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Stakeholder Analysis to Support Secondary Norway Spruce (*Picea abies* (L.) Karst.) Forest Conversion in the Ukrainian Carpathians

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Abstract – Stakeholder analysis is a crucial step in the participatory process to involve all groups of interests in sustainable forest management. This paper aims to develop a method of stakeholder analysis to identify and classify stakeholders involved in secondary Norway spruce (*Picea abies* (L.) Karst.) stand conversions. The method is based on a questionnaire survey and structured into three stages: (1) stakeholder identification; (2) analytical characterization of stakeholders; and (3) stakeholder aggregation. Stakeholders are classified according to their interest level and importance while considering the relationships among them (social network analysis). Stakeholder analysis is applied in the Ukrainian Carpathians, which is characterized by cultural and economic dependence on forest resources. The results highlight seven "supporters" and six "opponents" as well as three key stakeholders and four primary stakeholders. We propose involving up to three stakeholders from each homogeneous group to balance stakeholder contributions and enhance the democratization of the forest conversion decision-making process.

adaptive complexity / Norway spruce / forest management / questionnaire survey / social network analysis / public participation

Kivonat – Az érdekelt felek elemzése az Ukrán Kárpátok mesterségesen létrehozott norvég lucfenyő (*Picea abies* (L.) Karst.) erdeinek átalakításához. Az érdekelt felek elemzése kulcsfontosságú lépés az összes érdekcsoport tartamos erdőgazdálkodásba való bevonásának folyamatában. A tanulmány célja a mesterségesen létrehozott norvég lucfenyő (*Picea abies* (L.) Karst.) állomány átalakításában részt vevő érintettek azonosítására és osztályozására kifejlesztett módszer bemutatása. A módszer kérdőíves felmérésen alapul, és három szakaszra tagolódik: (1) az érdekelt felek azonosítása; (2) az érdekelt felek analitikus jellemzése; és (3) az érdekelt felek összesítése. Az érdekelt feleket érdekeltségi szintjük és jelentőségük alapján osztályozzuk, miközben figyelembe vesszük a közöttük fennálló kapcsolatokat (közösségi hálózatok elemzése). Az érdekelt felek elemzését az Ukrán Kárpátokban alkalmazzák, amelyet az erdészeti erőforrásoktól való kulturális és gazdasági függőség jellemez. Az eredmények hét „támogatót" és hat „ellenzőt", valamint három kulcsfontosságú és négy elsődleges érdekelt felet emelnek ki. Javasoljuk, hogy mindegyik homogén csoportból legfeljebb három érdekelt felet vonjanak be az érdekeltek közreműködésének kiegyensúlyozása és az erdő átalakításáról szóló döntéshozatali folyamat demokratizálásának elősegítése érdekében.

adaptív komplexitás / norvég lucfenyő / erdőgazdálkodás / kérdőíves felmérés / közösségi háló elemzés / a nyilvánosság részvétele

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1 INTRODUCTION

Timber-based forestry systems are often motivated to reduce structural and functional complexity, which had negative consequences on the adaptability and resilience of forest ecosystems (Drever et al. 2006). An example of this practice is extensive Norway spruce (*Picea abies* (L.) Karst.) production, which has replaced native mixed or broad-leaved forests across Europe (Spiecker et al. 2004, Krynytskyy et al. 2014, Lavnyy – Schnitzler 2014). Beginning in the nineteenth century, more than 1,800 km^2 of even-aged spruce stands (secondary stands) were established on sites in the Ukrainian Carpathians that are naturally dominated by European beech (*Fagus sylvatica* L.) and mixed coniferous-broadleaved forests (Slobodiyan 2012, Parpan et al. 2014). Secondary spruce stands are vulnerable to many challenges today (Schutz et al. 2006), with climate change being chief among them (Zahvoyska – Pelyukh 2016). Recently, some studies have shown that spruce stand dominance will decline in the Ukrainian Carpathians over the next 500 years due to climate change (Hlásny et al. 2016, Shvidenko et al. 2017, Kruhlov et al. 2018). A sharp increase in the number of cumulative dry days, a significant decrease of precipitation during a growing season, and a higher frequency of extreme events (drought, windstorms, abundant rainfall within short periods of time) are regarded as the most detrimental factors facing Norway spruce.

The destruction of secondary spruce stand structure and functionality is related to natural, socio-economic, and institutional driving forces (Zahvoyska – Pelyukh 2016). This requires a complex response from forest managers. Promoting a more diverse and resilient array of potential forest ecosystem responses to disruptions can be achieved through the realization of "adaptive complexity" (Fahey et al. 2018) and "close-to-nature" (Krynytskyy et al. 2014) approaches in forest management. Both concepts are based on the creation of stable and resilient forest stands that possess more flexible and accommodative characteristics to manage current and future environmental changes and stressors (e.g., climate change, invasive pests). Silvicultural conversion of secondary spruce stands in the Ukrainian Carpathians is a forest management strategy that aims to stabilize and adapt forest ecosystems to current challenges (Slobodiyan 2012, Krynytskyy et al. 2014, Lavnyy – Schnitzler 2014, Parpan et al. 2014, Pelyukh et al. 2016, Pelyukh 2018).

Conversion is a silvicultural treatment that aims at gradual stand transition based on natural regeneration, which can transform pure stands to mixed forest stands and even-aged stands to uneven-aged stands (Krynytskyy et al. 2014). Many studies in the scientific literature describe the main techniques for forest conversion (Spiecker et al. 2004, Krynytskyy et al. 2014, Soloviy – Chernyavskyy 2011). Spiecker et al. (2004) advanced two main arguments confirming the need for secondary spruce stand conversions. Firstly, interest in numerous and diverse ecosystem services has been increasing in step with the increase in the quality of life in society. Secondly, forest management practices applied in the secondary spruce forests in recent decades have become untenable as these forests face serious and increasing threats from natural disasters and the spread of pathological processes.

According to several authors, forest conversions can provide a broad range of benefits: (1) increased drought resistance (Merlin et al. 2015); (2) improved soil conditions (Prescott 2002); (3) reduced landslide and windfall risks (Schutz et al. 2006); (4) reduced forest fire risks (Gonzalez et al. 2006); (5) improved hydrological regime and an increased water supply (Kulchytskyy-Zhyhaylo – Kulchytska-Zhyhaylo 2011); (6) reduced pathogen impact risk (Parpan et al. 2014); (7) higher resilience and resistance to natural and anthropogenic disturbances and better climate change adaptation (Soloviy et al. 2011); (8) increased biomass productivity (Pretzsch et al. 2014); (9) decreased financial risks due to forest species diversification (Hildebrandt – Knoke 2009); (10) enhanced biodiversity (Krynytskyy et al.

2014, Carnus et al. 2006); and (11) increased recreational value of forest landscapes (Grilli et al. 2014). However, forest conversion is only implemented on smaller sites in the Ukrainian Carpathians. This slow expansion of the forest conversion process is associated with a strong focus on short-term financial interests by businesses and local stakeholders. These financial interests conflict with a long-term perspective regarding the benefits of secondary Norway spruce forest conversions. This makes conversions unattractive from the macroeconomic perspective of resource allocation. Discrepancy and a lack of coherence in stakeholder activity hinder conversion projects (Zahvoyska et al. 2016, Zahvoyska et al. 2017).

Achieving a successful forest conversion requires an inclusive participatory process (Balest et al. 2016, Grimble – Wellard 1997, Paletto et al. 2010, Paletto et al 2015, Reed et al. 2009, Zahvoyska – Pelyukh 2016) that incorporates an analysis of stakeholder interests and roles (Pelyukh et al. 2019c). A participatory process that aims to include differing stakeholder interests and point of view has the advantage of increasing social sustainability and reducing conflicts among interest groups involved in the decision-making process. In this context, an investigation of stakeholder interests and relationships is crucial for successful forest management (Sandström – Rova 2010). In the international literature, some authors have used the relationships between stakeholders as a tool to classify forest resource stakeholders. Paletto et al. (2015) used the social network analysis to support stakeholder analysis in two participatory forest plans in Italy (Matese and Arci-Grighine forest districts), while Krupa et al. (2018) mapped stakeholders in a case study in Alaska's Kenai Peninsula using social network analysis with the aim of increasing the transparency and legitimacy of the participatory process. Recently, Blanc et al. (2018) implemented participatory processes in forestry training in the Western Italian Alps (Piedmont, Liguria and the Aosta Valley) using social network analysis techniques.

Starting from these considerations, the main aim of this study is to develop an objective method of stakeholder analysis aimed at identifying and classifying stakeholders while considering their interests and relationships. The proposed method is based on selected stakeholder characteristics – ego-degree centrality and ego-betweenness centrality – identified through social network analysis. The proposed method identifies the main "supporters" and "opponents" of secondary spruce forest conversions in the Ukrainian Carpathians and seeks to involve these groups in the participatory decision-making process.

2 MATERIALS AND METHODS

2.1 Study area

The Ukrainian Carpathians is located in south-western Ukraine and covers a land area of 56,635 km^2 (*Figure 1*). The region includes four oblasts: Chernivetska Oblast, Ivano-Frankivska Oblast, Lvivska Oblast, and Zakarpatska Oblast with a population of 6.07 million inhabitants (population density of 108 inh./km^2). The present research has been conducted in five towns (Lviv, Ivano-Frankivsk, Uzhhorod, Rakhiv, Skole) and four villages (Bogdan, Roztoky, Verkhnye Syn′ovydne) located in the Ukrainian Carpathians.

Figure 1. The geographical location of study sites in the Ukrainian Carpathians

The altitude of the Ukrainian Carpathians is between 100 m and 2000 m a.s.l.; the climate is temperate with a moderate continental influence. The average annual precipitation range is between 900-1200 mm and the average temperature is from +20 °C to 6 °C in summer and from -3 °C to -10 °C in winter (Kuemmerle et al. 2009). The landscape in the Ukrainian Carpathians is characterized by glacier-shaped valleys and the slopes of different exposures and inclinations.

The forest area covers around 37% of the region (20,856 km^2), out of which 70.9% belong to the Forest Resources Agency, 20.1% to the Ministries of Agricultural Policy, 3.8% to the Ministries of Ecology and Natural Resources, 0.4% to the Ministries of Education and Science, while the remaining 4.8% are private forests. State-owned forests (95.2% of the forested area) are managed by state forest enterprises. The main forest types in the Ukrainian Carpathians are Norway spruce (*Picea abies* (L.) Karst.) (41%), followed by European beech (*Fagus sylvatica* L.) (35%), pedunculate oak (*Quercus robur* L.) (9%), silver fir (*Abies alba* Mill.) (4%), and other forest types (11%).

Secondary spruce covers 28% of all spruce forests (184.3 thou. ha) in the Ukrainian Carpathians (Slobodiyan 2012). According to Parpan et al. (2014), 193 km^2 of these forests with a wood volume of nearly 6 million m³ has experienced intensive drought. Most droughts in secondary spruce forests are distributed in the territory of Lviv (51.9% of all secondary spruce forests) and Ivano-Frankivsk (31.6%) oblasts.

2.2 Research framework

The research framework based on the questionnaire survey was developed in three stages: (1) stakeholder identification; (2) analytical characterization of stakeholders; (3) stakeholder aggregation.

2.2.1 Stakeholder identification

The first stage of stakeholder analysis is aimed at identifying all stakeholders who affect, and/or are affected by the policies, decisions, and actions of the system. Identifying stakeholders is an iterative process during which the preliminary list of relevant stakeholders is updated and integrated into subsequent steps (Reed et al. 2009).

In this study, the stakeholders were identified using the snowball sampling method. This method is a non-probability sampling technique used for the difficult task of defining and

accessing the population of interest. The snowball sampling method is applied to recruit a purposive sample (i.e. stakeholders thought to be most important to the issue under study), whereby the researcher asks respondents to identify other stakeholders the researcher may contanct (Etikan et al. 2016).

In the present study, all respondents were asked to indicate the name of other potential stakeholders to be involved in the survey. The main criteria used to identify stakeholders were professional experience and skills in forest management and planning, biodiversity conservation, and forest economics and policy.

At the end of survey, 50 stakeholders were identified and directly contacted for the survey, but only 25 stakeholders were willing to participate (for a response rate of 50%). All identified stakeholders are strictly related to the problem of diminishing secondary spruce stands and possess knowledge about socio-ecological and economic features and consequences of the forest conversion process. The 25 stakeholders involved in the survey belong to the following organizations and institutions: Ukrainian National Forestry University (16%), Ivan Franko State University (4%), Ukrainian Research Institute of Mountain Forestry (4%), Carpathians Biosphere Reserve (8%), Zacharovanyi Krai National Park (4%), State Enterprises "Rakhiv forestry" (8%) and "Skole forestry" (4%), local people (8%), environmental Non-Governmental Organization "Ecosphere" (4%) and "Rakhiv. Tourist" (4%). The remaining respondents represent the following groups: forest harvesters (4%), paper manufactures (4%) wood processing companies (4%), local authorities (4%), pickers of non-wood forest products (4%), and hunters (4%).

2.2.2 Analytical characterization of stakeholders

The second stage of stakeholder analysis refers to a set of methods aimed at characterizing and classifying the stakeholders based on certain attributes such as (Mitchell et al. 1997, Banville et al. 1998, Newman 2005, Paletto et al. 2015): urgency, legitimacy, influence, proximity, level of interest and influence, access to resources, relationships (cooperation/competition), and proximity to the resource.

In this study, stakeholders were characterized considering interests (benefits/loses) proposed by Lindenberg and Crosby (1981), and relationships between stakeholders proposed by Grilli et al. (2015). All identified stakeholders were contacted, and a semi-structured questionnaire was administrated face-to-face. This administration system was chosen because it could provide a higher response rate, higher quality of acquired data, and a better opportunity to explain unclear questions to respondents (De Leeuw 1992, Goyder 1985). During this stage, all respondents provided important information and opinions about stakeholder interests, influences, and relationships in the context of secondary spruce conversions in the Ukrainian Carpathians.

A preliminary version of the questionnaire was developed and pre-tested. The final version of the questionnaire consists of four thematic sections concerning the following aspects: (1) personal information of respondents (2) assessment of forest conversion impacts on stakeholder well-being; (3) assessment of stakeholder influence on the forest conversion process; (4) relationships between stakeholders in the context of secondary spruce stand management.

The first part of the questionnaire focused on the respondent's personal information, such as name, location, and respondent's role in the organization/institution/association.

The second thematic section investigated stakeholder well-being in the context of secondary spruce stand conversions. A preliminary list of stakeholders developed by researchers from the Ukrainian National Forestry University was proposed for the respondents. The main question in this stage was: Who wins or loses as a result of forest

conversion impacts? The results of this thematic section have been used as an indirect indicator of stakeholder interests.

The third thematic section investigated stakeholder influence on the forest conversion decision-making process using the following question: Who influences and who are influenced by the forest conversion decision-making process?

A 5-point Likert scale format (from 1 = very low to 5 = very high value) was used in order to rate impacts of forest conversions on stakeholder well-being and influences in the decision-making process (Likert 1932).

In the fourth thematic section, relationships among stakeholders in the context of secondary spruce conversion were investigated and distinctions between strong and weak ties were drawn (Granovetter 1973). A 3-point Likert scale format (1 = very weak ties, 2 = weak ties, 3 = strong ties) was used in order to quantify the strength of ties.

This paper presents the results of the second and fourth thematic section. We used information from the second thematic section of the questionnaire to divide all identified stakeholders into two groups within the context of secondary spruce conversion: "supporters" and "opponents". This division was done based on a comparative analysis of median value in the respondents' estimates towards stakeholder benefits and costs. If the median value of stakeholder benefits was higher than the median value of losses, then the stakeholder belonged to the "supporters" group; if the reverse appeared, the stakeholder was classified in the "opponents" group. For this case, descriptive statistics were developed using XLStat 2012. Information from the fourth section of the questionnaire was used to analyze stakeholder relationships in the third stage of the research framework.

In addition, we collected comments and qualitative information the respondents provided for each question. It was assumed the comments would help to interpret the results. In our case study, this information was used to explain the results of the respondents' estimations.

2.2.3 Stakeholder aggregation

The third stage of stakeholder analysis sorts the previously identified stakeholders into homogeneous groups in order to choose the appropriate degree of involvement for each group (Paletto et al. 2015). This stage is crucial in the participatory process because the choice of an inappropriate degree of involvement for one or more stakeholders may compromise the process. The degree of involvement – from simply receiving information (referred to as the information level) to jointly deciding policy or activity (co-deciding) (Hare et al. 2003) – is closely linked to the stake and/or importance of the stakeholders in an issue or context.

In this study, stakeholder aggregation was completed based on the relationships between stakeholders. Relationships that exist between identified stakeholders were analyzed through social network analysis (SNA), which is a formal theory to define and analyze the relationships that stakeholders have with each other, focusing on the structural patterns of stakeholder positions (Wasserman – Faust 1994). SNA allows for an aggregation of stakeholders into three homogeneous groups of importance (ODA 1995): key, primary, and secondary. Key stakeholders can significantly influence or are important to the success of the project. Primary stakeholders are those who are affected, either positively or negatively, by project results. Secondary stakeholders are those who have a marginal effect on the results of the project results. This aggregation aims to choose the appropriate degree of involvement each stakeholder holds in the decision-making process based on the ability of a single stakeholder to represent the interests of their interest group.

The social network can be analyzed based on degree centrality, betweenness centrality, and closeness centrality and are defined by "complete" or "sociocentric" network data that provide information on relationships among all actors within a bounded social network (Freeman 1979). Conversely, the "egocentric" design does not require a priori enumeration of

a population of stakeholders and is often used to measure social networks in survey-based studies. (Marsden 2002). In addition, it is better to use an "egocentric" design to analyze a personal network in the immediate locality of a given actor (Marsden 2002). Ego-centric networks represent the respective relational communities of a set of actors that are not necessarily connected (Salpeteur et al. 2017). Two ego-network features (ego-degree centrality and egocentric betweenness) were applied to aggregate stakeholders into homogeneous groups within the context of secondary spruce conversions in the Ukrainian Carpathians. These features were calculated with UCINET 6.666 software.

Degree centrality is measured simply as the number of direct ties that involve a given node and reflects the direct relational activity of node *pi* (Freeman 1979). A node with a high degree is therefore considered a hub in the network. There are no differences between degree centrality and ego-degree centrality (Marsden 2002). Since possible degree centrality can be considered an indirect indicator of stakeholder power (Grilli et al. 2015, Paletto et al. 2016), we use this measure of each stakeholder (ego) as an indicator of the personal power. The formula for calculating the ego degree centrality (C_d) is (Marsden 2002):

$$Cd = \sum_{k=1}^{N} a(pi, pk) \tag{1}$$

where,
C_d – the ego-degree centrality;
a_i – the egocentric matrix;
p_i – the "ego" node;
p_k – nodes in the first-order zone of p_i, i.e. nodes p_k for which $a(p_i, p_k)=1$;
N – the total number of stakeholders.

The egocentric network A_i for stakeholder p_i includes all other stakeholders p_k such that $a\ (p_i, p_k) = 1$.

Betweenness centrality is calculated as the fraction of shortest paths between node pairs that pass through the node of interest (Freeman 1979). Betweenness centrality measures the influence that a stakeholder has over the spread of information through the network. Therefore, it evidences the stakeholders that possess real power in information control and that assume the roles of intermediates in the decision-making process (Mizruchi – Potts 1998, Paletto et al. 2010). Egocentric betweenness may often be a reliable substitute for Freeman's sociocentric betweenness measure, which notes that some pairs (p_i, p_k) may be connected not only via the ego node, but also through other nodes in the egocentric network that thereby share the intermediary position for that relationship with the ego node (Freeman 1979, Marsden 2002). The formula for calculating the ego-betweenness centrality (C_b) is:

$$Cb = \sum_{u=1}^{N} \sum_{v=1}^{N} Puv(f)/Puv \tag{2}$$

where,
C_b – the ego-betweenness centrality;
u, v – the stakeholders in the ego network of stakeholders f;
N – the total number of stakeholders in the ego network;
P_{uv} – the total number of network paths linking stakeholder u and stakeholder v;
$P_{uv}(f)$ – the number of those paths that include stakeholders f.

Using the value of ego-degree centrality and ego-network betweenness, the Individual Index of Importance (I_i) for each stakeholder in the network was calculated using the following equation:

$$Ii = Cd + Cb \quad (3)$$

where,
I_i – the index of importance stakeholders *i*;
C_d – the ego-degree centrality of stakeholders *i;*
C_b – the ego-betweenness centrality of stakeholders *i*.

In order to aggregate the stakeholders into homogenous groups of importance, the stakeholders with an I_i higher than the third quartile are considered as key stakeholders, the stakeholders with an I_i between the third and first quartile are classified as primary stakeholders, whilst the remaining stakeholders are considered secondary stakeholders.

At the end of the aggregation stage, all stakeholders that were divided into groups of interest ("supporters" and "opponents") and homogeneous groups of importance (key, primary and secondary stakeholders) within the context of their participation in decision-making regarding secondary spruce stand conversions in the Ukrainian Carpathians.

3 RESULTS

In the context of secondary spruce stand conversions, all respondents identified 13 stakeholders: nature conservation organizations (NCOs), state forestry enterprises, harvesting companies, wood processing companies, paper manufacturers (PMs), environmental non-governmental organizations (ENGOs), tourists (people who travel or visit a place for pleasure), recreationists (people who enjoy outdoor leisure activities such as hiking, camping, fishing), hunters, pickers of mushrooms, berries and other non-wood products (NWFPs), scientists, local authorities, and local people. Only respondents from Ukrainian National Forestry University and State Enterprise "Rakhiv forestry" indicated other stakeholders such as government organizations (Department of Ecology and Environmental Protection under the Regional State Administration, the Ecological Inspection and Ukrainian government organization, Lisovporyadne Production Association "Ukrderzhlisproekt").

Regarding stakeholder well-being, the common view among respondents was that almost all stakeholders receive mostly benefits rather than losses from forest conversions (*Table 1*). In accordance with respondent opinions, the main beneficiaries are: NCOs (mean value=4.17), tourists (4.10) and recreationists (3.74), scientists (3.631), ENGOs (3.57), local people (3.55), and authorities (3.33). These stakeholders can be considered as potential "supporters" of the forest conversion process.

Conversely, the respondents consider the main losers of the secondary spruce stand conversions to be: harvesting companies (mean value=3.42), pickers of NWFPs (3.00), state forest enterprises (2.90), wood processing companies (2.71), hunters (2.33), and PMs (1.75). These stakeholders can be considered potential "opponents" of the forest conversion process.

Stakeholders such as state forest enterprises and wood processing companies were included in a group of opponents in view of their explicit forest conversion costs. A more detailed explanation of their inclusion in this stakeholder group is provided in the Discussion chapter.

Table 1. Characterization of stakeholders by interest (benefits / losses). Value present on 5-point Likert scale (from 1 = very low to 5 = very high value)

Groups of stakeholders	Benefits			Losses			Interest
	Mean	Standard deviation	Median	Mean	Standard deviation	Median	
NCOs	**4.17**	1.17	5	1.33	0.58	1	Supporter
ENGOs	**3.57**	1.54	4	2.20	1.10	3	Supporter
Tourists	**4.10**	1.12	4	1.75	1.49	1	Supporter
State forestry enterprises	3.10	1.59	3	**2.90**	0.99	3	Opponent
Harvesting companies	3.00	1.73	3	**3.42**	1.00	4	Opponent
Hunters	2.17	1.53	1.5	**2.33**	1.63	2	Opponent
Pickers of NWFPs	2.90	1.51	3	**3.00**	1.41	3	Opponent
Recreationists	**3.74**	1.05	4	2.08	1.31	1.5	Supporter
Scientists	**3.63**	1.71	4	2.33	1.75	1.5	Supporter
Local authorities	**3.33**	1.50	3	2.00	1.20	1.5	Supporter
Local people	**3.55**	1.15	3	1.75	1.16	1	Supporter
Wood processing companies	2.86	1.88	2.5	**2.71**	0.95	3	Opponent
PMs	1.40	1.17	1.2	**1.75**	0.58	2	Opponent

The stakeholders with the highest value of both ego-degree centrality and ego-betweenness centrality are the state forest enterprises (C_d=12, C_b=11.46), local authority (C_d=12, C_b=10.51), local people (C_d=11, C_b=6.41), and NCOs (C_d=11, C_b=6.29) (*Table 2*). In other words, these stakeholders hold more power and ability to spread information compared to other stakeholders. Some stakeholders, such as tourists and recreationists, possess a high value of ego-degree centrality and a low value of ego-betweenness centrality (C_d=9, C_b=0.17) (C_d=9, C_b=0.57). These stakeholders hold much power, but their ability to spread information is low.

Table 2 Ego-degree centrality, ego-betweenness centrality and Individual Index of Importance of stakeholders in the context of secondary spruce stands conversion in the Ukrainian Carpathians

Groups of stakeholders	C_d	C_b	I_i	Aggregation of stakeholders
State forestry enterprises	12	11.46	23.46	Key
Local authorities	12	10.51	22.51	Key
Local people	11	6.41	17.41	Key
NCOs	11	6.29	17.29	Primary
Harvesting companies	10	4.23	14.23	Primary
ENGOs	10	2.44	12.44	Primary
Scientists	9	2.47	11.47	Primary
Hunters	9	2.20	11.20	Secondary
Recreationists	9	0.57	9.57	Secondary
Tourists	9	0.17	9.17	Secondary
Pickers of NWFPs	8	0.73	8.73	Secondary
Wood processing companies	7	1.23	8.23	Secondary
PMs	5	0.25	5.25	Secondary

Stakeholder aggregation based on the Index of Importance (I_i) identified three key stakeholders: state forest enterprises, local authorities, and local people. Four other stakeholders are recognized as primary stakeholders (NCOs, harvesting companies, ENGOs, scientists), while the remaining six stakeholders (hunters, recreationists, tourists, pickers of NWFP, wood processing companies, and PMs) can be considered secondary stakeholders.

Key and primary stakeholders are mainly "supporters" (5 of 7 stakeholders), while secondary stakeholders are mainly "opponents" (4 of 6 stakeholders).

The SNA in the Ukrainian Carpathians (*Figure 2*) comprises 13 nodes (stakeholders) and 107 links (relationships). SNA results reveal no central stakeholder holds the key role in the decision-making process related to secondary spruce stand conversions. Instead, three stakeholders play key roles in the network: two of these three stakeholders are "supporters" (local authorities and local people) while the remaining stakeholder is an "opponent" (state forest enterprises). NOCs, important actors and primary stakeholders in this social network, are "supporters" of the forest conversion process. In addition, these stakeholders play the role of intermediaries with other stakeholders.

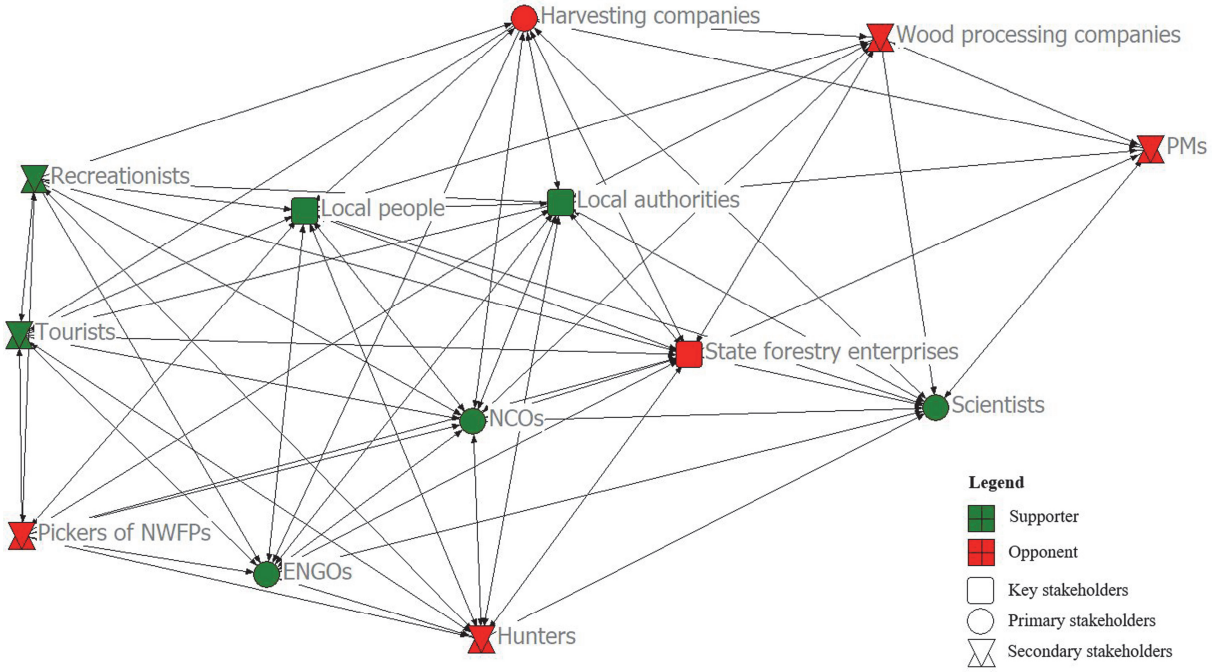

Figure 2. Social network considering all identified stakeholders in the context of secondary spruce stands conversion in the Ukrainian Carpathians

4 DISCUSSION

The present study used respondent answers to identify all relevant stakeholders in the context of secondary spruce stand conversions in the Ukrainian Carpathians. According to Grilli et al. (2015), the proposed approach provides a realistic picture of the network and reveals some hidden stakeholders with lower importance. This approach has three main advantages in stakeholder analysis: it is simple, easy to apply, and requires small amounts of data.

The division of stakeholders into two groups ("supporters" and "opponents") was based on the benefits or losses deriving from secondary spruce stand conversions. The qualitative comments provided by respondents during the questionnaire administration helped determine the appropriate group categorization for stakeholders with almost equal benefits and losses.

Costs of forest conversion are quite explicit for state forest enterprises, especially in the initial stages of this process. Forestry enterprises will bear significant financial costs due to higher harvest costs, logging equipment modernization, forest road network extensions, and additional training for forest technicians regarding the practice of forest conversion. Planting and protecting native tree species – such as European beech and silver fir – may be necessary in cases of poor natural regeneration. Planting and caring for seedlings increases forest conversion costs. Benefits for state forestry enterprises would be generated in the long-term rather than the short-term. More intensive financial investments over a conversion period of around 100 years with a questionable commercial return in a long-term perspective hinder the dissemination of forest conversion practices.

Hunters mainly lose from the secondary spruce stand conversions because the area under forest conversion should be fenced to avoid natural regeneration damage (Lavnyy – Schnitzler 2014). Thus, hunter benefits or losses depend on promoting the new generation on the sites under the conversion. Since most forest conversion sites are fenced, hunters and pickers of NWFPs must seek other forest sites.

The main "supporters" of forest conversion are NCOs due to the opportunities to eliminate the existing and massive dieback process of secondary spruce forests. These stakeholders are in the primary group of stakeholders (according to *Table 2*) because they are positively affected by the results of the forest conversion process.

Other potential "supporters" of forest conversion that are also key stakeholders are local people and local authorities. Their support of this silvicultural measure relates to revenue taxes from timber and firewood sales from conversion cutting, which increases the welfare of local people and authorities.

The high degree of power (ego-degree centrality) local people held in forest conversion decision-making relates to their involvement with Community Councils at the Regional Departments of Forestry and Hunting, which have been established with the aim of discussing important issues concerning the use of forest resources at regional and local levels.

The forest conversion process involves tree species composition and stand age changes that transform pure forests to mixed forests and even-aged forests into uneven-aged forests (Pelyukh et al. 2016, Pelyukh 2018). These changes could have a positive impact on the recreational attractiveness of this forest type. Investigations conducted in the Ukrainian Carpathians (Pelyukh – Zahvoyska 2018, Pelyukh et al. 2019a,b) confirm that people prefer mixed forests to coniferous forests and uneven-aged forests to even-aged ones. Other authors have obtained similar results in Italy and Poland (De Meo et al. 2015, Grilli et al. 2016, Paletto et al. 2017). Increasing recreational attractiveness through forest conversion contributes to an increase in the potential flow of tourists and local economic benefits.

Many tourist organizations operate in the territory of Ukrainian Carpathians: Tourist Association of Ivano-Frankivsk and Lviv region, Regional Tourism Organisation of Zakarpattia, Tourist Association of the Western part of Ukraine, Regional tourist alliances "Play" and "Chornohora", Tourist alliance "Carpathian paths", "Tourist Association of Recreational Development of Skolivshchyna", "Rakhiv.Tourist". These organizations coordinate the directions of tourism business. Many of them lobby to improve the recreational attractiveness of forests (increased tree species diversity, composition, and age structure) to attract more tourists to the Carpathian region of Ukraine.

Two primary stakeholders that "support" forest conversion are scientists and ENGOs. New opportunities to develop professionalism in the fields of adaptive forest management (i.e. forest conversion practice) are among the potential benefits for scientists, while the benefits for ENGOs are related to increased forest naturalness. Scientists should clearly articulate a holistic vision of the benefits from forest ecosystem services, close-to-nature

paradigms, and triggered conversion processes in the forestry curriculum. ENGO representatives should then promote this information to the local community.

Harvesting companies – classified as primary stakeholders – are negatively affected by the results of forest conversion processes. Conversion cutting (changes in age structure and tree species composition) is more complex than clearcutting. Since conversion cutting seeks to protect biodiversity and natural regeneration, it also requires greater attention, resources, and effort. Forest harvesting companies oppose these forest conversion challenges.

Other "opponents" that have a marginal effect on the forest conversion results are PMs and wood industries. The latter require many high-quality raw materials (roundwood), which places a higher value on coniferous stems with no branches and little crowns. Conifers in uneven-aged stands have a longer crown, which diminishes wood quality (Macdonald et al. 2009). A higher proportion of broadleaved wood leads to lower wood prices and, ultimately, financial losses. PMs also prefer coniferous species to broadleaved species because coniferous fibers are longer and pass through presses and other processing operations more easily (Andriyevska – Glushkova 2013).

In accordance with the results of the present study, in the participatory approach aimed to define the future of secondary spruce stands, we propose to involve up to three stakeholders from each homogeneous group of importance (key, primary and secondary stakeholders). This approach will help balance the differing stakeholder interests ("supporter" and "opponent") during the decision-making process.

5 CONCLUSIONS

The interviewed respondents are stakeholders and experts in forest conversion processes, which is the main advantage of the proposed method. Consequently, respondents possess extensive knowledge about all aspects of the forest conversion process, especially concerning stakeholder interests, stakeholder relationships, and power in decision-making.

On the other hand, a disadvantage of the proposed method is the collected data, which are mostly quantitative. Therefore, more qualitative data collection concerning the interests, conflicts, and interactions between identified stakeholders is needed. In-depth interviews and focus groups with key and primary stakeholders could allow for the collection of qualitative information. These aspects require further research in the future.

Stakeholder analysis conducted from the perspective of secondary spruce stand conversions in the Ukrainian Carpathians allows us to identify potential "supporters" and "opponents" of forest conversion processes. Stakeholder analysis also predicts the relationships between stakeholders and the impact stakeholders have on the decision-making process. The presented results are significant to practitioners and decision-makers in two significant ways. Firstly, to understand the advantages and disadvantages of the forest conversion process for different stakeholder groups in the Ukrainian Carpathians. Secondly, to identify stakeholders who could be involved in forest conversion decision-making. This combination of findings provides some support for the conceptual premise of forest policy formulation aimed at sustainability achieved through close-to-nature silviculture in the Ukrainian Carpathians. Research questions for a future investigation could include examinations of how to multiply "supporters" synergies in forest conversion processes and balance trade-offs between stakeholder benefits and losses.

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