

# Private Forest Owner's Cooperation in Machinery Ring: Is it a Solution for Wood Mobilization from Small-Scale Private Forests?

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## Abstract

Legislation and policy makers have recognized private forest owners cooperation in machinery ring as an instrument to support wood mobilization through efficient use of machinery. The study analyzes private forest owner's cooperation in the machinery ring in Slovenia and determines whether this cooperation contributes to wood mobilization from small-scale private forests. The research was conducted in two phases. In the first phase, the survey was conducted among the members of machinery rings at their annual general meetings (24 machinery rings participated in the survey, representing 64.9% of the total number of machinery rings). The questionnaire was distributed to all members present at the annual general meetings (n=529) and only those who were private forest owner or provided services within machinery rings were eligible to complete the questionnaire (n=438). In the second phase, data on the amount of service provided by machinery ring members were compared with the amount of felling in private forests for 2019 to gain insight into the extend of forestry work (timber harvesting) carried out in a private forest under neighbourhood assistance. The results show that machinery rings members are predominantly male, on average 50 years old, mainly with high school education and occupation in agriculture, owning on average 15.2 ha of forest. Regardless of forest management activities, machinery ring members perform forest management activities in their forest by themselves or with the help of family members. Only a small proportion of members use neighbourhood assistance to carry out the work. This most often occurs in the transport of timber. A very small proportion of members provide forest services through the machinery ring, but their scope of services is not insignificant. In 2019, machinery ring members most often performed harvesting activities with the chain saw, followed by timber skidding as a service. Equipment with machinery for providing services is good among members – about three quarters of them have a chainsaw and an adapted agricultural tractor, but this machinery is quite old, showing that machinery is insufficiently used for forestry operations. The results show that machinery rings are nowadays an essential part of strategic (operational) management in Slovenian agriculture and forestry, and provide important insights into the possibilities to improve forestry operations and the future development of cooperation between private forest owners in machinery rings to support wood mobilization from small-scale private forests.

*Keywords:* private forest management, harvesting intensity, cooperation, machinery cooperation, neighbourhood assistance

## 1. Introduction

Forests provide a variety of ecosystem services that are essential for human well-being (Juutinen et al. 2021). Climate change and environmental degradation are an existential threat to Europe and the world. To

overcome these challenges, European Union (hereafter EU) has adopted ambitious policies, such as the European Green Deal (2019), the European Climate Act (2021), the EU 2030 Biodiversity Strategy (2020) and the European Forest Strategy by 2030 (2021), to preserve the natural environment in Europe. The European

Green Deal (2019) introduces a new policy narrative and direction by setting a clear focus on climate, sustainability and biodiversity conservation for all policy areas. The main objective of the Deal is to achieve carbon neutrality and a healthy environment for the EU by 2050. In order to meet the greenhouse gases (GHGs) emission reduction target by 2030, EU member states will, among others, need to significantly increase the share of renewable sources (European Commission 2021). This focus on forests opens up new opportunities and highlights an increased responsibility of European forest owners (Wilkes-Allemann et al. 2021).

The diversity of forest ownership categories and the high number of individual forest owners are important features of European forestry. The share of privately-owned forests is increasing in Europe – according to data from 28 European countries, 56.0% of the forest area is privately owned, of which at least 65.0% is owned by individuals and families (Section 2020, Weiss et al. 2019). Therefore, private forest owners have a considerable influence on forest management outcomes and the fulfilment of various policy objectives. However, these prospects are offset by increasing political concerns about insufficient forest management, unmanaged or abandoned forestland, particularly in small privately-owned forests (Weiss et al. 2019, Wilkes-Allemann et al. 2021, Živojinović et al. 2015). Concerns related to unmanaged and underutilized private forests relate among others to shortages of wood supply for bioenergy and forest-based industries (Blennow et al. 2014, Curman et al. 2016, Posavec et al. 2015, Rauch et al. 2015) and the need to fulfill emerging national and EU policy goals for forests such as climate protection, biodiversity conservation, wood-based bioenergy, strengthening of bio-economy (Tiebel et al. 2021, Weiss et al. 2019).

Furthermore, the diversity of private forest owners has increased considerably over the last two decades due to demographic, economic, and social changes (urbanization of lifestyles, disengagement from agriculture, economic restructuring), which have changed interests, values, and demands of private forest owners on their forests (Weiss et al. 2019). Due to these changes, private forest owners lack interest in investments, technological know-how and the necessary mechanization and equipment to manage their forests and lack sufficient forest management knowledge and experiences to achieve financial and ecological sustainability (Lindroos et al. 2005, Rauch and Gronalt 2005, Sarvašová et al. 2015).

This calls for a turn towards more collaborative forms of forest management. Legislation and policy-decision makers have recognized cooperation between

and joint action by private forest owners, particularly where private forest ownership is small and fragmented, as a key instrument to support the sustainable management of private forests and implement policy objectives such as continued wood mobilization, climate change mitigation and adaptation, or biodiversity conservation (Lawrence et al. 2020, Pöllumäe et al. 2016, Sarvašová et al. 2015, Stern et al. 2013).

In many European countries, different organizational forms of cooperation between private forest owners are known (Section 2020), with various objectives, such as strengthening the political power of forest owners, improving market position through joint marketing of timber, obtaining financial incentives, organizing training courses, exchanging information and improving forest operation through joint work in the forest and joint purchase/use of forest machinery (Section 2020). These forms of cooperation consequently support sustainable forest management and wood mobilization, improve profitability and provide a range of services related to management (Schwarzbauer et al. 2010).

In Slovenia, private forests dominate as 77.0% of the total forest area is owned by private forest owners (ZGS 2021). Wood supply for forest-based industries from private forests is insignificant, as 65.3% of private forest owners have a forest property smaller than 1 ha (the average size of forest property is 3.2 ha), which is further fragmented into three plots on average (ZGS 2021). Small and fragmented forest property is often associated with passive management as private forest owners' primary management objectives relate to harvesting of wood for personal needs (Ščap et al. 2021). This, in turn, has a significant impact on the intensity of forest management (only two-thirds of planned annual fellings in Slovenian private forests is implemented), which means that the majority of private forest owners carry out only a few periodic operations in their forest (Marenč and Krč 2016). Ščap et al. (2021) found that from 2015 till 2019, 71.0% of private forest owners carried out felling and skidding in their forests, with the majority of the work being carried out by themselves or by family members.

In response to the above problems, the Slovenian government has aimed at stimulating wood mobilization and efficient use of machinery capacity in private forests through various strategic documents (e.g. National Forest Program, Rural Development Program and Wood Supply Chain Action Plan) (Aurenhammer et al. 2017) and has set the conditions for voluntary cooperation opportunities for private forest owners in Forest Act in 2007 (Pezdevšek Malovrh and Avdibegović 2021). According to the Forest Act No. 110/07 of 3 December 2007 (Forest Act 2007) (Article 74a),

voluntary cooperation among private forest owners in private forest owners associations (hereinafter PFOA) is encouraged to increase the efficiency of forest management and the marketing of forest products and biomass. In addition, the Forest Act stipulated that natural persons (private forest owners) may establish machinery rings for more efficient use of forest machinery and equipment, work force and other production capacities, in accordance with the regulation for agriculture (Pezdevšek Malovrh and Avdibegović 2021).

Cooperation between private forest owners has been one of the essential topics in forest policy research in the last decade, not only in Slovenia but also in Europe. Much research deals with cooperation between private forest owners (e.g. Fischer et al. 2019, Górriz-Mifsud et al. 2019, Pezdevšek Malovrh 2010, Pezdevšek Malovrh et al. 2017, Pöllumäe et al. 2016, Rauch 2007) and mostly analyzes PFOAs with the aim of understanding the influence of various factors on the willingness of private forest owners to cooperate in PFOAs (Pezdevšek Malovrh et al. 2010), the reasons for establishing PFOAs (Sarvašová et al. 2015, Schraml 2005), factors that influenced the establishment, development, professionalism and efficiency of PFOAs (Černač and Pezdevšek Malovrh 2020, Fabra-Crespo and Rojas-Briales 2015, Glück et al. 2010, Kronholm 2016, Leban 2014, Lönnstedt 2014, Pezdevšek Malovrh and Laktić 2017, Sarvašová et al. 2015), the motives of private forest owners and their benefits for joining PFOA (Hrib et al. 2018, Pezdevšek Malovrh et al. 2011, Pöllumäe et al. 2014), the effects of PFOAs on forest management (Hansmann et al. 2016, Seeland et al. 2011), and the role of stakeholders (Aurenhammer 2017a, Aurenhammer et al. 2017b, Šálka et al. 2016). These studies provide important insights into the state of the art of PFOAs, but mainly focus on only one organizational form of cooperation. Only a few papers analyze private forest owners cooperation in other organizational forms, especially cooperatives, focusing on the analysis of objectives, organizational structure and their operation (Černač and Pezdevšek Malovrh 2020, Lazdinis et al. 2005, Sonnhoff and Selter 2021, Sonnhoff et al. 2021, Trigkas et al. 2020). However, there is a considerable research deficit in private forest owners machinery cooperation in machinery rings. Machinery rings are an organized form of neighbourhood assistance as an association of farmers and private forest owners. The aim of the study is to present machinery cooperation of private forest owners in machinery rings in Slovenia and to determine whether this machinery cooperation contributes to wood mobilization from small-scale private forests, based on:

- ⇒ harvesting intensity in private forests and amount of neighbourhood assistance
- ⇒ characteristics of machinery ring members and their properties
- ⇒ forestry activities of machinery ring members in their forest and within the machinery ring
- ⇒ their equipment with machinery.

The results are important for the forest policy implementation, as currently little is known about the extent and characteristics of forestry services in the private forests in the context of neighbourhood assistance and, at the same time, it can be used as a basis for improving forest policy measures.

## 2. Private Forest Owners' Cooperation in Machinery Rings in Slovenia

The existing cooperation of private forest owners in Slovenia based on the use of machinery in the form of machinery rings is an important starting point to enable private forest owners to overcome cost-inefficient forest management and provide a more efficient use of mechanization. The economic benefits of participation in machinery rings are reflected in higher utilization of machinery and a resulting reduction in costs, higher productivity and quality of work, and the opportunity to generate additional income by working on other members' farms or forests. The social benefits of participation in machinery rings are connected to work safety and thus a reduction in the number of accidents, participation and offering help in labor during the holiday and peak seasons, improving social relations between neighbours and thus improving the quality of life on the farm (Pezdevšek Malovrh 2010, Pezdevšek Malovrh et al. 2012).

Slovenian legislation regulates the area of machinery rings operation well. Agriculture Act No. 45/08 of 9 May 2008 (Article 110) (Agriculture Act 2008) stipulates that in order to make the use of agricultural and forestry machinery and equipment, workforce and other production capacities more efficient, agricultural holdings, farm holders or members and forest owners may establish a machinery ring through which they may carry out services with agricultural and forestry machinery. Under this Act, a machinery ring is a legal entity under private law established under the Act regulating societies, primarily to provide information on agricultural and forestry machinery, promote the provision of such services, and link providers and recipients of such services. The Act also requires machinery rings to keep records of the services provided by each member of the machinery ring. Therefore, the

machinery rings are organized under the Societies Act and in legal transactions use the name »Association for Neighbourhood Assistance – Machinery Ring«.

The members are natural persons (including private forest owners) and holders or members of agricultural holdings. Cooperation based on the use of machinery is extended to the entire territory of a machinery ring. Members offer an available capacity of their own machinery or workforce to other members and get paid at a previously agreed price in the Catalogue of Cost of Agriculture and Forestry Machinery that covers the cost of the machinery. Machinery rings are responsible for informing members and providing services.

The provision of services only between agricultural holdings is exempt from personal income tax under the Personal Income Tax Act and under the provisions governing terms and conditions for exemption from personal income tax on receipts from mutual assistance among agricultural holdings within the machinery ring. The exemption applies to receipts whose income from basic agricultural and forestry activities is determined by cadastral income and to the provision of agricultural and forestry services (according to the standard classification of activities) for contracting authorities that are members of machinery rings and

for other contracting authorities that are not members but are agricultural holdings. These may be farms (an operator is a natural person), an agrarian community or a legal entity registered for an agricultural or agricultural and forestry activity (e.g. sole trader, limited liability company or joint-stock company). The exemption from personal income tax applies up to the amount of income of 420 €/ha of agricultural land (maximum total area of 20 ha) and 85 €/ha of forest (maximum total area of 30 ha). The provision of services by a machinery ring for clients who have only a forest and are not an agricultural holding cannot be used to be exempted from the payment of personal income tax for services provided in accordance with regulations in the field of personal income tax. In this case, the service providers must register the activity, e.g. subsidiary activity on their farm or private entrepreneurship, and comply with the business regulations (Dolenšek 2021).

The first machinery rings were established in Slovenia in 1994. Today (December 2021) 37 machinery rings with 6343 members are active and cover practically the whole country (Fig. 1).

The machinery rings are mainly active in agriculture; only three were established with a focus on forestry activities and are also mainly active in forestry.



Fig. 1 Distribution on machinery rings in Slovenia

Seven were established mainly for agricultural activities, but are also active in forestry. In total, this corresponds to 1831 members engaged in forestry activities or, 29% of all machinery ring members. In 2020, machinery ring members performed on average about 113,000 hours of services (work), which corresponds to about 17.8 hours of services per member (Dolenšek 2021).

### 3. Materials and Methods

#### 3.1 Data Collection

The research was conducted in two phases. In the first phase, the structured questionnaire was developed for machinery ring members within the project »Development of indicators and methodology for monitoring of forest contractors«, comprising both open-ended and closed-ended questions. The questionnaire consisted of 22 questions divided into three sections seeking information on:

- ⇒ members and their socio-economic characteristics
- ⇒ performance of forest management activities
- ⇒ equipment with machinery.

The questionnaire was pre-tested on a machinery ring – Machinery ring Gorjan in May 2019. Based on the pre-tests, the questionnaire was revised to make the questions as understandable and precise as possible. The survey was conducted during the annual general meetings of the machinery ring. Unfortunately, due to the COVID-19 epidemic, some annual general meetings were canceled, and others were moved to online platforms. Therefore, 24 machinery rings participated in the survey, which represent 64.9% of the total number of machinery rings currently operating in Slovenia, namely: Bela Krajina, Bled, Burja, Domžale, Drava, Gorjan, Klas-Lenart, Kmetovska, Litija, Ljubljana Vzhod, Ljutomer Križevci, Murska sobota, Novo mesto, Orač, Ormož, Posestnik, Pšata Bistrica, Savinjska dolina, Sejalce, Slovenske Konjice, Šaleška dolina, Temenica/Mirna, Urban and Žetalanec. The survey data were collected from March to August 2020. The questionnaire was distributed to all present at the annual general meetings. Some respondents ( $n=32$ ) were surveyed at the general assembly meeting of machinery rings associations. A total of 529 questionnaires were distributed and collected. First, members of the machinery rings were asked whether they were forest owners and whether they provided services in forests. Only those who answered yes to at least one of the exclusion questions were invited to complete the questionnaire ( $n=438$ ). Of these, 79% are forest owners and 46% of respondents provide forestry services within the machinery ring.

In the second phase, data on the amount of service provided by machinery ring members were compared with the amount of felling in private forests for 2019 to gain insight into the extent of forestry work (timber harvesting) carried out in a private forest under neighbourhood assistance. The data on the amount of fellings in private forests was obtained from the Slovenian Forest Service databases (ZGS 2021).

#### 3.2 Data Analysis

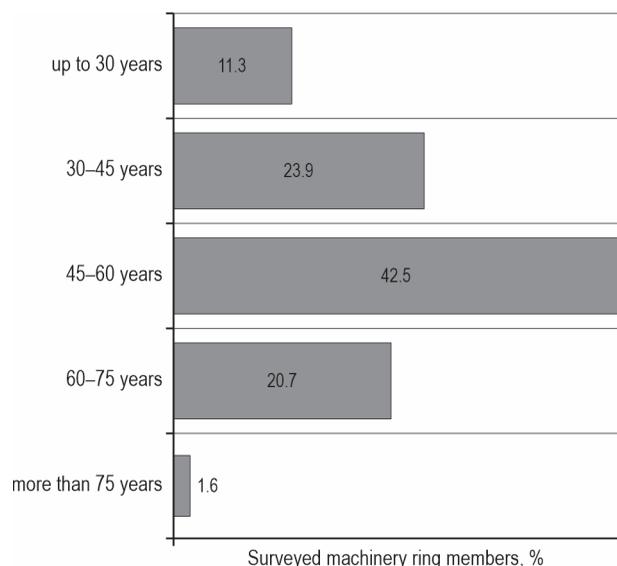
The data analysis in this study followed the process of data collection. The first phase involved a summary of the data collected via survey. The collected data were imported and coded in MS Excel and processed in IBM SPSS Statistics 24.0 (IBM 2021). To check the quality of the data and to detect errors, outliers and missing values, all data were first checked with frequencies. Variables in the questionnaires were analyzed using frequency distributions and mean values.

In the second phase, secondary data from the Slovenian Forest Service by forest management regional units were analyzed to assess the amount of fellings from Slovenian private forests, which was compared with the amount of services provided by machinery ring members. Since the reported data on performing harvesting services (as neighbourhood assistance) come from a log-normal distribution, the data were transformed prior to analysis. We were particularly interested in the confidence intervals for estimating the total harvesting potential of machinery ring members. The modified version of the Cox method was used to calculate an asymmetric confidence interval at 95% (Olsson 2005). Estimates were derived from calculated harvesting taking into account confidence interval and approximation of members performing the forestry services as neighbourhood assistance. Approximation of members performing the forestry services was modeled from a share of survey respondents who provide forestry services within the machinery ring multiplied with total number of active members per machinery ring. Transformations, harvesting mean and confidence interval calculations were performed using R version 4.0.3. (Team 2021) and the comprehensive R package for environmental scientists (Millard 2013).

## 4. Results

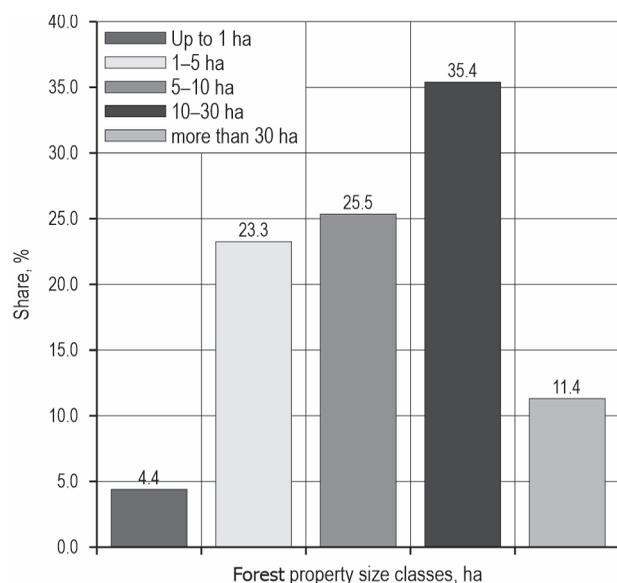
#### 4.1 Basic Characteristics of Surveyed Machinery Rings Members

The sample represents 438 machinery ring members, among which members of machinery ring Bled were the most represented (17.6%), followed by machinery ring Ormož (10.7%) and Gorjan (10.3%). The



**Fig. 2** Age structure of surveyed machinery ring members

surveyed members are predominantly male (98.0%), mainly with high school education (64.6%). 19.1% of surveyed members have a university degree (14.6% a bachelor's degree and 4.5% a master's degree or higher) and 14.6% have completed elementary school. The main occupation is agriculture, as 68.6% of the surveyed member have the status of a farmer, of which 28.4% have registered subsidiary activity on their farm. The average age of the surveyed machinery ring member is 50 years (range between 18 and 82 years).



**Fig. 3** Share of surveyed machinery ring members by forest property size classes

The age structure of the surveyed machinery ring members shows that with 42.5% of age class 45–60 years dominates, followed by age class 30–45 years (23.9%) (Fig 2).

The surveyed members of the machinery rings own a total of 11,100.12 ha of land, of which 6241.20 ha are forests. The average size of the owned properties is 27.2 ha (range between 1.0 and 322.0 ha). They own, on average 15.2 ha of forest land (range between 0.5 and 150.0 ha). From the forest property size classes of the surveyed machinery ring members, it can be seen that with 35.4% the forest property class 10–30 ha dominates, followed by the forest property class 5–10 ha (25.5%) and 1–5 ha (23.3%). (Fig 3).

#### 4.2 Performance of Forest Management Activities by Surveyed Machinery Rings Members

The machinery rings members were asked to explain how they had carried out various forest management activities in their forest over the last five years. We were interested to know whether forest management activities such as reforestation, silviculture and protection works, regular felling, sanitary felling, logging, timber transport and construction of forest roads were carried out by the owners themselves or with the help of family members, relatives, neighbours or friends, or whether they hired a service by machinery ring or a forestry company (Fig 4).

For all surveyed members of the machinery ring, regardless of forest management activities, the predominant activity is the performance of forest management activities by themselves or with the help of family members. Only a small proportion of surveyed machinery rings members use neighbourhood assistance to carry out the work – this most often occurs in the transport of timber.

In addition, we were also interested in the amount of forest services provided by members within machinery rings in 2019 (Table 1). A very small proportion of surveyed machinery ring members provide forestry services through the machinery ring, but their scope of services is not insignificant (Table 3). In 2019, surveyed machinery ring members most frequently performed timber harvesting with a chainsaw (14.8% of members) through the machinery ring. They have harvested 32,044.50 m<sup>3</sup> of timber or on average 414.27 m<sup>3</sup>. Timber skidding was done by 12.3% of the surveyed members and they skidded 34,250.00 m<sup>3</sup> of wood or on average 634.26 m<sup>3</sup>. The same proportion (5.3%) of the surveyed members of the machinery rings carry out silvicultural and protection work and timber transport. The members carried out a total of 89.2 ha of silvicultural and protection work or on

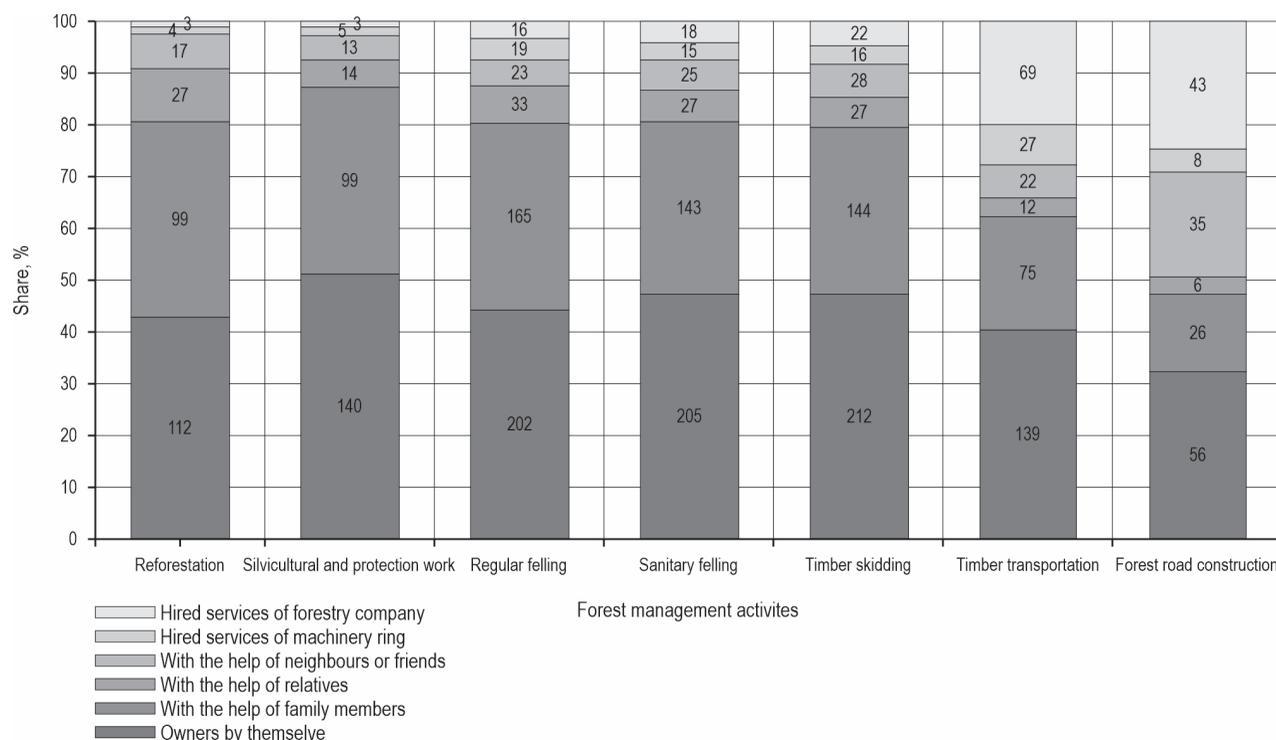


Fig. 4 Performance of forest management activities (multiple answers)

average of 3.87 ha and transported 9810.00 m<sup>3</sup> of timber or on average 426.52 m<sup>3</sup>. Production of fire wood was carried out by 8.7% of the survey members and they prepared in total 2723.00 stacked m<sup>3</sup> of fire wood or 71.66 stacked m<sup>3</sup> on average. The surveyed members of the machinery ring were least involved in the production of wood chips (2.1% of the members), their transport (1.1% of the members) and timber harvesting with harvester (0.9% of members). They prepared 10,990.00 bulk m<sup>3</sup> of wood chips or on average 1221.11 bulk m<sup>3</sup> and transported 1420.00 bulk m<sup>3</sup> or on average

284.00 bulk m<sup>3</sup>. The members of the machinery rings harvested with harvester 10,166.00 m<sup>3</sup> or on average 2541.50 m<sup>3</sup>.

### 4.3 Harvesting Intensity in Private Forests and Estimated Harvesting Services Potential within Machinery Rings

In one of the first questions, the members of the machinery rings were asked whether they performed services for other members of the machinery ring, and 46.0% of respondents said that they did provide

Table 1 Amount of forest services performed by surveyed machinery ring members

Type of services	Share of surveyed members, %	Total amount of services performed	Average amount of services performed
Timber harvesting with chainsaw, m <sup>3</sup>	14.8	32,044.50	414.27
Timber skidding, m <sup>3</sup>	12.3	34,250.00	634.26
Production of firewood, stacked m <sup>3</sup>	8.7	2723.00	71.66
Silvicultural and protection work, ha	5.3	89.20	3.87
Timber transportation, m <sup>3</sup>	5.3	9810.00	426.52
Production of wood chips, bulk m <sup>3</sup>	2.1	10,990.00	1221.11
Wood chips transportation, bulk m <sup>3</sup>	1.1	1420.00	284.00
Timber harvesting with harvester, m <sup>3</sup>	0.9	10,166.00	2541.50

**Table 2** Harvesting intensity in private forests and amount of neighborhood assistance

Forest management regional unit	Annual felling in private forests m <sup>3</sup>	Survey respondents/ Respondents performing harvesting service	Reported harvesting utilization as service – respondent, m <sup>3</sup>	Harvesting mean values (with 95% confidence interval in brackets)	Estimated total harvesting utilization potential of machinery ring members, m <sup>3</sup>	Estimated harvesting utilization potential of machinery ring members, %
Tolmin	205,336.42	45/13	2263.00	235.36 (96.22–692.64)	3113.25–22,410.75	2–11
Bled	549,069.69	77/16	29,717.50	1605.67 (211.92–34,323.44)	16,291.35–2,683,614.45	3–481
Kranj	281,004.29	0	n.a.	n.a.	n.a.	n.a.
Ljubljana	367,644.02	59/6	2050.00	302.23 (40.46–4226.56)	2987.82–312,115.20	1–85
Postojna	157,660.34	0	n.a.	n.a.	n.a.	n.a.
Kočevje	261,696.75	3/1	50.00	n.a.*	n.a.*	n.a.*
Novo mesto	321,668.82	57/2	250.00	125.00 (0.0065–4,015,063.00)	0.12–75,443,529.46	0–23,454
Brežice	203,319.21	0	n.a.	n.a.	n.a.	n.a.
Celje	174,264.75	35/5	590.00	118.7 (63.46–234.12)	3726.83–13,749.23	2–8
Nazarje	240,417.71	3/1	10.00	n.a.*	n.a.*	n.a.*
Slovenj Gradec	355,298.58	29/4	4800.00	1,225.63 (230.21–8630.02)	8348.95–312,982.06	2–88
Maribor	365,676.83	86/11	1920.00	183.72 (61.23–719.44)	4523.10–53,145.53	6.30
Murska Sobota	92,049.58	2/0	n.a.	n.a.	n.a.	n.a.
Sežana	95,671.85	41/6	500.00	72.82 (30.22–201.36)	572.17–3812.42	1–4
Total	3,670,778.84	438/65	42,210.50	414.27 (235.47–796.7)	183,175.67–619,764.96	5–17

\* The calculation could not be performed as dataset did not contain at least 2 non-missing distinct values or non-missing values were not positive

forestry services within the machinery ring. However, only 65 of those also reported quantities of harvesting services performed in 2019. In total, surveyed machinery ring members have reported 42,210.50 m<sup>3</sup> of harvested timber as a service of machinery ring. The 95.0% of the sampled means were measured in the interval from 235.47 m<sup>3</sup> to 796.7m<sup>3</sup> (Table 2).

#### 4.4 Equipment of Surveyed Machinery Rings Members with Machinery for Providing Forest Services

Respondents were also asked about the mechanization they use in providing forest services within the machinery ring to find out how equipped the machinery ring members are.

Chainsaw was the most often reported, as 77.0% of the surveyed members own at least one chainsaw.

53.1% of the members own two chainsaws and 18.8% own three chainsaws. In total, surveyed machinery ring members own 341 chainsaws, or an average of 2.3 chainsaws per member, but these are on average 9 years old (range between 1 and 46 years).

For timber skidding, 79.5% of the surveyed members own at least one adapted agricultural tractor and 19.9% own two adapted agricultural tractors. The surveyed machinery ring members own 416 adapted agricultural tractors in 35 different brands. Among them, Zetor brand dominates (13.0%), followed by Same (7.8%), John Deere and New Holland (7.7% each), Deutz-Fahr (5.8%), Univerzal and IMT (5.5% each). The engine power of the adapted agricultural tractors ranges from 15 kW to 200 kW (most frequently 60 kW). The average age of adapted agricultural tractors is 19.7 years (range between 1 and 51 years). Only 10.8% of

adapted agricultural tractors have a complete forestry upgrade. 66.4% of the surveyed machinery ring members use at least one winch for logging, 4.3% use two. In total, surveyed machinery ring members have 310 winches, 14 different brands, to provide their services. The largest share of winches is that of the Slovenian brands Krpan (35.8%), Tajfun (35.8%) and Uniforest (19.4%). All other brands are represented with significantly lower shares (<5%). The pulling capacity of the winches ranges from 15 kN (winch on a Husquarna chainsaw) to 160 kN. Winches with a pulling capacity of 50 kN (29.8%) account for the largest share, followed by winches with 55 kN (19.1%) and 40 kN (17.7%). All other winches with different pulling capacities follow much smaller proportions (<5%). Nearly half of the surveyed machinery ring members (47.2%) have a radio-controlled winch. Three-point winches predominate among the surveyed members (86.3%), probably since the owners are farmers, and the tractors are therefore used not only for forestry services but also for agricultural work.

The surveyed machinery ring members own a total of 84 forestry trailers with crane for timber transport. Palms forestry trailers predominate (28.6%), followed by home made forestry trailers (14.3%), Weimer brands (13.1%), Tehnostroj brand (13.1%) and Krpan brand (6.0%). The load capacity of forestry trailers ranges from 2 to 15 tons. The largest proportion of forestry trailers has a loading capacity of 10 tons (23.8%), followed by trailers with a loading capacity of 8 tons (14.3%), 12 tons (13.1%) and 6 tons (11.9%). Palms cranes predominate (37.0%) among the cranes installed on trailers, followed by Weimer (15.2%). The maximum outreach of crane varies widely, the minimum outreach is 3.6 meters and the maximum 12.0 meters. Among the other timber transportation machines used by the members to provide services, one respondent also owns a truck MAN TGS.

In wood fuel production (wood chips), the surveyed machinery ring members most frequently use Bider brand chippers (42.9%), while all other brands occur only once. The surveyed machinery ring members own 14 wood chippers to offer their services. The surveyed machinery ring members also use 139 wood splitters for the production of fire wood, of which 33.8% are horizontal and 66.2% are vertical. Among wood splitters, domestic brand Krpan dominates (45.3%), followed by another domestic brand Lancman (19.4%). All other brands are represented with significantly lower shares (<10%). Among the other wood fuel machines used by the members to provide services, one respondent also owns a Lancman circular saw.

## 5. Discussion and Conclusions

This study aimed to present machinery rings as a form of private forest owners' cooperation in Slovenia and to determine whether this machinery cooperation contributes to wood mobilization from small-scale private forests.

### 5.1 The Current Characteristics of Machinery Ring Members Show that Forest Policy Fails to Mobilize Wood from Small-Scale Forest Properties

The private forest properties in Slovenia are an example of small-scale forest property in Europe concerning the utilized agriculture and forest area and economic size (Guiomar et al. 2018). Typical Slovenian private forest owners belong to the elderly population, are retired or unemployed, have elementary education and have low income (Kumer and Štrumbelj 2017, Pezdevšek Malovrh 2010). In addition, a significant proportion of private forest owners in Slovenia (62.0%) use their forest for fuelwood production for their own use (Ščap et al. 2021).

In order to support sustainable forest management of private forests and wood mobilization from these forests, governments in Slovenia and across Europe prioritize active management of private forests and promote cooperation between private forest owners in various organizational forms – one of which is also machinery rings (Mizaraitė and Mizaras 2014, Pezdevšek Malovrh and Avdibegović 2021, Sonnhoff and Selter 2021, Weiss et al. 2012). Although there is an experience of private forest owner cooperation in Slovenia, targeting private forest owners who have small-scaled forest property, diverse management objectives (Feliciano et al. 2017, Ficko and Bončina 2013), and have become urbanized and less attached to the forest (Kumer 2017) is still a challenge for Slovenian forest policy decision makers and an obstacle in implementing policy objectives. This also confirms our results, as members of machinery rings are younger than typical private forest owners (on average 50 years old), better educated (64.6% have a high school education), with bigger forest properties (on average 15.2 ha). The situation shows that the current cooperation in machinery rings does not include the group of private forest owners that forest policy would like to activate (i.e. small-scale private forest owners without economics-centered forest management activity). Therefore, the question arises whether the cooperation in machinery rings promoted by the Forest Act No.110/07 of 3 December 2007 (Forest Act 2007) can really increase the efficiency of forest management and the efficient

use of machinery capacities, work force, and other production capacities in private forests and stimulate the mobilization of wood from small-scale private forests in the future. To support machinery cooperation of small-scale private forest owners and to achieve forest policy objectives related to wood mobilization, it would be necessary to decide who will be the key actors (e.g. the public forest administration, the Chamber of Agriculture and Forestry, the Machinery ring association or some private actors) and what will be their role in promoting and providing information about cooperation of small-scale private forest owners in machinery rings. The decision about an appropriate actor can be made based on previous studies that have shown that, in many cases, extension officers, local wood purchasers, and family members are the main source of normative pressure influencing the decision-making process of private forest owners regarding forest management and their willingness to cooperate (Feliciano et al. 2017, Upton et al. 2019). In addition, Gootee et al. (2010) reported that many forest management professionals failed to explain the rationale behind new approaches (e.g. private forest owners cooperation in machinery rings) or regulations before requiring private forest owners to implement them, resulting in owners being reluctant to accept or adopt much of the information provided and showing little interest in any kind of cooperation.

Since private forest owner's forest use and forest management activities may diminish in the future due to changing lifestyles and urbanization, the current forest governance system should enforce a set of adequate policy measures to align policy objectives with the future needs of private forest owners. On that basis, it is necessary to ensure that policy measures act as a »sermon« rather than a »stick«, and guide and encourage the private forest owners to pursue forest management practices that are considered desirable and to show them that cooperation in the machinery ring is beneficial to them. Furthermore, within the framework of the »Smart-regulation« principles (Gunningham and Grabosky 1999, Van Gossum et al. 2012), it would be useful to define a specific mix of supportive forest policy instruments targeted at different groups of private forest owners (large vs. small, active vs. passive, young vs. middle-aged vs. old, etc.), as according to the literature (e.g. Beach et al. 2005, Rodriguez-Vicente and Marey-Perez 2009) different characteristics influence the forest management activities of private forest owners. In addition, it is also important to consider options for long-term business cooperation between small-scale private forest owners and machinery ring members (or entrepreneurs) in the

form of forest management agreement, as is already the practice in Scandinavian countries (Kurttila et al. 2016, Laakkonen et al. 2019, Staal Wästerlund and Kronholm 2017), as only this type of cooperation gives small-scale private forest owner the chance to overcome cost-inefficient forest management.

## 5.2 Performance of Forest Management Activities by Members of Machinery Ring is an Important Component of Approaches to Wood Mobilization

The freedom of private forest owners to perform the harvesting activities is regulated by the Slovenian Forest Act No. 30/93 of 10 June 1993 (Forest Act 1993). The Forest Act stipulates in Article 9 that private forest owners may perform forest activities by themselves and may be assisted by their legal heirs, partners and other natural persons in the form of neighbourhood assistance or can be performed by natural or legal persons registered to perform such works, meeting the requirements of professional qualifications (Pezdevšek Malovrh and Avdibegović 2021, Triplat and Krajnc 2021). Similarly, in other European countries, Nichiforel et al. (2018) found that private forest owners have the right to harvest the trees by themselves in 78.0% of European jurisdictions. Accordingly, it is not surprising that members of machinery rings, regardless of forest management activities, perform them by themselves or with the help of family members. These results are in line with previous studies in Slovenia and Europe, which have shown that small-scale private forest owners generally perform forest management activities by themselves (Lindroos et al. 2005, Medved 1991, Medved 2000, Ní Dhubháin et al. 2010, Novais and Canadas 2010, Ščap et al. 2021). Surprisingly, only a small proportion of the machinery ring members use the help of the neighbourhood assistance to carry out the work in their forests – this is most frequently used in the transport of timber. This shows that they rarely decide to take advantage of the benefits offered by cooperation in the machinery ring, which can be explained by the fact that machinery ring members are well equipped for timber harvesting and skidding and less so for timber transportation. About three quarters of the members have a chainsaw and an adapted agricultural tractor, but these machinery is quite old (chainsaw on average 9 years and tractors 19.7 years). This again shows that, although private forest owners are equipped with machinery, it is old, which is in line with the previous research (Marenče and Krč 2016, Robek et al. 2005). The reason why machinery ring members do not use neighbourhood assistance to carry out the work in their forests may also lay in the fact

that some forest management activities (e.g. reforestation, silviculture and protection work) do not generate revenues to private forest owners at the time of service being performed that could cover the costs of services provided through the machinery ring. The study of Moskalik et al. (2017) also showed that private forest owners in Eastern European countries take an individual approach to forest operation – depending on the economic efficiency, they either perform it by themselves or through outsourced service providers.

In addition, a very small proportion of machinery ring members provide forestry services through the machinery ring, but their scope of services is not insignificant. This can be explained by the fact that most of the machinery ring members own adapted agricultural tractors without forestry upgrades, which shows that they are not primarily used for professional forestry work. In addition, three-point winches also predominate among the machinery ring members (86.3%), probably because the owners are farmers and the tractors are not only used for forestry services but also for agricultural ones. A small proportion of services performed by machinery rings members can also lay in the fact that, in Slovenia, many farmers are organized to perform forestry activities also as part of a subsidiary activity on their farm – this is actually the second most represented organizational form of forestry contractors in Slovenia (Triplat and Krajnc 2021).

From the overcapacity of the mechanization and low level of forestry services provided through the machinery rings, it can be concluded that the machinery is insufficiently used. According to Stampfer et al. (2001), inadequate use of machinery is recognized as a significant management problem in small-scale forests. These facts raise the question of whether machinery ring operation in forestry is consistent with the idea of machinery and labor costs rationalization and increasing utilization of machinery. The basic idea of machinery rings originates from the cooperation of agricultural machinery in Germany. Also, the first machinery rings in the field of agriculture were established in Slovenia with the strong technical support of agricultural extension service within the Chamber of Agriculture and Forestry. This original idea was then transferred to forestry, but only three machinery rings are particularly active in forestry and seven are partly active in forestry, so it is not expected that the forestry services activities will increase in the future if the amount of forestry services remains the same. Accordingly, the contribution of the machinery ring to wood mobilization from small-scale private forests is very doubtful. At the same time, under the current regulation of machinery ring operations, services cannot be

provided to members who own forests and are not farmers (agricultural holding) to be exempt from paying personal income tax on services provided. As a result of this limitation, farmers (agricultural holdings) are primarily interested in becoming a member of machinery rings. Also, the recent representative survey of private forest owners showed that only 9.0% of the surveyed owners are agricultural holding (Ščap et al. 2021), which is an obstacle for the future operation of machinery rings.

Notwithstanding the above-mentioned problems faced by machinery rings in providing services in forestry, it can be concluded that machinery rings are nowadays an essential part of strategic (operational) management in Slovenian agriculture and forestry. However, it seems that there are still many opportunities that are not fully exploited. In the future, it is necessary to extend the membership in machinery rings to small-scale forest owners or to strive for long-term business cooperation between machinery ring members and small-scale forest owners, to promote forestry services offered by members, to strengthen the operations in the field of forestry and to find new ways to promote cooperation of private forest owners in the machinery ring and their professionalization. Only with a proactive forest policy in the field of supporting the existing and developing new organizational models can a contribution be made to wood mobilization in the small-scale private forests.

### 5.3 Future Research and Limitation of Study

As with all studies, there are some limitations to this one. During data collection, it was not possible to draw a random sample of machinery ring members because the COVID-19 epidemic restricted in person general annual meetings of machinery rings. Therefore, only members who attended the general annual meetings and agreed to participate in the study were included in the sample, implying that the sample was self-selected. Therefore, the sample could be subject to selection bias and possible systematic sampling error. The possibility of including 64.9% of the total number of machinery rings currently operating in Slovenia in this study and all forestry-oriented machinery rings minimizes the inconsistency of the data and possible sources of error. However, these aspects should be considered when generalizing to the population of machinery rings. Due, to the above-mentioned limitation, we, (the authors) will strive to repeat the study after a few years and invite all members of the machinery rings to participate in the survey. In the meanwhile, a more complex case study among members of a single machinery ring is expected. In addition to

studying machinery ring capacity, we will also explore the possibilities of acting as a sole contractor instead of a machinery ring member.

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