levels and thus likely a point of future disputes in the case that the revised version of FPM is not able to cover both the preferred tasks of the local level and the wider range of tasks evaluated as being important by the departments.

Process Steps

Above all, it has to be realised that the heterogeneity of opinions about the importance of individual process steps is on a medium level, but there are no differences on average between the two workshops at the county level. With regard to the FMP processes, it turns out that there are only two process steps which are seen as prevalent: first, a joint inspection of the individual stands by the local ranger and the person who is responsible of the FMP; second, a discussion about the set of objectives, which received homogenously high preference in percentages. According to the findings discussed below, the possibility of the integration of external stakeholders meets wide scepticism. Again, the exclusion of externals becomes visible, and it can be shown that it reflects not only the opinion at the county level. At the

department level the heterogeneity, indicated by a high CV of 0.89, indicates various points of view on this account too. Unless it is known that there is a high demand from external stakeholder groups (environmental NGOs play the most substantial role), no common understanding of whether a framework for an external participation should be integrated in the FMP process was developed thus far, not even at the medium and upper management level.

Tools and Products

The results of the analysis of the tools and/or products provided by the FMP mirror those of the tasks and objectives. Again, traditional products/tools are characterised by a homogenously higher or medium preference. It can be shown that the preference structure of the department level differs substantially from that of the counties, where products which can be used directly from the field foresters are ranked - foreseeably- higher. Half of the products - mostly traditional ones - are evaluated to have a limited heterogeneity, and such is the case especially at the county level. The notably higher heterogeneity observed for products, which are suited to be used by or even mostly dedicated to externals, highlights the greater differences between the counties and departments in terms of relevance of participation and issues such as ecosystem services.

Users

The importance of different users of FMP is very homogenous when we consider the traditional users and stakeholders, which are the various communal enterprises (here especially at county level) and the representatives and managers of state forest land at the local and board level. New, mostly external users are viewed very sceptically at the county level. Other administrations and certifiers receive a homogenous, but only medium high, preference at the department level. Citizens and forest associations are, in general, of low importance. The higher CV indicates again that it needs the direct perception of a demand from external stakeholder groups, which can be observed only locally or in some departments that are confronted with these external requests. Consequently, the results reveal that it is again the traditional mind-set that dominates the approach regarding the users of FMP. It can be questioned whether this is forward-looking in a time, where political decision-makers have decided to publish detailed information and data from the FMP to the public.

Summarising comments

The patterns of the preferences confirm the expectations. For most members of forest administration, FMP has to primarily fulfil the traditional functions of their silvicultural activities. However, the heterogeneity even at the county level shows that the demand for new aspects differs widely. This corresponds with the tremendous variability of the framework conditions under which forest management takes place in Baden-Württemberg. It varies from forests situated close to urban congestions, which are to some extent heavily influenced by a high share of academically educated people, to rural regions where primary productions still play a significant role. It has to be stated that up to now no widespread intrinsic motivation to adopt these new aspects exists; it is more of an externally forced local shift in areas where a higher demand for societal participation has already developed. Furthermore, this plurality of opinions is not limited to the county level. At the middle and top management levels the heterogeneity is similar, but evidently and expectably the perception of the increasing demand of stakeholders for information and products from FMP is higher.

From a methodological point of view it can be confirmed that the pairwise comparison methods, which have met scepticism before the beginning of the process, have proved successful. The results show a clear consistency over the individual dimensions. Forest

management experts and decision-makers from the state forest enterprise unanimously stated that the results are to the point. The ability to arrange the individual items into a matrix with the axes corresponding to the importance and consentaneity can be used as guidance for strategic decisions about the core objectives and structural components of a future FMP-process. Despite the fact that the results proved the existing hypotheses in almost every case, additional information about the degree of consensus and presentability in the future process were identified as a valuable benefit of the process.

CONCLUSIONS, RECOMMENDATIONS AND OUTLOOK

The questionnaire and pairwise comparison methods can be seen as helpful tools when a clear and visible prioritisation is needed. Particularly the opportunity to deliver results, which are - due to its participants' absolute anonymity - more or less uninfluenced by hierarchical structures, is suited to derive an insight into the individual opinions in a group and reduce the chance to show tactical response behaviour.

The number of assessment criteria related to a topic or a dimension should be limited to 15-20 items. Questionnaires, which require up to 450 entries, are very time-consuming and are only applicable in groups with a strong willingness for cooperation. Means for reducing the number of items can be seen in a pre-selection using less sophisticated methods or the use of a higher number of dimensions or topics. When using (hardcopy) questionnaires, the result cannot be displayed in a workshop setting. This non-visibility leads to some degree of disappointment amongst the participants. The use of digital surveying methods is, when applicable, better suited when the results should be presented immediately. Furthermore, it reduces the workload of data entry tremendously. Excel applications can also be designed easily.

The percental preferences can and will be used as a framework for the application of a decision support tool. At the present stage this will be a utility analysis in which different structurally diverse FMP alternatives are compared using the percental preferences as utility values. The data could be used in other decision support systems (DSS) such as the Analytical Hierarchical Process. Regardless of which DSS is used, only the structured data derived from the evaluation process described above will allow for an undertaking of further supportive activities such as sensitivity-analysis or a comparison of different variations of the upcoming FMP in the ongoing development process in a reliable und trustworthy manner.

Acknowledgements: We thank the uncomplaining participants from the county level workshops who actively completed questionnaires for about an hour, and our students who helped us with compiling and entering all the data into a complex system.

REFERENCES

BECK, S.M. (2001): Partizipative Planungsinstrumente für eine nachhaltige und multifunktionale Waldbewirtschaftung. Schriftenreihe Freiburger Forstliche Forschung 49/2011. FVA Baden-Württemberg. 187 p.

EUROPEAN COMMISSION (1992): Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora.

EUROPEAN COMMISSION (2013): Guidance on Natura 2000 and Forests. (Draft Version, work in Progress).

FEINDT, P.H.; NEWIG, J. (2005): Partizipation, Öffentlichkeitsbeteiligung, Nachhaltigkeit. Perspektiven der politischen Ökonomie. Metropolis Verlag für Ökonomie, Gesellschaft und Politik GmbH. 327 p.

GRI (Global Reporting Initiative) (2013): Sustainability Reporting Guidelines. Global Reporting Initiative, Amsterdam. 92 p.
Online: https://www.globalreporting.org/reporting/g4/Pages/default.aspx.

HARTEBRODT, C. (2009): Benefits of information and internal and external participation during implementation of a sustainability balanced scorecard in a public enterprise. Proceedings of the Conference "Theory and practice in performance measurement". Dunedin, New Zealand, 14.-17.04.2009. 17 p.

HEINRICHS, H. (2007):Partizipation und Nachhaltigkeit. In Michelsen, G. – Godemann, J.; (eds.): Handbuch Nachhaltigkeitskommunikation: Grundlagen und Praxis. 2nd edition, oecom verlag, München. 715-726.

JOINT FAO/CE/ILO COMMITTEE ON FOREST TECHNOLOGY, MANAGEMENT AND TRAINING (2000): Public Participation in Forestry in Europe and North America. International Labour Office (ILO) Geneva, Sectoral Activities Department. 130 p.

LWaldG (2012): Waldgesetz für Baden-Württemberg. Kohlhammer-Verlag, 14. Lieferung Nov. 2012. 312 p.

NIKLAS, C. (2002): Mehr Entscheidungssicherheit mit der Nutzwertanalyse. Projektmagazin 7/2014, Berleb Media GmbH, Taufkirchen. Online: https://www.projektmagazin.de/artikel/mehr-entscheidungssicherheit-mit-der-nutzwertanalyse_1089305.

SAATY, T.L. (2008) Relative Measurement and Its Generalization in Decision Making - Why Pairwise Comparisons are Central in Mathematics for the Measurement of Intangible Factors - The Analytic Hierarchy/Network Process. Rev. R. Acad. Cien. Serie A. Mat. VOL. 102 (2), 2008, pp. 251–318.

SHEPPARD, S.R.J. (2005): Participatory Decision Support for Sustainable Management: A Framework for Planning with Local Communities at the Landscape Level in Canada. In: Canadian Journal of Forest Research 35: 1515–1526.

DOI: 10.1515/aslh-2016-0008 Acta Silv. Lign. Hung., Vol. 12, Nr. 1 (2016) 89–102

Balance Impossible? Between Customizability and Comparability of Employee Satisfaction Surveys

Christoph HARTEBRODT* – Yvonne CHTIOUI

Forest Research Institute Baden-Württemberg (Germany)

Abstract – In a significant share of cases, when multi-objective management systems (e.g. Balanced Scorecard, Quantum Performance Measurement) are in use, the goal of employee satisfaction is part of the set of strategic goals. Quite frequently, this goal is flanked by an indicator, mostly a so-called employee satisfaction index, which is frequently derived from an employee satisfaction survey (ESS). On one hand such a survey has to reflect the characteristics and structure of the enterprises, on the other hand it is known that the question for intercompany-comparison turns up immediately after the disclosure of the results. The paper discusses the results of a meta-analysis of ESS in seven of the larger forest enterprises in Germany. The main topics are underlined and the problems of comparability of customized ESS are shown, while focusing on both wording and scales used for their measurement. A methodological approach of dealing with various scales is discussed based on the results of inter- and intra-company ESS. A vision of a common ESS framework is outlined.

intercompany comparisons of employee satisfaction / transformation of Likert-scales

Kivonat – Lehetetlen középút? A munkahelyi elégedettségi felmérések testreszabhatósága és összehasonlíthatósága. Az esetek jelentős részében, amikor többcélú vállalatirányítási rendszerről (pl. kiegyensúlyozott stratégiai mutatószám-rendszer, quantum teljesítmény értékelés) van szó, a stratégiai célrendszer része a munkahelyi elégedettség. Gyakran, ezt a célt az un. munkahelyi elégedettségi indexszel jellemzik, amelyet a munkahelyi elégedettségi felmérésből származtatnak. Egyrészt egy ilyen felmérés vissza kell, hogy tükrözze a vállalkozás egyedi szerkezetét és jellegzetességeit, másrészt tudható, hogy a vállalkozások közötti összehasonlíthatóság igénye azonnal megjelenik, amint a vizsgálat eredményei megszületnek. Ez a cikk a munkahelyi elégedettségi felmérések meta-elemzését tárgyalja Németország hét nagyobb méretű erdészeti vállalata példáján. Az írás bemutatja a főbb témaköröket és az egyedi munkahelyi elégedettség felmérések összehasonlíthatóságát az alkalmazott fogalmak és a mérési skálák tekintetében. A különböző mérési skálák összevetésével kapcsolatos módszertani kérdésekre a vállalkozáson belüli és vállalkozások közötti munkahelyi elégedettség felmérések alapján szintén kitérnek a szerzők. A munkahelyi elégedettség felmérések jövőbeli közös általános kereteit felvázolják.

munkahelyi elégedettség felmérések vállalkozások közötti összehasonlítása / Likert skála transzformációja

* Corresponding author: christoph.hartebrodt@forst.bwl.de; Wonnhaldestraße 4, D-79100 FREIBURG

1 INTRODUCTION

1.1 Preface

Employee satisfaction is an objective that is on the agenda in almost all of the larger institutions. Especially if there are multidimensional (performance) management systems in use, it can be seen that the goal of 'employee satisfaction' is typically part of the set of strategic targets. A higher share of these 'modern' management systems, e.g. (sustainability) balanced scorecard, use indicators for the measurement of successes or failures in executing the strategy. In the case of the employee satisfaction, this is mostly an index value and in almost all cases the methodological approach is an employee satisfaction survey (ESS). The literature highlights, on one hand, the need for the characteristics of the individual organisation to be addressed in ESS; on the other hand, the matter of comparability is discussed. As participation of targeted groups is seen as a precondition for the later acceptance and success of the following measures, the issue of comparability is generally less important in the period of the design of the ESS. This changes notably when the results are published. After a short discussion of its own results, unavoidably the question of: "How does our company compare to other institutions?" arises. The question and core topic of the paper is whether a balance between customizing and comparability is possible.

1.2 Contents

Intensive research has been undertaken in past years in relation to the topic of employee satisfaction surveys (ESS). There is a consensus that these surveys cover on average all topics, which are evaluated as being important for employee satisfaction (Borg 2003). However, the opinions regarding what the minimum requirements of such a survey should be differ strongly. Borg (2003) underlines that most surveys include a combination of standard topics and questions related to the particular situation of the institution. This is even the case when the motive for the survey seems to be very specific. This can be explained by the fact that a narrow range of topics can result in a more or less strong refusal by the members of the institution. In addition, it can be stated that there is no unique recommendation on what the set of standard topics should be. Nonetheless, desktop research showed that there is a discussion about some type of an intersection-set of questions, which appears in a relevant number of questionnaires (inter alia. Balmer et al. 2000).

Borg (2003) classifies 11 standard contents from the point of view of the members of the institution and 9 performance and strategy-related contents, which are of particular relevance for the institution as such. He derives a structure for three areas of interest from these findings. Hossiep & Frieg (2008) undertook a study of 820 of the largest enterprises in Germany, Austria and Switzerland. They identify 19 standard and performance topics and 9 psychological issues, which are addressed in ESS. If this set of topics is split up into a stratum, which occurs in more than 50% of the surveys and one which is less frequent, a three-part classification emerges. This three-partite structure is basically confirmed by Bösch (2011), who identifies three standard topics that are part of almost every ESS, five that are frequent, and seven contents that are related to psychological, social or ethical issues. Fischer et al. (2008) do not define areas of interest. They define 12 fields of questions, which are seen as being the most important key drivers for satisfaction and commitment of employees. Domsch & Ladwig (2000) and the European Foundation for Quality Management (EFQM2013) define 9 areas of interest; from which five (so-called enablers) have a stronger relationship to the issue of employee satisfaction.

From the findings above, it can be subsumed that there is some type of an understanding of the important aspects, which are part of ESS, but the opinions about how to structure these

topics differ notably. As a reason for this heterogeneity, two main aspects seem to be of special significance: the need to develop a case-related solution (a) and the participation of the employees (b).

(a) Evaluation theory tells that core objective of every evaluation is answering the specific questions (Rossi et al. 2004). Borg (2003) and Fischer et al (2008) point out that the content of any kind of ESS should be related to the objective of the study, which means that the mere use of a standard set of questions would be misleading.

(b) As participation of employees in the stage of the development of ESS is recommended in order to cover all relevant aspects from the point of view of the employees, some very specific contents and / or questions are to be expected. Unless this is seen as a constraint with the later comparability of the results, this participation is seen as a precondition for the acceptance of the results and the consecutive measures (ibid.).

1.3 Scales

As shown for the contents, there is also no consensus about the use of scales in ESS. The spectrum ranges from the statement that there are no good or bad scales, but appropriate and inappropriate scales related to the respective questions (HBS 2002), to specific findings on what the best solution is (e.g. Cummins and Gullone (2000): no five point (odd) scale; e.g. Sturgis et al. (2014): pro neutral alternative). There is a certain consensus that five-point Likert scales are frequently used, and one should not exceed nine categories (Eurostat 2004). Less homogeneity can be found related to the question of whether balanced or unbalanced scales, or even or odd scales were favourable and also about the meaningfulness of a 'don't know' alternative.

1.4 Calculation of Index Values

It can be shown that there are different types of index values which are subsumed under the headline of ESS. Bösch (2011) differentiates between four types: (1) satisfaction-index, (2) leadership-index, (3) commitment-index and (4) acceptance-index. Evidence shows that there are various sets of questions, which are related to the respective indices. However, there is a wide overlap between sets related to different indices and evidently no consensus exists in terms of which question supports which type of index-value. Despite the fact that there is a discussion about the accuracy of deriving arithmetic means from ordinal and/or nominal scale by coding them with discrete numeric values, this is applied in almost all cases. After coding the questions, two basic approaches of deriving an index value from the questionnaires are used. The first one can be titled as the 'all questions approach'. Here the results of all individual questions are included in the calculation of an index, partially after calculating means of sections and combining these means to an overall index. The second approach can be subsumed under the 'index-question' method. Here a special set of questions, which are used to derive the overall satisfaction index, is included. These questions are frequently intended and used to include the antecedent section too.

2 MATERIAL AND METHODS

2.1 Material

As the study was embedded in an ESS-project under the umbrella of a Sustainability Balanced Scorecard (SBSC) project, which is a management approach more suited mainly for medium-sized and larger forest entities, it was decided to include only larger forest organisation in the

German-speaking regions. It was possible to identify six ESS studies from the past six years, which could be compared with the one of the state-owned Forest Enterprise of Baden-Württemberg from 2013. The comparative studies are listed in *Table 1*.

Table 1. List of comparative studies

Institution	Year
State Forest Enterprise Saxony-Anhalt	2007
State Forest Enterprise of Hessen (HessenForst)	2009
State Forest Enterprise of Bavaria (BaySF)	2010
Forest Research Institute Baden-Württemberg (FVA)	2010
State Forest Enterprise Mecklenburg-West Pomerania (Landesforsten M-V)	2010
Forest Research Institute of North-Western Germany (NW-FVA)	2011

2.2 Methods

The study focusses mainly on four topics. It was of special interest whether:

- the ESS forest case study addresses topics that are seen as being important in the general literature about ESS
- the wording of questions allows for a comparison between individual questions
- the scales applied allow for a direct comparison
- a normalisation of scale can be used in the case that comparable questions are evaluated with different scales.

The methodology applied in respect to these areas of interest is described below.

2.2.1 Topics

Different authors used a "frequency-approach" to classify the importance of the topics; this method was applied in this paper in order to identify the most important topics for further research. Based on desk research, six classifications were combined in a meta-analysis. Borg (2003), Hossiep & Frieg (2008) and Bösch (2011) use a three-partite scale, which was included directly into the meta-analysis with three, two, and one points respectively. Domsch & Ladwig (2000) differentiate their results into core topics and sub-items. Core topics were valued with two points, whereas sub-items receive a one point value. Bröckermann & Müller-Vorbrüggen (2010) and Fischer et al. (2008) define a limited set of key drivers which were coded with two points. The standards of the EFQM were – due to their international significance -ranked higher. In the case that a topic is listed in the standards of EFQM, three points applied. In a second step, the comparative questionnaires were analysed to determine if they contained questions related to the single topics that are included in the questionnaire; if they did, those questions were counted. The sum of points related to the individual topics was used to derive a ranking of important topics. For the most important topics, the number of questions in the comparative studies was analysed.

2.2.2 Questions and their Wording

The 'handbook for […] questionnaire-development' issued by Eurostat (2014) states: "Minor changes in wording can also have a significant effect on responses". Together with findings that standardized questions (questionnaires) are preferable whenever comparability is needed, it can be stated that it is widely accepted that the results of ESS can only be used for comparison studies in cases where the wording of the individual questions is more or less identical. Therefore, the questions in the ESS were assigned to the list of topics. Using text analysis, it was tested to see if a direct comparability of the wording was feasible or not.

2.2.3 Scales

The scales used in the questionnaires were analysed. Of special interest were:

- number of categories
- type of scale (ordinal / cardinal)
- use of a "don't know" category
- even or odd number of categories
- the use of a neutral category
- whether the wording for the scales applied was balanced or unbalanced

2.2.4 Normalisation

Based on the analysis of the questionnaires, a small set of questions from two comparative studies and the ESS from ForstBW from 2013 could be identified; these showed a sufficient similarity of wording, but different scales. For this small subset, the results have been normalised using formula (1):

$$\frac{x_i - x_{min}}{x_{max} - x_{min}} * 100 \quad (1)$$

x_i = Likert code resp. mean of Likert code
x_{max} = Maximum Likert code
x_{min} = Minimum Likert code

The factors derived from this normalisation were applied to the results of the individual questions in the ESS. *Table 2* gives an example of this kind of normalisation.

Table 2. Normalisation of different scales

Likert code	% Value	Likert code	% Value
6	100	5	100
5	80	4	75
4	60	3	50
3	40	2	25
2	20	1	0
1	0		

3 RESULTS

3.1 Topics

In total, 44 topics were identified from which 10 reached more than half of the maximum sum of points derived from the six studies included, and were furthermore used as the most important topics. A second group, which reached a quarter to half of the maximum value, is depicted as well (*Table 3*). Here we found 16 topics. At the bottom of *Table 3* the topics of lower importance (three points and less) are listed.

Table 3. Priority of topics in ESS studies

Topics	EFQM (from Bösch 2011)	Bösch	Bröckermann & Müller-Vorbrüggen	Domsch& Ladwig	Borg	Hossiep& Frieg	Max 16
Leadership / immediate superior	3	3	2	2	3	3	**16**
Cooperation / team (colleagues, service providers dept.)	3	1	2	2	3	3	**14**
Working conditions and safety	3	1	2	2	3	3	**14**
Advanced training / prospects		3		2	3	3	**11**
Functions and duties / objectives		1		2	3	3	**9**
Pay / statutory benefits / gratuities		1		2	3	3	**9**
Staff retention / fluctuation	3	1	2			3	**9**
Working atmosphere	3	1	2		3		**9**
Communication / information		1		2	3	3	**9**
Processes / internal organisation	3	1	2		3		**9**
Customer orientation / customer retention		1	2		2	2	**7**
Job satisfaction / overall satisfaction		1	2	1	3		**7**
Identification / commitment / emotional bonding		1	2		3		**6**
Assertion of strategy		1			2	3	**6**
Image / communication /attractiveness		2		1		3	**6**
Management of innovations		1			2	2	**5**
Motivation, performance / productivity				1	2	2	**5**
Workload/ stress / burnout		2		1	1	1	**5**
Equitableness and acceptance		1		1	1	1	**4**
Empowerment/ accountability and freedom / participation		2			1	1	**4**
Self-respect and perspectives		2		1	1		**4**
Quality (products/ services)					2	2	**4**
Motivation		1	2	1			**4**
Work-life balance		2			1	1	**4**
Change management					2	2	**4**
Project management					2	2	**4**
Topics of lesser importance							
Uncertainty of employment; Deficits / Potentials for improvement; Change of legal status, Reorganisation, Fusion; Engagement; Discrimination; Confidence in management und enterprise; Working hours schemes; Media; Social capital; Diversity; Mobbing; Demographic change; Confidence; Management instruments; Health management; Career planning / Career supervision; Management trends; Psychological contracts							

The analysis of the number of questions related to the most important topics used in the ESS showed that seven out of ten of the very important topics are addressed in the forest institutes' ESS as well. However, it has to be kept in mind that the intensity, in terms of number related questions, differs notably. The topics "payment, statutory benefits, gratuities', 'staff retention, fluctuation' and 'working atmosphere' are covered weakly in the studies (*Table 4*).

Table 4 Coverage of key topics in ESS in forest institutions

	Bavaria 2010	Hessen 2009	Saxony-Anhalt	Mecklenburg-West Pomerania	North-Western Research I.	Research I. Baden-Württemberg	Average Number of Questions
	Numbers of Questions						
Leadership / line manager	16	11	4	9	4	5	8.2
Cooperation / team (colleagues, service providers, departments)	9	8	1	0	1	3	3.7
Working conditions and safety	5	3	1	11	4	7	5.2
Advanced training / prospects	4	5	5	6	2	3	4.2
Function and duties / objectives	5	6	3	8	1	5	4.7
Pay / statutory benefits / gratuities	1	2	1	0	0	0	0.7
Staff retention / fluctuation	0	0	1	0	1	0	0.3
Working atmosphere	3	1	1	0	2	2	1.5
Communication / information	16	9	3	11	7	4	8.3
Processes / internal organisation	8	4	5	3	8	5	5.5

3.2 Wording

In the following table, the translation of the set of questions used for two topics is shown. It appears that the questions can differ widely and that only in a small share a direct comparability can be undertaken (*Tables 5 and 6*).

Table5. Examples for the different wording of questions related to the topic 'Leadership / Direct superior'; Subtopic appreciation

Original wording in German	Equivalent wording in English
Das Verhalten meiner direkten Führungskraft mir gegenüber ist von Wertschätzung geprägt.	The behaviour of my direct superior is based on respect.
Mein Vorgesetzter spricht seine Anerkennung aus, wenn ich gute Arbeit geleistet habe.	My direct superior expresses his/her appreciation, when I have done a good job.
Ich bin mit der Wertschätzung meiner Arbeit durch meinen direkten Fachvorgesetzten zufrieden.	I am satisfied with the appreciation shown by my direct superior.
Ich bekomme Lob und Anerkennung von meinem direkten Fachvorgesetzten gezeigt.	I receive praise and appreciation from my direct superior.
Werden von ihrer Führungskraft gute Leistungen erkennbar gewürdigt?	Does your manager clearly display appreciation for a good performance?
Mein Vorgesetzter lässt mich auf verschiedene Art wissen, dass meine Leistungen anerkannt werden.	My superior lets me know through different ways that my good performance is recognised.
Erkennt ihr Vorgesetzter gute Leistungen lobend an?	Does your superior recognise a good performance?

Table 6. Example for different wording of questions related to the topic 'Cooperation / Team (colleagues, service providers, departments)'

Original wording in German	**Equivalent wording in English**
Zusammenarbeit zwischen den Organisationseinheiten.	Cooperation between the individual units.
Die Zusammenarbeit meines Teams mit anderen Arbeitsbereichen innerhalb der Dienststelle ist so, dass wir gute Arbeitsqualität erbringen können.	The cooperation between my team and other units works in a way that we can achieve a good working quality.
Mit anderen Fachbereichen wird gut zusammengearbeitet	The cooperation with other units works well.
Die Arbeit in meinem Team funktioniert gut	My team works well together.
Wie zufrieden sind sie insgesamt mit der Zusammenarbeit mit Kollegen aus andern Abteilungen/Teams?	How satisfied are you in general with the cooperation with colleagues from other departments?
Zwischen meiner Abteilung/ Arbeitsgruppe und anderen Abteilungen/ Arbeitsgruppen besteht eine gute Kooperation.	There is good cooperation within my department / group and other departments / groups.
Wie beurteilen sie die Zusammenarbeit mit den Kollegen anderer Abteilungen/ Gruppen?	How do you assess the cooperation with colleagues from other departments / groups?
Zusammenarbeit mit anderen Abteilungen/ Teams (internen Kunden oder Lieferanten)	Cooperation with other departments / teams (internal customers or providers)
Aus meiner Sicht ist die Zusammenarbeit a) innerhalb meiner Abteilung reibungslos b) zwischen den Abteilungen gut.	From my point of view the cooperation a) in my department works unobstructed b) between the departments is good?
Die Zusammenarbeit zwischen der Zentrale und den Forstbetrieben funktioniert reibungslos.	The cooperation between the general office and the local units runs smoothly.
Internationale Zusammenarbeit: a) Ist die Zusammenarbeit mit Kollegen in anderen Ländern ein Bestandteil ihrer täglichen Arbeit? b) Wenn ja, funktioniert diese internationale Zusammenarbeit gut?	International cooperation: a) Is cooperation with colleagues in other countries a part of your daily work? b) If yes, does this cooperation work well?

The six questionnaires had 521 subtopics in total and were grouped in the 44 topics listed above. For 76 subtopics, more than one type of wording could be identified. The number of different wordings was 11 maximum; however, two to three wording alternatives for one subtopic cover more than 60% (*Table 7*).

Due to the qualitative nature of text-analysis, the number and share of comparable questions, which is also shown, allows for only a rough estimate about the possibilities of direct comparability of questions. The number of wordings, which allow intercompany benchmarking, normally does not exceed 3; in roughly two-thirds only one opportunity for subtopic-related comparison exists. Recalling that additionally a use of different scales applies (see also *Table 8*), the number of cases in which the wording and scale allow for direct comparison tends to be insignificant.

Table 7. Number and shares of differently worded questions related to a subtopic

Number of Wordings	11	8	7	6	5	4	3	2	Sum
Absolute Frequency [N]	2	2	3	6	9	7	14	33	76
Share [%]	2.6	2.6	3.9	7.9	11.8	9.2	18.4	43.4	100
Thereof number of subtopics with direct comparable wordings									
5		1	1						2
4				1					1
3	1	1	2	2	4	1	1		12
2				3	4	3	4	11	25
Share of wordings, basically suited for intercomp. benchmarking	14.3	50.0	52.4	44.4	44.4	32.1	26.2	33.3	36.4

3.3 Scales

Table 8 shows the number of different types of scale which were used in the six questionnaires.

Table 8: Types of scales

	Alternatives						Ordinal Scale	Nominal Scale	Symmetry		Neutral Alternative		"Don't know" Alternative	
	2	3	4	5	6	>6			yes	no	yes	no	yes	no
1				x				x		x		x		x
2		x						x		x		x		x
3	x							x		x		x		x
4	x							x	x			x		x
5	x							x		x		x		x
6		x						x		x		x		x
7			x					x		x		x		x
8				x				x		x		x		x
9					x			x		x		x		x
10						x		x		x		x		x
11					x		x		x			x		x
12					x		x			x	x			x
13				x			x		x		x			x
14				x			x		x		x		x	
15				x			x			x		x		x
16			x				x		x			x	x	
17			x				x			x		x		x
18			x				x		x			x		x
19			x				x			x	x			x
20		x					x			x		x		x
21		x					x			x		x	x	
22		x					x		x		x			x
23	x						x		x			x		x
Sum	4	5	5	5	3	1	13	10	8	15	5	18	3	20

The analysis of the applied scales shows tremendous variability. Even in the limited number of questionnaires we found 23 types of scale, without mentioning these questions which are related to demographic aspects. The number of alternatives shows an almost equal distribution between 2 and 5; 6 alternatives was less frequent and more than 6 alternatives was applied only one time. Roughly 60% of the scales are ordinal scales. From the 13 ordinal scales, 7 are balanced in the sense that the wording is identical except for the word that indicates whether the answer is proven true or false (e.g. totally agree / widely agree / widely disagree / totally disagree). Most parts of the ordinal scale were so-called 'forced scales', where no neutral position is offered and where the respondent has to make a choice whether he agrees or not. Only 3 types of scales offered the "don't know" alternative.

3.4 Comparability and Benchmarking

The results presented above gave hints that the level of comparability could be low when the search for benchmarks for the 2013 ForstBW ESS was started. This expectation proved true. It was possible to identify 12 questions, which could be used for intra-company benchmarking using the results from 2001 and 2013. A sufficient comparability that could be used for comparison with the two other forest institutions was observed in only 9 questions. As we warranted anonymity, these institutions are characterised with 'Org. 1' and 'Org.2'. In both cases the scale differed and a normalisation was carried out as described above (see *Section 2.2.4*).

The *Figures 1 and 2* depict the results of the inter- and intra-company comparison.

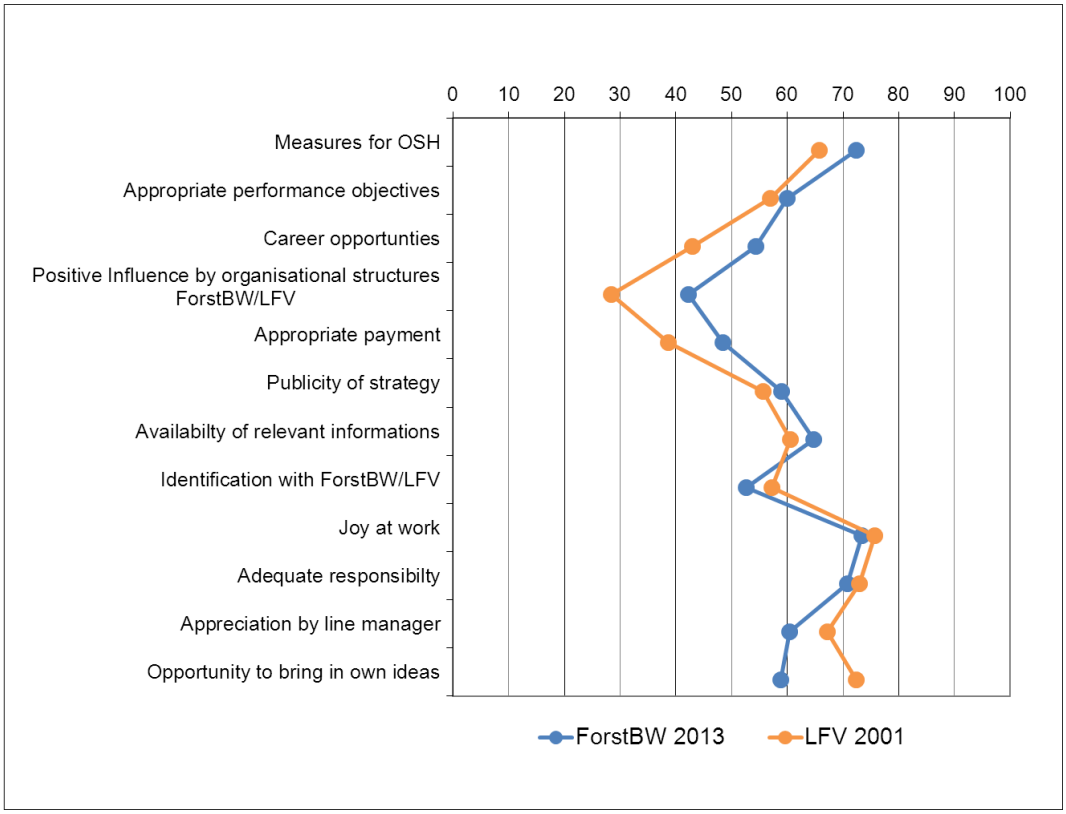


Figure 1. Intercompany benchmarking

It is clear that the patterns of the answers given by the employees of ForstBW in 2001 and 2013 are quite similar. In the year 2001 a five-point Likert scale was used, whereas in 2013 a six-point scale was applied. After the normalisation to a '100% scale', we found

values that are better and some that are worse. This can be seen as a strong indication that there is no bias caused by the normalisation. The absolute difference does not exceed 14%. The averages are very similar (ForstBW 2013 = 60, LFV 2001 = 58), that is, the coefficient of variation is smaller to some extent in 2013 (0.15) if compared with 2001 (0.24).

The intercompany differences are shown in *Figure 2*. The differences of the overall means are insignificant if comparing ForstBW with Org. 1 (1%), but can reach a notable amount in comparisons with Org. 2 (7%). The absolute values show the same characteristic. There are similarities and differences. With 27% maximum, the latter one reaches a higher level compared to the values of the intra company comparison. The coefficients of variations are at an astoundingly equal level (0.12, 0.12, 0.11). Again, it can be concluded that the normalisation allows for similar findings as well as the detection of various levels of satisfaction.

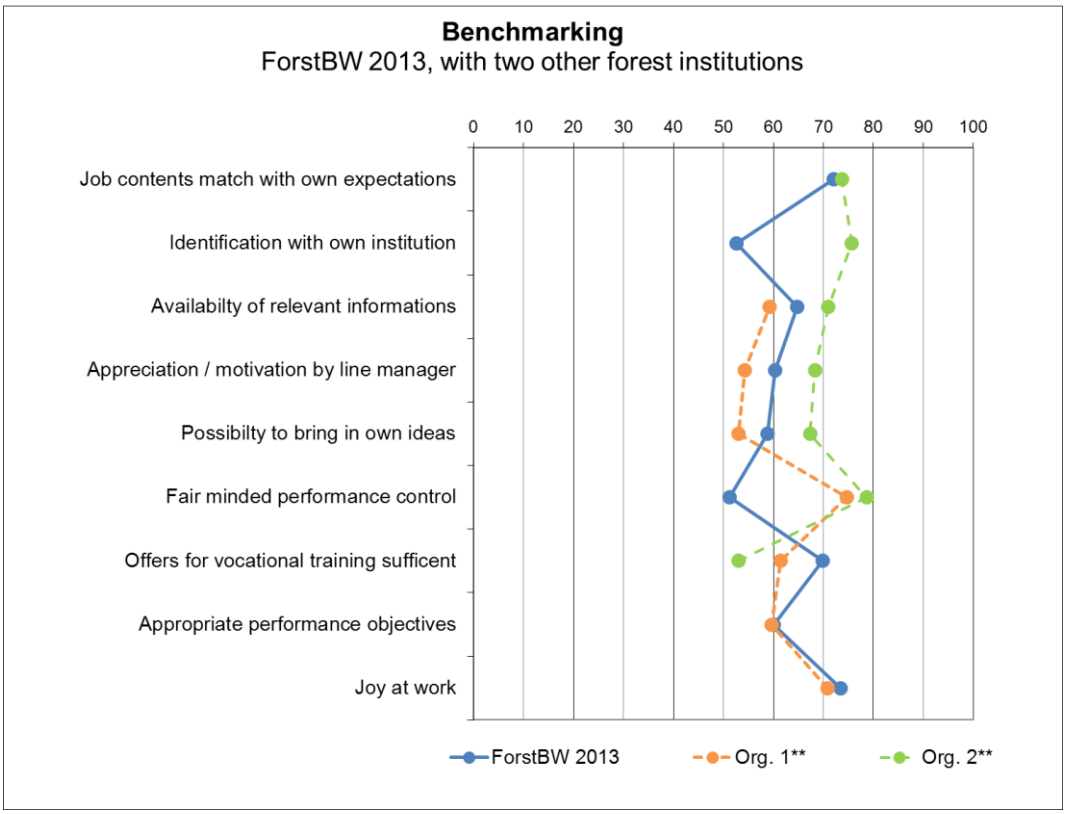


Figure 2. Intercompany comparison

4 DISCUSSION

4.1 Topics

The choice of topics within the individual ESS already shows a wide variability. Even from the 10 most important topics only 6 were addressed with at least one question in all surveys (*Table 4*). An analysis of the topics of middle and lower importance (not depicted in the paper) shows that a case-related choice of the contents prevails. Thus, it can be stated that forest ESS show the same selective or institution-related approach as described for ESS in other sectors. As participation of the employees during process of development of an ESS plays a relevant role in almost all cases, this situation is not surprising. As shown above, the number of questions related to the different topics varied tremendously. Consecutively, the importance of the topics can be very different in all cases where the satisfaction index is

calculated on the basis of the individual questions. The selection of topics and questions included in the indices is related to the total number of questions in the individual ESS, which varies too. Therefore, it has to be stated that the comparison of the overall indices should be avoided due to the fact that the issues addressed and the intensity of the ESS cannot be compared at a satisfactory level.

4.2 Wording

The analysis of the wording in the questionnaires reveals that there is no use of any kind of standards and even no visible desire to use wording from other ESS. It can be assumed that the design of the questionnaires is driven more by the personal experience and opinions of the developers, be it that this has been developed and carried out by the institution itself or from a consultant involved. In the latter case, it is rather probable that the standards of the consultant influence the wording, because this reduces the time and effort needed to develop the questionnaire. A tendency that the consultants prefer their own wordings would be supported as well by the fact that the offer of benchmarking data can be a profitable side business after the ESS. With regard to the forest ESS, it has to be stated that there were almost no identical questions and even the share of comparable questions is low. Together with a finding that the wording does not always meet technical standards, such as addressing only one topic in a single question or using only positive or negative statements in a section of a questionnaire, it has to be concluded that the chance for comparisons on the level of individual questions is limited as well.

4.3 Scales

The results of the scales applied in the six ESS used for a comparison to the ESS of ForstBW carried out in 2013 were almost self-explaining as 23 different scales could be identified in the underlying questionnaires. It has to first be questioned whether the questionnaires were designed professionally. The number of scales and changes of scale should be limited, because there is always the risk that the respondent does not realize this change and gives his answers on the basis of the scale of the previous sections. As there is almost no chance to verify whether the scales have been used properly, the results can be notably biased.

4.4 Comparability and Benchmarking

The possibilities for an in-depth benchmarking are very limited. This applies especially for the benchmarking of the employee satisfaction indices. The selection of topics and number of questions varies widely and even the way in which the indices were calculated can differ. Together with the use of different scales, partially more than one scale is used in a single ESS questionnaire; rendering it impossible to make assumptions about the differences of the overall satisfaction in the different forest institutions. This leads to a situation that benchmarking data are more or less unavailable, or have to be bought from consulting enterprises unless it is not known whether these data are comparable or not. It can be assumed that the price of the benchmarking data notably increases the costs of the whole analysis.

The analysis of the scales offered a detailed insight into the heterogeneity of the individual questionnaires and the alternatives for responses. Recalling that only seven questionnaires are included in the analysis, it became obvious that in most questionnaires a multitude of scales is applied. An in-depth analysis of the questionnaires shows that there is frequently a change of scale from one part of the questionnaire to the next. The scales are changed partially even from question to question. This conflicts with the dominant recommendation in the literature that the change of scale has to be avoided to a maximum extent. However, there are hints that this problem is limited in questionnaires that are used to

develop some kind of employee satisfaction index. Here the developers were more aware that a change of scale can provoke errors during the completion of the questionnaire. Nevertheless, it has to be stated that the degree of professionalism could be notably improved. The wish to evaluate the opinion in respect to very specific topics is not necessarily linked to the need to use different answer-scales.

However, there is one circumstance that helps to carry out comparison of equally worded questions in the case that only the number of categories applied differs. Recalling that the number of questions included in an inter- and intra-company comparison was very limited (9 respectively 12questions, see above), there are strong hints that a normalisation of the scales could be applied. The ESS in ForstBW (2013) and LFV (2001) was executed in almost the same situation about three years after a harsh reorganisation and with the awareness that the degree of dissatisfaction was high. As more than two-thirds of the people of the study overlapped, the basic hypotheses must be that no larger differences in the overall satisfaction are given, but variations in respect to different items are to be expected. The results achieved above, after the normalisation of a five- and six-point Likert scale, have basically proven these hypotheses.

4.5 Summary

The results reveal that forest ESSs are highly customized at the moment. The possibilities to make a meaningful benchmarking are limited to single questions and even here, some, but no significant, uncertainties remain in cases where different scales had been applied. This situation is mainly driven by the requirement to include the target groups in the development process of the ESS. In addition, it cannot be excluded that the consultants force this too, because any use of standardized questionnaires would reduce the need to involve them. Moreover, the sale of benchmarking results is, at least potentially, a side-business too; this furthermore reduces the interest of consultants to use standard questions or index calculations as well. Thus, it must be stated that the value of the ESS is at present limited to an intra-company time series. However, it has to be kept in mind that organisational changes are permanent concomitants that may hinder or prevent the realisation of meaningful replication of the ESS.

The results reveal that there are topics that are of interest in most forest enterprises and that the present wording and design of the questionnaires does not always reflect the best practice standards. Consecutively, it can be assumed that the choice of professionally-worded questions from a publicly available set of questions could improve the individual ESS without necessarily hampering the requirement to cover the issues that are of special interest in the respective institution.

5 CONCLUSION AND OUTLOOK

At present it can be stated that in the German-speaking region we found customized ESS with very limited possibilities to undertake any kind of benchmarking. Furthermore, a large potential of these surveys, which are always cost-intensive undertakings, is not used. At least two approaches that can lead to a stepwise improvement in possibilities for intercompany comparability can be identified.

A kind of database, in which properly worded questions related to individual topics are available during the design of new ESS, can facilitate and speed-up the process of the development in a way that the time consuming wording of questions is replaced by a choice of questions. In the case that at least the former users of these questions, or even better (anonymized) benchmarking data are available in the database too, a cost-free and reliable

comparison becomes basically achievable. Identical scales are useful; however, the normalization of scales seems to be a feasible approach to bridge that gap.

In the case that there are already existing ESS in an institution, any change of the structure of the questionnaire or even questions and their wording must be discussed carefully, because an intra-company time series of identical repetitive ESS is a value as such. Here, an inclusion of a set of additional index questions related to the most important topics (see *Table3*),which can be used to derive a sort of intercompany standard for employee satisfaction indices, could offer the chance to compare at least the overall employee satisfaction or the satisfaction in some thematic areas. These index questions could be seen as a subset out of the database discussed above.

Such a subset could be used as well for intermediate "snapshot-ESS" between the more comprehensive and therefore more expensive regular ESS, which are frequently carried out in longer time intervals.

The balance between customizing and benchmarking is not given yet. However, it seems possible to make progress using a more incremental approach without risking the loss of the own data and experiences. Therefore, it is less of a technical problem to come closer to a balance; rather, desire is needed to enhance the transparency by using benchmarking data.

REFERENCES

BALMER, R. – INVERSINI, S. – PLANTA, V. A. – SEMMER, N. (2000): Innovation in Unternehmen: Leitfaden für Selbstbewertung in KMU. Hochschulverlag an der ETH. Mensch, Organisation und Technik, Bd. 26. 198 p, with extensive set of appendices.

BÖSCH, W. (2011): Praxishandbuch Mitarbeiterbefragungen. Praxium-Verlag, Zürich, 295 S.

BORG, I. (2003): Führungsinstrument Mitarbeiterbefragung. Theorien, Tools und Praxiserfahrungen. 3. überarb. und erw. Auflage, Hogrefe-Verlag, Göttingen, 429 S.

BRÖCKERMANN, R. – MÜLLER-VORBRÜGGEN, M. (2010): Handbuch Personalentwicklung. Die Praxis der Personalbildung, Personalförderung und Arbeitsstrukturierung. Schäffer-Poeschel Verlag Stuttgart, 798 p.

CUMMINS, R.A. – GULLONE, E. (2000).Why we should not use 5-point Likert scales: The case for subjective quality of life measurement. Proceedings, Second International Conference on Quality of Life in Cities (pp.74-93).Singapore: National University of Singapore.

DOMSCH, M. E. – LADWIG, D. H. (2000): Handbuch Mitarbeiterbefragung. Springer Verlag, Berlin, 435 S.

EFQM (2013): EFQM Excellence Modell 2013, EFQM, Brüssel. 58 pp.

EUROSTAT (2004): (complete list of authors available from the author) Handbook of Recommended Practices for Questionnaire Development and Testing in the European Statistical System (2004 Edition), 142. p. and additional management summary http://ec.europa.eu/eurostat/ramon/statmanuals/files/Handbook_of_Practices_for_Quest.pdf, (accessed 18.09.2014).

FISCHER, J. – STAMS, A. – TITZKUS, T. (2008): Mitarbeiterzufriedenheitsanalyse. In Bröckermann, R. (2008): Handbuch Personalentwicklung. Die Praxis der Personalbildung, Personalförderung und Arbeitsstrukturierung. 2. Auflage. Schäffer-Poeschel Verlag, Stuttgart, 721 S. S. 305–321

HBS (Hans Böckler Stiftung((2002): Mitarbeiterzufriedenheit – Arbeitspapier 54 des Fachausschusses 2/99. Eigenverlage Hans Böcker Stiftung. 40 p.

HOSSIEP, R. – FRIEG, P. (2008): Der Einsatz von Mitarbeiterbefragungen in Deutschland, Österreich und der Schweiz. Planung& Analyse, 6/2008, 55–59

ROSSI, P.H. – LIPSEY, M.W. – FREEMANN, H.E. (2004) Evaluation – A systematic approach (7th edition). Sage Publications Inc., Thousand Oaks. 469 pp.

STURGIS, P. – ROBERTS, C. – SMITH, P. (2014). Middle alternatives revisited: How the neither/nor response acts as a way of saying "I don't know"? Sociological Methods& Research, 43(1), 15–38.

ACTA SILVATICA ET LIGNARIA HUNGARICA

Vol. 12, Nr. 2

Contents

ACTA SILVATICA ET LIGNARIA HUNGARICA

Vol. 12, Nr. 2

Tartalomjegyzék

DE GRUYTER OPEN DOI: 10.1515/aslh-2016-0009 Acta Silv. Lign. Hung., Vol. 12, Nr. 2 (2016) 105–116

Climate Change in Hungarian Rural Society: Assessment of Adaptive Capacity

Judit PAPPNÉ VANCSÓ[a*] – Mónika HOSCHEK[b] – Ferenc JANKÓ[a]

[a] Institute of International and Regional Economics, Faculty of Economics, University of West Hungary, Sopron, Hungary
[b] Institute of Economics and Methodology, Faculty of Economics, University of West Hungary, Sopron, Hungary

Abstract – Beside sustainable development, vulnerability might be the most frequently used expression in environmental studies. Vulnerability depends on the intensity of the impacts on a natural or social system as well as on its adaptive capacity. Appropriate adaptation warrants successful survival of the system even under high impact, when its vulnerability is significantly reduced; therefore, measuring adaptive capacity should have an established place in the methodology of impact – adaptation – vulnerability research. The main problem is to find relevant data that are required to establish indicators. In our study, the focus was laid on measuring adaptive capacity within vulnerability research, and on identifying possibilities for accurate calculation of adaptation. An attempt was made to determine the adaptive capacity to droughts in the micro-regions of Zala County. It could be established that the adaptive capacity of the population in the rural areas of Zala County to the expected increase in drought frequency is very low, which can be primarily explained by the lack of knowledge about adaptive agriculture.

adaptive capacity / vulnerability / adaptation / drought / climate change

Kivonat – A vidéki társadalom klímaváltozással szembeni alkalmazkodóképessége. A sérülékenység a fenntartható fejlődés mellett talán a legnépszerűbb fogalom a környezeti kutatásokban. A sérülékenység mértékét az adott ökológiai vagy társadalmi rendszert érő hatások erőssége és az alkalmazkodóképesség mértéke határozza meg. A megfelelő adaptáció még erős hatások mellett is lehetővé teszi egy rendszer sikeres fennmaradását, jelentősen mérsékelve a sérülékenységet, így a hatás – alkalmazkodás – sérülékenység összefüggésben értelmezett vizsgálatok módszertanában kiemelt jelentőséget kellene kapnia az alkalmazkodóképesség körültekintő becslésének. A mérések során felmerülő legfőbb probléma az indikátorok előállításához szükséges releváns adatok felkutatása. Tanulmányunkban a sérülékenység vizsgálatokon belül első sorban az alkalmazkodóképesség becslésének kérdéseit igyekeztünk körüljárni, feltérképezni azokat a lehetőségeket, amelyek az alkalmazkodás pontosabb számítását teszik lehetővé, majd kísérletet tettünk aszállyal szembeni alkalmazkodóképesség meghatározására Zala megye kistérségeiben. A leglényegesebb következtetéseket összegezve kijelenthető, hogy Zala megyében az aszályosság várható növekedése mellett a rurális tereken élők alkalmazkodási kapacitása jelentéktelen, ami elsősorban az alkalmazkodó mezőgazdálkodással kapcsolatos ismeretek hiányával magyarázható.

alkalmazkodási kapacitás / sérülékenység / alkalmazkodás / aszály / klímaváltozás

* Corresponding author: vancsojudit@gmail.com; H-9400 SOPRON, Erzsébet u. 9. Hungary

1 INTRODUCTION

Measurement and estimation of societal adaptive capacity mostly belongs to the methodology of vulnerability research. Impacts, which enhance social vulnerability to outside stress, should be mapped and social preparedness for those negative effects must be assessed. Previous research showed that accurate measurement of adaptive capacity causes the greatest problem among the factors of vulnerability; quantitative methods are combined with qualitative techniques (e.g. Wilhelmi – Wilhite 2002, Adger – Wincent 2005; Brooks et al. 2005; Gupta et al. 2010). These questions earn great importance in the Hungarian literature as well (Pálvölgyi et al 2010, Pálvölgyi – Czira 2011, Pappné Vancsó et al 2014a, 2014b; Farkas 2015), so we put the focus of the study here on showing a methodological case study from a rural region in Hungary (Zala County). Nevertheless, it is important to introduce the context in which adaptive capacity is interpreted; thus, we also present how vulnerability has come into the focus of climate change research, and review the definition and methodological issues around vulnerability studies.

Vulnerability as a term has been known for a long time. It was first used in the medical and biological sciences; however, it has become an interdisciplinary concept, which has a crucial role in climate change and adaptive capacity research both from the side of natural and social sciences (see e.g. Vincent 2004, Smit – Wandel 2006; Kittel et al. 2011). Assessment of vulnerability and adaptive capacity research can be interpreted as responses given to the challenges of climate change, which started from the examination of local areas and reached the comparative analysis of national capacities. Local and regional-level analyses, however, have still remained very important as climate change affects certain areas in different ways and, therefore, the adaptive opportunities and capacities of local populations may also be different. Fortunately, research on regional level vulnerability not only appears in foreign professional literature, but similar studies have also been carried out in Hungary mainly in connection with the impacts of climate change on ecological and built environment (droughts, forest fires and urban heat waves, see Pálvölgyi et al. 2010, Pálvölgyi et al. 2011), and its complex impacts from the perspective of the environment (Farkas 2015).

Within the group of indices used for vulnerability calculation, indices for adaptive capacity are typically made of data, which are able to approach a particular problem indirectly, since information for large-scale examinations may be obtained almost exclusively from statistical databases. However, this does not present a problem in the case of indices used for impact-mapping because the indices of given possible outcomes of climate change (drought, heat wave frequency, excess water inundation) are already available (e.g. drought index) or they can be easily established (e.g. changes in the frequency of days with excess water inundation). However, given the lack of data which directly measure adaptive capacity, the results may become broad-brush.

Our research focuses on the elimination of this problem, and also on how to measure adaptive capacity accurately. Following the above mentioned domestic studies, we measured drought and flash flood vulnerability in micro-regions of Zala County, taking the concept of adaptive capacity into further consideration (Pappné Vancsó et al. 2014 a, 2014b). The local population will face two major problems concerning the proposed impacts of forecasted climate change delineated in mainstream national documents (Láng et al. 2007, NCCS 2008; NCCS 2013) and publications (e.g. Pongrácz et al. 2009; Sábitz et al. 2013), underlined as well as by the results of a questionnaire survey carried out in 2013, which examined the impacts of climate change on agricultural society. These are the increase in drought frequency as a result of decreasing amount of uneven precipitation and the gradually warming climate (1), and the more frequent flash floods, which can also be attributed to the uneven distribution of rainfall (2).

This paper does not provide a comprehensive picture of vulnerability, but it aims to highlight the problems of measuring adaptive capacity by the example of adaptive capacity to droughts.

2 THEORETICAL BACKGROUND

The term "vulnerability" was first placed into the focus of climate change research by Peter Timmerman (1981) under the influence of the major objectives of the World Meteorological Organisation (WMO) at that time. The WMO set it as a key research objective to determine those characteristics which made societies at different levels of development vulnerable or adaptive to fluctuations or changes in the climate. Timmermann's definition – "vulnerability is the degree to which a system acts adversely to the occurrence of a hazardous event" (ibid. p. 21.) – has been transformed in several ways, which suggests that similarly to sustainable development and sustainability, vulnerability is a term that is subject to constant change and is difficult to define.

According to the working group of IPCC engaged in vulnerability research, from the perspective of climate change, a vulnerable system is sensitive even to slight changes in climate, and its adaptive capacity is seriously limited. In contrast, a flexible system or society is insensitive to fluctuations or changes in the climate, and is capable of adaptation (McCarthy et al 2001).

Similar to vulnerability, adaptation and adaptive capacity are diverse terms, which can be approached from several perspectives. Attempts have been made to formulate a general definition for adaptive capacity as well, according to Brooks, N. (2003) for instance, it is interpreted as "adjustments in a system's behaviour and characteristics that enhance its ability to cope with external stress". Actually, the term can be interpreted from several perspectives, for example, from that of biology (e.g. Bock 1980), or forestry (Mátyás – Kramer 2016). Environmental adaptive capacity, which is closely related to our topic, may also be interpreted from the perspective of ecosystem and society. Adaptation depends on the natural systems, genetic and biological diversity, and the diversity of species. However, in social systems the existence of institutions and networks which preserve knowledge and experience support flexible problem-solving and restore the balance of power among different social groups (Berkes et al. 2002).

Naturally, different interpretations have been formulated to define adaptive capacity to climate change. Smit, B. et al (2000) describes adaptation as adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli, their effects or impacts. In another perspective, adaptations are interpreted as the adjustments in individual groups and institutional behaviour in order to reduce society's vulnerability to climate change (Pielke 1998). According to the IPCC, adaptive capacity is defined as the ability of a natural or social system to adapt to climate change, to moderate potential damages, to take advantage of the opportunities, or to cope with the consequences (McCarthy et al 2001). The common feature of the different definitions is that they imagine adaptive society as a system which is capable of self-organisation and self-regulation, and is able to cope with the potential negative consequences of climate change.

3 MATERIALS AND METHODS

During our work, we took the methodology and certain findings of earlier Hungarian vulnerability research as a basis, which started from the correlations between impacts, adaptive capacity and vulnerability proposed by the IPCC. As a first step in applying the model, we identified those climatic problems (e.g. drought) which may make the affected systems, in our

case agricultural society, vulnerable. Secondly, we identified those impacts which stemmed from the exposure (e.g. exposure to drought) and sensitivity (e.g. soil sensitivity to drought) of the system, by taking the appropriate indicators into consideration. As a third step, we calculated adaptive capacity, and evaluated vulnerability based on the relationship between the impacts and adaptive capacity (Pappné Vancsó et al 2014 a, 2014b).

For the purposes of calculation, we took the parameters presented in *Table 1* into consideration, where we also included some other indicator groups used for vulnerability research as a comparison. In our study, the main objective was to make adaptive capacity calculations more accurate; therefore we would not delineate the comprehensive process of vulnerability calculations.

As can be seen in *Table 1,* vulnerability research focusing on the same problem may be very different in terms of perspective. Similarly, the different methods for calculating adaptive capacity are also varied. When establishing the indicators for measuring adaptive capacity of the rural population in Zala County, we started from the findings of a questionnaire survey and interviews which were conducted within the framework of a project acknowledged below. The aim of the questionnaire survey was to measure the respondents' perception of climate change, their knowledge of adaptation, and their established strategies and practices.

Table 1. Indicators used for calculating drought sensitivity

Indicators used for measuring social vulnerability to drought (*Pappné et al 2014a*.)		
Impact		Adaptation
Exposure	Sensitivity	
PaDI	- certain physical and water management features of the soils: field water capacity, wilting point, available water resource, infiltration rate, hydraulic conductivity, bedding of soil profile, features determining soil's special water management, water retention ability	- level of knowledge relating to adaptive agriculture (e.g. technology and varietal conversion) - availability of water for irrigation - proportion of direct and indirect agricultural support per farming unit - HDI - Indicator calculated based on the figures above
Indicators used for measuring social vulnerability to drought (*Pálvölgyi et al. 2010; 2011*)		
Impact		Adaptation
Exposure	Sensitivity	
Pálfai Drought Index (PDI)	- certain physical and water management features of the soils: field water capacity, wilting point, available water resource, infiltration rate and hydraulic conductivity, bedding of soil profile, features determining soil's special water management, water retention ability	- gross value added of agriculture per farmer - agricultural subsidies per hectare

Table 1 cont. Indicators used for calculating drought sensitivity

Indicators used for measuring environmental, economic and social vulnerability (*Farkas et al. 2015)*		
Impact		Adaptation
Exposure	Sensitivity	
Changes in the number of hot days (1980-2010) Changes in the average temperature (1980-2010) Changes in the amount of rainfall (1980-2010) Size of plot Amount of water supplied	- proportion of people employed in agriculture - proportion of income from small-scale agricultural production - proportion of people employed in industry - number of people suffering from respiratory or circulatory diseases per 1,000 people - number of patients taking GP consultation per 1,000 people - ratio of people over 65 to total population	- amount of income per one tax payer - ratio of people with university degree within the population aged 25 or over - number of scientific or engineering-technological enterprises per 1,000 people
Indicators used for measuring vulnerability to droughts (Drought Vulnerability Index) (*Wilhelmi – Wilhite 2002*)		
Impact		Adaptation
Exposure	Sensitivity	
agro-meteorological data: long-term precipitation Crop Moisture Index (CMI)	- water retention ability of the soils	- availability of irrigation

Their knowledge about adaptive agriculture and about the need for changes in the existing agricultural practices formed the basis of the indicator, including the changes in crop structure, planting periods and planted varieties, the use of plastic tunnels against frosts, covering, hail protection nets against hail damage, more efficient spraying, collecting rainfall, planting cover crops instead of ploughing that leads to soil dehydration and constructing draining systems. Increasing the proportion of forests and establishing water reservoirs for the purposes of irrigation. These factors were indicated in proportion to all the respondents (*Table 2*), interpreting it as 100% when each respondent was aware of and used the particular solution. When calculating the indicator for adaptive capacity, this component was taken into account as a factor weighting 60%.

A significant proportion of the respondents mentioned irrigation as an adaptive solution; therefore, we also took irrigation into account in the micro-regions subject of the research (proportion of surface water to the size of lands not irrigated) as a factor weighting 20%. However, seeing that irrigation may become an issue, and water sources suitable for irrigation may be scarcer in the future (NDS, 2014), this indicator should be taken into account with due care in our case. Prevention would be the appropriate solution in the adaptation process, increasing the water retention capacity of the soil, reducing evaporation by using modern agro-technological equipment and growing plant species with abilities to adapt to uneven precipitation.

Therefore, irrigation offers a less efficient solution for adaptation to droughts compared to the other possibilities mentioned above; however in Zala County, such opportunities are far from being exploited: based on the data provided by WTWD (2014) only 0.2% of the total arable land belongs to that category. Therefore, it can be presumed that there would be

remaining reserves even in the case of increasing droughts. Seeing that irrigation is basically connected to surface waters, we considered the ratio of available surface waters (water courses, channels and standing waters) to the size of arable lands not irrigated in the particular micro-region when calculating the indicator. We used the CORINE land cover data included in the NISRDP (TEIR) database. For instance, the 2.1 value of region Nagykanizsa means the proportion of the extent of surface waters to the total area used as not irrigated arable land in the micro-region. Naturally, the indicator is not perfect as the geographical extent of surface waters may not determine their actual water content; however, it illustrates well the availability of and limited access to surface waters. Irrigation, therefore, may be a necessary solution in certain cases, which cannot be ignored when calculating adaptive capacity, thus it was taken into account as a factor weighting 20%.

For adaptive capacity calculations, another 5-5% was assigned for three indicators relating to farmers' ability in applying for tenders. Aptitude and resilience may also be very important factors of adaptation, which were expressed in the successful applications of farmers living in the micro-regions for agricultural support. It can be reasonably assumed that micro-regions which are able to apply for tenders efficiently are more capable than their less successful counterparts. Regions where the proportion of support other than direct area-based payment is higher are presumed to be more capable since obtaining indirect subsidies and the application process pose great challenges due to the difficulties of application. It is also a significant indication, whether there are differences in the amount of funds received per farmer because a wealthier farmer may also be more successful in forced adaptation. In the case of the three indicators, we always regarded the best performing regions as 100%, and compared the performance of the other regions to that percentage. The data required to establish the three indicators were obtained from the public-interest database of the Agricultural and Rural Development Agency (ARDA 2014).

Adaptation also depends on human factors including knowledge and preparedness; therefore, when formulating our index, we also took the Human Development Index (HDI) into consideration. HDI is an aggregate index, with the components of life expectancy at birth, years of schooling, and gross national income per capita. Considering the fact that the latter component cannot be constructed on the regional level, we substituted it by income per capita. In our calculations, HDI was evaluated between 0 and 100, and similar to agricultural support, the micro-region with the best HDI index was regarded as 100%. Similar to the last three indicators, this one was also taken into account as a factor weighting 5% for the calculation of adaptive capacity. The data relating to life expectancy at birth and the years of schooling were provided by the Hungarian Central Statistical Office (HCSO 2011) broken down by micro-region. The data relating to income per capita broken down by settlement were retrieved from the NISRDP database.

4 RESULTS AND DISCUSSION

Based on the results of the questionnaire survey, it can be generally established that nearly 90 percent of the respondents perceived the signs of climate change. It was reflected by the occurrence of dry summers, uneven precipitation and the changes in the normal pattern of the seasons. It was generally stated that such changes had negative impacts on agriculture. Only 30 percent of the respondents claimed that they would be able to adapt to the consequences of climate change in some way. They saw that the success of adaptation laid in environmentally-conscious lifestyle (approximately 20%), irrigation (nearly 60%), and the changes in existing agricultural practices i.e. adaptive agriculture (17%). As highlighted above, the latter would offer a more efficient solution than irrigation in the battle against drought; relatedly, that is why

we weighted the "level of knowledge relating to adaptive agriculture (technology and varietal conversion)" as the most important indicator representing the adaptive capacity of the society. Seeing that in this respect we observed no significant differences among the micro-regions, the results were also similar in every case. Obviously, the efficiency of comparative analyses carried out on micro-regional level within a single county may be challenged even at that point, especially in the case of Zala County, where there are no significant differences in terms of natural conditions or land-use. It is more likely to obtain mathematically interpretable results from research addressing the whole country.

Table 2 shows that the access to surface waters is severely limited. The regions of Lake Balaton and Kis-Balaton would be exceptions, but we did not take their whole water surface into consideration because their access and availability is low relative to the proportion of their water surface, and Balaton is not surrounded by arable lands but areas for holiday purposes, and Kis-Balaton is a nature protection area. In the future, in the case of increased needs for irrigation, the availability of surface waters may be improved by constructing irrigation channels, water reservoirs among the hills and down-hole wells; however, such infrastructural investments and water use would incur additional expenses for agriculture.

Table 2. Calculation of adaptive capacity in the micro-regions of County Zala

	Micro-region								
	Hévíz	Keszthely	Lenti	Letenye	Nagykanizsa	Pacsa	Zalaegerszeg	Zalakaros	Zalaszentgrót
Level of adaptive agriculture (variety and technology conversion %)	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
Ratio of surface waters to size of arable lands not irrigated (%)	1.2	5.0	0.2	0.9	2.1	5.0	0.5	5.0	0.3
Proportion of tender amounts won per farmer in relation to the best-performing micro-region (%)	23.0	58.0	72.0	38.0	50.0	100.0	49.0	41.0	56.0
Ratio of tender-winning farmers from all the farmers in relation to the best-performing micro-regions (%)	58.0	77.0	100.0	42.0	51.0	60.0	70.0	59.0	67.0
Ratio of indirect support from all the support won in relation to the best-performing micro-regions (%)	68.0	74.0	100.0	58.0	84.0	67.0	77.0	69.0	64.0
HDI in relation to the best-performing micro-regions (%)	93.66	94.10	79.53	45.58	91.64	47.24	100.0	35.62	57.74
Adaptive capacity (%)	**12.0**	**16.0**	**18.0**	**9.0**	**14.0**	**15.0**	**15.0**	**11.0**	**12.0**

Source: data calculated based on data by WTWD 2014, NISRDP 2014, ARDA 2014, HCSO 2011 and own questionnaire survey data.

In the case of indices related to tender applications, it is very difficult to assess the success or failure of certain micro-regions. The number of tender applications per farmer is very low: the county average is 23 percent, which means that only 23 percent of all registered farmers receive some agricultural support. This, however, can be explained by the high rate of small-scale farmers rather than by their failure (there are nearly 20,000 registered farmers in Zala County). The distribution around the average is insignificant: the micro-region of Nagykanizsa has the lowest (18%) and Lenti has the highest (35%) figures.

The tender amounts won per farmer (HUF 540,000 in county average) represent more significant differences between the micro-regions even if not on a large scale. Accordingly, the micro-region of Pacsa was in the most advantageous (HUF 1,000,000) while that of Hévíz in the least successful (HUF 230,000) position.

The ratio of direct area payments to indirect agricultural support was 48-52 percent on the county level in favour of indirect supports. The distribution of the amounts won is similar between the two tender types. It was typical of the majority of the micro-regions that the proportion of direct area payments exceeded that of indirect support with the exception of the micro-regions of Zalaegerszeg (50.7%), Nagykanizsa (56%) and Lenti (66%) where the ratio of direct area payments exceeded 50 percent; therefore, in this regard these three micro-regions are considered to have the highest performance.

Although there are differences among the three micro-regions, such differences are insignificant, and they do not modify the extent of adaptation, but only modulate it. Due to land fragmentation and the significant number of land owner farmers who possibly do not apply for tenders at all, it is very difficult to assess their success in tender applications.

The HDI values of the micro-regions in Zala County are between 24 (Zalakaros) and 64 (Keszthely), the average value of the nine micro-regions is 48, which significantly falls behind the ideal maximum values. Based on the index it cannot, therefore, be established that people in the county have good or exceptional socio-economic conditions. The general conditions of the society may also influence its adaptive capacity. It is arguable whether qualification or income position have an impact on adaptive capacity; however, poor health or low life expectancy at birth may contribute to it.

As it can be seen in the table above, based on the parameters examined there are no significant differences among the micro-regions in terms of adaptive capacity. The main reason is that local knowledge, which is required for adaptation about technology and varietal conversion, is typically not significant in the county as a whole. Having regard to the other indicators, no significant differences can be observed either between the micro-regions, which would essentially affect the findings. The micro-regions are prepared for the increasing needs for irrigation since agricultural irrigation has no traditions in the area. Based on the HDI, which indicates the level of schooling, income position and health condition, the social conditions of people living in the agricultural area of Zala County is about average, but far from being ideal.

Micro-regional level research focusing on one county if compared to the best performing research area, are not sufficient due to the limited comparability. Although databases are linked mostly to administrative boundaries, it would be more useful to connect climate change adaptation research to boundaries of geographical or agricultural regions, because perception of drought and its problems seems more relevant in case of cultural landscapes than on the micro-regional level.

In comparison with previous research (Wilhelmi – Wilhite 2002, Pálvölgyi et al. 2010, 2011, Farkas et al. 2015), we attempted to review the issue of adaptation, and in this regard we found it essential and important to ask for the opinion of the concerned people. Another difference was that in consultation with the relevant water authority, we obtained detailed information about the current utilisation of irrigation, and we also gained access to an individual database for the establishment of the micro-regional level HDI index. Previous research

attempted to measure adaptive capacity based on indirect data, focused mainly on economic indicators, and referred to factors such as schooling or financial position (Wilhelmi – Wilhite 2002, Brooks et al. 2005; Smit, B. – Wandel, J. 2006; Pálvölgyi et al. 2010, 2011, Farkas et al. 2015). Even though these characteristics are naturally important for adaptation, neither of them can specifically suggest whether the local population is or would actually be able to adapt to climate change. Comprehensive and reproducible studies require data that are also available to everyone over time; such studies, however, cannot be used to directly measure adaptive capacity. The rural population's knowledge about droughts and climate change in general, and about adaptation seen as responses to such challenges can only be measured accurately if we directly ask the opinion of the people concerned by means of detailed field work. Conducting field questionnaire surveys and interviews is time-consuming and their results may not be reproduced easily year by year; their main advantage, however, is that their findings are more specific compared to other studies which use available data exclusively; also, significant information will not get lost.

5 CONCLUSION

The study of societies' vulnerability to climate change has been brought into the focus of scientific research in the last few years. Similar to the diverse impacts of climate change, vulnerability studies are also diverse. However, the common feature of all such studies is that they examine the extent of vulnerability in relation to impacts and adaptive capacity in every case. Adaptive capacity has an essential role in dealing with the impacts. Nevertheless, the common ground of studies to date is for the means used for measuring adaptive capacities. They mostly used indirect indices which could be established on the basis of data retrieved from electronic databases with easy access, relating to the economic and social relations of the particular society, and presuming that societies with good conditions can adapt better to the challenges posed by climate change. In our research, we examined how the method of measuring adaptive capacity could be made more precise, and how to introduce new indicators in addition to the existing ones which are based on the opinion, experiences, and established adaptation practices of the society concerned. We found that if we want to learn about a society's knowledge about actual adaptation, direct questioning of the people concerned and detailed field work are essential. Indirect data relating to a society's health conditions, economic situation and qualification may be necessary components of the adaptation indicator; however, the most important index of the indicator must relate to adaptation practices. The drawbacks of questionnaire surveys and field work is that they are very difficult to reproduce with the lapse of time. Nonetheless, their main advantage is that they contribute more specific results to the adaptation index than indirect data, which, therefore, significantly increases the usability of the findings of vulnerability research and their occasional application in adaptation policies.

Acknowledgements: The research described in this study was supported by the VKSZ_12-1-2013-0034 Agrárklíma 2 project. The ENSEMBLES data used in this work was funded by the EU FP6 Integrated Project ENSEMBLES (Contract number 505539) whose support is gratefully acknowledged, as well as the one of CARPATCLIM Database © European Commission – JRC, 2013.

REFERENCES

ADGER, W.N. VINCENT, K. (2005): Uncertainty in adaptive capacity. 337 (4): 399–410.

BERKES F. – COLDING, J. – FOLKE, C. (eds.) (2002): Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, Cambridge, UK

BOCK, W. J. (1980): The definition and recognition of biological adaptation. Integrative and Comparative Biology. 20 (1): 217–227.

BROOKS, N. (2003): Vulnerability, Risk and Adaptation: A Conceptual Framework. Working Paper 38, Tyndall Centre for Climate Change Research, University of Eat Anglia, Norwich.

BROOKS, N. – ADGER W. N. – KELLY P. M. (2005): The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. Global Environmental Change 15: 151–163

FARKAS, J.ZS. – RAKONCZAI, J. – HOYK, E. (2015): Környezeti, gazdasági és társadalmi éghajlati sérülékenység: esettanulmány a Dél-Alföldről [Environmental, Economic and Social Climate Vulnerability: a Case Study in the Southern Great Plain]. Tér és Társadalom 29 (1): 149–174. (in Hungarian)

GUPTA, J. – TERMEER, C. – KLOSTERMANN, J. – MEIJERINK, S. – VAN DEN BRINKE, M. – JONG, P. – NOOTEBOOM, S. – BERGSMA, E. (2010): The Adaptive Capacity Wheel: a method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. Environmental Science and Policy 13 (6): 459–471.

LÁNG, I. – CSETE, L. – JOLÁNKAI, M. (eds.) (2007): A globális klímaváltozás: hazai hatások és válaszok: a VAHAVA jelentés [Global Climate Change: Hungarian Impacts and Responses; VAHAVA Report]. Szaktudás Kiadó Ház, Budapest, ISBN 978-963-9736-17-7. (in Hungarian)

KITTEL, T.G.F. – BAKER, B.B. – HIGGINS, J.V. – HANEY, J.C. (2011): Climate vulnerability of ecosystems and landscapes on Alaska's North Slope. Regional Environmental Change 11 (1) 249–264.

MÁTYÁS CS. – KRAMER K. (2016): Adaptive management of forests and their genetic resources in the face of climate change: Reference to the document: Climate change affects forest genetic resources: consequences for adaptive management. FORGER Policy Brief, Bioversity International, Rome

MCCARTHY, J.J. – CANZIANI, O.F. – LEARY, N.A. – DOKKEN, D.J. – WHITE, K.S. (2001): Climate Change 2001. Working Group II. Impacts, Adaptation and Vulnerability.

NCCS (2008): National Climate Change Strategy 2008–2025. Ministry of Environment and Water Budapest. Accessed: 06.06.2016. http://klima.kvvm.hu/documents/14/National_Climate_Change_Strategy_of_Hungary_2008.pdf

NCCS (2013): Második Nemzeti Éghajlatváltozási Stratégia 2014–2025 kitekintéssel 2050-re. Szakpolitikai vitaanyag [Second National Climate Change Strategy 2014–2025 with an Outlook to 2050. Discussion Paper] Magyar Földtani és Geofizikai Intézet Nemzeti Alkalmazkodási Központ. Accessed: 06.06.2016. http://www.kormany.hu/download/7/ac/01000/M%C3%A1sodik%20Nemzeti%20%C3%89ghajlatv%C3%A1ltoz%C3%A1si%20Strat%C3%A9gia%202014-2025%20kitekint%C3%A9ssel%202050-re%20-%20szakpolitikai%20vitaanyag.pdf

NDS (2010): Nemzeti Aszálystratégia – vitaanyag [National Drought Strategy – Discussion Paper] http://2010-2014.kormany.hu/download/7/0a/90000/Aszalystrategia.pdf Accessed: 15.07.2014. (in Hungarian)

PAPPNÉ VANCSÓ, J. – HOSCHEK, M – OBÁDOVICS, CS. (2014a): A társadalom klímaváltozással szembeni sérülékenysége: Aszállyal szembeni sérülékenység vizsgálat a zalai kistérségekben [Vulnerability of Society to Climate Change: Analysis of vulnerability to Drought in Zala Micro Regions]. In: Kulcsár, L. (ed.): Az erdészeti és agrárszektorban történő klímaváltozás gazdasági-társadalmi hatásának elemzése, monitorozása [Social and Economic Impact of Climate Change in Rural Hungary: Analysis and Monitoring]. 45–57. (in Hungarian)

PAPPNÉ VANCSÓ, J. – HOSCHEK, M. – OBÁDOVICS, CS. (2014b): A társadalom klímaváltozással szembeni sérülékenysége: Villámárvizekkel szembeni sérülékenység vizsgálat a zalai kistérségekben [Vulnerability of Society to Climate Change: Review of Vulnerability to Flash Floods in Zala Micro Regions]. In: Kulcsár, L. (ed.): Az erdészeti és agrárszektorban történő klímaváltozás gazdasági-társadalmi hatásának elemzése, monitorozása [Social and Economic Impact of Climate Change in Rural Hungary: Analysis and Monitoring]. 45–57. (in Hungarian)

PÁLVÖLGYI, T. – CZIRA, T. – DOBOZI, E. – RIDEG, A. – SCHNELLER, K. (2010): A kistérségi szintű éghajlat-változási sérülékenység vizsgálat módszere és eredményei [Micro Region Level Climate Change Vulnerability Analysis. Method and Results]. Klíma-21 füzetek, 62: 88–103. (in Hungarian)

PÁLVÖLGYI, T. – CZIRA, T. (2011): Éghajlati sérülékenység a kistérségek szintjén [Climate Vulnerability in Micro Regions]. In: Tamás P. – Bulla M. (ed): Sebezhetőség és adaptáció – A reziliencia esélyei [Vulnerability and Adaptability – Changes of Resilience]. MTA Szociológiai Kutatóintézet Budapest. 237–253. (in Hungarian)

PÁLVÖLGYI, T. – CZIRA, T. – BARTHOLY, J. – PONGRÁCZ, R. (2011): Éghajlati sérülékenység a hazai kistérségek szintjén [Climate Vulnerability in Hungarian Micro Regions]. In: Bartholy, J. – Bozó, L. – Haszpra, L. (ed): Klímaváltozás – 2011. Klímaszcenáriók a Kárpát-medence térségére [Climate Change – 2011: Climate Scenarios for the Carpatian Basin]. MTA és ELTE Meteorológiai Tanszéke, Budapest. 235–257. (in Hungarian)

PIELKE, R.A.J. (1998): Rethinking the role of adaptation in climate policy. Global Environmental Change 8: 159–170.

PONGRÁCZ ,R. – BARTHOLY J. – GELYBÓ, GY. – SZABÓ, P. (2009): Detected and Expected Trends of Extreme Climate Indices for the Carpathian Basin. Bioclimatology and Natural Hazards. 15–28.

SÁBITZ, J. – PONGRÁCZ, R. – BARTHOLY, J. (2013): Az aszályhajlam várható változása a Kárpát-medence térségében [Expected Variation of Inclination to Droughts in the Carpathian Basin]. In: Pajtókné Tari, I. – Tóth, A. (ed.): Változó Föld, változó társadalom, változó ismeretszerzés, 2013: a megújuló erőforrások szerepe a regionális fejlesztésben: nemzetközi tudományos konferencia [Changing World, Changing Society, Changing Learning, 2013: Role of Renewable Energy Sources in Regional Development: international scientific Conference]. 242 p. Konferencia helye, ideje: Eger, Magyarország, 2013.10.10-2013.10.12. Eger: EKF Földrajz Tanszék; Agria-Innorégió Tudáscentrum; Agria Geográfia Közhasznú Alapítvány. 82–86.

SMIT, B. – WANDEL, J. (2006): Adaptation, adaptive capacity and vulnerability. Global Environmental Change 16: 282–292.

SMIT, B. – BURTON, I. – KLEIN, R. – WANDEL, J. (2000): An anatomy of adaptation to climate change and variability. Climatic Change 45: 223–251.

TIMMERMANN, P. (1981): Vulnerability, Resilience, and the Collapse of Society. Environmental monograph No 1. Institute for Environmental Studies, University of Toronto. 46 p.

VINCENT, K. (2004): Creating an index of social vulnerability to climate change for Africa. Tyndall Centre for Climate Change Research and School of Environmental Sciences, University of East Anglia Norwich NR4 7TJ. Tyndall Centre Working Paper No. 56: 45 p.

WILHELMI, O. V. – WILHITE, D. A. (2002): Assessing Vulnerability to Agricultural Drought: A Nebraska Case Study. Drought Mitigation Center Faculty Publications 9: 37–58.

DATA SOURCES

SZALAI, S. – AUER, I. – HIEBL, J. – MILKOVICH, J. – RADIM, T. – STEPANEK, P. – ZAHRADNICEK, P. – BIHARI, Z. – LAKATOS, M. – SZENTIMREY, T. – LIMANOWKA, D. – KILAR, P. – CHEVAL, S. – DEAK, GY. – MIHIC, D. – ANTOLOVIC, I. – MIHAJLOVIC, V. – NEJEDLIK, P. – STASTNY, P. – MIKULOVA, K. – NABYVANETS, I. – SKYRYK, O. – KRAKOVSKAYA, S. –VOGT, J. – ANTOFIE, T. – SPINONI, J.: Climate of the Greater Carpathian Region. Final Technical Report.www.carpatclim-eu.org [monthly average data about temperature and precipitation for the years1981–2010 in Zala county]

ENSEMBLES DATA ARCHIVE Monthly average data about temperature and precipitation for the years 2011–2100 in Zala county derived from models

HCSO 2011: Data of micro regions in Zala County. Life expectancy at birth and the highest level of education. Hungarian Central Statistical Office, Budapest www.ksh.hu

ARDA 2014: Settlement data connected to the amount of agricultural subsidies. Agricultural and Rural Development Agency, Budapest

WTWD 2014: The number of the water abstraction licenses for irrigation in Zala county (individuals and legal entities). West-transdanubian Water Directorate, Szombathely

NISRDP 2014: Income per capita in the settlements of Zala county. National Information System of Regional Depelopment and Planning, Hungary, https://www.teir.hu

CORINE 2010: Landcover data in the micro regions of Zala county (non irrigated arable lands and surface water)

DOI: 10.1515/aslh-2016-0010 ActaSilv. Lign. Hung.,Vol. 12, Nr. 2 (2016) 117–124

Sudden *Phytophthora* Dieback of Wild Cherry Trees in Northwest Hungary

Judit SÁRÁNDI-KOVÁCS[a*] – László NAGY[b] – Ferenc LAKATOS[a] – György SIPOS[a,c]

[a] Institute of Silviculture and Forest Protection, Faculty of Forestry, University of West-Hungary, Sopron, Hungary
[b] Szombathely Forestry Corporation, Sárvár Forestry Directorate, Sárvár, Hungary
[c] WSL, Swiss Federal Research Institute, Birmensdorf, Switzerland

Abstract – During a regular survey of declining forests in 2011, sudden dieback symptoms were observed on scattered wild cherry trees (*Prunus avium*) in a mixed deciduous forest stand, located in the flood plain area of the Rába River, in northwest Hungary. In this study, we correlated both soil conditions and presence of *Phytophthora* spp. to dieback of cherry trees. Two *Phytophthora* species, *P. polonica* and *P. plurivora*, were isolated from the rhizosphere soil of the dying trees. By contrast, only *P. polonica* was recovered from the necrotic tissues of symptomatic roots. Stem and root inoculation tests on cherry seedlings showed pathogenicity of both species, although *P. polonica* proved to be more virulent. This is the first report of natural infections of *P. polonica*.

soilborne pathogens / forest protection / *Phytophthora polonica* / *Phytophthora plurivora*

Kivonat – **Madárcseresznye fák fitoftórás pusztulása Északnyugat-Magyarországon.** Egy 2011-ben, pusztuló erdőállományokban végzett egészségi állapot-felmérés során egy elegyes erdőállományban a madárcseresznye fák pusztulására figyeltek fel a szerzők. Az erdőállomány a Rába folyó egy holtága mentén terül el. Egy két éves esettanulmány során, talajvizsgálatot és a talaj és a talált *Phytophthora* fajok hatását vizsgáló patogenitásteszteket végeztünk. Eredményeinket statisztikailag értékeltük. Míg az erdőállomány talajából *Phytophthora plurivorá*t és *Phytophthora polonicá*t tenyésztettünk ki, a pusztuló fák tüneteket mutató gyökereiből csak *P. polonicá*t sikerült izolálni. Madárcseresznye-csemetéken elvégzett törzssebzési és gyökérfertőzési kísérletek egyaránt kimutatták mindkét izolált faj patogenitását. agresszivitását statisztikai elemzések bizonyítják. Ez az első olyan alkalom, amikor természetes körülmények között a *P. polonica* kórokozónak bizonyult.

talajlakó kórokozó / erdővédelem / *Phytophthora polonica* / *Phytophthora plurivora*

1 INTRODUCTION

Wild cherry (*Prunus avium* L.) is present in Hungarian mixed deciduous forests as scattered trees. Besides fungal and bacterial pathogens, several *Phytophthora* species are known to cause dieback of cherry trees under natural or experimental conditions (Santini et al. 2006, Kurbetli 2014, Vettraino et al. 2008). Among *Phytophthora* species, *P. alni* Brasier & S. A. Kirk, *P. cactorum* (Lebert & Cohn) J. Schröt., *P. cambivora* (Petri) Buisman, *P. cinnamomi* Rands, *P. citricola* Sawada, *P. citrophthora* (R. E. Sm. & E. H. Sm.) Leonian, *P. cryptogea*

* Corresponding author: sarandi-kovacs.judit@emk.nyme.hu; H-9400 SOPRON, Bajcsy-Zs. u. 4. Hungary

Pethybr. & Laff., *P. drechsleri* Tucker, *P. megasperma* Drechsler, *P. nicotianae* Breda de Hahn and *P. syringae* (Kleb.) Kleb. are known to cause dieback of cherry trees under natural or experimental conditions (Mircetich – Matheron 1976, Thomidis – Sotiropoulos 2003, Santini et al. 2006, Thomidis et al. 2008, Vettraino et al. 2008). In this paper we describe the sudden death of wild cherry trees in northwest Hungary and evaluate the role of the combined impact of soil texture and soilborne *Phytophthora* spp. in the etiology of the disease.

2 MATERIALS AND METHODS

2.1 Isolation

In spring 2012 sudden dieback of twelve-year-old wild cherry trees was surveyed in a 1.84 ha mixed deciduous forest stand (pedunculate oak: 60%, common ash: 25%, wild cherry: 5%, eastern black walnut: 5%, other broadleaved tree species: 5%) partly surrounded by a backwater of the Rába River, near Sárvár (150 m above sea level) in northwest Hungary. Six symptomatic trees were randomly selected and necrotic root and rhizosphere soil samples were collected in a total amount of 500 g/sample. Both sample types were processed as previously described (Szabó et al. 2013). To recover *Phytophthora* isolates from the soil samples, cherry laurel (*Prunus laurocerasus* L.) and *Rhododendron* sp. leaves were used as baits. The infected leaf segments were placed onto selective PARPNH media (Jung et al. 2000). Morphological characterization was carried out as described by Szabó et al. (2013). All of the collected isolates were examined. For molecular identification, pure mycelial cultures were used for direct PCR with the PHIRE Plant Direct PCR Kit (Thermo Scientific) according to the manufacturer's user's guide. The ITS1-5.8S-ITS2 regions of the rDNA of selected isolates were amplified using the ITS6 and ITS4 primer pair (Cooke – Duncan 1997) in an Eppendorf Mastercycler Personal PCR machine. PCR conditions were as follows: 5 min initial denaturation at 98 °C, 5 s denaturation at 98 °C, 5 s annealing at 55 °C, 20 s extension at 72 °C (1 min for the final cycle) with 39 cycles in total. The amplified DNA fragments were sequenced in both directions in the Eurofin Laboratory (Ebersberg, Germany). All of the six collected isolates were sequenced and their sequence homologues were identified using Blast searches against the NCBI GenBank database (http://blast.ncbi.nlm.nih.gov/Blast.cgi). Accession numbers: KT693123; KT693124; KT693125; KT693126; KT693127; KT693128).

2.2 Pathogenicity tests

Pathogenicity tests were performed using two different soil conditions to compare the effect of the local sandy alluvial soil versus the control soil type typical of the forests of the region. Both soil types proved to be free of *Phytophthora* species prior to infestation according to the result of leaf baiting controls. Soil analyses were performed in the WSL soil laboratory (Swiss Federal Research Institute, Birmensdorf, Switzerland). The pathogenicity of one *P. plurivora* (Jung – Burgess 2009) and one *P. polonica* (Belbahri – Moralejo – Lefort 2011) isolate (both 14 days old, grown on 39g/l PDA at 20°C in the dark) was assessed in both soil types (sandy alluvial and control soils). Stem inoculation and root infection tests were carried out on two-year-old, container-grown wild cherry seedlings, using 10 replicates per *Phytophthora* species and 10 replicates as control (not infected). For root infection, four equal aliquots of mycelial culture were put into the planting medium in four directions around the stem of the seedlings (altogether two cultures/seedling). Stems were wound inoculated by inserting an infested PDA plug (5-mm in diameter) under the bark using a sterile scalpel. Control seedlings were inoculated with sterile PDA. Wounds were sealed with Parafilm (Pechiney, Chicago, IL). Seedlings were maintained under outdoor natural conditions and were watered when

necessary. Lesion sizes were measured and the health condition of the shoots and roots was evaluated based on a five-point scale 13 weeks after inoculation (see *Table 1*). Necrotic tissues from the stem and roots of infected seedlings, and soil samples from the container of infected seedlings were collected for the re-isolation of *Phytophthora* species in order to fulfill Koch's postulates.

2.3 Statistical analyses

Statistical analyses were performed with STATISTICA 12 software (StatSoft, Inc. [2014]). Kruskal-Wallis and Mann-Whitney U tests were used for the comparison of the treatment groups. The effects of the two contributing factors (pathogen versus soil type) were evaluated both separately and together. Pearson Chi-square tests were performed to evaluate whether there is a significant correlation between treatments applied and the parameters of the root system. Boxplots were created and edited using SPSS (IBM, v. 22).

Table 1: The five-point scale used for the evaluation of pathogenicity tests

Stage	Crown symptom	Root symptom
1	Asymptomatic sapling	Healthy root system with plentiful healthy fine roots
2	Smaller leaves with yellowish discolouration	Dead root tips and fine roots occurring locally (less than 30%)
3	30%–50% of the crown is dead	30%–50% of the root system is already dead
4	More than 50% of the crown is dead	More than 50% of the root system is already dead
5	Completely dead sapling	Completely dead sapling

3 RESULTS

3.1 Isolation and identification

Sudden dieback of young wild cherry trees was clearly observed in a forest stand at the inundation area of the Rába River at the time of budburst in spring 2012. Approximately 70% of the wild cherry trees showed severe wilting symptoms or were already dead. Bark cracking and stripping, gummosis and wood discoloration under necrotic bark on the lower stems and also necroses on the main roots were observed. Six *Phytophthora* isolates were obtained from five from of the six soil samples using leaf baiting and a single isolate from the necrotic tissues. Based on the comparison of morphological traits and homology (99-100%) to other ITS sequences, four *P. polonica* (three from the soil and one from necrotic tissues) and two *P. plurivora* isolates (both from the soil) were identified. The isolates of the two species could be easily distinguished based on the daily growth rate, the shape and amount of sporangia produced and the presence or absence of hyphal swellings. While the two *P. plurivora* isolates had a daily growth rate 6.50–6.83 mm, *P. polonica* colonies grew more slowly (4.50–4.67 mm/day). The colonies of *P. plurivora* isolates formed readily and abundantly sporangia with variable shapes but hyphal swellings were absent. In contrast, *P. polonica* isolates produced abundantly single or catenulate hyphal swellings either with globose or irregular shapes and only two isolates formed a few, ovoid, non-papillate sporangia.

The analysis of the soil types illustrated that the base saturation values were nearly identical and only soil textures were different (*Table 2*).

Table 2: Soil types used for the pathogenicity tests

		Sárvár	Control soil
Texture	(% sand, silt, clay)	*61, 24, 15*	*12, 54, 34*
pH	(0.02 M $CaCl_2$)	*5.06*	*7.35*
Ca_{exch}	(mg kg^{-1})	3819.39	6983.97
Mg_{exch}	(mg kg^{-1})	604.76	700.45
K_{exch}	(mg kg^{-1})	269.37	431.95
Na_{exch}	(mg kg^{-1})	< 5.20	14.83
Mn_{exch}	(mg kg^{-1})	67.81	6.95
Fe_{exch}	(mg kg^{-1})	2.75	< 1.60
Zn_{exch}	(mg kg^{-1})	1.27	< 1.20
Al_{exch}	(mg kg^{-1})	3.52	< 2.00
CEC	($mmol_c$/kg)	*125.13*	*209.03*
Base saturation	(%)	98.80	99.94

3.2 Pathogenicity tests

In the case of the uninfected seedlings, the root system remained healthy and rich in fine roots. In contrast, altogether six *P. polonica*-, and four *P. plurivora*-infested seedlings died during the thirteen weeks of the root infection experiment. Thinned root system, dead fine roots and root tips, and extremely short main roots were observed (*Figure 1*). Significant differences in the health conditions of roots ($p = 0.000$) and in the root widths ($p = 0.000$) were identified according to the results of the Kruskal-Wallis tests. For the roots' health conditions (*Figure 2A*), both the effect of soil type ($p = 0.015$) and the pathogen ($p = 0.000$) were significant according to the results of the Kruskal-Wallis tests. There was a significant correlation between the applied treatment and the health condition of the root system ($p = 0.00000$) according to the Pearson Chi-square test. Altough, there wasn't any significant correlation between the applied treatment and the root width based on the Pearson Chi-square test. *P. polonica* seemed to be slightly more aggressive than *P. plurivora*. Both *Phytophthora* species were re-isolated from symptomatic roots and from the infected growth media.

In the stem inoculation experiment, sunken and dark necrotic lesions developed at the inoculation points of infected seedlings while only callus formation was observed on the control stems. Significant differences in the health conditions of shoots ($p = 0.002$) and necrotic areas ($p = 0.001$) were found between the treatment groups according to the results of the Kruskal-Wallis tests. For shoot health conditions (*Figure 2B*), only the effect of soil type was significant ($p = 0.000$) and the soil type did not have a significant impact on the size of the necrosis on the stems (*Figure 2C*). There was no significant difference in the aggressivity of the two species. Both *Phytophthora* species were re-isolated from the border of the lesions.

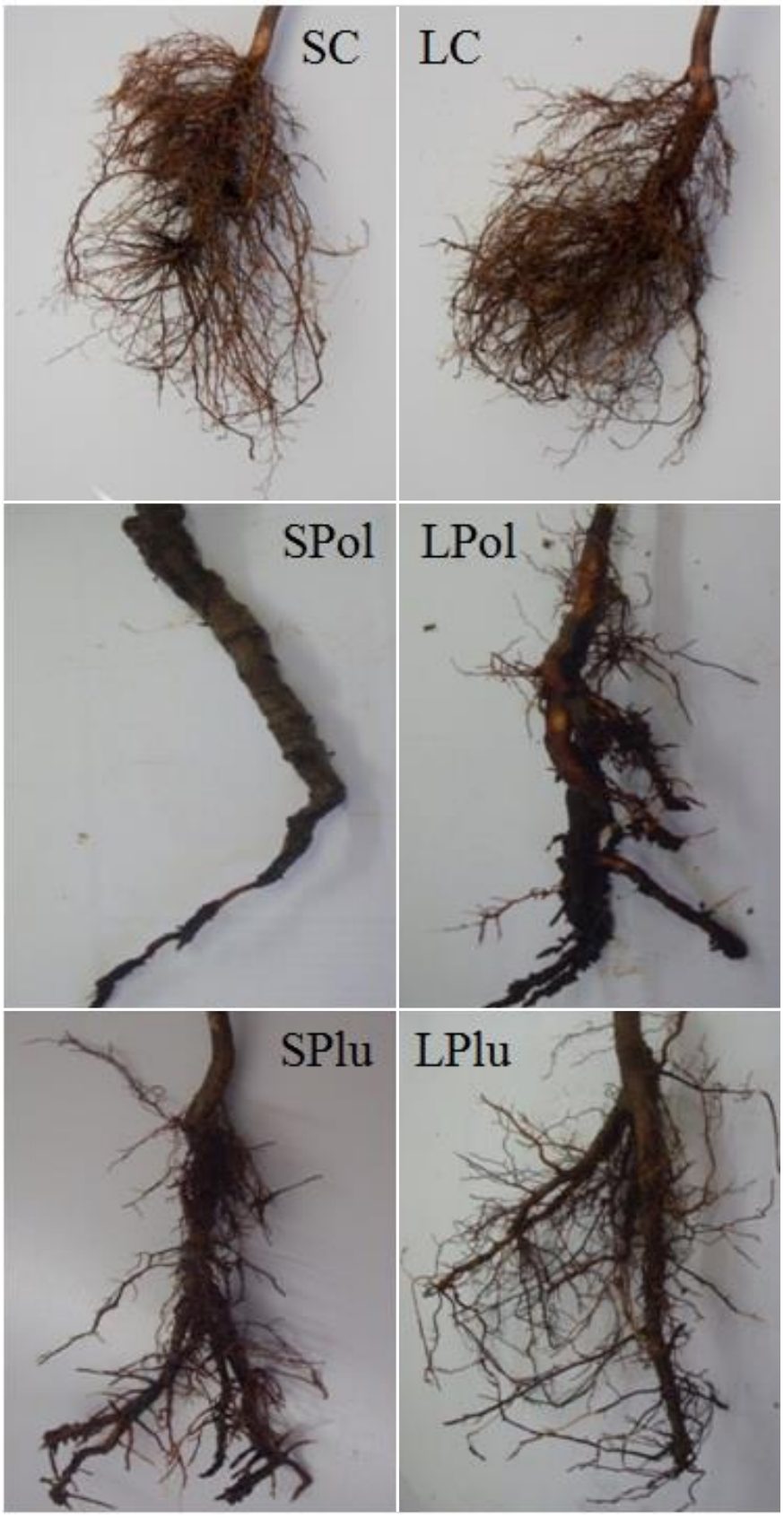


Figure 1. Root development in soil infection test (Abbreviations: L: control soil type, S: local alluvial soil type, Pol: P. polonica, Plu: P. plurivora, C: non-infected control)

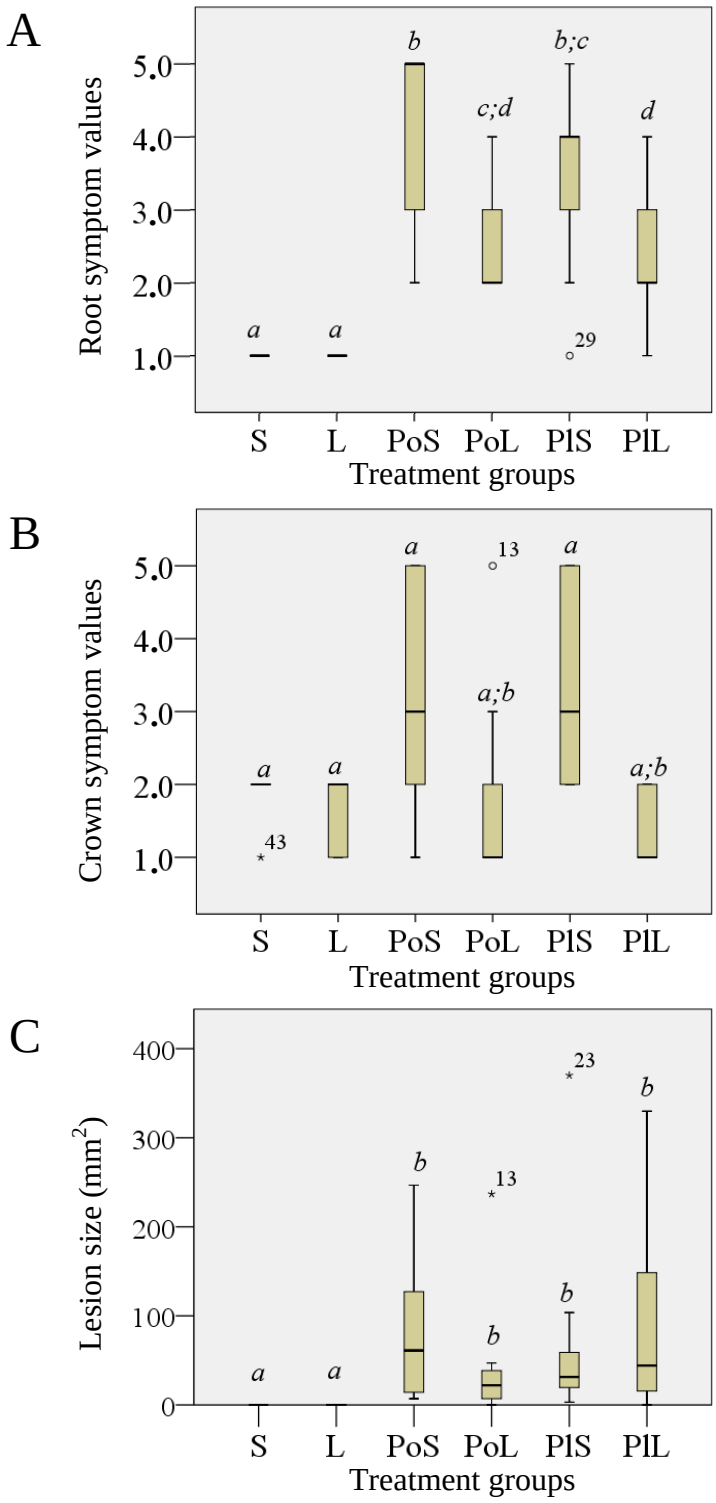


Figure 2.

A: Root system health conditions in the different treatment groups (mean values; different labels mean significantly different groups based on the Mann-Whitney U test).

B: Health conditions based on crown symptoms in the different treatment groups (mean values; different labels mean significantly different groups based on the Mann-Whitney U test).

C: Lesion sizes in the different treatment groups (mean values; different labels mean significantly different groups based on the Mann-Whitney U test).

4 DISCUSSION

The main goal of our study was to determine the causal agents of the selective wild cherry mortality in a mixed deciduous forest stand growing in a flooded riverside area. Initially, the sandy alluvial soil and the impact of the fluctuating water levels were suspected as they represent poor growth conditions for cherry trees. However, various bark cracking and necrosis symptoms in the trees that were still alive indicated a possible *Phytophthora* infection. At the same time, we did not observe any visible symptoms of a potential fungal or bacterial attack, neither in the dead, nor in the dying trees. The recovery of *P. polonica*, from both the necrotic tissues and the rhizosphere soil of the dying trees, suggested a primary role of this *Phytophthora* species in the observed dieback. *P. plurivora*, regarded as a pathogenic species (Oßwald et al. 2014), was also isolated from the soil and was considered as a potential contributing factor to the rapid decline of the trees.

Stem and root infection tests demonstrated the pathogenicity of both *Phytophthora* species, with *P. polonica* showing slightly more virulence against wild cherry seedlings. The significant differences in the root infection between the two different planting media used suggest that the poor site conditions may have led to weakened immunity in the wild cherry trees. The unusually high precipitation in the region, which occurred in August 2011 (112 mm), combined with the loose sandy soil texture, may have caused ideal environmental circumstances that exposed the vulnerable cherry trees to a rapid *Phytophthora* invasion.

Although all cherry trees were planted ones, suggesting that the pathogen may have emerged and been introduced to the forest site from a nursery, the seedlings were indeed grown from local seed resources in a nearby nursery. Therefore, the origin of the pathogen remains still unclear and a recent colonization of the forest site cannot be ruled out.

While *P. plurivora* has previously been associated with the decline of various forest stands in Hungary (Szabó et al. 2013), this is the first report of *P. polonica* being directly involved in rapid tree mortality. Since 2012, no similar decline of wild cherry trees has been reported in Hungary. Nevertheless, our results provide a warning of a potential threat to *Prunus* species and highlight the importance of considering site conditions when planning plantations or reforestations.

Acknowledgements: The authors would like to thank their Hungarian colleagues and family members who helped with the field work and pathogenicity tests, and to Professor Ilona Szabó (University of West-Hungary, Sopron, Hungary), for her helpful comments. We are also grateful to Roger Köchli, Dr. Stephan Zimmermann, Roland Engesser (WSL Birmensdorf, Switzerland) for the soil analysis and advice, and to Curtis Gautschi (WSL Bellinzona, Switzerland) for his helpful comments and English correction. This work was supported by the "AGRÁRKLÍMA.2 VKSZ_12-1-2013-0034" grant in Hungary.

REFERENCES

BELBAHRI, L. – MORALEJO, E. – CALMIN, G. – OSZAKO, T. – GARCÍA, J.A. – DESCALS, E. – LEFORT, F. (2006): *Phytophthora polonica*, a new species isolated from declining *Alnus glutinosa* stands in Poland. FEMS Microbiological Letters 261: 165–174.

COOKE, D.E.L. – DUNCAN, J.M. (1997): Phylogenetic analysis of *Phytophthora* species based on ITS1 and ITS2 sequences of the ribosomal RNA gene repeat. Mycological Research 101 (6): 667–677.

JUNG, T. – BLASCHKE, H. – OSSWALD, W. (2000): Involvement of soilborne *Phytophthora* species in Central European oak decline and the effect of site factors on the disease. Plant Pathology 49: 706-718.

JUNG, T. – BURGESS, T.I. (2009): Re-evaluation of *Phytophthora citricola* isolates from multiple woody hosts in Europe and North America reveals a new species, *Phytophthora plurivora* sp. nov. Persoonia 22: 95–110.

KURBETLI, I. (2014): Involvement of *Phytophthora cryptogea* in sweet cherry decline in Turkey. Phytoparasitica 42 (5): 627–630.

MIRCETICH, S.M. – MATHERON, M. E. (1976): *Phytophthora* root and crown rot of cherry trees. Phytopathology. 66: 549–558.

OßWALD, W. – FLEISCHMANN, F. – RIGLING, D. – COELHO, A. C. – CRAVADOR, A. – DIEZ, J. – DALIO, R.J. – HORTA JUNG, M. – PFANZ, H. – ROBIN, C. – SIPOS, G. – SOLLA, A. – CECH,T. – CHAMBERY1, A.S. – DIAMANDIS, S. – HANSEN, E. – JUNG, T. – ORLIKOWSKI, L.B. – PARKE, J. – PROSPERO, S. – WERRES, S. (2014): Strategies of attack and defence in woody plant–*Phytophthora* interactions. Forest Pathology. doi: 10.1111/efp.12096

SANTINI, A. – BIANCALANI, F. – BARZANTI, G. P. – CAPRETTI, P. (2006): Pathogenicity of four *Phytophthora* species on wild cherry and Italian alder seedlings. Journal of Phytopathology 154 (3): 163–167.

SZABÓ, I. – LAKATOS, F. – SIPOS, G. (2013): Occurence of soilborne *Phytophthora* species in declining broadleaved forests in Hungary. European Journal of Plant Pathology 137 (1):159–168.

THOMIDIS, T. – SOTIROPOULOS, T. (2003): Pathogenicity of 11 *Phytophthora* species on CAB-6P cherry rootstock. New Zealand Journal of Crop and Horticultural Science 31 (4):355–360.

THOMIDIS, T. – KARAYIANNIS, I. – TSIPOURIDIS, C. (2008): Susceptibility of thirty cherry genotypes on *Phytophthora cactorum, P. citrophthora, P. citricola and P. parasitica.* Journal of Phytopathology 156 (7–8): 446–451.

VETTRAINO, A.M. – FLAMINI, L. – PIZZICHINI, L. – PRODI, A. – NIPOTI, P. – VANNINI, A. – LAGNESE, R. (2008): First report of root and collar rot by *Phytophthora cryptogea* on sweet cherry in Italy. Plant Disease 92 (1): 177.

DOI: 10.1515/aslh-2016-0011 ActaSilv. Lign. Hung.,Vol. 12, Nr. 2 (2016) 125–134

Root Stability Evaluation with Non-Destructive Techniques

Ágnes Kinga BUZA[a*] – Ferenc DIVÓS[b]

[a] József Bódig Non-destructive Testing Laboratory, University of West Hungary, Sopron, Hungary
[b] Institute of Physics, University of West Hungary, Sopron, Hungary

Abstract – Due to their huge benefits when compared to invasive or destructive techniques, the use of non-destructive approaches is continuously increasing in many fields. The visual assessment method is commonly applied in tree inspection, but it has limitations. Investigations using appropriate non-destructive instruments can well complement visual tree inspection. This paper is a short overview that describes non-destructive techniques for evaluating the load-bearing capacity of individual trees' root systems. The techniques used are acoustic root detection and the pulling test. Safety factors were also calculated to provide a hazard assessment.

root detection / pulling test / acoustic root detection / safety factor / non-destructive evaluation

Kivonat – A gyökérzet biztonságosságnak becslése roncsolásmentes vizsgálati technikákkal. A roncsolásmentes megközelítés számos területen terjed folyamatosan a roncsolásos technikákhoz képesti előnyeinek hála. A fák vizuális értékelése elterjedten használt, ám ennek megvannak a maga korlátai. A műszeres vizsgálatok jól kiegészíthetik a vizuális méréseket. Jelen cikk egy összefoglaló, mely a biztonságosság és terhelhetőség irányából közelíti meg a fák gyökérzetének vizsgálhatóságát. A bemutatott roncsolásmentes technikák az akusztikus gyökér érzékelés és a húzóvizsgálat. Emellett a biztonsági faktorok számítása is röviden összefoglalásra kerül.

gyökér érzékelés / akusztikus gyökér keresés / húzóvizsgálat / biztonsági faktor / roncsolásmentes értékelés

1 INTRODUCTION

Trees have played a vital role in human life and civilization for thousands of years; their significance in society and industry is undeniable. The many roles trees play within the human sphere makes the examination of tree conditions an especially important task.

The root system is an 'invisible' part of trees that is crucial to both tree metabolism and stability. There are numerous techniques to study the root system – some are invasive and cause harm to the tree, while others are non-destructive and do not harm the tree. Non-destructive methods have the advantage of repeatability – that is they can be employed more than once on the same tree. Long term study of the root system and growth is becoming possible.

Non-destructive evaluation of trees is an area of non-destructive testing (NDT). Non-destructive evaluations are increasingly being recognized as effective methods for examining

*Corresponding author: agnes.kinga.buza@gmail.com; H-9400 SOPRON, Bajcsy-Zs. u. 4. Hungary

the internal conditions of various materials without disturbing or destroying them. Even though some NDT techniques have already become well-proven in research, it takes time for the technology to be implemented in field.

This paper briefly reviews NDT techniques for root stability evaluations. The aim is to present summarized information to help understand the usage and the limitations of these techniques. An instrumental background is required to quantify the effects of injuries and infections (e.g. fungus), or to quantify the sizes or loss of material in the case of decay and cavities. We believe that NDT methods have their benefits and deserve to have wider utilization.

Non-destructive evaluation techniques have been applied with varying objectives in many fields such as urban trees, forestry, ecology, and horticulture.

The main trends in research focus on:

a) Determining the biomass content of forest, trees or roots and underground biomass content (Morelli et al. 2007; Borden et al. 2014);

b) Evaluating the safety of individual trees including root systems (Brudi – Wassenaer 2002; Wu et al. 2014);

c) Determining tree response to static and the dynamic loads such as wind, snow or rockfalls (Dorren– Berger 2005; James – Kane 2008);

d) Assessing wood quality in standing trees and determining the effect of site conditions, stand age, and silvicultural treatments on wood quality (Wang et al. 2006; Grabianowski et al. 2006; Wang 2013).

Instrumental techniques are diverse according to the aim or/and the use of the measurement.

The major applied non-destructive techniques in root system investigations are pulling tests, ground penetration radar (Guo et al. 2013), and electric resistivity tomography (Amato et al. 2008; Zenone et al. 2008). A comparison of ground penetration radar and pulling tests (Danjon – Reubens 2007) has been reported.

With respect to tree safety, visual assessment has been used to determine the load-bearing capacity of root systems. Several researchers have reported the relationships among the diameter at breast height (DBH), tree height (H) and the stability of roots, anchorage strength, the maximum of force or bending that can be survived without damage. (Some researchers use calculations with standardized, unified force, while in other works bending is the parameter used. If force is applied at different heights, the same force can lead to different bending.)

In many experiments the force, or bending moment, causing uprooting or trunk failure was determined. For instance, Peltola and colleagues (2000) pulled over 95 trees (51 Scots pines (*Pinussylvestris L.*), 33 Norway spruces (*Piceaabies (L.) Karst.*), and 11 birches (*Betula spp.*)) and their analysis showed that the second power of DBH multiplied by tree height (DHB^2 H) predicted anchorage strength; while the third power of breast height diameter (DHM^3) best served for forecasting stem failure. Similar results are presented in the work of Lundstrom and colleagues (2007) who collected data on a total of eighty-four trees (including 57 Norway spruces (*Piceaabies (L.) Karst.*), 23 silver firs (*Abiesalba Mill*) and other species) and stated that the breast height diameter squared times tree height (DHB^2 H) is a parameter to forecast root stability. However, Achim and Nicol (2009) found breast height to be an acceptable parameter for predicting anchorage strength.

The instrumental techniques presented in our paper are pulling test and acoustic root mapping; it is possible to predict the root system and stability with both methods. These instrumental methods can also be employed in the evaluation of safety needs calculations on loads (with wind load being the most common) and estimations of the load-bearing capacity of trees. The safety factor is a value quantifying safety to help decide whether a tree should be retained or felled. One way of calculating safety factors is also described in the work of Brudi and Wassenaer (2002).

2 PULLING TEST

The pulling or winching test is a method for investigating the root-soil system and root anchorage. Assessing the safety of trees and evaluating stem conditions are other applications of pulling, as well as serving as calibration for measurements in real wind situations. (The moment caused by winching and the created inclination is measured. In wind or storm conditions, the inclination can be measured and the inducing moment, that is the "strength of the wind," can be evaluated.) Destructive pulling should also be mentioned at this point. With this method, researchers can uproot trees in order to compare different conditions for the bending moment causing failure. Plenty of excellent papers are available on the implementation and the usage of these tests (Bell et al. 1991; Wessolly 1991; Rodgers et al. 1995; Ray – Nicoll 1998; Neild – Wood 1999; Moore 2000; Peltola et al. 2000; Silins et al. 2000; Brudi – Wassenaer 2002; Clair et al. 2003; Lundström et al. 2007A; Lundström et al. 2007B; Kane – Clouston 2008; James – Kane 2008; Sani et al. 2012; Siegert 2013; James et al 2013; Rahardjo et al. 2014).

During a pulling test (*Figure 1*) a cable is generally placed on the tree as close as possible to the crown center or half of the trunk. The other end of the cable should be anchored to another tree or other object, and the applied force should be measured. During the test, a pulling force is applied through the cable to bend the tree and the inclination, elongation, and dislocation of the ground are monitored and measured. (Elongation is usually measured along the trunk at higher levels as seen in *Figure 1*. As the stem bends, it elongates as well. Conditions of the trunk can be evaluated. Dislocation of the ground is caused by the roots as they move and/or break during the pulling. Measurements can be performed on the ground near the winched tree.)

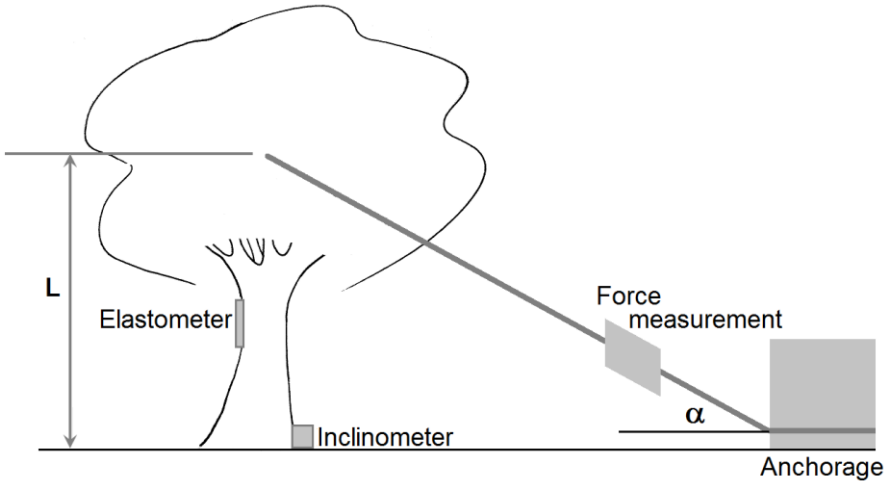


Figure 1. The schematic diagram of a pulling test. The cable should be anchored in a secure object for the test. L is the height of the cable's anchor point at the center of the crown

The inclination of the tree's trunk should be measured if the purpose of the testing is to evaluate the risk of tree uprooting. The inclinometer should be fixed to the trunk at ground level. (At higher levels the trunk's elastic deformations modify the results. A ratchet strap can go around the trunk and fix a flat little "shelf" which folds the inclinometer. If the fastening is tight, the inclinometer moves with the trunk.)

The pulling test usually continues until the inclination of the trunk at ground level reaches 0.020-0.6 degrees. The collected force-inclination data should be filtered according to the relaxation of the tree. (Winching stresses the tree, causing inclination; although relaxation of the wood material of the tree does occur. For the evaluation of safety, only the inclinations immediately responsive to the pulling are used. Inclination data that are collected during the

relaxation effects should be neglected.) (Divós et al. 2009; Sani et al. 2012; James et al. 2013). The difference between trees can be stated clearly, even for the same species at the same field; the measured pulling moment ranges between 0.07 and 0.6 degrees. The force used and the caused moment were higher for trees whose tilt was 0.07, which refers to more enormous anchorage strength than trees that tilted 0.6 degrees for weaker winching. (James et al. 2013)

The pulling of a tree should be less than 0.25-0.6 degrees to avoid injuring the roots. (This range is quite great according to the difference of trees.) Coutts (1983) found that the first sound indicating root breaking started at a 0.5 tilt. Rahardjo and colleagues (2014) established a model of tree felling based on their field experiences. They also verified roots breaking during uprooting and stated root cross-sectional area and root plate radius to be relevant for root anchorage evaluations. Modeling focusing on root failure (shape and stresses) was presented by Lundstorm and colleagues (2007B).

Brudi and Wassenaer (2002) reported that irreversible failures usually occur above 2 degrees of inclination. Nearly no additional force is needed to pull a tree over from 2 to 40-60 degrees. Lundstrom et al. (2007B) found that the maximum bending moment is observed between 2-15 degrees. An example of turning out is seen in *Figure 2*. The maximum tilt reported was 0.9 degrees in wind gusts up to 90 km/h, while 0.5-0.6 degrees were declared as average (James et al. 2013).

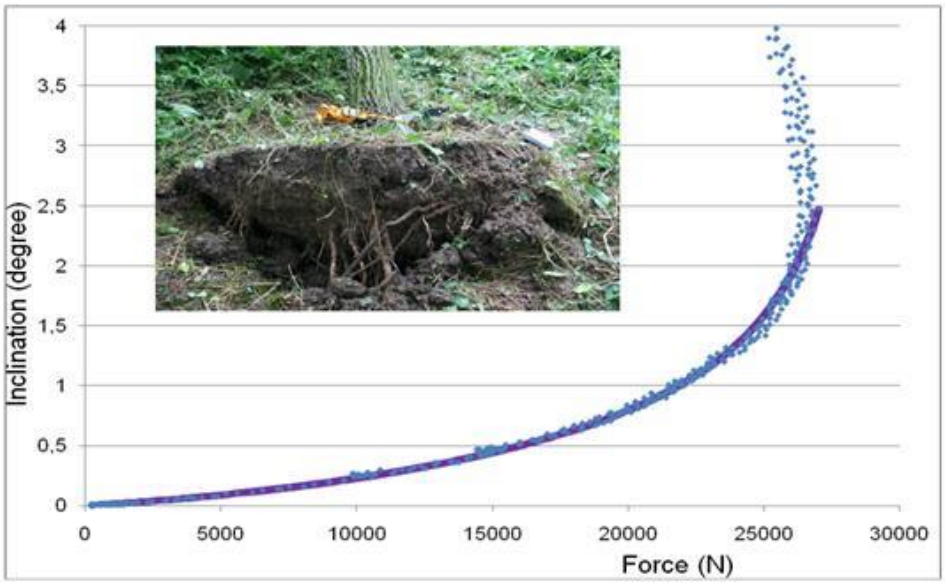


Figure 2. An example of uprooting (shown in the photo) and the pulling test data. (Divós et al. 2009)

After a pulling test, the whole tree should return to its original position. However, a complete recovery from a pulling test can take several minutes (James et al. 2013). Bending of the trunk was studied for Sitka spruce both in the field and with models by Neild and Wood (1999) who found out root flexibility is a non-negligible factor in pulling testing.

Pulling tests can also be performed on trees with buttresses. The stability of the trees was found to be lower for pulling tests conducted on the buttress sides (Clair et al. 2003).

Soil conditions can affect tree stability measured by pulling tests as it is described in the work of Moore (2000) and Bergeron and colleagues (2009).

Temperature conditions, particularly frozen soil and frozen trunks, will affect pulling testing. For instance, Silins and colleagues (2000) performed the pulling test to determine strength in frozen and unfrozen conditions. Peltola and colleagues (2000) declared that a higher bending moment is needed to break the stems of trees in frozen conditions (no turn out happened).

Wind gusts cause different moments compared to pulling tests (which are static). Tree failures were reported at 17.5 m/s wind speeds, which were less than the pulling test predicted (James – Kane 2008). (The study of the behavior of groups of trees under windy conditions started as well. Schindler (2008) measured movements of 10 nearby trees during windy conditions and wrote down an analysis of crown interactions.)

Pulling tests can also be used to evaluate trunk conditions at different levels. The pulling happens in the same way while the measurements are done on the trunk, on the stem using elastometers, prisms, accelerometers, or other equipment (Wessolly – Erb 1998; Brudi – Wassenaer 2002; Moore et al. 2005; Hagrey 2006; James et al 2013).

The main limitation of the pulling test is its static nature of loading. Wind usually comes in gusts and is dynamic in nature. The pulling test also requires heavy equipment. For an overall evaluation of a tree, a pulling test should be performed in two perpendicular directions, which may not be possible due to the surroundings found in some environments (Brudi – Wassenaer 2002, Sani et al 2012).

In urban areas, the most common usage of a pulling test is to predict the safety of the trees in windy conditions without uprooting the tree or even without decreasing safety. A safety factor calculation used in urban areas is shown in the next section.

3 SAFETY FACTOR

Safety factors give us information about tree stability. The simplest definition for safety factor (SF) is given by *Equation 1*. SF is the ratio of the evaluated capacity and the calculated load (wind, snow, effects of gravity (Gardiner et al. 2000)). SF helps us to evaluate the measurements in the perspective of safety. SF is usually a number or a percent. Regarding trees, safety factors can be established for uprooting, and for trunk breaking.

$$SF = \text{capacity of the tree} / \text{estimated load} \quad (1)$$

The estimations presented in this section are the estimations of wind loads for trees (tree surfaces) and load bearing capacities of root systems estimated from pulling tests. The calculations are simplified; however, they have proved their usefulness innumerous field experiences in the work of Wessolly (1991), Brudi and Wassenaer (2002), Divós and his colleagues (2009), Buza and Göncz (2015).

According to the estimations, during the measurements and the calculations, a safety factor for a tree is considered good from 1.5 to 150%. (An assessment of "good" refers to retaining the tree.)

3.1 Wind load for trees

Wind is the most common load of trees. As the wind reaches the surface of the crown and the stem, it causes a moment to which the tree should respond. The moment of wind load is estimated by *Equation 2*.

$$M_{wind} = f\, c\, ½\, \rho\, \Sigma\, \{u(z)^2\, h(z)\, A(h(z))\} \quad (2)$$

where f is the natural frequency factor, ρ [kgm^{-3}] denotes the air density, u(z) [ms^{-1}] expresses the wind velocity, h(z) [m]is the height of unit-area at a specific position in crown surface, A [m^2] is the crown surface at respective height, and c is the aerodynamic drag factor.

Note that wind speed and air density depend on the geographical and the topographical situation as well as the seasonal and meteorological influences.

3.2 Safety factor for the root system for uprooting

Evaluation of SF for uprooting is based on pulling and uprooting experiments. Force and inclination data are collected during the pulling test. These data should be filtered according to the relaxation of the tree. For the description of the relationship between the applied force and the inclination of the trunk at ground level during uprooting tests, a tangential function proved suitable.
This function can be fitted to the filtered data and shown by *Equation 3*.

$$\varphi_{calc} = 0.33 \tan (F / F_{tip}) + 0.5 (F / F_{tip})^2 - 0.1 (F / F_{tip}) \quad (3)$$

where φ_{calc} is the fitted inclination, F [N] is the measured force and F_{tip} [N] is the evaluated tipping force. (See the filtered data in *Figure 2*.)

The moment which could uproot the tree is

$$M_{tip} = F_{tip} L / \cos\alpha \quad (4)$$

where L [m] is the cable's height on the examined tree and α is the cable's degree (*Figure 1).*

Based on *Equation1*, the following equation can describe the SF for the root system for uprooting calculated from a pulling test.

$$SF_{root} = M_{tip} / M_{wind} \quad (5)$$

The presented calculations are used after pulling tests as well for the evaluation of tree safety along streets, in parks, or in other situations. Advice regarding the retaining or felling of a tree can really help the work of the gardeners.

4 ACOUSTIC DETECTION OF ROOTS

Acoustic detection of roots is a technique inspired by other acoustic techniques (time-of-flight measurement, tomography; Grabianowski et al. 2006; Wang 2013) used for tree evaluation. The method has been developed at the University of West Hungary and the new method has been tested in the university's botanical garden (Divós 2008).

The physical background of the measurement is the velocity-difference in wood and soil. The acoustic signal's velocity in soil is about 250-400 m/s depending on soil type and moisture content, while the velocity in the roots is between 2000 and 4000 m/s (Bucur 1995; Divós et al. 2009).

Based on these differences, models have been constructed to estimate the acoustic signal's path in both pure soil and the soil containing roots. After successful experiments, a set-up for field usage has been designed. The device consists of a transmitter, a receiver, and a time-measuring component. The transmitter is needle-like and should be placed onto the trunk at ground level, while the receiver is a long metal spike (30 cm or longer), which has a good coupling for the soil(*Figure 3)* (Divós et al. 2009; Buza – Göncz 2015).

At realization of acoustic detection, a very short signal (an 'acoustic flash') is sent from the transmitter to the tree and to the roots. The time measure turns on. When the receiver detects the arrival of the acoustic signal, the time measure stops. When a root is nearby (closer than 10 cm), the travel time decreases significantly. The depth of the root can be estimated as well. This technique can find roots from 4 cm diameter and can separate two roots from each other if there is at least 20 cm distance between them (Divós et al. 2009). The maximum depth for detection is 50 cm.

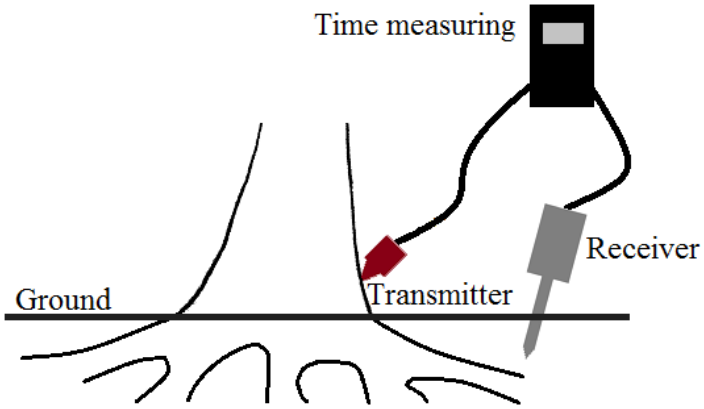


Figure 3.Acoustic root detection needs a transmitter placed on the trunk near to the ground and a receiver which can be stuck into the ground. The transmitter generates an acoustic signal which travels through the wood material. If the receiver is near a root, the traveling time of the signal changes significantly.

The measure is usually performed along a circle around the trunk, with a step of 10-15 cm. The measurement is repeated along wider and wider circles. The direction of the roots can be marked by sand or typed to a program. An example of root detection is seen in *Figure 4 and 5*. A comparison of predictions of the theoretical model and the measured data were performed; contrasting of evaluated root system and real root situation was completed as well. The roots were excavated and the 3D model of the evaluated root system fit well to the roots found by uncovering.

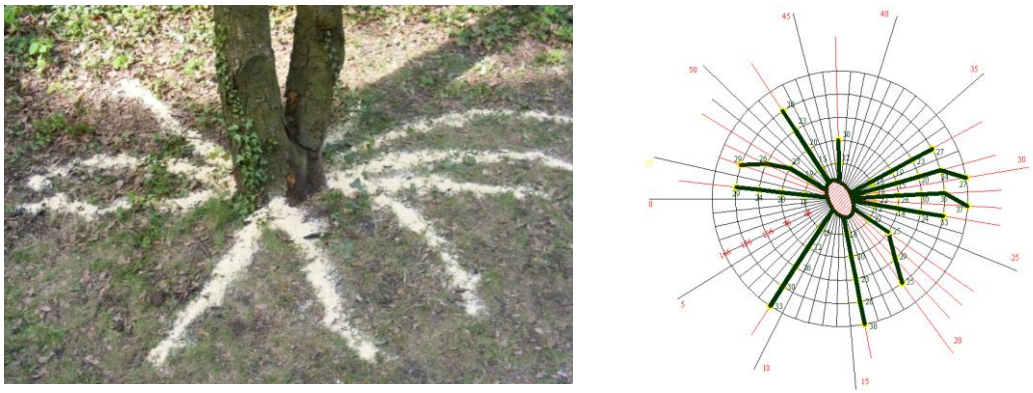


Figure 4. A measured tree in the botanical garden of the University of West Hungary (left) and the root map calculated by the program (right) (Divós 2008)

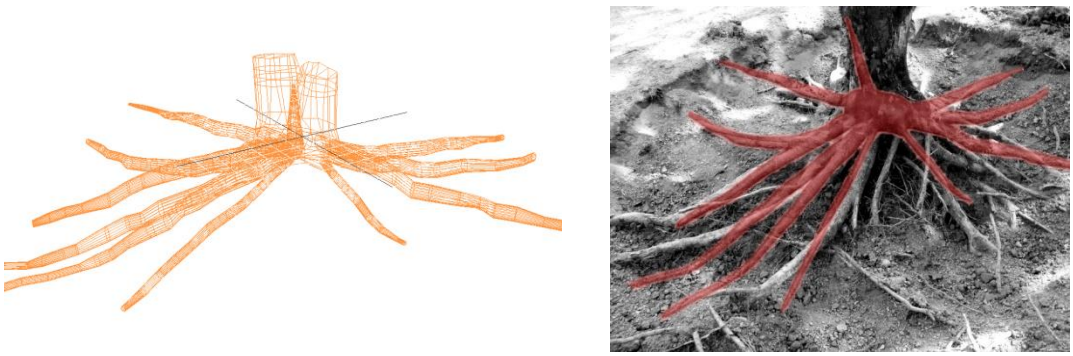


Figure 5. The 3D model of the root system (left) compared to the result of excavation (right) (Divós et al. 2009)

In further measurements, the area reached by the roots was evaluated and compared with

safety factors from the pulling test. The calculated data were different; however, the results of acoustic root detection seem to be in correlation with the safety factors predicted by the pulling test. For instance, the ratios of the data for two trees were 1.68 from the pulling test and 1.53 from acoustic root detection. This is a difference about 10%; however, the rations are promisingly close (Buza – Göncz 2015).

Limitations of the presented technique are clear; roots with diameters smaller than 4 cm are not seen by acoustic detection, and the maximum depth of the measure is about 0.5 m. Nevertheless, compared to other available techniques like ground penetration radar (GPR) or electric resistivity tomography (ERT), acoustic root detection has a remarkable advantage; the roots of the measured tree are detected. Signals of GPR and ERT both change in the presence of a root. However, GPR and ERT signals also change even if tubes, rocks, or other materials are buried (Hruska – Cermak 1999; Cermak et al. 2000; Stokes et al. 2002; Hirano et al. 2008).

5 SUMMARY

Non-destructive tests can provide quantifiable information about the inner conditions of trees. As the trees are not injured during the tests, repeated measurements and long term monitoring are possible as well. Safety is an important topic as tree failure can cause property damage or harm to humans.

NDT techniques were presented for the evaluation of root system safety; the pulling test was described along with the calculation of safety factors. Acoustic root detection was also presented.

Even though real wind is different from static tests, a pulling test can be used to evaluate the moment the wind load needed to turn out the trees is achieved. Usages, possibilities, and limitations of the pulling test were summarized in this paper.

One of the advantages of acoustic root detection is its ability to find the root of a selected tree, but it can also be utilized as a tool for safety evaluations.

Predicting the conditions of root systems is an area where complex knowledge is needed to get useful results. By collecting information about the mentioned techniques, our aim was to present the work occurring at the University of West Hungary, where the acoustic root detection method was developed, and to help involved researchers understand the available measurements and their limitations.

REFERENCES

ACHIMA, A. – NICOLL, B.C. (2009): Modelling the anchorage of shallow-rooted trees. Forestry 82 (3): 273–284.

AMATO, M. – BASSO, B. – CELANO, G. – BITELLA, G. – MORELLI, G. – ROSSI, R. (2008): In situ detection of tree root distribution and biomass by multi electrode resistivity imaging. Tree Physiology 28: 1441–1448. http://dx.doi.org/10.1093/treephys/28.10.1441

BELL, H.J. – DAWSON, A.R. – BAKER, C.J. – WRIGHT, C.J. (1991): Tree stability. In: Hodge, S.J. (Ed.), Research for Practical Arboriculture. HMSO, London, University of York. 94–101.

BERGERON, C. – RUEL, J.-C. – ELIE, J.-G. – MITCHELL, S. J. (2009): Root anchorage and stem strength of black spruce (Piceamariana) trees in regular and irregular stands. Forestry 82 (1): 29–41.

BORDEN, K.A. – ISAAC, M.E. – THEVATHASAN, N.V. – GORDON, A.M. – THOMAS, S.C. (2014): Estimating coarse root biomass with ground penetrating radar in a tree-based intercropping system. Agroforestry Systems 88: 657–669. http://dx.doi.org/10.1007/s10457-014-9722-5

BRUDI, E. – VAN WASSENAER, P.J. (2002): Trees and Statics: Nondestructive Failure Analysis. In: Tree

Structure and Mechanics Conference Proceedings: How Trees Stand Up and Fall Down. International Society of Arboriculture, Champaign, Illinois. 53–70.

BUCUR, V. (1995): Acoustics of Wood. CRC Press. 1995 298 p. ISBN-10: 0849348013

BUZA, A.K. – GÖNCZ, B. (2015): Comparison of trees and NDT methods. Wood Research 60 (1): 45–58.

CERMAK, J. – HRUSKA, J. – MARTINKOVA, M. – PRAX, A. (2000): Urban tree root systems and their survival near houses analyzed using ground penetrating radar and sap flow techniques. Plant and Soil 219: 103–116. http://dx.doi.org/10.1023/A:1004736310417

CLAIR, B. – FOURNIER, M. – PREVOST, M.F. – BEAUCHENE, J. – BARBET, S. (2003): Biomechanics of buttressed trees: bending strains and stresses. American Journal of Botany 90 (9): 1349–1356.

COUTTS, M.P.(1983): Root architecture and tree stability.Plant and soil 71: 171.

DANJON, F. – REUBENS, B. (2007): Assessing and analyzing 3D architecture of woody root systems, a review of methods and applications in tree and soil stability, resource acquisition and allocation. Plant and Soil 303: 1–34. http://dx.doi.org/10.1007/s11104-007-9470-7

DIVÓS, F. (2008): Acoustic evaluation of tree's root system for evaluation of stability (Available in Hungarian: "Fák gyökérzetének akusztikus vizsgálata a stabilitás meghatározásához."). Report for "Acoustic examinations of roots of trees" FAGYOKER, NKTH (Baross)-06 tender2007.07.02.-2008.06.30. 19 p.

DIVÓS, F. – BEJO, L. –TOTH, A. (2009): Instrument supported tree evaluation in Hungary. In: Zhang H., Wang X. (ed) Proceedings of the 16th International Symposium on Nondestructive Testing of Wood. Beijing Forestry University, Beijing, China. 71–76.

DORREN, L.K.A. – BERGER, F. (2005): Stem breakage of trees and energy dissipation during rockfall impacts. Tree Physiology 26: 63–71. http://dx.doi.org/10.1093/treephys/26.1.63

GARDINER, B. – PELTOLA, H. – KELLOMAKI, S. (2000): Comparison of two models for predicting the critical wind speeds required to damage coniferous trees. Ecological Modelling 129: 1–23.

GRABIANOWSKI, M. – MANLEY, B. – WALKER, J.C.F. (2006): Acoustic measurements on standing trees, logs and green lumber. Wood Science and Technology 40: 205–216. http://dx.doi.org/10.1007/s00226-005-0038-5

GUO, L. – CHEN, J. – CUI, X. – FAN, B. – LIN, H. (2013): Application of ground penetrating radar for coarse root detection and quantification: a review. Plant and Soil 362: 1–23. http://dx.doi.org/10.1007/s11104-012-1455-5

HAGREY, AL S.A. (2006): Geophysical imaging of root-zone, trunk, and moisture heterogeneity. Journal of Experimental Botany 58: 839–854. http://dx.doi.org/10.1093/jxb/erl237

HIRANO, Y. – DANNOURA, M. – AONO, K. – IGARASHI, T. – ISHII, M. – YAMASE, K. – MAKITA, N. – KANAZAWA, Y. (2008): Limiting factors in the detection of tree roots using ground-penetrating radar. Plant and Soil 319: 15–24. http://dx.doi.org/10.1007/s11104-008-9845-4

HRUSKA, J. – CERMAK, J. – SUSTEK, S. (1999): Mapping tree root systems with ground-penetrating radar. Tree Physiology 19: 125–130. http://dx.doi.org/10:1093/treephs/19.2.125

JAMES, K.R. – KANE, B. (2008): Precision digital instruments to measure dynamic wind loads on trees during storms. Agricultural and Forest Meteorology 148: 1055–1061. http://dx.doi.org/10.1016/j.agrformet.2008.02.003

JAMES, K. – HALLAM, C. – SPENCER, C. (2013): Measuring tilt of tree structural root zones under static and wind loading. Agricultural and Forest Meteorology 168: 160–167. http://dx.doi.org/10.1016/j.agrformet.2012.09.009

KANE, B. – CLOUSTON, P. (2008): Tree pulling tests of large shade trees in the genus Acer. Arboriculture and Urban Forestry 34 (2): 101–109.

LUNDSTRÖM, T. – JONAS, T. – STÖCKLI, V. – AMMANN W. (2007A): Anchorage of mature conifers: resistive turning moment, root–soil plate geometry and root growth orientation. Tree Physiology 27: 1217–1227. http://dx.doi.org/10.1093/treephys/27.9.1217

LUNDSTRÖM, T. – JONAS, T. – KALBERER, M. (2007B): The root–soil system of Norway spruce subjected to turning moment: resistance as a function of rotation. Plant Soil 300: 35–49 http://dx.doi.org/10.1007/s11104-007-9386-2

MOORE, J.R. (2000): Differences in maximum resistive bending moments of Pinus radiata trees grown on a range of soil types. For. Ecol. Man. 135: 63–71.

MOORE, J.R. – GARDINER, B.A. – BLACKBURN, G.R.A. – BRICKMAN, A. – MAGUIRE, D.A. (2005): An inexpensive instrument to measure the dynamic response of standing trees to wind loading. Agricultural and Forest Meteorology 132: 78–83. http://dx.doi.org/10.1016/ j.agrformet.2005.07.007

MORELLI, G.F. – ZENONE, T. – TEOBALDELLI, M. – FISCHANGER, F. – MATTEUCCI, M. – SEUFERT, G. (2007): Use of ground-penetrating radar (GPR) and electrical resistivity tomography (ERT) to study tree roots volume in pine forest and poplar plantation. In: Proceedings of the 5th International Workshop on Functional-Structural Plant Models p. 21-1 21-4.

NEILD, S.A. – WOOD, C.J. (1999): Estimation stem and root-anchorage flexibility in trees. Tree Physiology 19: 141–151. http://dx.doi.org/10.1093/treephys/19.3.141

PELTOLA, H. – KELLOMAKI, S. – HASSINEN, A. – GRANANDER, M. (2000): Mechanical stability of Scots pine, Norway spruce and birch: an analysis of tree-pulling experiments in Finland. Forest Ecology and Management 135: 143–153. http://dx.doi.org/ 10.1016/S0378-1127(00)00306-6

RAHARDJO, H. – HARNASA, F.R. – INDRAWANA, I.G.B. – LEONGA, E.C. – TANB, P.Y. – FONGC, Y.K. – OWC, L.F. (2014): Understanding the stability of Samaneasaman trees through tree pulling, analytical calculations and numerical models. Urban Forestry and Urban Greening 13: 355–364. http://dx.doi.org/10.1016/j.ufug.2013.12.002

RAY, D. – NICOLL B.C. (1998): The effect of soil water-table depth on root-plate development and stability of Sitka spruce. Forestry 71 (2): 169–182.

RODGERS, M. – CASEY, A. – MCMENAMIN, C. – HENDRICK, E. (1995): An experimental investigation of the effects of dynamic loading on coniferous trees planted on wet mineral soils. In: Coutts, M.P., Grace, J. (Eds.), Wind and Trees. Cambridge University Press. 204–219.

SANI, L. – LISCI, R. – MOSCHI, M. – SARRI, D. – RIMEDIOTTI, M. – VIERI, M. (2012): Preliminary experiments and verification of controlled pulling tests for tree stability assessments in Mediterranean urban areas. Biosystems Engineering, 112 (3): 218–226.

SCHINDLER, D.(2008): Responses of Scots pine trees to dynamic wind loading. Agricultural and forest meteorology 148: 1733–1742.

SIEGERT, B. (2013): Comparative Analysis of Tools and Methods for the Evaluation of Tree Stability Results of a field test in Germany. Arborist•News april: 26–31.

SILINS, U. – LIEFFERS, V.J. – BACH, L. (2000): The effect of temperature on mechanical properties of standing lodgepole pine trees. Trees 14 (8): 424–428.

STOKES, A. – FOURCAUD, T. – HRUSKA, J. – CERMAK, J. – NADYEZHDIN, N. – PRAUS, L. (2002): An evaluation of different methods to investigate root system architecture of urban trees in situ: I. Ground penetrating radar. Journal of Arboriculture 28 (1): 2–10.

WANG, X. (2013): Acoustic measurements on trees and logs: a review and analysis. Wood Science and Technology 47: 965–975. http://dx.doi.org/10.1007/s00226-013-0552-9

WANG, X. – ROSS, R.J. – CARTER, P. (2006): Acoustic evaluation of wood quality in standing trees—Part I. Acoustic wave behavior. Wood and Fiber Science 39: 28–38. .

WESSOLLY, L. – ERB, M. (1998): Handbuch der Baumstatik und Baumkontrolle. Patzer Verlag, Berlin, Germany. 1998 270 p. ISBN 3-8761-093-1

WESSOLLY, L. (1991): Verfahren zur Bestimmung der Stand- und Bruchsicherheit von Baumen. HolzalsRoh- und Werkstoff 49: 99–104.

WU, Y. – GUO, L. – CUI, X. – CHEN, J. – CAO, X. – LIN, H. (2014): Ground-penetrating radar-based automatic reconstruction of three-dimensional coarse root system architecture. Plant and Soil 383: 155–172. http://dx.doi.org/10.1007/s11104-014-2139-0

ZENONE, T. – MORELLI, G. – TEOBALDELLI, M. – FISCHANGER, F. – MATTEUCCI, M. – SORDINI, M. – ARMANI, A. – FERRE, C. – CHITI, T. – SEUFERT, G. (2008): Preliminary use of ground-penetrating radar and electrical resistivity tomography to study tree roots in pine forests and poplar plantations. Functional Plant Biology 35: 1047–1058. http://dx.doi.org/10.1071/fp08062

DOI: 10.1515/aslh-2016-0012 Acta Silv. Lign. Hung., Vol. 12, Nr. 2 (2016) 135–143

Bondability of Beech Wood with One-component Polyurethane Structural Adhesive

Norbert HORVÁTH[a*] – Csilla CSIHA[b]

[a] Institute of Wood Science, University of West Hungary, Sopron, Hungary
[b] Institute of Wood Products and Technologies, University of West Hungary, Sopron, Hungary

Abstract – The bondability of beech (*Fagus sylvatica* L.) wood with a one-component polyurethane (1K PUR) structural (load-bearing) adhesive has been investigated at the Simonyi Károly Faculty at the University of West Hungary. Our trial is considered a preliminary investigation in order to set the convenient parameters of bonding for the structural gluing of beech wood. Wood samples were characterized by their oven dry density, and the surfaces to be bonded were characterized by their surface roughness and surface tension after machining. Based on our measurements, we have made a suggestion on the value of the ensemble of open time, applied quantity and pressure, pressing time, and surface preparation/surface roughness parameters which result in good bonding and a shear strength higher than 10 N/mm^2. Furthermore, we investigated the penetration of the adhesive into the surface and state that one-sided adhesive application results in differing levels of penetration. In order to check the suitability of beech wood for glued laminated timber production, further investigations according to EN standards are necessary. Based upon the considerations noted above, delamination tests are already under evaluation.

***Fagus sylvatica* / load-bearing glued laminated timber / bondability / penetration**

Kivonat – Bükk faanyag ragaszthatósága egykomponensű poliuretán szerkezeti ragasztóval. Bükk (*Fagus sylvatica* L.) faanyag ragaszthatósági vizsgálatait egykomponensű poliuretán (1K PUR) szerkezeti ragasztóval a Nyugat-magyarországi Egyetem Simonyi Károly Karán végeztük. Vizsgálatuk a bükk faanyag szerkezeti ragasztásához megfelelő paraméterek beállításához szükséges előzetes kísérletnek tekinthető. A famintákat abszolút száraz sűrűséggel a ragasztandó felületeket pedig a felületi érdességgel és felületi feszültséggel jellemeztük. Méréseink alapján javaslatot tettünk a nyílt idő, a felhordott ragasztómennyiség, a présnyomás, a présidő a megmunkálás/fafelületi érdesség, a faanyag nedvességtartalom, illetve a felületi feszültség paraméterek együttesének olyan értékére, mely mellett a ragasztás elvégezhető és a ragasztott kötés nyírószilárdsága nagyobb, mint 10 N/mm^2. Vizsgáltuk továbbá a ragasztó penetrációját a faanyagban, és megállapítottuk, hogy különbség van az egyoldalas és a kétoldalas ragasztó felhordás esetén előálló behatolási mélységek között. A bükk faanyag rétegelt-ragasztott tartók gyártására való alkalmasságához további, az MSZ EN szabvány szerinti vizsgálatok is szükségesek. Ezen megfontolások alapján a rétegelválás (delamináció) vizsgálatok értékelése már folyamatban van.

***Fagus sylvatica* / rétegelt-ragasztott szerkezeti fa / ragaszthatóság / behatolási mélység**

[*] Corresponding author: norbert.horvath@skk.nyme.hu; H-9400 SOPRON, Bajcsy-Zs. u. 4. Hungary

1 INTRODUCTION

In Europe, coniferous species are the most commonly used species for glued laminated timber production. Yet according to Wittmann (2000), theoretically, no species can be excluded from the field of structural application. However, economic considerations, structural specificities, and other requirements set some limitations and the use of all species is not justified. Ebener (2001) points out that 60–75% of German sawn timber production meant for construction purposes are coniferous species, and the proportion of classical construction timber, length jointed timber, and other glued laminated timber reaches 30–50%. Furthermore, he emphasizes that the need for glued laminated structural timber is increasing.

Numerous tests have been conducted regarding structural gluing of beech wood in order to answer whether the wood material of broadleaved species is suitable for glulam structural element production and what the generally valid gluing parameters of fluent production technology are (Frühwald et al. 2003, Blaß et al. 2005, Frese 2006). Frühwald et al. (2003) tested six layer glulam beams, steaming the beech lamellas before gluing in order to homogenize color deviations originated from redheart and to decrease internal tension existing in the wood material. They found that beech can be a key important raw material for slim structures as it possesses good mechanical properties, but it should be used primarily indoors due to its limited durability.

Besides the use of coniferous species, there is an international trend towards the use of hardwoods for structural purposes; this is supported by intense research activity. Ohnesorge (2009) published comprehensive results on the usability of beech (*Fagus sylvatica* L.) wood bonded with PUR, MUF, PRF structural adhesives for structural purposes. His investigations targeted both the strength of the bond and the delamination as well. According to his results, when determining the shear strength of the samples prepared according to MSZ EN 14080, the breakage of grains was around 15% in the case of the PUR adhesive, around 91% in the case of PRF adhesive, and around 81% in the case of MUF adhesive. Furthermore, he stated that neither heartwood nor steaming exert a relevant effect on the bondability of MUF adhesives. In addition to this, he pointed out that by choosing a convenient open time and a maximized lamella thickness of 30 mm, good bondline strength can be achieved.

Along with the successful bonding of different hardwood species, delamination behavior is another issue that needs to be considered; thus, several investigations have been conducted in order to increase the bond strength and to decrease the delamination by using surface-activating agents (Csiha et al. 2010) or by changing the chemical status of the wood surface by treatments like plasma or laser (Gerstenberg – Viöl 2005). Improvements have also been reported by using hydroxy-methylated resorcinol (HMR polymer) (Vick et al. 1995, Christiansen et al. 2003, Christiansen 2005, Eisenheld – Gardner 2005). Lópes-Suevos and Richter (2009) observed significantly reduced delamination of glue laminated eucalypt timber (*Eucalyptus globulus*) when bonded with HMR primer.

2 MATERIALS AND METHODS

2.1. Wood species investigated

The investigations have been performed in order to gain information regarding the bondability of beech wood with the available 1K PUR structural adhesive. Wood samples have been characterized by their oven dry density and the surfaces to be bonded have been characterized by their surface roughness and surface tension after machining.

Primarily, beech (*Fagus sylvatica* L.) is a central European wood species, but is also present in Britain and southern Scandinavia between the 40° and 60° latitudes. In the north it

also grows on the low plains, but generally it is considered a wood species of hilly-mountain regions at 600–800 m altitude. In Hungary beech forms coherent stands in Északi-középhegység (the mountains east of the Danube), Magas-Bakony (the highest part of the Bakony), Zala County, Mecsek, Zselicség, Kőszeg and Sopron Mountains (Molnár – Bariska 2006).

2.2. Wood samples and adhesive

A total of 50 lamellas of 15 mm thickness were prepared by planing from defect free specimens of beech wood. They were conditioned at room temperature (20 °C air temperature, 60% relative humidity). The chosen adhesive was the Jowat 686.60 type 1K (PUR) adhesive, frequently used by industry for structural bonding of coniferous species (except larch). The lamellas were glued together at one side using 220 g/m^2 of adhesive application, 30-40 minutes open assembly time, 1 N/mm^2 of pressure, and 3 hours of pressing time (closed assembly time of 6–8 min).

2.2.1 Determination of moisture content and density of the samples

For the measurement of net moisture content (MC) and respective density after conditioning at normal climate, 20 mm × 20 mm (perpendicular to the grain) and 30 mm parallel to the grain prism-like samples were prepared. In order to measure their size and weight, a digital caliper and a digital balance were used, both with measuring accuracy down to 0.01. Drying of samples was performed in a drying chamber at 103 ± 2 °C air temperature. The values were calculated by the following formulas (1 and 2):

$$MC = \frac{m_x - m_o}{m_o} \cdot 100 \tag{1}$$

Where:

MC is the moisture content in %
m_x is the wet mass in g
m_o is the oven dry mass in g

$$\rho_0 = \frac{m_0}{l_0 \cdot r_0 \cdot t_0} \cdot 10^6 \tag{2}$$

Where:

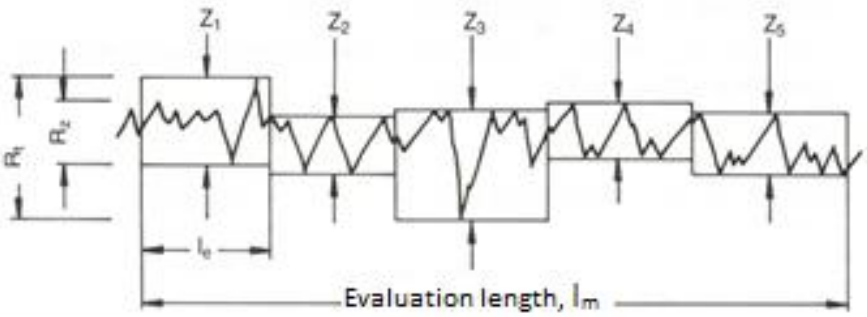
ρ_0 density of the absolute dry samples, in kg/m^3
l_0 the size of the absolute dry samples parallel to the grain, in mm
r_0 the size of the absolute dry sample in radial direction, in mm
t_0 the size of the absolute dry sample in tangential direction, in mm
m_0 the weight of the absolute dry sample, in g

2.2.2 Surface roughness measurement

The measurements were performed on the planed surface of the samples with 150 mm × 50 mm × 15 mm dimension. A total of 50 roughness measurements were performed, one on each sample, using a Mahr Perthen SP 3 instrument equipped with a stylus tip of 5 μm radius *(Figure 1)*. The instrument calculates the roughness parameters automatically using a Gaussian filter.

Figure 1. The S3P Perthometer with the stylus tip

The surface roughness profile and the chosen roughness values were printed on thermo-paper. For the surface roughness characterization, the R_z parameters were chosen for evaluation. The stylus detected the surface geometry perpendicular to the grain, along a 17.5 mm long trace, consisting of 7 of 2.5 mm long consecutive sampling lengths. R_z parameters are calculated as mathematical mean of five consecutive l_e sampling lengths, not considering the first and the last l_e of the total measured length as shown on *Figure 2*. Since single extreme profile peaks usually have only a limited influence on the part's performance, R_z followed by R_a is the most suitable surface parameter for the characterization of diffuse porous wood species with relative homogeneous structure (Perez et al. 2012). R_z followed by R_a (average roughness) and R_{max} (the maximal roughness) are suitable to describe the status of the surface (Magoss – Tatai 2009).



$$R_z = \frac{Z_1 + Z_2 + Z_3 + Z_4 + Z_5}{5}$$

$$R_{max} = Z_3$$

Figure 2. The calculation of the R_z parameter along the evaluation length (Csiha – Krisch 2000)

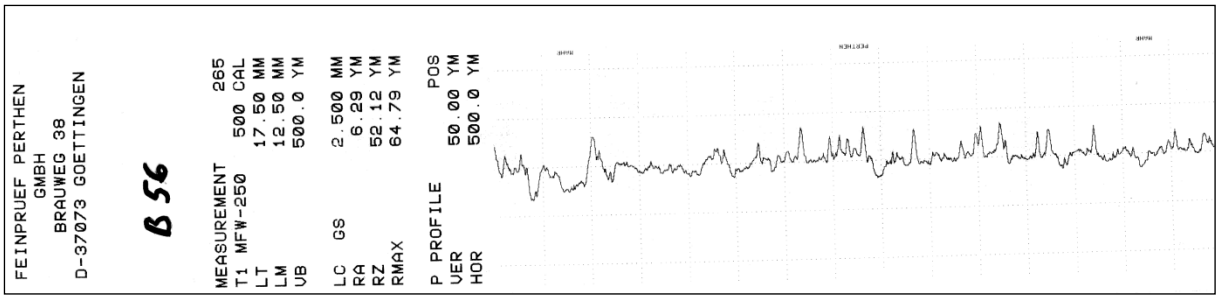


Figure 3. A roughness profile on thermo-paper

2.2.3 Surface tension measurement

Surface tension was measured by means of a PGX Goniometer, taking 10 measurements on each sample type. During the measurements, a drop of liquid was placed on the surface of wood sample. It was assumed that the liquid does not react with the solid. It was emphasized that contrary to ideal smooth surfaces, the drop of water is distorted along the grains, taking a form of a semi oval sphere. The volume of the measuring drop was of 0.4 µl, and the contact angle was automatically detected and measured at 1 sec after the release of the droplet, as previously agreed. Distilled water was used as the test liquid. The measuring instrument was calibrated before each measurement. The contact angle was measured as the angle between the outline tangent of the smaller diameter and surface. The surface free energy was automatically calculated by the computer equipped Goniometer.

Figure 4. A PGX goniometer for surface tension measurement

2.3 Pressing of samples

The application of the adhesive and pressing of samples were performed in the workshop of the UWH, Simonyi Károly Faculty of Engineering, Wood Science and Arts. The adhesive was applied at room temperature at 65% relative humidity. The chosen amount of adhesive according to the technical datasheet was 220 g/m^2. It was applied on one side with a roller within an open time of 30–40 min. A total of 24 samples were prepared using a Stromab STH hydraulic press *(Figure 5)* in one step pressing, by stacking the samples. The pressing load was 1.0 N/mm^2, with a pressing time of 3 hours.

Figure 5. The Stromab STH press

2.4 Determination of the bond strength

Samples suitable for shear strength measurement were prepared according to MSZ EN 302-1 *(Figure 6).* The samples were acclimatized according to MSZ EN 302-1 for 7 days at room temperature (20°C temperature and 65% relative humidity) and tested afterwards. The shear strength was determined by using a TiniusOlsen H10K type instrument *(Figure 7).* The area that was supposed to shear on each sample was measured by digital calliper. The shear strength of the 24 samples was calculated using the following equation:

$$\tau = \frac{F_{max}}{A} [\text{N/mm}^2] \tag{3}$$

Where:

F_{max} the maximal force, in N
A the area of the exposed portion, in mm^2

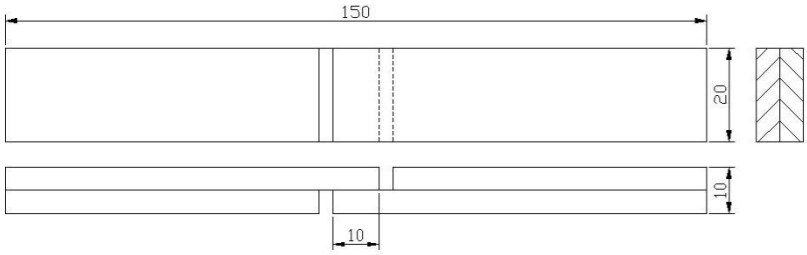


Figure 6. Sample for shear strength measurement according to MSZ EN 302-1

Figure 7. TiniusOlsen H10K instrument with a sample

2.5 Determination of adhesive penetration

For the determination of adhesive penetration, a Nikon SMZ800 microscope was used *(Figure 8).* Samples that were 10 mm thick were cut perpendicularly to the grain as the falling end from the glued samples right after the stock was taken out of the press. During the investigation, microscope images were taken from the butt end of the glued samples, and thus from the glueline aided by an Image Pro software.

Figure 8. Nikon SMZ800 microscope

3 RESULTS AND DISCUSSION

The investigations were performed in order to gain information regarding the bondability of beech wood with the available 1K PUR structural adhesive as the chosen adhesive (Jowat 686.60 type 1K (PUR)) is frequently used by industry for structural bonding of coniferous species (except larch). The thickness of the glueline was around 0.3 mm, lower than the maximum suggested by the adhesive manufacturer. The average density of the samples was 735 kg/m^3, which is typical for beech wood. The average MC of the samples was 9.22%. There were some samples with MC around 8–9%, but later on they did not show any difference in their shear strength suggesting that the reaction of the PUR adhesive was performed without any obstacle in their case also. The pressing load used was 1.0 N/mm^2, while the pressing time was 3 hours. The shear strength of the bond and the penetration of the adhesive were determined. In each shear test, the wood broke, meaning that the adhesive bond was stronger than the cohesion of the beech wood material.

3.1 Results of surface roughness and surface tension

The surface roughness of the planed beech surfaces was influenced both by machining – planing in this case – and the tissue structure of the wood. The average surface roughness of the samples is given in *Table 1*.

Table 1. Contact angle, surface tension and surface roughness (R_a, R_z, R_{max}) of planed beech samples

	Contact angle (^{o})	Surface tension (N/m)	R_a (μm)	R_z (μm)	R_{max} (μm)
Average	72.73	38.8	6.52	50.45	67.31
st. dev.	20.79	7.61	1.43	8.7	17.05

3.2 Results of bond strength

Samples were subjected to pulling and thus shear stress was induced. In each case the wood broke, meaning that the adhesive bonding was stronger than the cohesion of the beech wood material. The values of the shear strength are as per *Table 2*.

Table 2. The shear strength of the samples (parallel to the grain)

	Average	St. dev.	Min	Max
Shear strength (N/mm^2)	16.79	4.05	11.08	29.38

3.3 Results on adhesive penetration

According to the images taken, the adhesive penetrated twice as deep with direct application (334.23 μm) than it did with indirect adhesive application. *(Table 3)* The thickness of the glueline was around 280 μm, lower than the maximum suggested by the adhesive manufacturer.

Table 3. Adhesive penetration

	Average	St. dev.	Min	Max
Direct adhesive application (μm)	334.23	154.28	97.14	647.60
Indirect adhesive application (μm)	149.19	63.89	45.33	304.40

4 CONCLUSIONS

Surface roughness and surface tension measurements were also performed. The average surface roughness of the samples was: (R_a) 6.52 μm, R_z) 50.45 μm and (R_{max}) 67.31 μm associated with an average surface tension of 38.80 N/m. The samples possessing the above characteristics were glued together with a Jowat 686.60 1K PUR structural adhesive The average value of the shear strength was 16.79 N/mm^2, while the lowest value was 11.08 N/mm^2 *(Table 2).*

According to the results, the strength of the adhesive suits level A1 (EN 301). As evidenced in the images taken, the adhesive penetrated twice as deep on the side of direct application (334.23 μm) than it did on the side of indirect adhesive application *(Table 3).* Although the shear test results were satisfactory, the information is relevant for future investigations regarding the measurement of shear strength in light of adhesive penetration.

Based on the above mentioned results, one can state that planed beech surfaces that have 9.22% average MC, 735 kg/m^3 average density, average roughness of R_z = 50.45 μm, surface tension of 38.80 N/m with Jowat 686.60 type 1K (PUR) adhesive of 220 g/m^2 quantity applied to one side, open time of 30–40 min, closed time of 6–8 min, and pressing time of 3 hours, that bonding can be performed without obstacles. Also, at dry strength a higher value than 11 N/mm^2 can be expected.

Acknowledgements: The authors are grateful to Kálmán Kránicz for the technical assistance provided in the measurements.

REFERENCES

BLAß, H. J. – DENZLER, J. – FRESE, M. – GLOS P. – LINSEMANN, P. (2005): Biegefestigkeit von Brettsichtholz aus Buche – Karlsruher Berichte zum Ingenieurholzbau. Universität Karlsruhe, Universitätsverlag Karlsruhe

CSIHA CS. – KRISCH J. (2000): Vessel filtration – a method for analisyng wood surface roughness of large porous species. Drevasky Vyskum 45: (1) 13–22.

CSIHA CS. – CSÓKA L. – LITRESITS G. – BICZÓ G. (2010): LbL treatment of wood surfaces in order to improve bondline performance. In: Processing Technologies for the Forest and Biobased Products Industries. Salzburg, Austria. 48–49.

CHRISTIANSEN, A.W. – VICK, C.B. – OKKONEN, E. (2003): Development of a novalak-based hydroxymethylated resorcinol coupling agent for wood adhesives. Forest Prod. J. 53 (2):32–38.

CHRISTIANSEN, A. W. (2005): Chemical and mechanical aspect of HMR primer in relationship to wood bonding. Forest Prod. J. 55 (11):73–78;

EBENER, G. (2001): BSH – Kapazitätsbau – Mittelfristig eine Million mehr am Markt. Holzkurier Sonderheft 856:11 p.

EISENHELD, L. – GARDNER, D.J. (2005): Developing an industrial friendly process for hydroxymethyl resorcinol (HMR) priming of wood using a novolak-based HMR. Forest Prod. J. 55 (9): 61–66.

FRESE, M. (2006): Die Biegefestigkeit von Brettschichtholz aus Buche experimentelle und numerische Untersuchungen zum Laminierungseffekt. Universitätsverlag Karlsruhe

FRÜHWALD, A. – RESSEL, J.B. – BERNASCONI, A. (2003): Hochwertiges Brettschichtholz aus Buchenholz. Abschlussbericht. Institut für Holzphysik und mechanische Technologie des Holzes, Bundesforschungsanstalt für Forst- und Holzwirtschaft, Hamburg

GERSTENBERG, K. – VIÖL, W. (2005): Plasma-Behandlung von Holzoberflächen – Umsetzung in die Industrielle Praxis. Vortrag, Symposium „Holz Innovativ“ 2005.04.07. Kultur- und Kongress-zentrum Rosenheim

LÓPES-SUEVOS, F. – RICHTER, K. (2009): Hydroxymethylated resorcinol (HMR) and novolak-based HMR (n-HMR) primers to enhance bond durability of *Eucalyptus globulus* glulams. J. Adhes. Sci. Technol 23 (15):1925–1937

MAGOSS, E. – TATAI, S. (2009): Surface roughness of natural wood – rality versus measured figures. In: Proceedings of the 20th International Wood Machining Seminar. Skelleftea, Sweden.

MOLNÁR, S. – BARISKA, M.(2006): Magyarország ipari fái. [Wood Species of Hungary] Szaktudás Kiadó Ház, Budapest. p. 70–82. ISBN: 9639422533

MSZ EN 301 (2006): Classification and performance requirements

MSZ EN 302-1 (2004): Adhesives for load-bearing timber structures – Test methods – Part 1: Determination of longitudinal tensile shear strength

MSZ EN14080 (2013): Timber structures. Glued laminated timber and glued solid timber. Requirements

OHNESORGE, D. (2009): Verklebungseigenschaften von Brettschichtholz aus Buchenholz (*Fagus sylvatica* L.), Fakultät für Forst- und Umweltwissenschaften der Universität Freiburg, und Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg, ISBN 978-3-933548-44-3

PEREZ A.G. – SALCĂ, E.A. – MALDONADO, I.B. – HIZIROGLU, S. (2012): Evaluation of surface quality of medium density fiberboards (MDF) and particleboards as function of weathering. Pro Ligno Journal 8: 10–17.

VICK, C.B. – RICHTER, K. – RIVER, B.H. – FRIED, A.R. (1995): Hydroxymethylated resorcinol coupling agent for enhanced durability of bisphenol-A-epoxi donds. Wood Fiber Sci. 27 (1): 2–12.

WITTMANN, GY. (2000): Mérnöki szerkezetek I. [Engineering structures I.] Mezőgazdasági Szaktudás Kiadó, Budapest. p. 115; 310; 330–339; ISBN: 963 356 3143

DE GRUYTER OPEN DOI: 10.1515/aslh-2016-0013 Acta Silv. Lign. Hung., Vol. 12, Nr. 2 (2016) 145–156

A Methodology for Experimental Research of the Freezing Process of Logs

Nencho DELIISKI* – Natalia TUMBARKOVA

Department of Woodworking Machines, Faculty of Forest Industry, University of Forestry, Sofia, Bulgaria

Abstract – This paper describes a methodology for experimental research of the change in the temperature and humidity of the air processing medium and also in the temperature at 4 points of the longitudinal section of logs during freezing. The suggested methodology is used to research the change in the mentioned parameters of poplar logs with diameters of 240 mm, lengths of 480 mm and moisture content above the hygroscopic range during 50 h of freezing in a freezer at a temperature of about –30 °C. The automatic measurement and recording of the parameters is carried out with the help of Data Logger type HygrologNT3 produced by the Swiss firm ROTRONIC. The precise instrumentation allowed, for the first time ever, the measuring of the impact the latent heat released by the free water on the log had on the warming up of the wood during water crystallization in the logs.

poplar logs / freezing / temperature distribution / automatic measurement / latent heat

Kivonat – **Rönkfagyasztás kísérleti kutatásának módszere.** Ez a cikk leírja a hőmérséklet és a nedvességtartalom változását levegőben elhelyezett rönk fagyasztásakor, és mutatja a hőmérsékletet hosszirányban lévő 4 különböző pontban. A javasolt módszert használtuk, hogy megvizsgáljuk a fenti paraméterek változását 240 mm átmérőjű, 480 mm hosszú, nedves állapotú nyár rönkök fagyasztási vizsgálatainál –30 °C körüli hőmérsékleten, 50 órás időtartamon. A paraméterek automatikus mérése és rögzítése a svájci ROTRONIC cég által gyártott HygrologNT3 eszközzel történt. A pontos mérőrendszerrel, első alkalommal sikerült megmérni a megfagyó víz által kibocsátott látens hőnek a faanyagot felmelegítő hatását.

nyár rönkök / fagyasztás / hőmérséklet eloszlás / automatikus mérés / latens hő

1 INTRODUCTION

The duration and energy consumption required for the thermal treatment to plasticize logs for veneer production depends on the degree of the icing of the log (Chudinov 1966, 1968, Shubin 1990, Požgaj et al. 1997, Trebula – Klement 2002, Videlov 2003, Pervan 2009, Deliiski – Dzurenda 2010, Deliiski 2013b).

In the specialized literature, there are limited reports about an experimentally determined or computed temperature distribution of frozen logs subjected to defrosting (Steinhagen 1986, 1991, Steinhagen et al. 1987, Steinhagen – Lee 1988, Khattabi – Steinhagen 1992, 1993, 1995, Deliiski 2004, 2005, 2009, 2011, 2013a, Deliiski – Dzurenda 2010, Deliiski et al. 2014, 2015a,

* Corresponding author: deliiski@netbg.com; 1756 SOFIA, Kliment Ohridski Blvd. 10, Bulgaria

2015b) and there is no information at all about the experimentally determined temperature distribution in logs during their natural or artificial freezing. That is why the experimental research and the multiparameter study of the freezing process of logs are of considerable scientific and practical interest.

The aim of this work is to suggest a methodology for experimental research of the freezing process of logs and to present the first results from its usage for precise temperature and humidity change measurements of the air processing medium, t_m and φ_m, respectively. This applies also for measurement of the non-stationary temperature distribution in 4 characteristic points of the longitudinal section of poplar logs during their many hours in a freezer with an adjustable temperature range from –1 °C to –30 °C. An important part of the work is to present and analyze, for the first time ever, the measuring of the experimentally determined impact the latent heat released by the free water on the log had on the warming up of the wood during water crystallization in the logs.

2 MATERIAL AND METHODS

The logs subjected to experimental research had a diameter of 240 mm and a length of 480 mm. They were produced from the sap-wood of freshly-felled poplar trunks (*Populus nigra* L.) with a diameter of 630 mm according to a scheme given on *Figure 1* (left).

Before the experiments, 4 holes with diameters of 6 mm and of different lengths were drilled into each log (*Figure 1* – right and *Figure 2*). Sensors with long cylindrical metal casings were positioned in these 4 holes to measure the temperature of the wood during the experiments. The number of the characteristic points, in which the changes in the wood temperature were measured, was limited by the number of available temperature sensors the automatic system used for the experiments had.

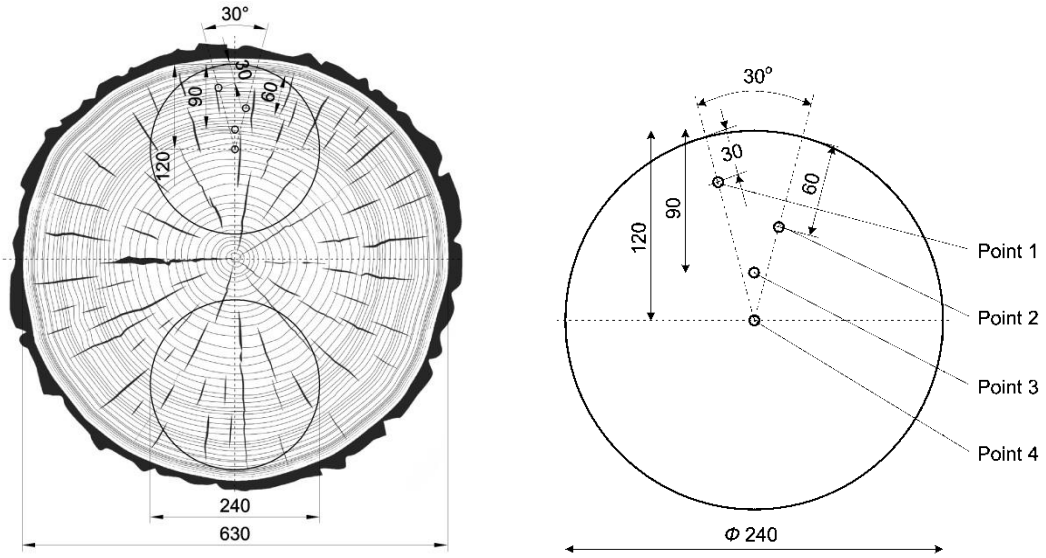


Figure 1. An approach for the production of logs for the experiments (left) and radial coordinates of 4 characteristic points for measurement of the temperature in the logs (right)

The coordinates of the characteristic points of the logs are, as follows:

Point 1: along the log radius $r = R/4 = 30$ mm and along the log length $z = L/4 = 120$ mm;
Point 2: along the log radius $r = R/2 = 60$ mm and along the log length $z = L/4 = 120$ mm;
Point 3: along the log radius $r = 3R/4 = 90$ mm and along the log length $z = 3L/8 = 180$ mm;
Point 4: along the log radius $r = R = 120$ mm and along the log length $z = L/2 = 240$ mm.

These characteristic point coordinates allow for the impact of the heat fluxes to be simultaneously covered in radial and longitudinal directions on the temperature distribution of freezing logs *(Figure 2*). Point coordinate values that were suitable for temperature computation and visualization in these points were chosen with the help of a 2D model of the freezing process of the logs aimed at its verification (Deliiski et al. 2014).

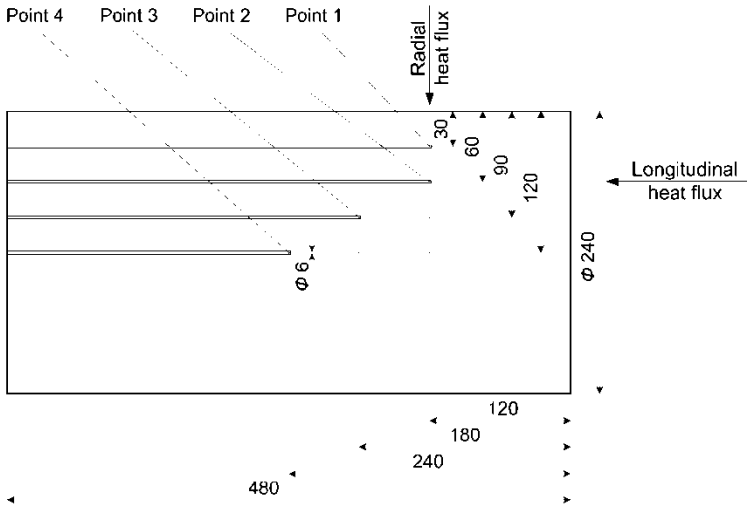


Figure 2. Longitudinal section of log with drilled holes for positioning of sensors for measurement of the wood temperature during the freezing process

Each log prepared for the experiments was placed in a PVC bag with the aim of homogenizing the moisture content in its volume as far as possible. Following this, the experiments began.

To freeze the logs, a horizontal freezer with length of 1.1 m, width of 0.8 m, depth of 0.6 m and adjustable temperature range from –1 °C to –30 °C was used *(Figure 3 – left).*

The automatic measurement and recording of the temperature and humidity of the air processing medium in the freezer as well as of the temperature in the 4 characteristic points in the logs during the experiments was carried out with the help of Data Logger type HygroLog NT3 *(Figure 3 – right)* produced by the Swiss firm ROTRONIC AG (http:/www.rotronic. com).

Figure 3. General view of the freezer containing a log (left) and of the Data Logger (right)

The suggested methodology for the research of the freezing process of poplar (*Populus nigra* L.) logs with diameter of D = 0.24 m, length of L = 0.48 m, and moisture content above the fiber saturation point was used. Such moisture content allows for the observation of the freezing of both the free and the bound water in the wood during the experiments.

When the logs were completely frozen, they were subjected to defrosting at room temperature. After that, 35 mm-thick disks from the central, undrilled area of the logs were prepared. According to requirements of the standard BDS ISO 3130: 1999, eleven samples with dimensions of 60 x 30 x 35 mm were made (see *Figure 6* below).

The samples were dried at 103 ± 2 °C to estimate their initial moisture content u and basic wood density ρ_b, which is equal to the dry mass divided by the green volume. The average values of u and ρ_b are needed for experimental results analysis and also to solve, modify and verify the mathematical models of the freezing process of the logs (Deliiski et al. 2014, 2015a). The measured results obtained by the Data Logger during the experiments were additionally processed with the help of a personal computer with an installed licensed software, ROTRONIC HW4.

The very precise instrumentation used during the experiments allowed us to detect the latent heat released by the free water and its impact on the wood freezing process during the crystallization of this water (see below). This phenomenon is not well-known or easily comprehensible, hence it will be explained in detail below.

It is common knowledge that when a given substance is subjected to heating, its internal energy and its temperature increase. However, under certain circumstances, the heat deposited in the system is spent performing work without increasing its temperature. This happens when a phase transformation in the substance occurs.

The phase transformation consists in moving from one aggregate state to another – for example, the passing of ice into water. In those cases, the heat introduced in the substance is transformed into work needed for destruction of the bonds between molecules, which are available in the substance before heat introduction. It is acceptable to term this heat as the latent heat of the phase transformation (Efimov 1985, Pahi 2010).

Therefore, the latent heat is used for description of the thermal energy, which is needed for the change of the aggregate state of a given substance without changing its temperature. When the ice is transformed into water, it is acceptable to term this latent heat as latent heat of fusion and when the water turns into steam it is called latent heat of vaporization. It was found that the latent heat of fusion is equal to $3.34 \cdot 10^5$ J·kg^{-1} and the latent heat of vaporization is about 6.5 times larger and equal to $2.2572 \cdot 10^6$ J·kg^{-1} (Chudinov 1966, 1968, Rivkin – Aleksandrov 1975, Efimov 1985, Spears – Zollman 1990, Pahi 2010).

Ice molecules are connected to one another with significant forces of attraction. The kinetic energy of ice molecules increases during heating, which translates into the increase of their amplitude oscillations. When the melting point of the ice is reached, the amplitude of the oscillations increases so much that separate molecules begin to detach from their places and become free. This process is not accompanied by an increase in ice temperature because of the usage of the latent heat introduced for the overcoming of the intermolecular bonds.

The freezing and melting processes of the water in the wood are reversible.

When the water passes into ice during cooling, it releases latent heat in an amount of $3.34 \cdot 10^5$ J·kg^{-1}. With the help of precise instrumentation, the research and the quantity determination of the impact of the water's latent heat release on the freezing process of the logs are of considerable scientific and practical interest.

3 RESULTS AND DISCUSSION

As an example, in *Figure 4* and *Figure 5*, the change in t_m, φ_m, and t in 4 characteristic points of two poplar logs with different moisture content u = 1.78 kg·kg^{-1} and u = 1.04 kg·kg^{-1} (named below as Log 1 and Log 2 respectively) during their 50 h freezing is presented. The record of all data was made automatically by Data Logger with intervals of 15 min.

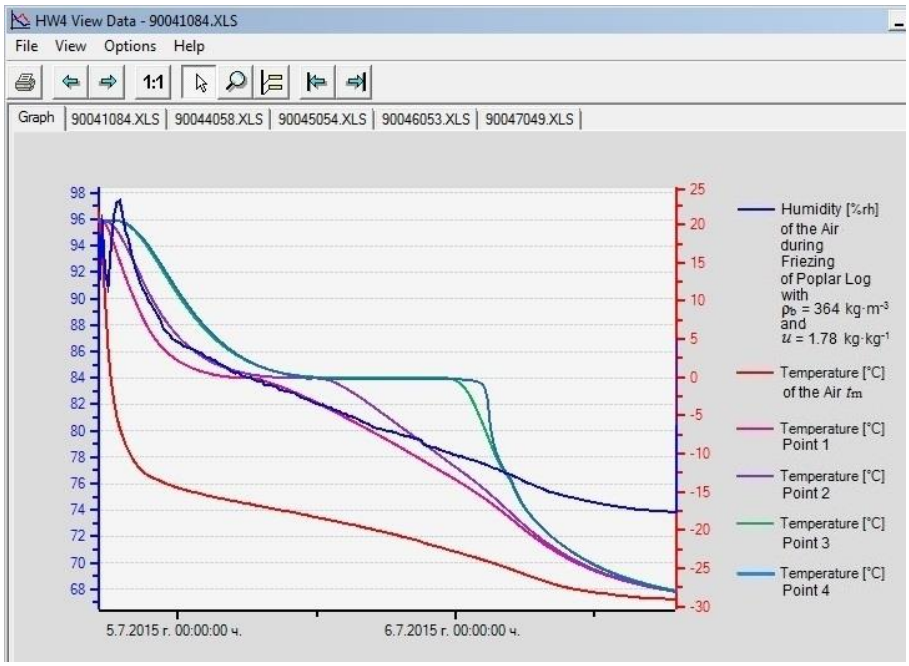


Figure 4. Change in t_m, φ_m, and t in 4 characteristic points of poplar Log 1 with D = 0.24 m, L = 0.48 m, t_0 = 20.5 °C, ρ_b = 364 kg·m^{-3}, and u = 1.78 kg·kg^{-1} during its 50 h freezing from 17:00 on 04.07.2015 to 19:00 on 06.07.2015

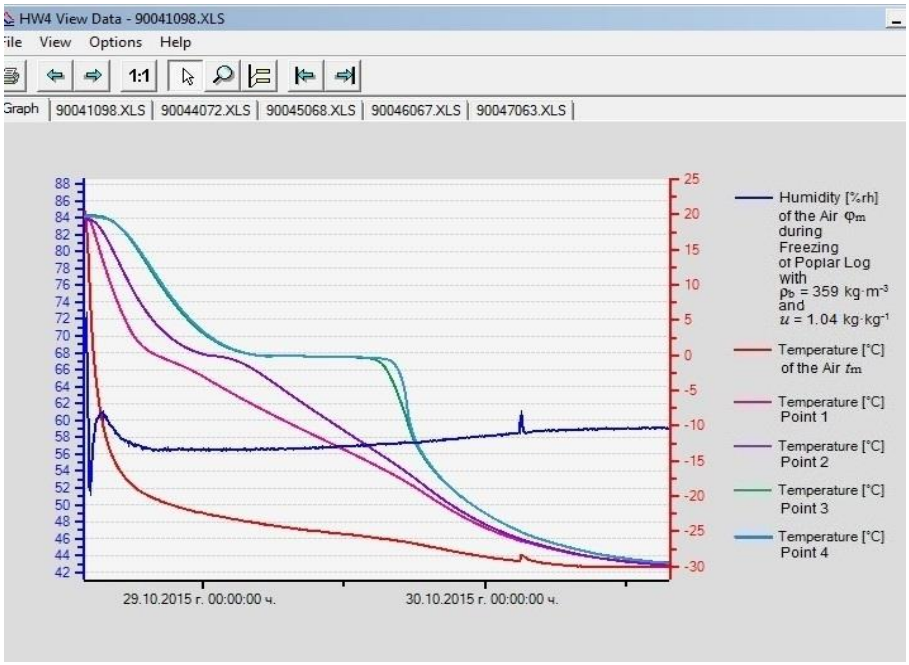


Figure 5. Change in t_m, φ_m, and t in 4 characteristic points of poplar Log 2 with D = 0.24 m, L = 0.48 m, t_0 = 19.8 °C, ρ_b = 359 kg·m^{-3}, and u = 1.04 kg·kg^{-1} during its 50 h freezing from 12:00 on 28.10.2015 to 14:00 on 30.10.2015

In *Figure 6* the distribution of the moisture content *u* and of the basic density ρ_b in the cross section of Log 1 is shown.

In *Figure 7* and *Figure 8* the change in *t* of the separate 4 characteristic points of Log 1 in temperature range from 0 °C to –1 °C is shown. The experiments determined that the freezing of the free water in the wood occurs in this range.

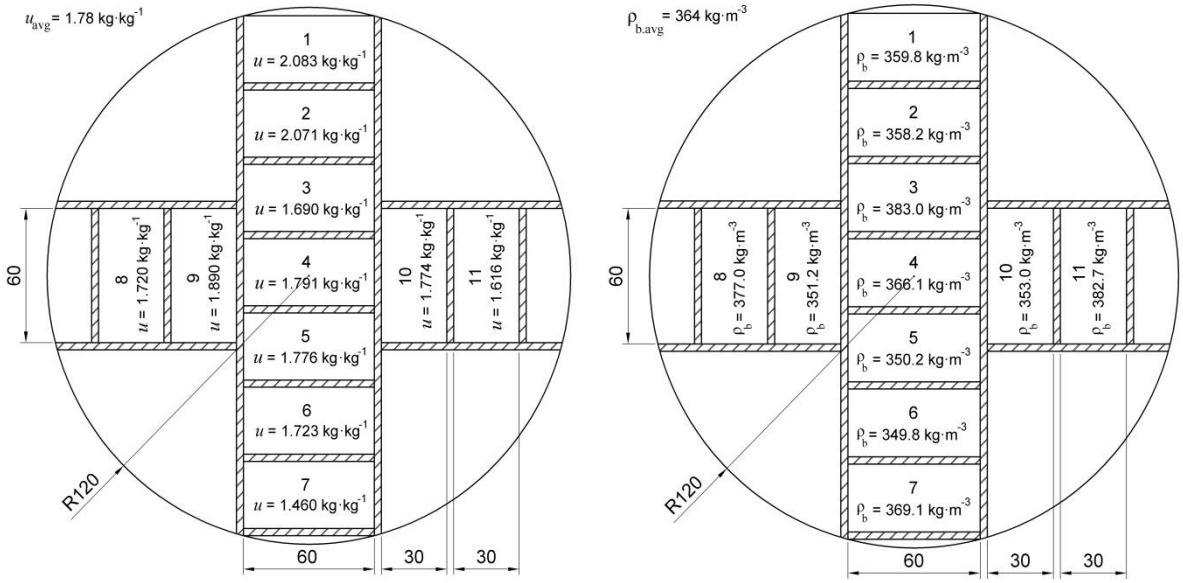


Figure 6. Distribution of u (left) and ρ_b (right) in the cross section of Log 1

In *Figure 9* and *Figure 10* the zoomed change in *t* in the characteristic points of Log 1 in the temperature ranges is shown, in which the impact of the release of the latent heat of the free water on the increasing of the wood temperature during log freezing is observed.

On the horizontal and vertical axis of *Figure 7* to *Figure 10* the astronomic time during the experiments and the temperature in °C are presented respectively.

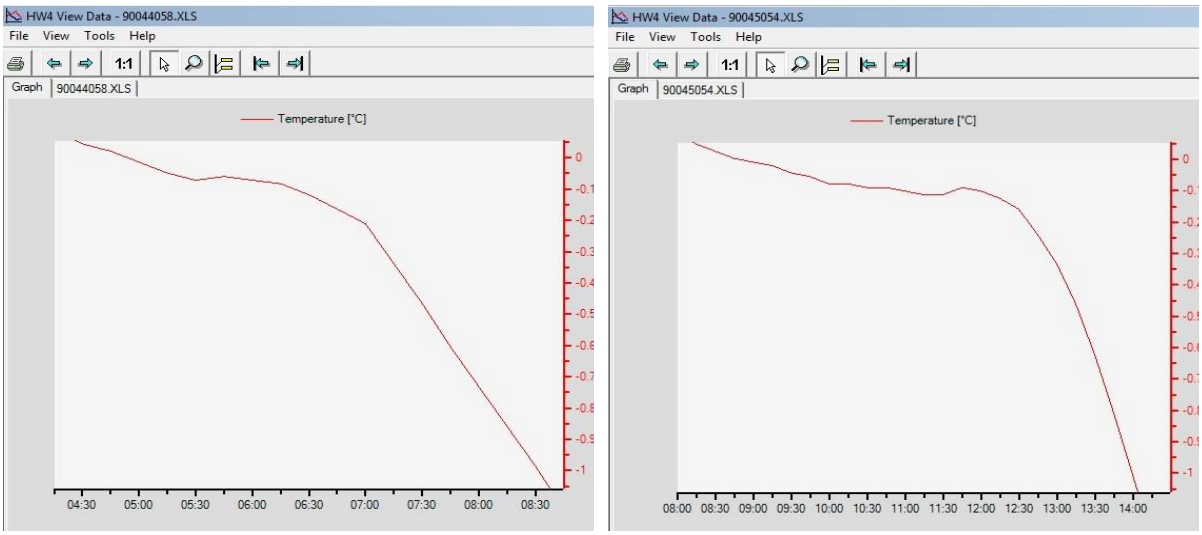


Figure 7. Change in t in Point 1 (left) and in Point 2 (right) of Log 1 in the range from 0 °C to –1 °C during log freezing, depending on time

In *Table 1* the duration of the temperature decrease in the characteristic points of Log 1 and Log 2 in the range from 0 °C to –1 °C is given (see *Figure 7* and *Figure 8* for Log 1). This duration is needed for its further comparison to the duration of the defrosting process of the same logs in the temperature range from –1 °C to 0 °C.

In Table 2 the temperature ranges and the duration of the impact of the latent heat of the free water in the wood on the change in *t* of the characteristic points in Log 1 and Log 2 is illustrated.

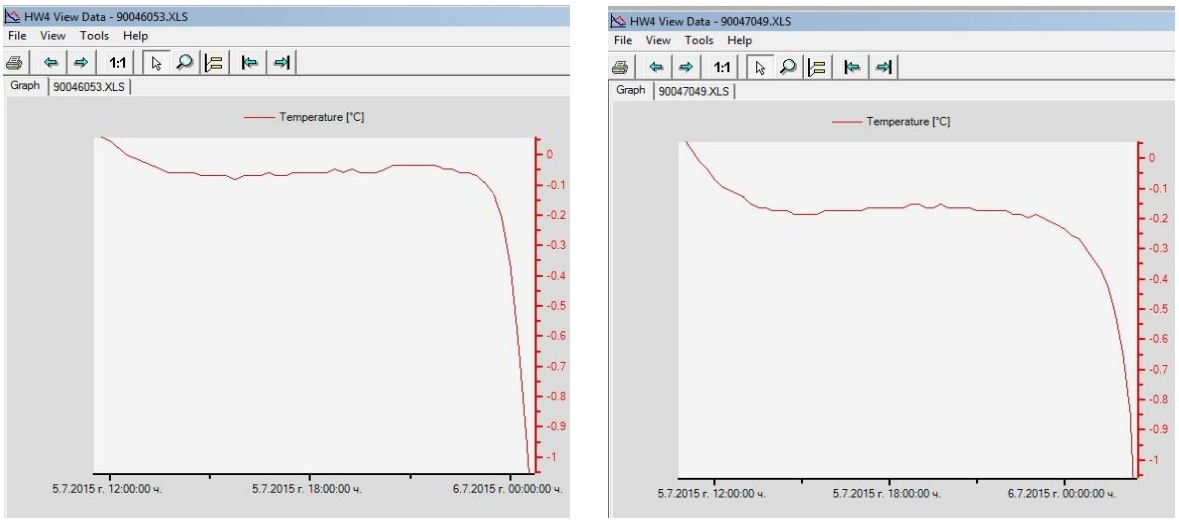


Figure 8. Change in t in Point 3 (left) and in Point 4 (right) of Log 1 in the range from 0 °C to –1 °C during log freezing, depending on time

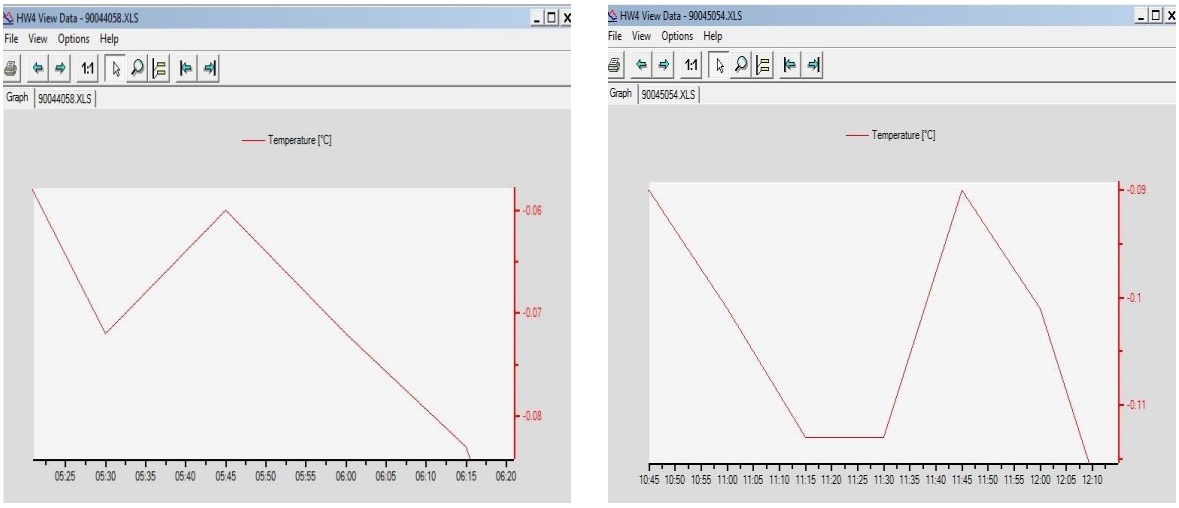


Figure 9. Change in t in Point 1 (left) and in Point 2 (right) of Log 1 during the impact of the release of the latent heat of the free water on the log freezing process

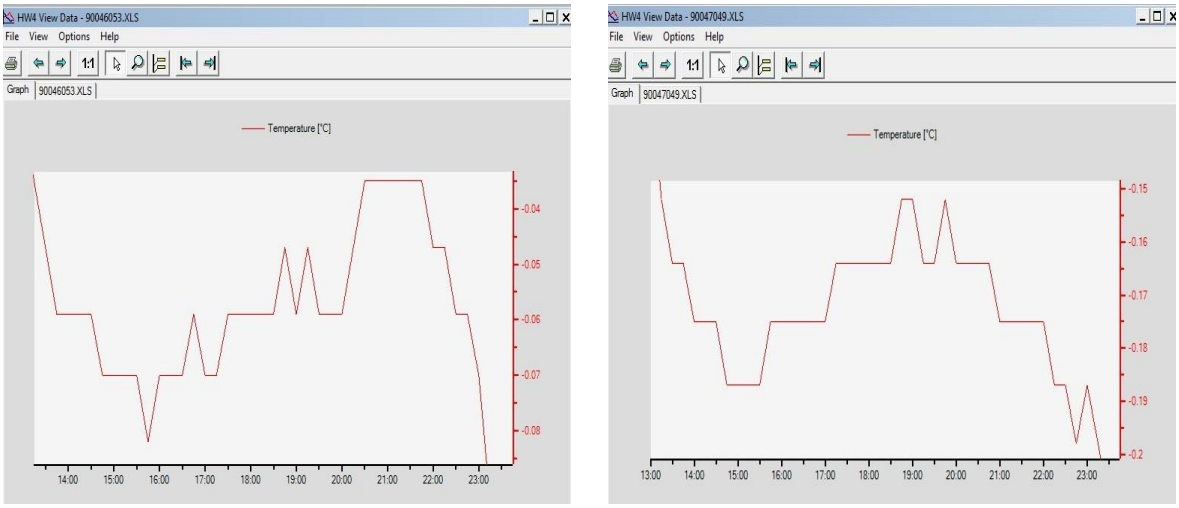


Figure 10. Change in t in Point 3 (left) and in Point 4 (right) of Log 1 during the impact of the release of the latent heat of the free water on the log freezing process

Table 1. Duration of the decreasing of t from 0 °C to –1 °C in the characteristic points of poplar logs during their 50 h freezing

№	Time of reaching of temperature equal to		Duration of the decreasing of *t* from 0 °C to –1 °C, h
	0 °C	–1 °C	
Log 1 with t_0 = 20.5 °C, ρ_b = 364 kg·m^{-3}, and u = 1.78 kg·kg^{-1}			
Point 1	4:54 on 05.07.2015	8:32 on 05.07.2015	3.63
Point 2	8:49 on 05.07.2015	14:00 on 05.07.2015	5.18
Point 3	12:30 on 05.07.2015	0:32 on 06.07.2015	12.03
Point 4	11:24 on 05.07.2015	2:19 on 06.07.2015	14.92
Log 2 with t_0 = 19.8 °C, ρ_b = 359 kg·m^{-3}, and u = 1.04 kg·kg^{-1}			
Point 1	20:07 on 28.10.2015	21:34 on 28.10.2015	1.45
Point 2	0:31 on 29.10.2015	3:14 on 29.10.2015	2.72
Point 3	4:45 on 29.10.2015	15:07 on 29.10.2015	10.37
Point 4	4.40 on 29.10.2015	16:10 on 29.10.2015	11.50

Table 2. Duration τ_{LH} and temperature difference Δt_{LH} of the impact of the latent heat (LH) of the free water on the increasing of the wood temperature in the characteristic points of poplar logs during their 50 h freezing

№	Time and wood temperature at the beginning and ending of the impact of LH on the wood freezing		Maximal wood temperature and time of its reaching under impact of LH on the wood freezing		τ_{LH},	Δt_{LH},
	Time	t_{LH}^{beg}, °C	t_{LH}^{max}, °C	Time	h	°C
Log 1 with t_0 = 20.5 °C, ρ_b = 364 kg·m^{-3}, and u = 1.78 kg·kg^{-1}						
Point 1	5:30 and 6:00	–0.072	– 0.060	5:45	0.50	0.012
Point 2	11:15 and 12:07	–0.113	–0.090	11:45	0.87	0.023
Point 3	15:45 and 22:45	–0.082	–0.035	20:30	7.00	0.047
Point 4	14:45 and 23:00	–0.187	–0.152	18:45	8.25	0.035
Log 2 with t_0 = 19.8 °C, ρ_b = 359 kg·m^{-3}, and u = 1.04 kg·kg^{-1}						
Point 1	20:15 and 20:30	–0.120	– 0.120	20:15	0.25	0.093
Point 2	1:10 and 1:30	–0.110	–0.110	1:10	0.33	0.070
Point 3	5:05 and 7:24	–0.059	–0.001	5:30	2.32	0.058
Point 4	5:40 and 10:20	–0.164	–0.036	6:15	4.70	0.128

The experimental results presented above, and also the results from our research of the freezing process of logs from some wood species (poplar, beech, pine, and spruce) at different moisture contents, show that the free water in the wood freezes in the temperature range between 0 °C and –1 °C. This fact did not prove the points of view of Chudinov (1966, 1968) and Topgaard – Söderman (2002), which have been presented in Deliiski et al. (2015c). According to these scientists, if the wood has a significant quantity of free water, i.e. if the cell holes and the gaps among the cells are almost completely filled with water (such a condition was fulfilled in our experiments presented above), the centers of crystallization during cooling arise in the water at temperatures around –5 °C ÷ –6 °C. According to the same authors, if the wood moisture content is slightly larger than the fiber saturation point, i.e. a small quantity of free water is present in the wood, then the centers of crystallization in it arise even at temperatures around –12 °C ÷ –15 °C.

The analysis of the obtained results about the freezing process of the studied logs showed the following:

- The temperature decrease of the processing air medium t_m in the freezer goes on exponentially at the beginning of the freezing process of the logs and, after that, gradually passes into an almost straight line *(Figure 4 and Figure 5)*.
- The change of the humidity of the processing air medium φ_m in the freezer goes on according to a complex curve. At the beginning of the freezing process it jumps up to 97% at Log 1 *(Figure 4)* and up to 73% at Log 2 *(Figure 5)*, but after that it gradually decreases smoothly and reaches a value of 74% (Log 1) and of 59% (Log 2) at the end of the 50 h logs' freezing.
- The non-stationary decreasing of the temperature in the logs' characteristic points goes on according to very complex curves during the freezing process *(Figure 4 and Figure 5)*.
- While the water in the log is fully in a liquid state, the decreasing of t_m causes a smooth decreasing of t in the characteristic points. The smoothness of the decreasing of *t* depends proportionally on the distance of the points from both logs' surfaces.
- Specific, almost horizontal sections of temperature retention for a long period of time in the range from 0 °C to –1 °C can be seen, while in the points a complete freezing of the free water in the wood occurs *(Figure 7 and Figure 8)*. How far the point is distanced from the logs' surfaces and the larger the amount of the free water in the wood determines how much these sections with temperature retention are extended, as follows *(Table 1)*:
  - in Point 1: 3.63 h for Log 1 and 1.45 h for Log 2;
  - in Point 2: 5.18 h for Log 1 and 2.72 h for Log 2;
  - in Point 3: 12.03 h for Log 1 and 10.37 h for Log 2;
  - in Point 4: 14.92 h for Log 1 and 11.50 h for Log 2.

  The reason of such a long retention of wood temperature is the very low temperature conductivity of the wood during freezing of the free water in it (Deliiski et al. 2015b).
  It is seen in *Table 1* that the temperature *t* in Point 4, which is the most distanced from the logs' surfaces, reaches a value of 0 °C earlier than *t* in Point 3 during the initial cooling of logs before their subsequent freezing. This apparent anomaly can be explained by the influence of the smaller moisture content *u* of the bottom part of the logs (in comparison with the moisture content of their upper parts) on the wood temperature conductivity, *a*. For example, the average value of *u* for the bottom layers 5, 6, and 7 of Log 1 *(Figure 6 – left)* is equal to 1.653 $kg \cdot kg^{-1}$; however, the average value of *u* for the upper layers 1, 2, and 3 is equal to 1.948 $kg \cdot kg^{-1}$ i.e. it is larger by about 18%.
  The coordinates of Point 3 determine that the change of *t* in this point depends on the heat transfer only through the upper log's layers *(Figure 1 – right and Figure 2)*, but the change in *t* of central log's Point 4 depends on the heat transfer through all the log's layers.
  It is well known that the decrease in *u* of the non-frozen wood causes an increase in its temperature conductivity *a* (Chudinov 1966, 1968, Shubin 1990, Požgaj et al. 1997, Trebula – Klement 2002, Videlov 2003, Deliiski 2013b, Deliiski et al. 2015b). In our case, this means that the lower moisture content of the bottom logs' layers causes an accelerated heat transfer in radial direction to Point 4 in comparison to the heat transfer to Point 3. As a consequence, the temperature of 0 °C is reached earlier in Point 4 than in Point 3 during the log's cooling, which is an initial part of the logs' freezing process. The difference between the average moisture contents of the bottom and upper (wetter) layers of Log 2 is significantly less than of Log 1. That is why reaching 0 °C in Point 4 of Log 2 occurs only 5 min earlier than in Point 3 while Point 4 of Log 1 reaches 0 °C 60 min earlier than Point 3 (refer to *Table 1*).

- During the freezing of the free water in the log, specific sections of insignificant increases in wood temperature arise (Figure 9 and Figure 10). The reason for this is the impact of the latent heat of the free water, which is released during water crystallization and causes the warming up of the wood (Efimov 1985, Spears – Zollman 1990, Pahi 2010).
  The increase of the wood temperature, Δt_{LH}, which is caused by the released latent heat, for poplar Log 1 with moisture content u = 1.78 kg·kg^{-1} was measured to be equal between 0.012 °C and 0.047 °C. The duration of the warming up of the wood because of the latent heat release, τ_{LH}, was equal to 0.50 h for Point 1; 0.87 h for Point 2; 7.00 h for Point 3 and 8.25 h for Point 4 (*Table 2*).
  Analogously, the temperature increase Δt_{LH} for poplar Log 2 with lower moisture content u = 1.04 kg·kg^{-1} was measured to be equal between 0.058 °C and 0.128 °C. The duration τ_{LH} for this log was equal to 0.25 h for Point 1; 0.33 h for Point 2; 2.32 h for Point 3, and 4.70 h for Point 4.
  It can be noted that if the temperature data recording by Data Logger had been performed with intervals shorter than 15 min, the maximum wood temperature, t_{LH}^{max}, and time of its reaching under impact of LH on wood freezing would be different than these given in Table 2; thus, the values of Δt_{LH} for Log 1 probably would be larger than the values of Δt_{LH} for Log 2.
- After the whole amount of free water in the separate characteristic point freezes, the bound water in the wood starts to freeze. The decreasing of t in all points during the freezing of the bound water is smoother than the decreasing of t during the cooling of the logs before the starting of the water crystallization in the wood.
  When the 50 h freezing process ends, the temperature of all characteristic points of Log 1 and Log 2 reach a value equal to –27.9 ± 0.2 °C and –29.6 ± 0.1 °C respectively. Then the temperature t_m is equal to –29.1 °C and –30.1 °C respectively *(*see *Figure 4 and Figure 5).*

4 CONCLUSIONS

This paper describes a methodology for experimental research of the freezing process of logs. It also presents the first results from the usage of the suggested methodology for measurement of the change in the temperature and humidity of the processing medium, t_m and φ_m, respectively, and also in the non-stationary temperature distribution in 4 characteristic points of the longitudinal section of poplar logs during their 50 hours freezing in a freezer with an adjustable temperature range from –1 °C to –30 °C.

The precise instrumentation allowed, for the first time ever, the measuring of the impact the latent heat released by the free water on the log had on the warming up of the wood during water crystallization in the logs. The increase of the wood temperature caused by the released latent heat, for the studied poplar logs with moisture content u = 1.78 kg·kg^{-1} (Log 1) and u = 1.04 kg·kg^{-1} (Log 2) was measured to be equal between 0.012 °C and 0.047 °C for Log 1 and between 0.058 °C and 0.128 °C for Log 2. The impact of the latent heat release on the wood's warming up lasts from 0.50 h in the peripheral layers of the Log 1 to 8.25 h in the log's center and from 0.25 h to 4.70 h for Log 2.

It can be noted that in the accessible specialized literature, there is no information at all about the impact of the release of the latent heat on the wood freezing process.

Our experimental results show that the free water in the wood freezes in a temperature range between 0 °C and –1 °C. This fact did not prove the points of view of some of the above mentioned authors who claim the free water in the wood freezes at much lower temperatures.

Our results prove the popular belief that after the whole amount of free water freezes, the freezing of the bound water in the wood starts and that it takes place gradually during the rest time of the experiments.

The obtained experimental results will be used for the modification and verification of our 1D and 2D mathematical models of the freezing process of logs (Deliiski et al. 2014, 2015a). They could be very useful for the creation, solution, and verification of analogous models by other researchers.

The methodology suggested in this work could be used for experimental research of the freezing processes of different capillary-porous bodies. For example, for winter research concerning the impact of free water in live trees or in fresh concrete regarding freezing along the radius or the thickness at different ambient temperatures, etc.

REFERENCES

CHUDINOV, B. S. (1966): Teoreticheskie issledovania teplofizicheskih svoystv i teplovoy obrabotki dreveciny. [Theoretical Research of Thermo-Physical Properties and Thermal Treatment of Wood]. Dissertation for DSc., SibLTI, Krasnoyarsk, USSR (in Russian)

CHUDINOV, B. S. (1968): Teoria teplovoy obrabotki drevesiny [Theory of Thermal Treatment of Wood]. Nauka, Moscow, USSR, 255 p. (in Russian)

DELIISKI, N. (2004): Modelling and Automatic Control of Heat Energy Consumption Required for Thermal Treatment of Logs. Drvna Industrija, 55 (4): 181–199.

DELIISKI, N. (2005) Modeling and Automatic Control of the Process of Thermal Treatment of Logs. Information Technologies and Control, UAI, Sofia, 3 (2): 9–14.

DELIISKI, N. (2009): Computation of the 2-dimensional Transient Temperature Distribution and Heat Energy Consumption of Frozen and Non-Frozen Logs. Wood Research, 54 (3): 67−78.

DELIISKI, N. (2011): Transient Heat Conduction in Capillary Porous Bodies. In Ahsan A. (ed) Convection and Conduction Heat Transfer. InTech Publishing House, Rieka: 149–176, http://dx.doi.org/ 10.5772/21424

DELIISKI, N. (2013a): Computation of the Wood Thermal Conductivity during Defrosting of the Wood. Wood research, 58 (4): 637–650.

DELIISKI, N. (2013b): Modelling of the Energy Needed for Heating of Capillary Porous Bodies in Frozen and Non-Frozen States. Lambert Academic Publishing, Scholars' Press, Saarbrücken, Germany, 116 p., http://www. scholars-press.com//system/covergenerator/build/1060

DELIISKI, N., DZURENDA, L. (2010): Modelling of the thermal processes in the technologies for wood thermal treatment. TU Zvolen, Slovakia, 224 p. (in Russian)

DELIISKI, N. – BREZIN, V. – TUMBARKOVA, N. (2014): Modelling of the 2D convective heat exchange between subjected to freezing and to following defrosting logs and the surrounding environment. Annals of Warsaw University of Life Sciences, Forestry and Wood Technology, 86: 67–75.

DELIISKI, N. – BREZIN, V. – TUMBARKOVA, N. (2015a): Modelling of the 1D Convective Heat Exchange Between Logs Subjected to Freezing and to Subsequent Defrosting and the Surrounding Environment. Acta Silvatica et Lignaria Hungarica, 11 (1): 77–88, DOI: 10.1515/aslh-2015-0001 http://aslh.nyme.hu/fileadmin/dokumentumok/fmk/acta_silvatica/cikkek/Vol11-2015/06_deliiski_et_al.pdf

DELIISKI, N. – DZURENDA, L. – TUMBARKOVA, N. – ANGELSKI, D. (2015b): Computation of the Temperature Conductivity of Frozen Wood During its Defrosting. Drvna Industrija, 66 (2): 87–96, http://hrcak.srce/hr/index/php?show=clanak&id_clanak_jezik=207489 doi: 105552/drind. 2015/1351

DELIISKI, N. – TUMBARKOVA, N. – DZURENDA, L. – BREZIN, V. (2015c): Computation of the wood thermal conductivity above the hygroscopic range during freezing of the wood. Acta Facultatis Xilologiae, TU-Zvolen, 57 (2): 27–37, ISSN 1336-3824, DOI: 10.17423/afx.2015.57.2.03.

EFIMOV, S. N. (1985): Temperaturnaya zavisimost tepla kristallizacii vody [Temperature Dependence of the Heat of Water Crystallization]. Engineering-Physical Journal of the Institute of Physic-Technical Problems of the Nord, Siberian Department of the Academy of Sciences of USSR, Yakutsk, 49 (4): 658–664 (in Russian)

KHATTABI, A. – STEINHAGEN, H. P. (1992): Numerical Solution to Two-dimensional Heating of Logs. Holz als Roh- und Werkstoff, 50 (7–8): 308–312, http://dx.doi.org/10.1007/ BF02615359

KHATTABI, A. – STEINHAGEN, H. P. (1993): Analysis of Transient Non-linear Heat Conduction in Wood Using Finite-difference Solutions. Holz als Roh- und Werkstoff, 51(4): 272–278, http://dx.doi.org/10.1007/ BF02629373

KHATTABI, A. – STEINHAGEN, H. P. (1995): Update of "Numerical Solution to Two-dimensional Heating of Logs". Holz als Roh- und Werkstoff, 53(1): 93–94, http://dx.doi.org/10.1007/ BF02716399

PERVAN, S. (2009): Technology for Treatment of Wood with Water Steam. University in Zagreb (in Croatian)

PAHI, S. (2010): Understanding Specific Latent Heat. Lesson 4.3 – Understanding Thermal Latent Heat. Bidang sains dan matematik.
https://keterehsky.files.wordpress.com/.../ lesson-4.3-understanding-ther

POŽGAJ, A. – CHOVANEC, D. – KURJATKO, S. – BABIAK, M. (1997): Štruktúra a vlastnosti dreva [Structure and properties of wood]. 2nd edition, Priroda a.s., Bratislava, 485 p. (in Slovak)

RIVKIN, S. L. – ALEKSANDROV, A. A. (1975): Termodinamicheskie svoystva vody i vodyanogo para [Thermodynamic Properties of Water and Water Steam]. Energia, Moskow, 85 p. (in Russian)

SHUBIN, G. S. (1990): Sushka i teplovaya obrabotka drevesiny [Drying and Thermal Treatment of Wood]. Lesnaya Promyshlennost, Moskow, URSS, 337 p. (in Russian)

SPEARS, J. – ZOLLMAN, D. (1990): Fascination of Physics. Chapter 10: Thermal Energy in Matter. Benjamin/Cummings Publishing Co., 221–224, https://web.phys.ksu.edu/fascination/contents. html

STEINHAGEN, H. P. (1986): Computerized Finite-difference Method to Calculate Transient Heat Conduction with Thawing. Wood Fiber Science, 18 (3): 460–467.

STEINHAGEN, H. P. (1991): Heat Transfer Computation for a Long, Frozen Log Heated in Agitated Water or Steam – A Practical Recipe. Holz als Roh- und Werkstoff, 49 (7–8): 287–290, http://dx.doi.org/10.1007/ BF02663790

STEINHAGEN, H. P. – LEE, H. W. (1988): Enthalpy Method to Compute Radial Heating and Thawing of Logs. Wood Fiber Science, 20 (4): 415–421.

STEINHAGEN, H. P. – LEE, H. P. – LOEHNERTZ, S. P. (1987): LOGHEAT: A Computer Program of Determining Log Heating Times for Frozen and Non-Frozen Logs. Forest Products Journal, 37 (11-12): 60–64.

TOPGAARD, D. – SÖDERMAN, O. (2002): Self-diffusion of nonfreezing water in porous carbohydrate polymer systems studied with nuclear magnetic resonance. Biophysical J. 83: 3596–3606.

TREBULA, P. – KLEMENT, I. (2002): Drying and Hydro-thermal Treatment of Wood. Technical University in Zvolen, Slovakia, 449 p. (in Slovak)

VIDELOV, CH. (2003): Sushene i toplinno obrabotvane na darvesinata [Drying and Thermal Treatment of Wood]. University of Forestry in Sofia, Sofia, 335 p. (in Bulgarian)
http:/www.rotronic.com/humidity-measurement-feuchtemessung-temperaturmessung-data-loggers-datenlogger/hygrolog-hl-nt3.html

DE GRUYTER OPEN DOI: 10.1515/aslh-2016-0014 Acta Silv. Lign. Hung., Vol. 12, Nr. 2 (2016) 157–171

The Hungarian Wood-Based Panel Industry and its Impact on the Environment

Gábor LABORCZY* – András WINKLER

Institute of Wood and Paper Technology, Simonyi Károly Faculty of Engineering, Wood Sciences and Applied Arts, University of West-Hungary, Sopron, Hungary

Abstract – It is well known that worldwide deforestation has a negative impact on the global environment. Forests play an important role in producing oxygen as well as retaining gases that create the greenhouse effect. Forests primarily absorb carbon dioxide, the major air pollutant released by the industrial activities. Energy production is the major source of environmental contamination. In addition to reducing CO_2 emissions, another issue this industrial sector must tackle is to decrease the use of fossil fuels by substituting them with renewable, environmentally friendly energy sources. One of the answers to these challenges is the utilization of biomass as energy sources. However, biomass-based fuels include short bolts, split round-wood, pulpwood, bark and by-products of sawmilling, which are the raw materials for the wood-based panel industry as well. Wood utilization of the forest products industry has a major impact on the delayed release of carbon dioxide stored in the wood. All over the world, just as in Hungary, the wood–based panel industry mainly uses low quality wood resources and turns them into value added products. The elongation of the life cycle of low quality wood materials decreases CO_2 emissions, thus significantly contributing to environmental protection. Furthermore, it is assumed that raw material demand of the wood-based panel industry could be satisfied by focusing on sustainable forest management and well-planned reforestation. Additionally, special energy-plantations may provide extra wood resources, while waste and other non-usable parts of trees contribute to the effective and economic operation of biomass utilizing power-plants.

This paper summarizes the current situation of the Hungarian wood-based panel industry and discusses the effects of the panel manufacturing processes on the environment. Also, it outlines the possible future of this important segment of the forest products industry.

wood-based panel industry / raw material production / biomass utilization / forests for energy production / short rotation plantations / carbon dioxide emission / forest management

Kivonat – A magyar falemezipar jelenlegi helyzete és környezeti hatásai. A természeti környezet és ezen belül az erdőterületek további rombolása visszafordíthatatlan káros következményekkel jár. Az erdő egyik fontos szerepe az éltető oxigén termelése és az üvegházhatású gázok, különösen a légkörben lévő széndioxid megkötése. A környezeti terhelés egyik legjelentősebb tényezője az energia előállítás. E téren a kibocsátott széndioxid mennyiségének csökkentésén túl jelentős kérdés a fosszilis energiahordozók felhasználásának kiváltása az újratermelhető környezetbarát tüzelőanyagra átállított biomassza erőművekkel. Ezeknek az erőműveknek az egyik meghatározó alapanyagai az ilyen módon hasznosított faanyagok, melybe beletartoznak a falemezipar alapanyagbázisát jelentő sarangolt ipari választékok és erdei aprítékok is, rosszabb esetben az erdőgazdaság által kitermelt bármely ipari célra

* Corresponding author: lgabi2008@gmail.com; H-9400 SOPRON, Bajcsy-Zs. u. 4., Hungary

egyébként még hasznosítható faanyag is. A fában megkötött szén-dioxid minél későbbi felszabadításában a fafeldolgozásnak és a fahasználatnak fontos szerepe van. A legsokoldalúbban gyengébb minőségű faanyagot hasznosító iparág a Magyarországon is nagy múltra visszatekintő falemezipar. Az iparág a faipar egyik meghatározó ágazata. A hazai erdőgazdálkodás fenntarthatóságot szem előtt tartó tervszerű fejlesztésével megoldható a falemezipar számára megfelelő minőségű és mennyiségű alapanyag biztosítása, valamint energetikai ültevények telepítésével, a felhasznált faanyag összegyűjtésével, a keletkezett hulladékok és az ipari célra már nem alkalmazható faanyag felhasználásával a biomassza erőművek hatékony és gazdaságos működtetése is.

lemezipar / falemezipari alapanyag-termelés / biomassza hasznosítás / energiaerdők / szén-dioxid kibocsátás / erdőgazdálkodás / falemezipar jövőképe

1 INTRODUCTION

Forests are important habitats that are home to diverse forms of life that are governed by the law of nature and human interference. Over the past several decades societies have recognized that further destruction of the natural environment, including deforestation, has a catastrophic effect on the well-being of human life. Two important roles of forests are oxygen generation and the carbon dioxide retention (Shmulsky et al. 2011). For the latter, wood products manufacturing and utilization are key factors in retaining the stored CO_2 by delaying natural decay and burning (Nieder et al. 2008). Due to the intense harvesting of trees over the last thirty-year period, the Earth's forested areas has decreased by an area the size of Hungary (~ 90.000 km^2) annually (Molnár 2005; Barbu 2011). To stop or reverse this trend, a new philosophy suggested decreasing the volume of harvesting and substituting solid wood with synthetic or man-made materials. This practice resulted in the intensive use of metals, synthetic polymers, reinforced concrete, and other types of construction materials. However, the comparison of energy consumption to produce these construction materials shows unfavourable characteristics. If we take the 580 kWh energy required to produce one metric ton of solid construction wood as unity, then the equivalent energy necessary to produce one ton of brick, cement, plastic, glass, steel and aluminium takes 4, 5, 6, 14, 24, and 126 units, respectively (Molnár – Börcsök 2011). Additionally, if we consider the environmental pollutants emitted by the manufacturing processes of these man-made construction materials, the negative impact on the environment is quite clear. In Hungary the only source of renewable material is the forest. Furthermore, timber production requires less energy and can be utilized without generating harmful wastes. Consequently, it is the interest of any society to manufacture products made of wood and that it should be using these wooden products for as long as it is possible (Hoadley 2000).

An excellent example of wood usage in construction is the lookout tower of Pyramiden summit built in 2013 near Klagenfurt at Worth Lake. The 100 m high superstructure is currently the highest wooden structure in the world. Regional timber sources certified by the PEFC were used to erect the tower (Pyramidenkogel 2013).

In Hungary the consumption of wood products (round-wood equivalent) is about 0.7 m^3 annually per person. This figure corresponds to the overall world average, though it is lagging behind the consumption of 1–1.2 m^3 per year reported by more developed countries (Molnár 2011).

2 HUNGARY'S CARBON DIOXIDE EMISSIONS

According to the report of the European Council issued in April 2, 2013, the 200 Hungarian manufacturing companies participating in the European Union's CO_2 regulations (EU ETS) released 21 million tons of CO_2 into the atmosphere in 2012 *(Figure 1).* This means a more than 6% decrease in CO_2 emissions compared to the year 2011. The average emissions of the 27 EU countries shows 1.4% decrease during the same period. While countries like Great Britain and France had increased emissions, Germany stayed on the same level. Poland and Italy decreased their CO_2 emissions, but by fewer percentage than Hungary did. It should be noted, however, that the decrease in Hungarian emissions is mainly caused by a decrease in industrial production, rather than energy efficiency initiatives in manufacturing processes.

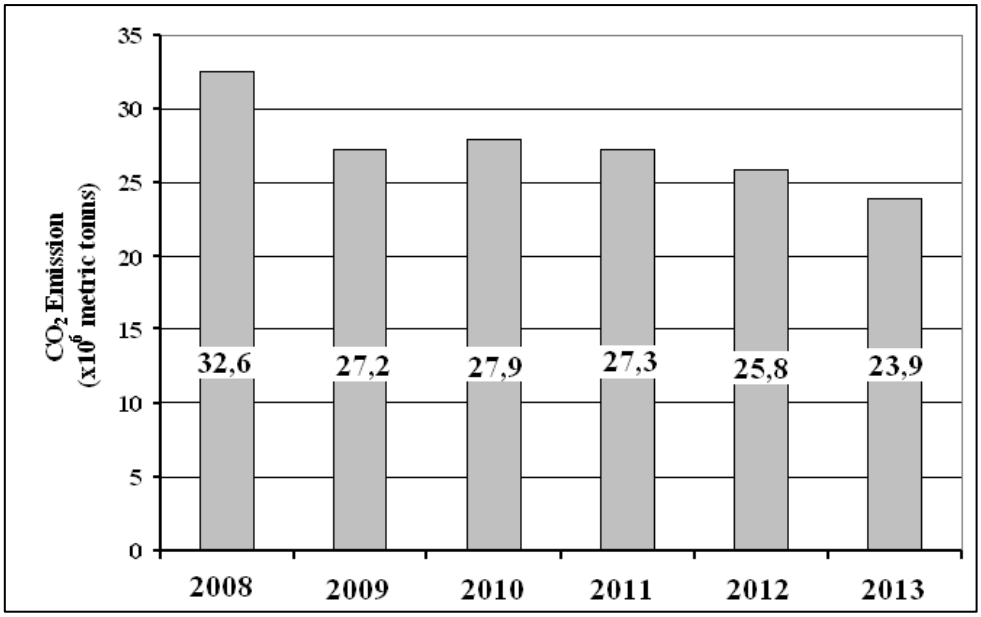


Figure 1. Hungarian industrial carbon dioxide emissions (Source: KSH STADAT 2015)

According to section 3.3 of the Kyoto Agreement report, since 1990 forest operations (including natural growth, plantations and harvesting) have resulted in 1.26 million tons of net CO_2 absorption. Furthermore, section 3.4 of this report states that other forest management practices resulted in an additional 1.68 million net tons of carbon retention. To adhere to the regulations of the Kyoto Agreement, control of gas emissions that generate the greenhouse effect, is necessary. This can be achieved efficiently by the plantation of new forests (NÉBIH 2012).

3 THE PATHWAY OF WOOD-STORED CARBON DIOXIDE UNTIL RE-EMISSION

Like other plants, trees produce organic materials, absorb water from the soil, capture carbon dioxide from the atmosphere, and release oxygen through photosynthesis. Then, through the transformation of natural sugars, trees build up their different organic compounds. The stored CO_2 in the woody tissues is released during natural decomposition of the material or by incineration (Hinckley et al. 2011). Carbon dioxide emissions are a major cause of the greenhouse effect. Therefore, elongated CO_2 retention is a crucial factor regarding climate change. It is a common interest to keep the stored CO_2 within the woody tissues for as long as possible (Batjes 1999). In this context, the wood-based panel industry has important functions; as represented by the explanatory diagram on *Figure 2.*

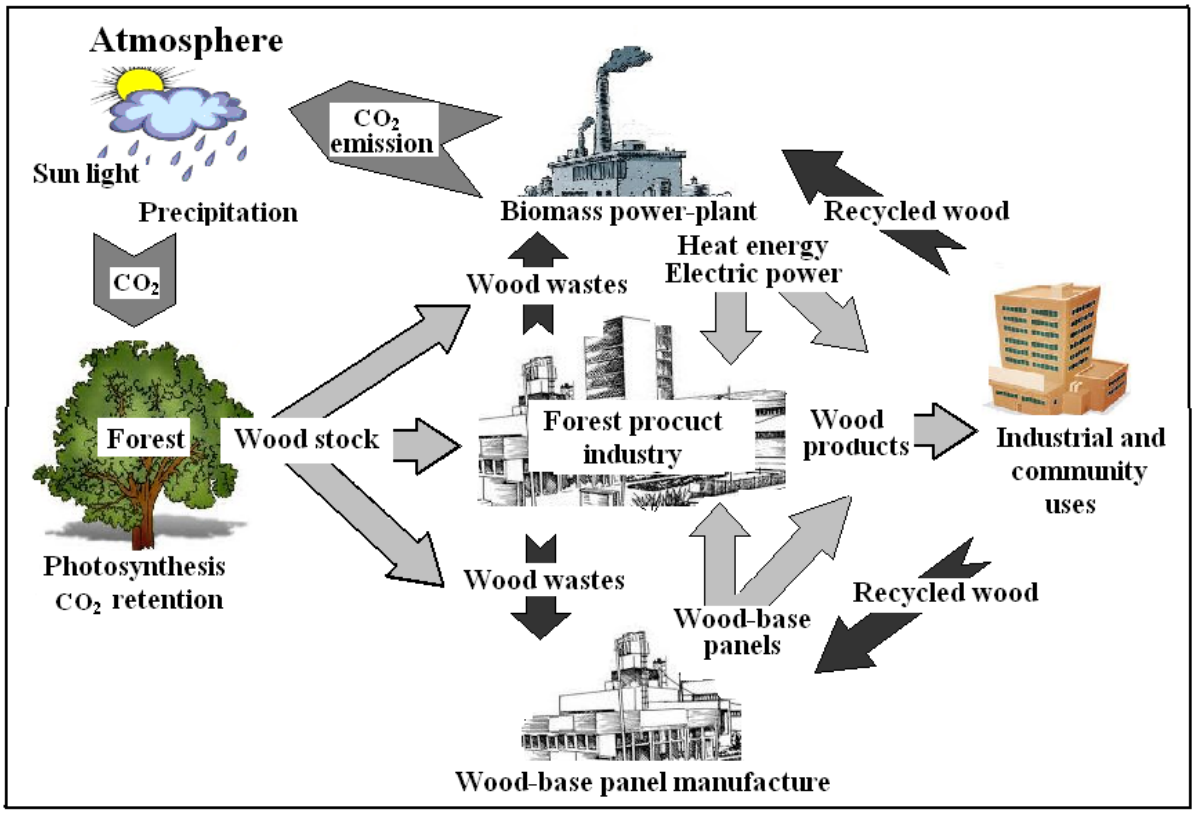


Figure 2. The cycle of carbon dioxide stored in wood. (Source: own construction)

The wood processing industry uses different kinds of solid wood materials harvested from forests. These raw materials contain stored CO_2, and when in the form of different commodities or products, ensure the retention of carbon for a longer period of time.

The other form of utilization of forest resources is energy production. Firewood, forest residuals, and industrial wastes or residuals like bark, wood slabs, etc., are burned to generate heat or electrical energy (Sdrjevic 2007). The forest products industry generally uses its own residues as a supplemental energy source. However, the drawback of this practice is that the stored carbon is immediately released into the atmosphere in the form of CO_2.

The most favourable wood utilization, in view of the carbon cycle, includes the use of wood that is below industrial grade, the incorporation of wastes from other wood processing technologies, and the reuse of former structural wood products (recycled wood) in the wood-based panel manufacturing processes. Thus, the immediate CO_2 emission is eliminated, value-added products are produced in the construction and furniture industries, and long-term carbon storage in wood is ensured.

If we want to emphasize the positive role of wood products in climate protection, then the forest products industry should be run on continuous positive carbon retention. The civilization carbon cycle[1] of wood products is continuously positive if the carbon entering the system is less than the carbon being released or less release than carbon intake occurs (Schöberl 2012). This requires that wood products remain continuously in the civilization carbon cycle for an increased period of time. This may be achieved by the utilization of recycled wood in the wood-based panel industry and decreasing the volume of incinerated wood. However, achieving these goals makes the involvement of judicial and economical regulations necessary.

[1] civilization carbon cycle: the flow of carbon, stored in wood products, caused by human activities

European Parliament and Council renewable energy source utilization directives require that Hungary produce a minimum of 13% of its overall energy consumption from renewable energy sources by the year of 2020 (USZT 2010a).

In addition to CO_2 emissions, another issue is replacing fossil energy carriers with renewable alternatives. Biomass combustion energy plants use environmental friendly fuels that originate mostly from renewable sources (Scurlock et al. 1993). Biomass primarily originating from agriculture and forestry are used to generate heat energy through burning. Other renewable energy sources include biogas, biodiesel fuels, as well as geothermal, solar, wind and hydro energies. In Hungary, 80% of energy currently produced with renewable sources comes from biomass, with about 50% of this volume being wood (USZT 2010b). This amount includes wood resources that may be used for wood-based panel manufacturing, such as short bolts, split round-wood, forest residues, and other types of harvested trees that are still utilized by industry.

Environmental protection is an additional concern that runs parallel with the energy problem. Changing climate conditions require particularly close attention. Hungary volunteered to increase its energy consumption from renewable sources by 14.65% by the year of 2020. This goal can only be achieved if the country produces approximately 3-3.5 million tons of solid biomass annually for the purpose of generating electricity. This biomass volume is equivalent to 7–10% of the country's imported natural gas. According to another study, 10-12 million tons of biomass are needed altogether to achieve the objectives of this energy plan (Lontay 2011). Considering the current yield of fire wood harvesting, the volume of by-products and other waste materials, it is forecasted that at least 100,000 ha new energy-wood plantations would have to be created to satisfy this increased demand. Also, all biomass production should be done by sustainable forest and agricultural operations.

There is great potential to produce biomass on plots released from traditional agricultural cultivations. These areas are possible growing sites for new energy-wood plantations and other types of energy-plants. Biomass production in Hungary shows encouraging features. Within this, based on the traditional forest managements and operations, dendromass production for energy use is particularly feasible.

On the other hand, the extensive establishment of biomass operated energy plants may cause wood shortages that impact the wood processing industry in the region. (De Cock 1999). A typical example of this situation occurred in Austria during the Klagenfurt biomass energy plant project realization where 150 wood processing manufacturers in Carinthia requested guarantees that their wood supply would not be affected by the biomass energy plant that required 300,000 m^3/ of fuel wood per year in order to operate. Prognoses revealed that there would be a round-wood deficiency of about 3 million m^3 in Carinthia by the year of 2020. Between 2003 and 2011, the prices for energy–wood increased by 50% and further increases in fuel wood prices are expected (Klagenfurti Biomassza Erőmű 2013).

Further opportunities in environmental protection for the wood-based panel industry

Wood-based panel production, like all industries using wood, place pressure on a resource that is vital to oxygen creation and environmental protection.

In the quota calculation method introduced in the new section of the Kyoto convention, the quantity of wood-based panel products containing stored carbon of a given year has already been included in the quantity of stored carbon prescribed for the country (Király – Kottek 2013). Therefore, wood-based panel production has become more important in this aspect as the country may obtain considerable additional income from the sale of its unused quotas.

Further environmental protection may be achieved through the marketing of Hungarian wood material and wooden products to familiarize consumers with the beneficial characteristics of wood products; this would also help fortify environmentally friendliness in product choice.

4 THE HUNGARIAN WOOD-BASED PANEL INDUSTRY

The current situation of wood-based panel manufacturers

The economic recession had a serious impact on the Hungarian forest products industry. Since 2005, production volume and net revenue generation show ups and downs, but on average the trend is decreasing. First, the volume of production decreased by 10%; then in 2008, there was a significant increase (22.1%) compared to the production volume before 2005. The largest drop in production (29%) occurred in the following year due to the recession in West Europe. Domestic and export sales dropped by 24 and 40%, respectively. In recent years the demand for export wood products increased by 25.7%, while domestic sales rose only slightly. Since then, production and revenue generation of the forest products industry shows decreasing trends; however, the severity is not so pronounced (FAOSTAT 2005–2015).

Due to changing market and economic circumstances, revenue generation varies year-by-year for important segments of the forest products industry. In 2000, wood-based panel manufacturing was second, with 29.5% share of the total revenue generated by the industry; while construction joinery manufacturing was the first (37%). Based on sales data obtained during the first half of the year 2012, construction joinery product manufacturing preserved its top position, although its overall share decreased (33.4%), while lumber production took the second place (24.6%), and wood–based panel manufacturing dropped to third (23.2%). Despite the drop in the production of important wood products, the import of such commodities is still significant.

Generally, the volume of production is governed by the demand. The decreased raw material need of the largest customers (construction and furniture industries) decreased the demand for wood-based panels. Diagrams in *Figure 3* clearly indicate this trend for a five-year period. The main reason for the drops in production is the closure of manufacturing facilities like the INTERSPAN particleboard plant at Vásárosnamény. The closing of domestic manufacturing facilities triggered some increase in the import of wood base-panels within these weak market circumstances.

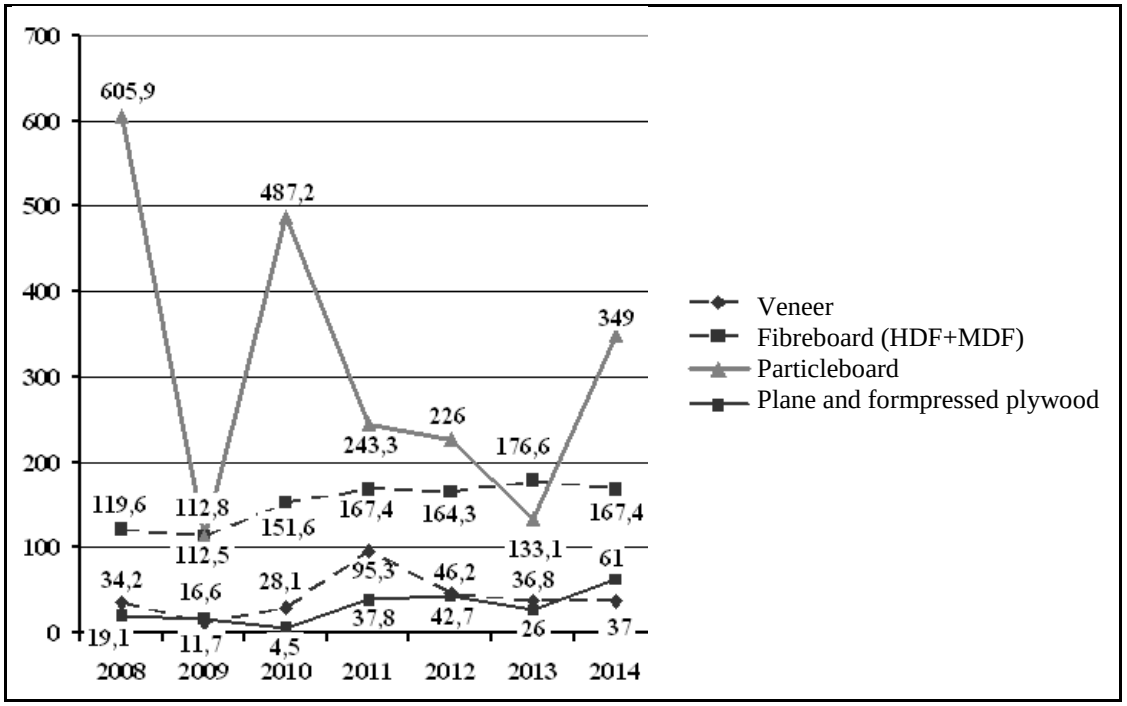


Figure 3. The annual production volume of selected wood-based panel products. Oy: Production volume (x $10^3 m^3$); Ox: Years Surveyed (Source: FAOSTAT data bases 2015)

Despite the decrease in wood-based panel production, production began increasing again in recent years (*Table 1*). For the same period, the foreign trade balance of wood products is compiled in *Table 2*. The substantial negative balance of sawmill products is due to the mill closures that caused increased imports of softwood and hardwood lumber and timber. For the revitalized domestic sawmill industry and for the structural composite manufacturers, this means a possible market area.

Table 1. Production volume of selected wood products (x 10^3 m^3)

Wood Products	2008	2009	2010	2011	2012	2013	2014
Particleboard	605.9	112.8	487.2	243.3	226	133.1	349
Fibreboard (HDF+MDF)	119.6	112.5	151.6	167.4	164.3	176.6	167.4
Veneer	34.2	11.7	28.1	95.3	46.2	36.8	37
Plane and form pressed plywood	19.1	16.6	4.5	37.8	42.7	26	61

(Source: FAOSTAT data bases2015)

Table 2. Foreign trade balance of wood products (x10^3 m^3)

Wood products	2008	2009	2010	2011	2012	2013
Round-wood	537	628	610	832	922	13,012
Sawn wood	–223	–364	–251	–246	–81	–140
Wood-based panels	51	–64	19	4	–149	–148

(Source: FAOSTAT data bases 2015)

The overall European economic recession affected all sectors of the forest products industry and destabilized them financially. Thus, the biggest consumers of panel products, the furniture and construction industries, were also distressed. Furthermore, the raw material producing forest management enterprises were also indirectly negatively motivated.

5 DEVELOPMENT OF MANUFACTURING FACILITIES

Hungary had a great tradition of wood-based panel manufacturing, but through the privatization of state owned enterprises, several smaller plants seized to exist, while the larger facilities were soon acquired by foreign companies. Nevertheless, these mergers did not automatically mean survival. A typical example of such a situation occurred in 2011 when Interspan Kft. in Vásárosnamény was shut down by the Swiss KronoGroup. The owner could not see guarantees for the return of investments totalling about 15-20 billion HUF that was needed to update the entire manufacturing technology (HVG 2010). Instead, a new OSB plant is being built at the same location and it is expected to begin operations in 2016.

For several other Hungarian companies, merging with foreign enterprises meant not only survival, but prosperity as well:

- In 1994 the available wood-based panel manufacturing capacity triggered the formation of Derula Manufacturing and Trade Co. The Italian affiliated manufacturing facility is operating in Szolnok, in Central Hungary (Derula 2013).
- Since 1995, OWI Zala Bt. has been operating as a subsidiary of the German OWI GmbH. & Co. KG. Their products are usually marketed in Europe, but thorough the mother company, they can sell to overseas market as well (OWI ZALA 2013).

- In 2004 the former Fibreboard Manufacturing Co. of Mohacs (MOFA) and KRONOSPAN Holding Limited formed KRONOSPAN-MOFA Hungary Fibreboard Manufacturing Co. (MOFA 2013).
- Szombathely based FALCO particle board plant, established in1939 as a small-scale sawmill operation facility, joined KRONOSPAN Holding in 2007. Since then, it has turned out to be the largest furniture and structural panel manufacturer in Central-East Europe (FALCO 2013/a).

The primary goals of all modern manufacturing facilities are to use high technology and to optimize the price/quality ratio of their products. Beyond these, environmental protection is gaining significance too as customers increasingly prefer products manufactured by environment friendly technologies. There are several establishments like FSC[2], CARB[3], and PFC[4] that evaluate and certify the use of environmentally friendly technologies. The majority of Hungarian wood-based panel manufacturers fulfil the requirements of these environment protective regulations.

Due to constant competition, market success requires significant investment and technological development. Some Hungarian wood-based panel manufacturers won state and European Union grants although these required some self-financing as well. Derula LLC received financial support for doubling its forest area in 2001, and for doubling production capacity in 2013 (HVG 2011; Derula 2013). In 2013, the MOFA-Hungary LLC received financial support to switch from using the wet process to a more environmentally friendly dry fibreboard manufacturing technology. This increased production capacity and by-product utilization (MOFA 2013). A grant received by FALCO Zrt. in 2013 helped them develop innovative surface finishing technologies and contribute to quality and production improvements (FALCO 2013/b). At Furner-Pack LLC, the upgrade of production equipment was financed through a grant (Furner-Pack 2013).

There are two segments of the industry competing for the same wood raw materials, namely the wood-based panel and the bioenergy generating enterprises. Whether or not Hungarian forest management would be able to fulfil increased demand in the long term is questionable.

7 HUNGARIAN FOREST MANAGEMENT

As a consequence of the Trianon peace treaty at the end of World War I, Hungary became the least forested country in Europe with only 11.8% of its territory under forest cover. With significant efforts and investments in plantations, the percentage of forest cover reached 20.8% by 2014. Still, this is only 35% of the European average and compared to the forested areas of Central-European countries like Slovenia (62%) or even Poland (30%), it is a modest value. The long term strategy of Hungarian forest management is to attain 26–27% forest coverage for the country (FAO 2015; Barbu 2011; NÉBIH 2015).

An increase of forest cover yields an increase of current growth and an increase in usable growing stock. However, exploitation is limited to 62.7% of the total forested area designated for industrial utilization. The remaining areas are protected (36.2%) and recreational (1.1%) forests where harvesting for industrial purposes is not allowed (NÉBIH 2014). The volume of tree harvesting is about 70–75% of the current grow *(Figure 4)*.

[2] FSC (Forest Stewardship Council) certifies the use of sustainable forestry operations by monitoring the responsible wood utilization until it reaches the end users.
[3] CARB (California Air Resources Board) certifies the conformance to air quality and contamination regulations.
[4] PEFC (Pan European Forest Certification Scheme) certifies that wood raw material originates from sustainable forestry.

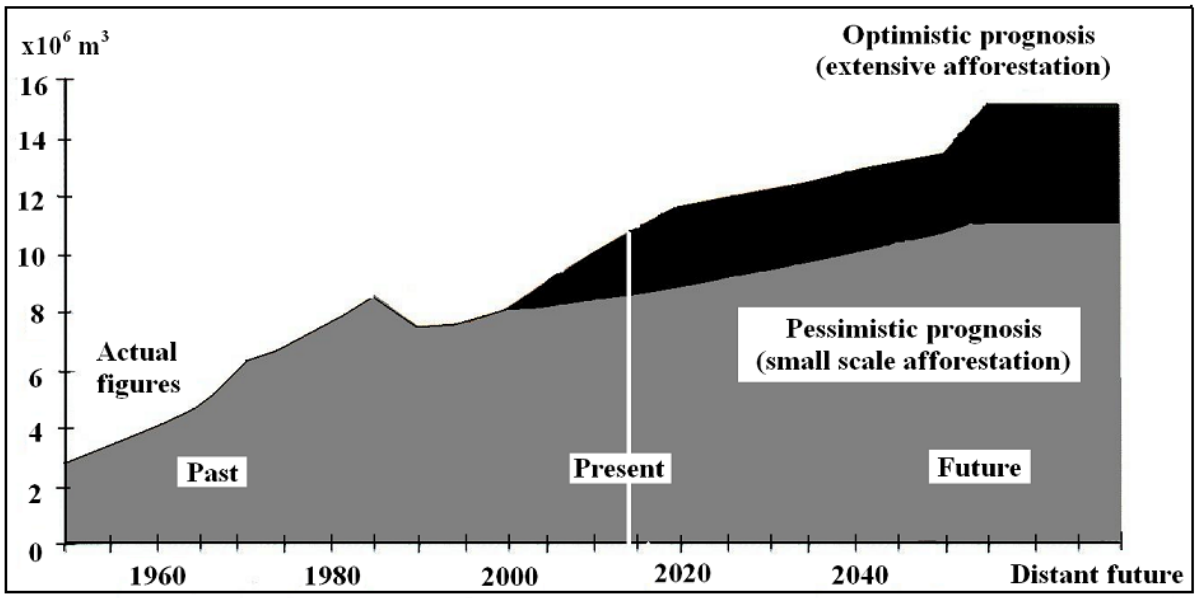


Figure 4. Prognosis of Hungarian timber yield (Source: ÁESZ 2002, p. 62)

Figure 4 shows the actual past, present, and the expected timber yield of the future. The prognosis includes two scenarios. It seems that extensive afforestation will be realized. This means that if the current trend continues, forest enterprises will produce sufficient volumes of wood to supply all domestic sectors of the wood processing industry.

The species composition of Hungarian forests is uniquely diverse (*Figure 5*). Angiosperms are dominant (88.9%) and only 11.1% of the total area are covered with conifers. Native hardwoods like oak, turkey-oak, beech and hornbeam comprise 63% of the forest. The remaining 37% is covered with introduced wood species such as black locust, red-oak, as well as some spruce and pine species. Consequently, this diversity in species determines the composition of split round-wood and fuel wood materials.

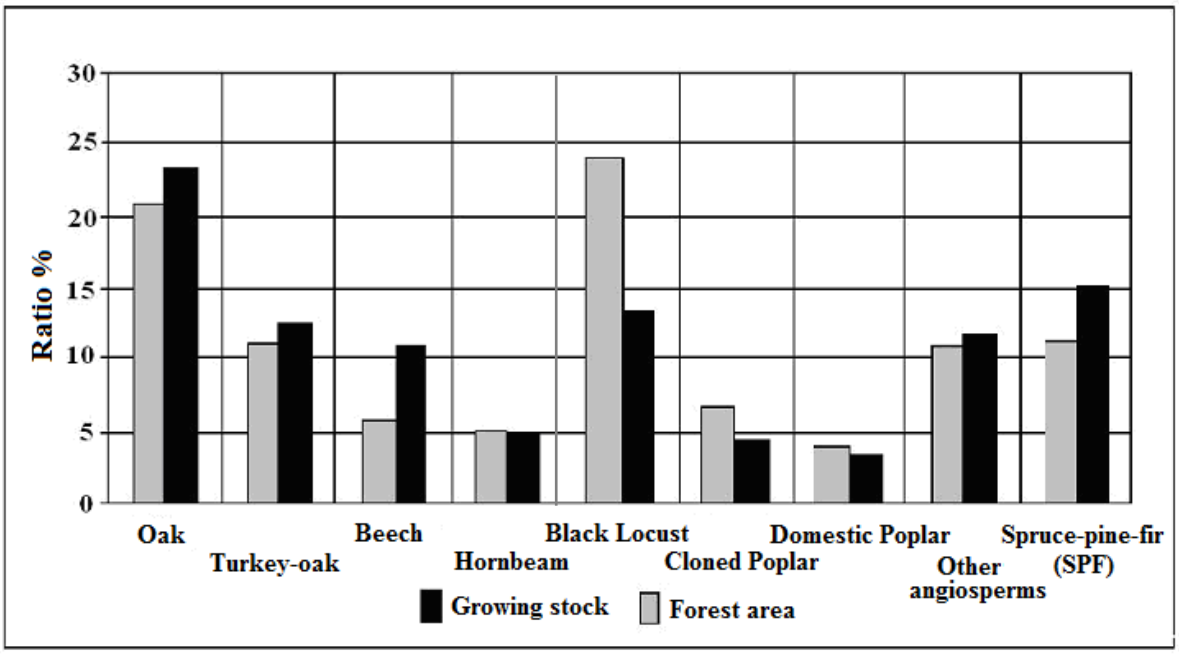


Figure 5. Species distribution of Hungarian forests and growing stock (Source: NÉBIH 2014)

It is worth considering afforestation or plantation forest management on land abandoned by agricultural cultivations because of unfavourable characteristics such as sloping, hard to approach locations, or game-damaged territories. These available areas may be as large as 650-700 kha (Molnár et al. 2008). Plantation trees show improved characteristics within species. For black locust and cloned poplar, the average height increase is about 20%, while in terms of the diameters, a 30% improvement was reported (Németh et al. 2004).

The ratio of domestic and cloned poplar species in the growing stock increased from 7.3% to 10% due to the long term investments of financially stable panel manufacturing companies like Derula LLC in Szolnok. However, the volume of growing stock of beech, which has a longer rotation period, reduced by 0.3% (NÉBIH databases 2010–2014. year). Beech is the most valued raw material of wood-based panel manufacturing. According to a report, the area of good quality beech forest might decrease further (Molnár 2004).

The suitability of two readily available species, the turkey-oak and black locust, for medium density fibreboard (MDF) manufacturing has already been researched. Experimental results indicated appropriateness (Winkler 1999). A poplar-black locust-oak-Scotch pine mixture was successfully tested for particleboard production (Winkler 1998). Unfortunately, none of the above mentioned research results reached commercialization. Wood processing wastes could be a supplementary raw material source of the wood-based panel industry. Wastes or residues generated by different wood processing technologies are usually incinerated to produce heat or electrical energy. Instead of burning wood wastes, the creation of value added products and elongated carbon retention are the key arguments for building these by-products into wood-based panels. All of the segments of the forest products industry generate wastes like sawdust, wood bark, etc. Outcomes of completed research works demonstrated the viability of such wastes for particleboard production. Despite these results, no industrial utilization has happened yet (Winkler 2005a).

Inorganic bonded wood composite panel manufacturing is another major sector of the wood-based panel industry. Several research results demonstrated that wastes produced by other segments of the wood processing industry and domestic hardwoods like black locust and turkey oak can be successfully converted into inorganically bounded panel products. For gypsum bonded fibreboard, the use of recycled flue-gas, gypsum and fibre-silt creates not only a good quality panel, but eliminates environmental hazards as well (Winkler 2005b).

Experiments with fibrous plastic wastes were conducted at the fibreboard manufacturing plant of Mohacs. Results showed that residues of packaging material processes can be transformed into structural panels (Winkler et al. 2005).

The volume of green trees increased continuously during the past years. By now, the growing stock is about 13.1 million gross m^3 annually (NÉBIH 2014). This increase is partially due to sustainable harvesting, afforestation practices, and the conversion of forest structures. Additionally, less demand for woody raw materials resulted in less extraction than allowed by the annual felling target.

The primary purpose of energy-forests is to provide fuel for biomass operated power-plants. However, such special forests may also contribute to the raw material supply for wood-based panel manufacture if appropriate technology is used for the conversions.

The composition of the 2338.3 ha of recently planted energy-forests has three dominant species. Namely, they are willow, black locust and poplar species *(Figure 6).*

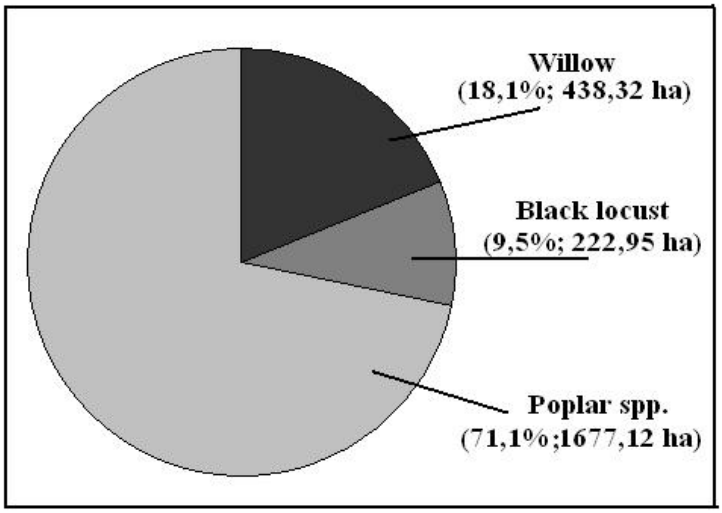


Figure 6. – Species composition of planted Hungarian energy-forests. (Source: NÉBIH 2013)

Table 3. The use of wood-based biomass in Hungary

Application type	Domestic raw materials	Imported raw materials
Direct use for energy production	3.5 Million m^3 firewood 5,000 tons pellets 2,000 tons wood briquettes	78,000 m^3 firewood 15,000 tons and other archives
Indirect use for energy production (waste)	65,000 m^3 wood waste for energy purposes	240,000 tons wood waste for energy purposes
Short rotation energy plantation	3,398 m^3 (poplar and willow)	–
All energy	656.3 ktoe	89.5 ktoe

(Source: NÉBIH 2014)

The use of wood-based biomass is based not only on domestic available supplies, but also on additional imported sources (*Table 3*). The latter could be reduced or even completely replaced by further afforestation, which could affect major cost savings.

Further possibilities to increase the area of plantation forests are:

- Drained flood-plains and flood-prone areas are excellent growing sites for near-to-nature plantation forests.
- By controlling water supply on former flood-plains, the non-native species may result in plantations having different growing cycles.
- Planting drought resistant (xeromorphic) non-native species on arid growing sites may increase dendromass production.

The major advantage of plantation forests is that fast growing, non-native species can be cultivated. This provides quick return of investments for the owners and lessens the extractions from the primary forests. However, there is a hazard that non-native species become invasive and may transmit dangerous infections to which the indigenous trees are not immune (OEE 2012).

The major financial basis of forest management and forest conservation is the revenue generated by forest sales (Gémesi 2005). Only 60% of the volume allowed by the harvesting plans is realized as gross logging. From this about 1.5–3% are high quality veneer logs that are the raw materials for veneer-based wood panels and decorative veneers (Németh – Szabadhegyi 2003).

Besides wastes/residues of the forest products industry, the raw materials of particleboard, fibreboard, cellulose and paper manufacture are stacked and split round woods. These comprise 20% of the total volume of harvest, while the fuel wood share is 50% (NÉBIH 2010–2015). These two forest materials gained importance because of the widespread use of wood as fuel for energy generation. However, split round wood use for wood–based panel manufacturing generates significantly higher revenue than can be achieved by burning (Fekete 2004).

The volume of industrial use saw logs is about 15–18% of the total harvest. The highest quality saw logs are usually exported though. The price and utilization of the domestically available stock may be affected by foreign polices of forest management. This indirectly harms the local wood–based panel industry. For instance, in Poland the profitability of the forest products industry and workplaces are endangered because German entrepreneurs buy out Polish forest lands near the border. They pay a higher price than the local market value because in Germany the exploitation of forests had been limited (Barabás 2013). It is expected that in Romania the significant volume of log and timber products export will be limited to protect the raw material supply of the local forest products industry (Balogh 2013; Barbu 2013). These phenomena can manifest in Hungary too and may influence the wood supply and the current situation of the wood processing industry.

8 FUTURE OF THE WOOD-BASED PANEL INDUSTRY

Reviewing the raw material supply, as well as the technological and ownership situations of the wood-based panel industry, several trends may be recognized. The interactions between these deterministic factors can influence the future of this segment of the forest products industry. Some facts regarding the existing or expected circumstances may be as follows:

- The quantity of available wood raw material is continuously increasing due to sustainable forest operations. By the expansion of plantations and private forests, a significant volume of good quality industrial wood may ensure the raw material supply of the panel industry.
- The major manufacturing facilities were acquired by foreign companies. The locally produced raw material decreases transportation cost, increases profitability and may motivate the owners to further invest in technology development for which EU and state grants may be available.
- Belonging to large foreign enterprises has a definite advantage. Domestic products can reach an extensive foreign market via the mother company.
- The wood-based panel industry already operates in an environmentally conscious manner. The significance of this segment of the forest products industry may increase in the future. However, its raw material demand is certainly competing with the needs of biomass utilizing power-plants. Plantation of short rotation trees on private and energy forests is one of the solutions for this problem.
- There is a great potential to supplement the raw material source by recycling wood, though it requires a well-developed collection, storage, and redistribution network.
- Finally, the export of wood resources may harm the supply of the domestic wood-based panel manufacturers, thus it should be limited to a certain extent.

9 SUMMARY

Nowadays environmental protection plays as important a role in industrial activities as profitability does. The irreversible destruction of the natural environment, including

deforestations, have a catastrophic effect on nature and on the well-being of human life. The forests and the comprising wood species produce oxygen, the basis of life, and absorb CO_2 gas, which is a major contributor to the greenhouse effect. The most harmful load on the environment is generated by energy production. In an effort to decrease CO_2 emissions, non-renewable energy sources the majority of these power plants use, like coal, crude oil and natural gas, need to be replaced by renewable, environmentally friendly fuel. The energy sources of biomass power-plants come from forest operations and agricultural production. It includes short bolts, split round-wood, pulpwood, bark and by-products of sawmilling. These materials are raw materials for the wood-based panel industry. The delayed release of CO_2 in woody materials requires the long-term use of wood products containing stored carbon. Traditionally, the wood-based panel industry of Hungary is one of the most effective segments of the forest products industry in the utilization of low quality wood resources. Its products, manufactured in an environmentally conscious manner, satisfy the international regulations of clean production processes and quality. The raw material demand of the wood-based panel industry could be satisfied with the current afforestation practice in the country. New special energy-plantations not only provide extra wood resources, but the wastes and other non-usable parts of trees contribute to the profitable operation of biomass utilizing power-plants.

REFERENCES

BALOGH, L. (2013): Időszakosan leállítaná a faexportot a román kormány [Periodically stopping the export of wood from the Romanian Government], Krónika.ro; (in Hungarian) Online: http://kronika.ro/erdelyi-hirek/idoszakosan-leallitana-a-faexportot-a-kormany (accessed: 01.02. 2014)

BARABÁS, T. (2013): Németországba vándorolnak a lengyel erdők [Polish forests migrate to Germany], Napi.hu; (in Hungarian) Online: http://www.napi.hu/nemzetkozi_gazdasag/nemetorszagba_vandorolnak_a_lengyel_erdok.557113.html (accessed: 10.02. 2014.)

BARBU, M.C. (2011): Actual developments of the forestry and wood industry. Proceeding of 8th ICWSE, Brasov. 615–624.

BARBU, M.C. (2013): Forest and Wood Industry in Romania. Proceeding of 9th ICWSE, Brasov. 3–6.

BATJES, N.H. (1999): Management options for reducing CO2 –concentrations in the atmosphere by increasing carbon sequestration in the soil, International Soil Reference and Information Centre, Wageningen. 46–47.

ÁESZ (2002): Magyarország erdőállományai 2001. [Forest stands in Hungary 2001], Állami Erdészeti Szolgálat, Budapest. 250 p. (in Hungarian)

DE COCK, F. (1999): Topical Developments in the European Wood-Based Panel Industry, 2nd European Wood-Based Panel Symposium, Mobil Schmierstoff GmbH, Hanover. 1–9.

DERULA (2013): Derula Gyártó és Kereskedelmi Kft. honlapja Online: http://www.derula.hu/versenykepesseg_javitas.html (accessed: 02.11.2014)

FALCO (2013/a): Falco Zrt. honlapja Online: http://www.falco-woodindustry.com/main.php (accessed: 12.10.2014)

FALCO (2013/b): Falco Zrt. honlapja Online: http://www.falco-woodindustry.com/main.php (accessed: 12.10.2014)

FAOSTAT (2015): http://faostat.fao.org/site/626/DesktopDefault.aspx?PageID=626#ancor (accessed: 01.12.2015)

Furnér Pack (2013): „Furnér-Pack" Kereskedelmi Kft. honlapja Online: http://www.furner-pack.hu/modules.php?name=furnerpack_palyazat (accessed: 01.10.2014)

GÉMESI, J. (2005): Gazdálkodás az állami erdőkben. [Management of state forests] In: Solymos, R. (ed.) Erdő és fagazdaságunk időszerű kérdései, MTA Agrártudományok Osztálya, Budapest. 22–26. (in Hungarian)

HINCKLEY, T.M. – LACHENBRUCH, B. – MEINZER, F.C. – DAWSON, T.E. (2011): Size- and Age- Related Changes in Tree Structure and Function; A Lifespan Perspective on Integrating Structure and Function in Trees, Springer Science + Business Media B.V., Dodrecht. 3–30.

HOADLEY, R.B. (2000): Understanding wood, 14 chapter Veneer and plywood, The Thauton Press Inc, Newtown. 225 p.

HVG (2010): Kelet-Magyarország: bezárja forgácslapgyárát az Interspan Kft. [Eastern Hungary: Interspan Ltd. closes his chipboard factory] (in Hungarian) Online: http://hvg.hu/gazdasag/2010111_interspan_gyarbezaras (accessed: 01.2014.)

Király, É. – Kottek, P. (2013): A hazai fatermékekben tárolt szén mennyiségének és készletváltozásának becslése a 2013 IPCC Supplementary Guidance módszertana alapján. [Estimation of carbon content stored in harvest wood products and domestic volume and based on the 2013 IPCC Supplementary Guidance], Erdészettudományi Közlemények 4 (1): 95–107. (in Hungarian)

Klagenfurti Biomassza-Erőmű (2013): meinbezirk.at (accessed: 2013.05.29)

KSH STADAT 2015: Légszennyező anyagok és üvegházhatású gázok kibocsátása. [Emission of air pollutants and greenhouse gas] (in Hungarian) Online: http://www. ksh.hu/docs/hun/xstadat/stadat_eves/i_ua002d.html?down=579 (accessed: 25.11.2015)

LONTAY, Z. (2011): Bioerőművek a vidékfejlesztésben. [Biomass power plants in the rural development] (in Hungarian) Online: http://www.meta.org.hu/index.php?option=com_content&view=article&id=28:biovidekfejl&catid=21:bioermvek&Itemid=2 (accessed: 05.01.2014).

MOFA (2013): KRONOSPAN-MOFA Hungary Farostlemezgyártó Kft. honlapja. Online: http://kronospan-mofa.hu/Minoseg/Iranyelvek.html (2014.11.02.)

MOLNÁR, S. (ed.) (2011): Örök társunk a fa. [Our eternal fellow: the tree] Nyugat-magyarországi Egyetem Kiadó, Sopron, 55 p. (in Hungarian)

MOLNÁR, S. – BÖRCSÖK, Z. (2011): Barátaink a fák. [Trees are our friends] Napkor, Sopron. 28. p (in Hungarian)

MOLNÁR, S. – FÜHRER, E. – TÓTH, B. (2008): Az ültetvényes fagazdálkodás fejlesztése. [The development of wood plantations] Hillebrand Nyomda, Sopron. 93 p. (in Hungarian)

MOLNÁR, S. – WINKLER, A. – MAROSVÖLGYI, B. (2005): Az újratermelhető környezetbarát fa a jövő nyersanyaga. [Reproducible environment friendly wood is raw material of the future] In: Solymos, R. (ed.) Erdő- és Fagazdaságunk időszerű kérdései, MTA Agrártudományok Osztálya, Budapest. 27–32. (in Hungarian)

NÉBIH (2012): Erdővagyon, erdő- és fagazdálkodás Magyarországon, Energiaerdők. [Forest resources, forest and timber management in Hungary, Energy forests] Nemzeti Élelmiszerlánc-biztonsági Hivatal, Erdészeti Igazgatóság Budapest (in Hungarian) Online: https://www.NÉBIH.gov.hu/szakteruletek/szakteruletek/erdeszeti_igazgatosag/kozerdeku_adatok/adatok/ada_tok.html (accessed: 11.02.2015)

NÉMETH, J. – HARGITAI, L. – SZABADHEGYI, GY. – GERENCSÉR, K. (2004): Az értékes minőségi hengeresfa feldolgozásának korszerűsítése. [The modernization of valuable, quality roundwood processing] In: Solymos, R. (ed.) Erdő- és Fagazdaságunk időszerű kérdései, MTA Agrártudományok Osztálya, Budapest. 121–132. (in Hungarian)

NÉMETH, J. – SZABADHEGYI, GY. (2003): Furnérok és furnér alapú rétegelt termékek gyártása. [Production of veneer plywood and veneer-based products] Nyugat-magyarországi Egyetem, Faipari Mérnöki Kar, Sopron. 15–18. (in Hungarian)

Nieder, R. – Benbi, D.K. (2008): Carbon and Nitrogen in the Terrestrial Environment, Springer Science Business Media B.V. Jupiterimages Corporation. 5–43.

OEE (2012): Erdők a világban, Európában és Magyarországon. [The forests in the World, Europe and Hungary] Erdészeti Lapok Különszám. Országos Erdészeti Egyesület, Budapest. 147 (1) : 14–15. (in Hungarian)

OWI ZALA (2013): OWI Zala Bt. honlapja. Online: http://www.owizala.hu/information.htm (2014.02.11.)

PYRAMIDENKOGEL (2013): Pyramidenkogel kilátó honlapja. Online: pyramidenkogel.info; pyramidenkogel-ktn.at (accessed: 01.11.2015)

SCHÖBERL, M. (2012): Fatermékekben tárolt szén hazai civilizációs anyagárama és a klímavédelem. [The domestic anthropogenic flow of carbon stored in wood products and the climate protection] Faipar 60 (4): 12. (in Hungarian)

SCURLOCK, J.M. – HALL, D.O. – HOUSE, J.I. – HOWES R. (1993) Terrestrial Biospheric Carbon Fluxes Quantification of Sinks and Sources of CO_2 , Utilising biomass crops as a energy source: A European perspective, Springer Netherlands, Dodrecht. 499 p.

SRDJEVIC, B. – HILLRING, B. – GALLIS,C. – OLSSON, O. (2007): Management Systems for Recovered Wood in Europe. In: Gallis, C.: Management of Recovered Wood, University Studio Press, Klagenfurt. 54. p.

SHMULSKY, R. – JONES, P.D. (2011): Forest Products and Wood Science. An Introduction. Sixth edition, Willey-Blackwell, Chichester. 425 p.

ÚSZT (2010 a): Új Széchenyi Terv, Zöldgazdaság-Fejlesztési Program 2010. 98–102. (in Hungarian) Online: http://www.polgariszemle.hu/app/data/ Uj_Szechenyi_Terv.pdf (2014.02.11.)

ÚSZT (2010 b): Új Széchenyi Terv, Zöldgazdaság-Fejlesztési Program 2010. 110–112. (in Hungarian) Online: http://www.polgariszemle.hu/app/data/ Uj_Szechenyi_Terv.pdf (2014.02.11.)

WINKLER, A. (1998): Faforgácslapok. [Particleboards] Dinasztia Kiadó, Budapest. 156 p. (in Hungarian)

WINKLER, A. (1999): Farostlemezek. [Fibreboards] Mezőgazdasági Szaktudás Kiadó, Budapest. 142 p. (in Hungarian)

WINKLER, A. (2005a): Új fafeldolgozási és fahulladék feldolgozási technológiák. [New wood processing and wood waste processing technologies] In: Solymos, R. (ed.): Erdő- és fagazdaságunk időszerű kérdései, MTA Agrártudományok Osztálya, Budapest. 146–152. (in Hungarian)

WINKLER, A. (2005b): Falemez szerkezetek és gyártásuk új módszerekkel. [Wood board structures and their production with new processing] In: Solymos, R. (ed.) Erdő- és fagazdaságunk időszerű kérdései, MTA Agrártudományok Osztálya, Budapest. 276–298. (in Hungarian)

WINKLER, A. – ALPÁR, T. – BITTMAN, L. – BEJÓ, L. – TAKÁTS, P. (2005): Sarangolt faválasztékok felhasználása tervezett tulajdonságú lemeztermékekhez. [Forest's waste utilization for proposed structured wood boards] In: Solymos, R. (ed.) Erdő- és fagazdaságunk időszerű kérdései, MTA Agrártudományok Osztálya, Budapest. 269–275. (in Hungarian)

Guide for Authors

Acta Silvatica et Lignaria Hungarica publishes original reports and reviews in the field of forest, wood and environmental sciences. ASLH is published twice a year (Nr. 1 and 2) in serial volumes. It is online accessible under: http://aslh.nyme.hu

Submission of an article implies that the work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis), that it is not under consideration for publication elsewhere. Articles should be written in English. All papers will be reviewed by two independent experts.

Authors of papers accepted for publication should sign the Publishing Agreement that can be downloaded from the homepage (http://aslh.nyme.hu).

All instructions for preparation of manuscripts can be downloaded from the homepage.

Contents and Abstracts of the Bulletin of Forest Science

Bulletin of Forest Science (Erdészettudományi Közlemények) is a new journal supported by the Hungarian Forest Research Institute and by the Faculty of Forestry of the University of West Hungary. The papers are in Hungarian, with English summaries. The recent issue (Vol. 6, 2016) contains the following papers (with page numbers). The full papers can be found and downloaded in *pdf* format from the journal's webpage (www.erdtudkoz.hu).

Vol. 6, Nr. 1, 2016

Abstract – The consequences of the projected climatic changes on the health and growth of European forests are for the time being still unresolved and debated. Analysis of provenance tests and dynamic modeling of four European tree species indicate that the impacts are regionally different. In the temperate-maritime zone, expected rise of temperature – in case of sufficient precipitation – may lead to growth acceleration without significant genetic change. In the southern continental and Mediterranean zone, at the lower (xeric) limits of distribution, however, summer drought increase will trigger higher susceptibility to diseases and mortality, and may cause local extinctions and shifts of distribution area. Extreme selection may narrow genetic variation and cause decline of stability, key attributes to withstand environmental changes. Results confirm that the prudent use of regional differentiation in genetic diversity and stability may provide possibilities for alleviating climate change risks and increase the fitness of next generations. The presented policy principles of adaptive management are based on results of the FORGER project, and were published as Policy Brief (Mátyás and Kramer 2016).

Abstract – According to the tasks of Agroclimate 2 project it was necessary to compile from forestry and agriculture viewpoint an equally applicable soil and landsite database with countrywide coverage. To achieve this by the unification of present forestry and agricultural landsite databeses and by using a set of meaningful environmental predictor variables under the umbrella of digital soil mapping approach we started to compile digital soil maps. Our efforts resulted in the first version of Hungary's new digital soil map, which provides information on soils with a spatial resolution of 1 ha. On the basis of the validation of the map

we concluded that its confidence is approximately 70%. By the exploitation of refining possibilities provided by the digital soil mapping methods further efforts will be made to achieve prediction accuracy above 80%.

Abstract – Climate change requires actions from political, social, economic, and scientific stakeholders. The AGRAGIS project during the development of National Adaptation Geo-information System aimed to assess the climate change induced potential impacts on yield conditions of forests. During the project on the basis of the historical meteorological database of the country (CarpatClim-Hu), and using the ALADIN and RegCM regional climate models we have assessed the expected forest climate zone shifts in Hungary. Yield data of forests as a baseline came from forest stands that were established in the early 1960s, which are being now the 6th age-class. Yield data for forests under changed conditions came from forest stands that were established in the early 1990s, which are being now the 3rd age-class. Climate change facts between the periods of 1961-1990 and 1991-2010 can be statistically evaluated in this way together with yield changes of forest stands. By the projection of average statistical differences according to site we can assess the expected changes in yield potential for future time windows of 2021-2050 and 2071-2100. Results showed that a drop is expected for all major species' yield potential to different extent under future climate conditions.

Abstract – Multidecadal trends of mean basal area increments of beech from three sites and four different stand ages were investigated in Western and Northern Hungary. Regardless location and age, our findings show a slowdown in growth or even significant increment decrease for the past 30-40 years. Although the phenomenon is connected to unfavorable changes of climatic conditions, no clear linear relationship can be detected between the decadal trends of increments and the widely used forest aridity indices.

Abstract – We examined the database of the Forest Research Institute derived from the reports of the forest-managers. We indicated the important pest and pathogen damage areas from the last 50 years. We also compared the data to drought-indexes. The frequency and severity of damages increased from the mid-1980's. The beech-decline occurred on larger areas, if the values of the drought indexes were above certain values in the predecessing 2 years.

Abstract – We studied the effect of meteorological parameters on the basal area increment (BAI) of a beech stand in the Sopron Mountains between 1985 and 2007. We evaluated the meteorological conditions of the area by using breakpoint-analysis, and the results showed

rising temperature and decreasing rainfall in certain months of the vegetation period. Regarding to the trends of BAI, we observed a significant decrease in the main growth period (May–August) and a significant increase in the final growth period (September–October), while the annual tree growth showed a strong significant decreasing trend. Multivariate regression analysis was used to determine the relationships between the BAI and the climatic variables in the given and also in the previous two years. We found that the previous year's precipitation has positive, while autumn temperature has negative effect on the BAI. At the same time current spring to early summer precipitation enhances the beech growth, and in contrary, the mean temperature in June and July has negative effect on the BAI. Based on the results, we can conclude that according to the forecasted changes in climate, not only further loss in growth but also drastic decay in vitality and tolerance can be expected for beech at this site in the future.

Éva KONKOLY-GYURÓ and Pál BALÁZS

Forest cover change in the Carpathian Basin from the mid 19th century till nowadays…79–97

Abstract – Human impact on landscape might be followed by the assessment of land use and land cover change. In the project „200 Years of Land Use and Land Cover Changes and their Driving Forces in the Carpathian Basin in Central Europe" founded by the NASA Land-Cover/Land-Use Change Science Program, a GIS dataset on the historic land cover, of a nearly 350.000 km^2 area has been provided. Four time layers, based on historic maps and CLC data have been assessed by GIS and statistical methods. The focus of the present paper is the forest cover change amongst the results of the land cover transformation processes. The main tendencies of changes of the entire study area and the specificities of the main landscape types are being presented here.

Vol. 6, Nr. 2, 2016

Gábor ÓNODI

Habitat transforming effects of non-native and invasive tree species…101–113

Abstract – The spread and habitat transformation effects of invasive plant species cause global environmental problems. In Hungary occurring invasive tree species, such as black cherry, common hackberry, russian olive, black locust, tree of heaven, boxelder and green ash, can transform native communities and architecture of habitats considerably. These species have usually less consumer species comparing to native tree species. Their pests can be introduced with them as well, which can also become invasive. Tree rot fungi can colonize them slower, so that less diverse microhabitats would form on them, and so less species would inhabit them. Habitat transformation can be facilitated by antropogen influences further, such as soil works, deforestation and river control. Climate change can influence the range and occurrence patterns of both native and alien species. Alteration of native communities could be so intensive, that habitat restoration would be much source and work intensive, even if it would be possible.

Abstract – The aim of present study was to discover the morphological variety of vegetative organs of two native *Fraxinus* species (*F. excelsior*, *F. angustifolia* ssp. *danubialis*) and to separate different taxa and hybrids through their vegetative morphological characteristics. Studied populations were originated from Rábaköz – Répce-plain area, Sopron-Hills and Gemenc. During statistical analysis multivariate statistical methods were applied such as Principal Component Analysis (PCA) and Principal Coordinates Analysis (PCoA) to demonstrate the correspondences between morphological characteristics and specimens. As a result of statistical analyses *F. excelsior* specimens separated significantly from the sample group consisted of specimens identified *F. angustifolia* ssp. *danubialis* and hybrids. Most of measured morphological variables proved to be highly distinctive in the case of above mentioned two sample groups, if they were applied collectively. Strongest distinctive features between *F. excelsior* and mixed group were the width variables of leaflets and leaflet teeth density, although these variables proved to be unsuitable for separation of hybrids.

Abstract – During transformation of even-aged forests to selection forests it is important to follow the changes in stand structure. Detailed forest mapping was made in Sopron 182 B experimental selection forest, where the research was started by Roth Gyula in 1936. The main purpose of the survey was to create a database which can be used for timeline analysis in the future. We developed a survey method which is accurate enough to generate spatial forest stand databases. We made a 3D model of the forest and examined its structure. During the decades of the experiment beech became dominant, light-demanding tree species withdrew to upper canopy regions. Diameter and height distribution is heterogeneous, in some areas it shows the characteristic of selection or structurally differentiated forests.

Abstract – The aim of this study was to examine the distribution of European mistletoe (*Viscum album*) in the castle park Lednice, Czech Republic studying the dependence of the infection intensity and location of host species. From the most common host species (23) more than 1600 infected individuals were involved in the analysis. Based on our results it can be concluded that the host species are infected differently, since some hosts (e.g. *Acer saccharinum, Acer sacharum, Juglans nigra*) are more sensitive to the presence of mistletoe and these woody species are much heavily infected. Our results also show that the relationship between the tree location and the intensity of mistletoe infection is statistically significant. It means that solitary trees are most heavily contaminated with mistletoe. Furthermore, those individuals are less endangered, which are situated in closed canopy groups. Nevertheless, the ratio of uninfected and infected individuals are almost the same in case of solitary trees or in different canopy groups too.

Abstract – The Lepidoptera fauna of the Sopron Mountaiuns is well known; more than 800 species was published. The oak forests have high importance in the region, because they support a high species richness of Lepidoptera. Macromoths which occur in sessile oak-hornbeam forests in the study area are classified in five larger faunal types. The most important are the Trans-Palearctic, West-Palearctic and "Siberian" species from which the Euro-Siberian, Holomediterranean and Boreo-Continental faunal types compose the basic fauna. Moreover, several further faunal elements are known from the Sopron Mountains, such as South Continental and Extra-Palearctic species, furthermore other Mediterranean and Boreal components.

Abstract – We made artificial ground nest predation investigations at a varied habitat in Somogy County, Hungary. During the investigation we were interested in determining which predator species pose a potential risk for the nests of small game species (pheasant and grey partridge) in a territory, where the habitats are suitable for both small game and big game. We monitored 20-20 artificial ground nests in April and May. In each nest we put 2 chicken eggs, 1 wax egg and 1 plasticine egg, respectively. We placed the artificial nests at the edge zones of different habitats and checked the predation every 4 days. We found the Red Fox (*Vulpes vulpes*) (51%) and the Wild Boar (*Sus scrofa*) (37%) to be the most common predator species. We found in April the highest predation at the edges between the Alder forests and crop fields and the Alder forests and pastures and in May at inner micro edges of young afforestation, the differences were significant. The predation risk was also very high for artificial nests left at inner micro edges of young afforestation for 2 months, but the differences between the study periods were not significant.

Abstract – The Little Owl (*Athene noctua*) is a strictly protected species that avoids closed forests. The species originally nested in cavities in the trunk and branches of decaying trees. These natural nesting sites have become extremely scarce so the species have switched to an anthropogenic nesting environment where potential nesting hazards associated with the presence of beech martens (*Martes foina*) (74 %), with electrocution risk by uninsulated medium-voltage power-lines (51 %) and with danger of poisoning by rodenticides (32 %) may occur. During the period covered by the present study (2003-2015) nearly 400 artificial Little Owl nest boxes were installed in the Upper-Kiskunság region and a total of 467 birds (adult and pullus) were ringed. It can be safely assumed that the growing nest box occupancy rate in recent years indicates a rise in population. By 2015, nest box occupation rate had risen to 25,4 %. The present study, besides outlining the conservation solution of artificial nest boxes in the short term, proposes a suggestion for a long-term solution based on international practice by restoring the natural nesting environment for Little Owls.

Zoltán VARGA and Attila FARKAS

Examination of food of badgers (*Meles meles* L.) in Komárom-Esztergom county, Hungary…189–197

Abstract – In the 2009/2010 hunting season 77 badgers were collected in the territory of Komárom-Esztergom county. Some of the animals were legally hunted specimens, but the 41.5% of sample resulted by road accidents. On the samples, analysis of dietary habits was performed, which was accomplished by analysis of stomach contents. The results were evaluated separately according to habitat types and seasons, based on location and time of the killing, or inventing. We examined the relative frequency of occurrence and diversity of food items in stomach contents, as well as trophic niche breadth and standardized trophic niche breadth of badgers. We intended to reveal the occurrence of small game species in badger's diet and differences in feeding habits between the various habitats and seasons. The studies have shown that feeding habits of badgers living in different habitats and collected in different seasons differ significantly based on consumption frequency of certain food categories. However, the presence of small game species in the diet of badgers has not been proved. We found that on the test area badgers are feeding generalist species, with periodic specialist features characteristic only in certain habitats.