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Contents

SPECIAL ISSUE – *The role of traditional, transforming and new commons in landscapes*

POSEBNA IZDAJA – *Vloga tradicionalnega, preobraženega in novega skupnega v pokrajinah*

- Mimi URBANC, Keiko HORI, Mateja ŠMID HRIBAR
Commons, collective actions and landscapes: A short introduction 9
- Hans RENES, Alexandra KRUSE, Kerstin POTTHOFF
Transhumance, commons, and new opportunities: A European perspective 15
- Nevenka BOGATAJ, Janez KRČ
Towards the efficient response of forest owners to large-scale forest damage: An example of forest commons 33
- Joana NOGUEIRA, José Pedro ARAÚJO, Joaquim Mamede ALONSO, Sara SIMÕES
Common lands, landscape management and rural development: A case study in a mountain village in northwest Portugal 51
- Tanja ŠUMRADA, Emil ERJAVEC
Will farmers cooperate to conserve biodiversity? The use of collective bonus in the High Nature Value farmland in Slovenia 69
- Primož PIPAN, Mateja ŠMID HRIBAR, Mimi URBANC
Motivation, robustness and benefits of water commons: Insights from small drinking water supply systems 85
- Mateja ŠMID HRIBAR, Mimi URBANC, Matija ZORN
Commons and their contribution to sustaining Slovenian cultural landscapes 101
- Lucia PALŠOVÁ, Zina MACHNIČOVÁ
Common lands as a system of joint management to contribute to community resilience? Case from Slovakia 119

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Front cover photography: Common lands, like the pastures around Čadrg, reflect socio-economic change in the landscape. Their conservation and successful management are crucial for preserving local culture and biodiversity and supporting sustainable development (photograph: Jure Tičar).

Fotografija na naslovnici: Skupna zemljišča, kot so pašniki v okolici Čadrga, so odsev družbeno-gospodarskih sprememb v pokrajini. Njihovo vzdrževanje in uspešno upravljanje sta nujni za ohranjanje lokalne kulture ter biotske raznovrstnosti in zagotavljanje trajnostnega razvoja (fotografija: Jure Tičar).

TOWARDS THE EFFICIENT RESPONSE OF FOREST OWNERS TO LARGE-SCALE FOREST DAMAGE: AN EXAMPLE OF FOREST COMMONS

Nevenka Bogataj, Janez Krč



MIHA PAVŠEK

A large scale ice-break hit Postojna region in February 2014.

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Nevenka Bogataj¹, Janez Krč²

Towards the efficient response of forest owners to large-scale forest damage: An example of forest commons

ABSTRACT: This article aims to analyse the response of private forest owners to a series of extreme environmental disturbances in the Slovenian karst region in the period 2014–2016. Quantitative and qualitative analysis of empirical forest management data on response time and harvesting time, as well as interpretations of response drivers, led to the identification of forest commons as a fast and efficient type of forest ownership, despite almost a century of state suppression of their local institutions. Among the internal and external response drivers, a norm of responsibility and forest management competence were highlighted. Our study highlights the potential of forest commons for active forest management in Europe. A concerted response from private and state institutions should not only take into account economies of scale, but also traditional knowledge and local social norms.

KEY WORDS: harvesting behaviour, natural disturbances, forest management, Slovenia

Za učinkovit odziv lastnikov gozda na veliko površinske poškodbe gozda: primer agrarnih skupnosti

POVZETEK: Preučili smo odziv zasebnih lastnikov gozda na zaporedje ekstremnih okoljskih motenj gozda v kraški pokrajini v Sloveniji v obdobju 2014–2016. Kvantitativna in kvalitativna analiza empiričnih podatkov o hitrosti odziva na poškodbe gozda in o trajanju sečnje ter vpogled v razlage domačinov omogočajo interpretacijo agrarnih skupnosti kot učinkovite oblike lastništva gozda, kljub skoraj stoletnemu državnemu omejevanju njihovega delovanja. Razlogi za to so različni, med notranjimi pa sta tudi norma odgovornosti in kompetence gospodarjenja z gozdom. Študija osvetljuje potencial agrarnih skupnosti za aktivno gospodarjenje z gozdom v Evropi. Usklajen odziv zasebnih in državnih institucij naj ne bi upošteval le ekonomije velikosti, ampak tudi tradicionalno znanje in lokalne družbene norme.

KLJUČNE BESEDE: sanitarna sečnja, naravne motnje, gospodarjenje z gozdom, Slovenija

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1 Introduction

The increasing frequency and severity of environmental challenges underscores the need for a collective response (Bodin 2017). Ecosystems on limestone bedrock are particularly vulnerable to disturbances (Vilhar et al. 2022). Climate induced large-scale forest disturbances have been reported from nearby Austria (The Orientgate... 2014) to distant China where a monsoon climate and human activities are threatening a fragile soil layer to the point of desertification (Xiao et al. 2020). The negative impacts of large-scale forest disturbances on karst hydrology have been thoroughly analysed by Vilhar et al. (2022), who found that ice storms in Europe often affect the Dinaric Alps. Slovenia experiences several types of weather-related stress such as drought, wind, storms and ice-breaks, resulting in numerous studies on forest disturbances, including those caused by ice storms (Sinjur et al. 2014; Saje 2014; de Groot, Ogris and Kobler 2018; Mori and Poljanec 2019; Kutnar, Kermavnar and Pintar 2021; Unay-Gailhard and Bojnec 2021). Weather-related forest disturbance occurs regularly but on a relatively small scale. In 2014, a large-scale ice-break and the subsequent bark beetle outbreak in 2016 stimulated the response of both professional state forest institutions and local forest owners. The infrequent consideration of the social perspective of these events as well as the inadequate recognition of common-pool resources as public goods motivated our research (Šmid Hribar et al. 2018).

We focused on the Inner Karst region of Slovenia. We examined the post-disturbance forest management interventions of organized local forest owners, known as forest commons (hereinafter FC). They are a local tradition of collective action that has not been evaluated thus far from the perspective of addressing uncertainty in forest management. We aimed to fill the knowledge gap in the provision of an efficient response to large-scale forest disturbances. This represents a particular knowledge gap, as there is no international literature on the response of FC to natural disturbances, and FC in Slovenia have only recently gained legal recognition (Premrl et al. 2015; see also Agricultural communities Act published in the Official Gazette of the Republic of Slovenia, 2015). The FC is the best known form of collective action, but there are also other types of commons (Šmid Hribar, Urbanc and Zorn 2023). Activities of FC generally refer to group functioning and property maintenance (infrastructure maintenance and construction, harvesting, initiatives to decision-makers, local investments (Bavec et al. 2021). On average, this age-old form of social organization can still be flexible and responsive (Andersson, Keskitalo and Bergstén 2018).

This study aims to determine whether FC responded to the ice-break and the bark beetle outbreak in 2016 more quickly in comparison to other types of forest owners. The hypothesis is that the response of FC was faster than that of other types of private forest owners. The objectives of the article were 1) to fill the gap in the empirical examination of private forest owner behaviour, 2) to compare the response of FC and other types of private forest owners to forest disturbance and 3) to provide a basis for strengthening the active response to large-scale forest disturbance. According to the Agricultural Communities Act (2015), Slovenian FC are formally recognized agrarian communities. They are groups of people who jointly own and manage their properties. These groups predominantly consist of local inhabitants with established relationships with each other and with the territory. Their relational character is crucial and was well described by Harvey in 2012 (cited in Casas-Cortes, Cobarrubias and Pickles 2014, 450) as »a form of relation as well as production based on social cooperation«. Their collaborative activity, joint action and particular governance model in Slovenia has already been presented (Bogataj and Krč 2014; Premrl et al. 2015; Šmid Hribar et al. 2018; Bavec et al. 2021), as well as related to other European practices (De Moor 2015; Lawrence et al. 2020; Haller et al. 2021). In addition to their specific governance model, the essential element of FC are social norms. Post-disturbance interventions might account for this (Deuffic, Arts and Sotirov 2018; Holt et al. 2021). This is particularly important in collaborative governance arrangements, as their joint problem identification (e.g. forest management) and negotiated solutions have been found to be effective for socio-environmental sustainability (Bodin 2017; Tucker et al. 2023).

1.1 Theoretical background

Private forest owners have the legal right to »freely and exclusively use, control, transfer or otherwise benefit from forest« (Food and ... 2018, 16). Their management behaviour balances short-term individual and long-term shared collective benefits and aims. However, in addition to individual and community needs, institutional regulations and actions impact their management behaviour (Deuffic, Arts and Sotirov 2018;

Lawrence et al. 2020), as forest ownership is defined as »a system of interrelated but distinct features which includes institutional setting, the allocation of property rights, the nature of ownership, the character of the owning entity and the regulation(s) and organization of the forest management« (Weiss and Nichiforel 2020, 19). Regulatory instruments and organization in former communist countries, including Slovenia, are rooted in a restrictive approach (Nichiforel et al. 2020), including the suppression of community institutions (Premrl et al. 2015; Lidestav et al. 2017; Weiss et al. 2017; Wong, Posavec and Bogataj 2019; Lawrence et al. 2020). Therefore, it is not surprising that the active engagement of forest owners in forest management and their actual behaviour in response to environmental challenges remain gaps in our understanding. While examples of responses to forest-related storms (Hartebrodt 2004; Marzano, Blennow and Quine 2013; Magomedova 2015; Lidskog and Sjödin 2016), community forest management related to the socio-ecological context (Pagdee, Kim and Daugherty 2006) and extreme natural events (Qin et al. 2017) exist, Slovenian studies mostly focus on structuring private forest owners according to particular indicators, such as motives, wood production and gender (Table 1).

The large and heterogeneous population of private forest owners in Europe live in very diverse contexts. Their management behaviour is poorly understood due to the absence of contextualized empirical information (Canadas and Novais 2014; Weiss et al. 2017; Ficko et al. 2019; Kumer and Pezdevšek Malovrh 2019; Stare, Grošelj and Pezdevšek Malovrh 2020). For example, the tradition of joint forest management has no statistical background at the national or international level (Lidestav et al. 2017; Lawrence et al. 2020). The tradition of local institutions representing socio-ecological systems links dynamic ecosystems with adaptive management practices (Bodin 2017; Colding and Bartel 2019). The importance of practice is therefore well founded and should complement reductionist »command and control« approaches to forest management (Lawrence 2017). Furthermore, the effective combination of local and state governance approaches may improve forest management under climate change (Seidl et al. 2017), where routine responses are rarely possible. We have assumed that an extreme environmental disturbance precludes a routine response, and this is how the PIAAC study (PIAAC ... 2009) defines problem solving. The intentional study of documented forest owner post-disturbance behaviour is therefore an advantage of our study as it sheds light on how FC solved a problem of forest disturbance after an ice-break. While examples from Germany (Hartebrodt 2004; Ewers 2010) and Sweden (Lidskog and Sjödin 2016; Eriksson 2017) exist, there is a lack of research in the karst areas we examined. Forest management decision-making (Veselič et al. 2015; Ficko 2019) required a rapid response and the involvement of local and state stakeholders.

The state forest management method in Slovenia, called the control method (Gašperšič 2008), requires informational loops that periodically adjust forest management measures to the specific field situation during ten-year forest management plans. These informational loops enable learning. However, learning loops are also present among local forest owners whose learning loops are not prescribed, regular or formal, but rather experiential and unpredictable. The ability to learn and implement concerted action is crucial. European studies of response to forest disturbance, such as the Swedish Gudrun windstorm (Lidskog and Sjödin 2016)

Table 1: The dominant perspectives of Slovenian private ownership studies.

Dominant perspective	Topic of analysis	Source
Production	Property size & fragmentation, Typology, Associative potentials, Conceptualization of Forest Management	Medved 2003; Krč et al. 2008; Ficko and Bončina 2013; Pezdevšek Malovrh et al. 2015; Češarek, Ficko and Bončina 2018; de Groot, Ogris and Kobler 2018; Ficko 2019
	Harvesting, Management, Adaptive management	Poje, Pezdevšek Malovrh and Krč 2016; Ficko et al. 2019; Ficko and Bončina 2019; Mori and Poljanec 2019; Stare, Grošelj and Pezdevšek Malovrh 2020; Stare, Grošelj and Pezdevšek Malovrh 2022
Social structures and empowerment	Female representation	Bogataj 2010; Krajnc et al. 2021;
	Local knowledge transfer	Čoderl, Jamnik and Bogataj 2012
	Collective forest management	Bogataj and Krč 2014; Gatto and Bogataj 2015; Bavec et al. 2021

and wildfires in Catalonia, Spain (Rodríguez-Carreras and Úbeda 2020), are theoretically based on communities of practice (Wenger 2000), as this approach considers the social drivers of complex behaviour and situational reflexive learning, which is practiced through socialization and the evolution of social norms. These are regarded as a system-wide factor in environmental governance (Bodin 2017). It is assumed that recurring ice-breaks in the past enabled the accumulation of forest management competence and effective problem solving, as people learn and adapt through practice (Lawrence 2017). A complex individual cognitive process of simultaneous thinking and action takes place when goals cannot be achieved routinely (PIAAC ... 2009; Janssen 2015), which is closely linked to the formation of ties in collaborative networks (Bodin 2017) and spatial clusters (Mantilla 2018).

2 Study area and methods

2.1 Study area

The study area was the Postojna regional forest district of the Slovenia Forest Service (hereinafter SFS) (Figure 1). It is located in the so-called Inner Karst, also called the Green Karst for its typical forest cover. Around 50,000 inhabitants are dispersed across 261 settlements and the town of Postojna, which is home to approximately one-third of the population of the Inner Karst (Zavod za gozdove ... 2011). The economy of the Postojna area is based on industry and services, such as tourism. Residents also commute daily to nearby towns. Forests cover 74% of the area, which is above the Slovenian average (60%) and is still increasing, e.g. by 21% in the last four decades (Zavod za gozdove ... 2011). Forests currently cover 79,640 hectares. This typical rural area of pre-alpine Dinaric forests serves multiple functions and provides a variety of ecosystem services, hydrology and biodiversity being the most important, but wood production is also important as the forests are highly productive. Beech and mixed forests dominate, and only 24% of forests are protective forests. The average annual amount of salvage logging in this area between 1995 and 2012 was 72,000 m³, representing 3% of the annual Slovenian harvest and 7% of the total sanitary logging in Slovenia (Saje 2014; Sinjur et al. 2014).

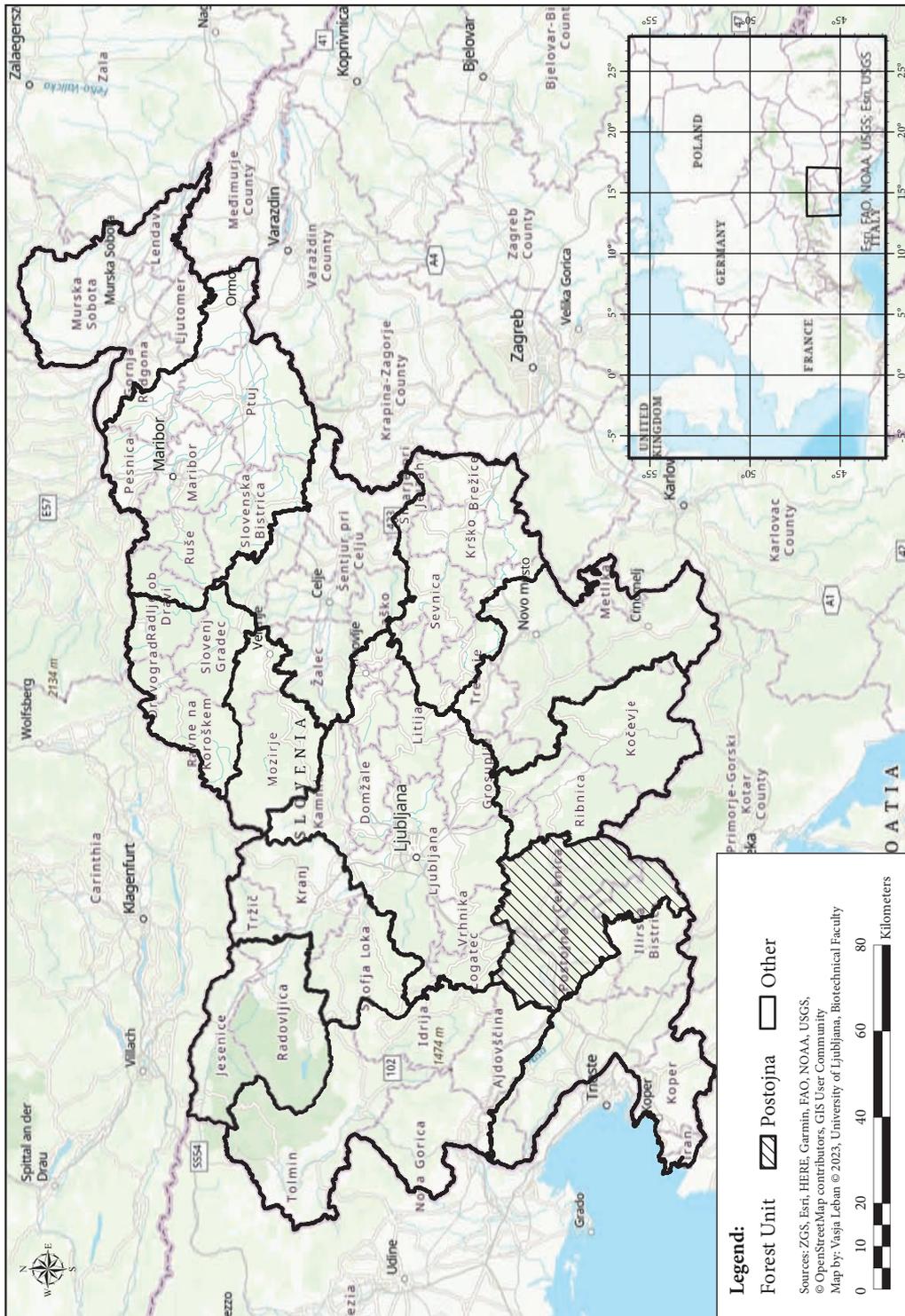
The Postojna forest district was severely affected by a natural ice-break between 30 January and 10 February 2014, which damaged all Slovenian forests. At the national level, this event resulted in more than the entire average annual logging, a rapid increase in salvage costs and negative implications in the medium and long term (Unay-Gailhard and Bojnec 2021). In the area of observation, the ice-break affected the area between 500 and 999 m a.s.l. where planted spruce dominates. Outside of this belt, less than 1% of the timber was harvested. The result was approximately 943,400 m³ of damaged wood. Sudden amounts of wood may have been a market opportunity, but the role of the market was outside the scope of this analysis, as the wood was mobilized due to natural factors and not intentionally. Insect outbreaks followed in the spring of 2016, followed by a windstorm in 2017 that caused further disturbance on steeper slopes (de Groot, Ogris in Kobler 2018). The direct salvage costs have never been calculated. Due to a lack of local and national technical capacities, facilities from Austrian Alpine forest districts were called in. The regional SFS authorities prioritized larger parcels of woodland regardless of the type of forest owner.

2.2 Methods

The study uses a mixed methods approach, combining quantitative and qualitative analysis. A description of the analytical approach is provided below together with a description of the data source and variables.

The quantitative component focuses on the following response indicators:

- Response time defined as the difference between the date of realization of the legislative order and the date of its uptake; minimum response time refers to the first legislative order, average response time refers to the average for all legislative orders, and maximum response time refers to the last legislative order.
- Harvesting time, defined as the average time difference between the realization of the last and the first legislative order.



- Realization of legislative orders, defined as the average time difference between the conclusion of harvest and the deadline prescribed in legislative orders.

The forest related data used in this study are derived from the forest management plan for the period 2012–2022 (Zavod za gozdove ... 2011) documented in the official database of the SFS. Variables analysed were site and forest stand characteristics and transport distances indicating accessibility. Harvests affected by the ice-break in 2014 and by bark beetles in 2016 in privately owned forests and the forest owner data were obtained from obligatory directives for sanitary and salvage forest operations, entitled »legislative orders« which specify the volumes and deadlines of harvests and silvicultural/protective measures for sanitary and salvage logging. The source of these data were the SFS database for 2014 and 2016. State-owned forests were excluded from the analysis. The ice-break did not affect all FC in the area.

The deadlines for the conclusion of harvesting after the ice-break (considered primary forest disturbance) were set for up to two years after the event, while those for the bark beetle outbreak (considered secondary disturbance) were adapted to local situations. The forest-related data (forest area (sum of parcels), amount of wood harvested for conifers/broadleaves) were linked with salvage logging in the following way: first, we linked these data with owners and evaluated harvests according to types of ownership, and then

Table 2: Description of the qualitative data collection.

Phase of work	Participants	Place, Time, No. of participants	Method
Pilot phase	head of the regional SFS district	Postojna, 13 October 2017	Interview (I1)
	group of local inhabitants organized into the Forest guardians study circle	Postojna, 25 October 2017, n = 7	Interview (I2)
Main phase	regional forestry professionals, representatives of the municipality and the national FC Association	Postojna, 13 October 2017, n = 6	Focus groups (FG1)
	municipality inhabitants	Postojna, 26 November 2018 to 13 December 2018, n = 99	Web-survey (Web1)
	local FC leaders and representatives of local institutions	Slavina, 11 April 2019, n = 7	Focus group (FG2)
Test (post-analysis) phase	regional forestry professionals	Postojna, 13 November 2019, n = 22	Focus group (FG3)
	National inquiry of FC	December 2020, n = 4 for Postojna region	Literature analysis

Table 3: Qualitative data on response to forest damage (web-survey, focus groups).

Thematic area	Question content
Forest (2 questions)	Self-regeneration Importance/use/relation to forests close to your home
Activity of citizens (7 questions)	General activity Frequency of forest visits Purpose of forest visits Roles of forests in the area Awareness of sanitary harvests in the area Interest in learning in a study circle Interest in learning in a forest-related course
Response to large-scale disturbance (7 questions)	Involved individuals, groups, institutions The best respondent FC characterization Explanation/reasoning Differences between the response to primary and secondary forest-damage The key obstacle Future forest management proposals

we analysed the eventual response drivers: geographical (altitude above sea level, terrain slope) and technical characteristics of forest properties (accessibility, defined as the share of property accessible by skidding machinery, technology used) and information on the number of legislative orders. Finally, we calculated response time, harvesting time and realization of legislative orders for each forest owner. Private forest owners were classified into two categories: FC and »other« forest owners. For 26 FC, which received 159 legislative orders, we calculated Pearson correlations between response indicators and eventual response drivers.

Qualitative measures improved the understanding of the decisions and actions of FC. Primary qualitative data were collected by triangulating three methods: semi-structured interviews, focus groups and surveys (Table 3). We also limited potential bias by iterative communication in the four-year period 2017–2020 and with different target groups, some of which intentionally overlapped (professional foresters of the SFS, regional forest owners, FC representatives and general regional population). Qualitative observations started in 2017 with pilot interviews and a focus group. In 2018, a municipal web-survey and a repeated focus group were organized. The third focus group in 2019 and the control from the national survey in 2020 tested the interpretations collected in previous years. A summary of the data collection is presented in Table 2.

Interpretation of the qualitative data was based on the framework of Deuffic, Arts and Sotirov (2018), who proposed five general decision-making profiles.

3 Results

3.1 Forest ownership structure in the area

Nearly 60% of forests in the area are privately owned, covering 47,728 ha (Zavod za gozdove ... 2011). Private properties are fragmented into plots that are predominantly in the size range of 10 to 30 hectares, which is larger than before denationalization. Forest management is attributed to the SFS according to the Forest Act (published in the Official Gazette of the Republic of Slovenia in 1998). Three general problems of private ownership in the area are low motivation, poor road infrastructure (average forest road density amounts to 16.3 m/ha) and the strong influence of wildlife, particularly that of large predators (Zavod za gozdove ... 2011). Private forest owners are predominantly regarded as inactive.

There were 49 FC in the Postojna district in 2011 (Zavod za gozdove ... 2011), and 46 according to the SFS archives in 2017. Their properties are located on the least productive sites (9% (4,300 ha) of the district forests). Part of these sites were planted with spruce before Second World War. FC can be considered as large forest owners, as most of their properties exceed the average size of individually owned forest land (Table 4).

Table 4: FC properties according to the size classes in the Postojna district (Zavod za gozdove ... 2011).

Size class (ha)	No. of FC	Average property size (ha)
< 10	8	5.1
11–30	9	19.9
31–50	6	40.3
51–100	15	71.8
101–300	7	151.0
> 300	4	434.3

Table 5: Size of FC in the observed area by the number of members according SFS archive data from 2017.

Size class (No. of members)	No. of FC	Total members
3–30	6	97
31–60	7	325
61–90	1	70
91–120	1	105
>120	1	250
Missing data	30	?
Total	46	847 +?

The average property size of FC is 88.4 ha, fragmented into approximately 5 parcels (Zavod za gozdove ... 2011, 22). Information on the number of shareholders is scarce. SFS archives provide information on the number of shareholders; therefore, the size per shareholder varies (from 0.1 to 14.3 ha). SFS databases on legislative orders for 2014–2016 provide some insight but with gaps, as 26% of the data on the number of shareholders is missing. The trend of larger average property size up to 2017 is attributed to denationalization in this period.

Large variation is typical both with regard to number (from 7 up to 250 members) and relation to the property (from 20 shareholders possessing 2 ha to 7 shareholders possessing 100 ha), with an average possession of 4 ha per shareholder (Table 5).

The SFS legislative order database for 2014 and 2016 provides information on 26 FC affected by both the ice storm and bark beetles. However, information on the number of shareholders in this database is limited, as data on shareholders are missing for 7 FC.

3.2 Harvest quantity

Legislative orders prescribed a total of 1,264,680 m³ of timber harvested after the ice-break and 694,906 m³ after the insect infestation in the Postojna district. After the ice-break, FC were required to process 6.7% of the total amount. The average harvest per legislative order was 4.2 times higher for FC than that for other private forest owners after the primary disturbance and 1.4 times higher after the secondary disturbance. This reflects the less fragmented forests of FC and relatively large quantities of harvested wood.

The realized harvest in FC forests between 2014 and 2016 was close to that prescribed for FC. Only 4% of the required timber harvest was not realized on disturbed FC plots, while other private forest owners left 57% of the prescribed harvest.

Fully mechanized harvesting dominated the approach of FC. For other private forest owners, motor manual harvesting prevailed (Table 6).

3.3 Response time, harvesting time and realization of prescribed deadlines

Response time indicates how fast FC reacted to legislative orders and refers to the difference between the date of realization of the legislative order and the date of its uptake. Harvesting time indicates the duration of harvesting. Realization of legislative orders reflects the relationship between the conclusion of harvesting and the prescribed harvesting deadline.

An immediate start was initially noticed in the pilot interview (I1) for one FC whose forest was located near the village. Later, FC leaders reported that they were impatiently waiting for the end of the rainy period that followed the ice-break and eventual application for training courses. They changed their mind after becoming aware of the immense scale of the disturbance (FG2) and applied for machinery services. This confirms that they considered time to be very important, which was also recognized by the leaders

Table 6: Proportion of conifers harvested according to the technology used (%) according to the SFS archive.

Forest owner type	Motor Manual	Mechanized	Combined
Forest commons	43	56	1
Other private forest owners	85	10	5

Table 7: Average realization of legislative orders for FC and other private forest owners after primary and secondary forest disturbance (days). Negative figures indicate harvesting before the deadline. The greater the negative figure, the faster the response.

Private forest owner type	Forest commons	Other private forest owners	All
Realization of legislative orders after primary disturbance	-405	-240	-322
Realization of legislative orders after secondary disturbance	-8	4	-2

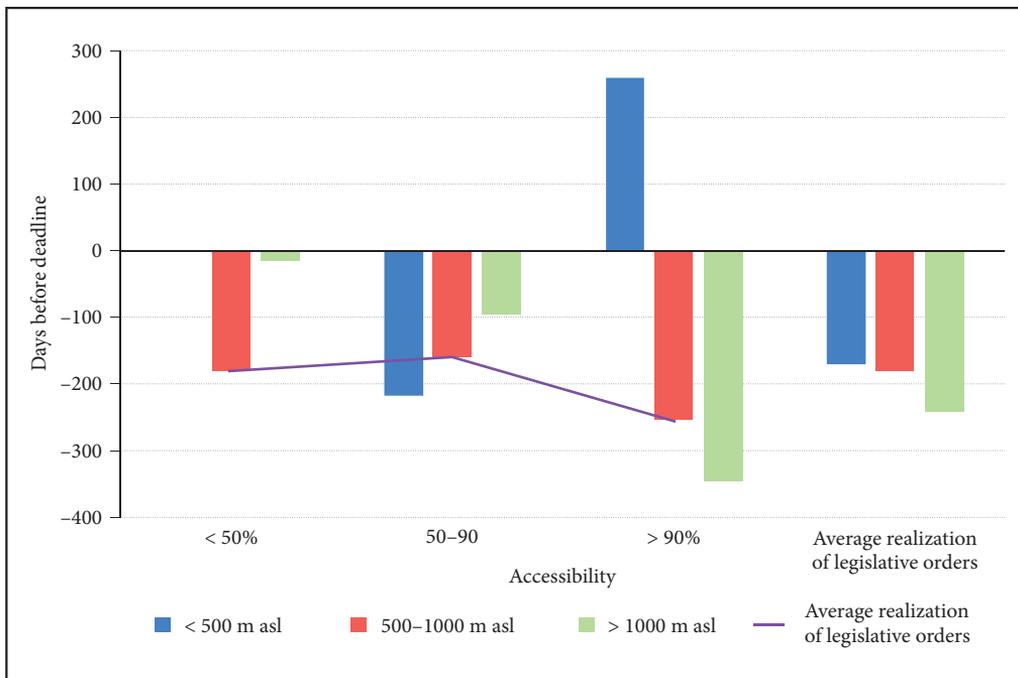


Figure 2: Realization of legislative orders decreases with increasing accessibility. Negative figures indicate realization before the deadline.

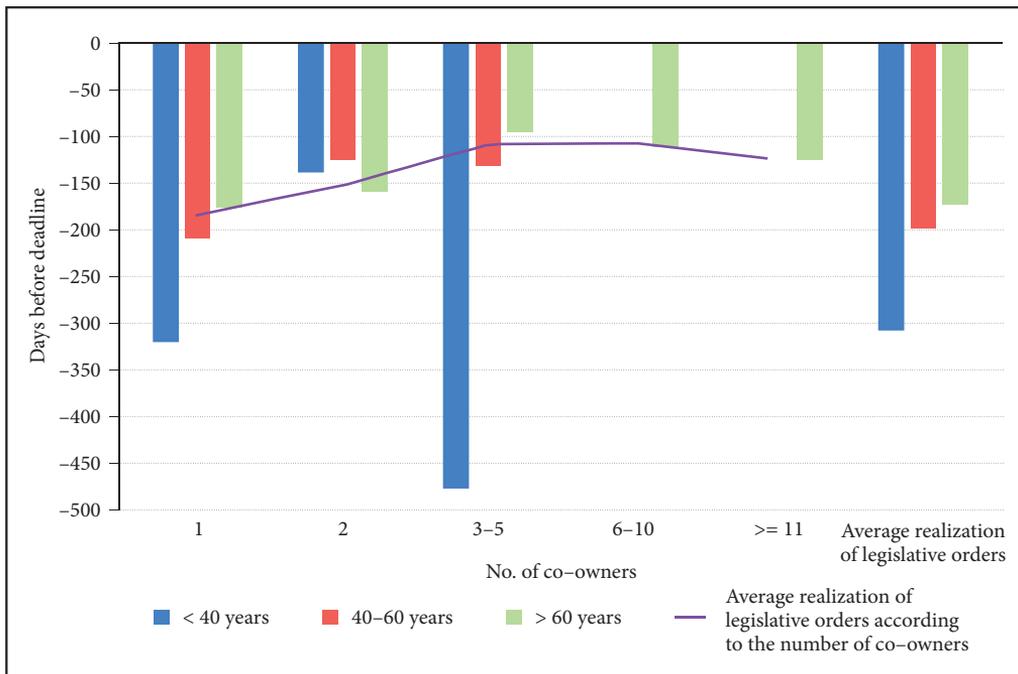


Figure 3: Realization of legislative orders according to the number of co-owners and their average age.

of the SFS: »The first responders were extra-large forest owners, followed by internally well-organized FC« (I1). At least the generally active FC started harvesting as soon as possible.

The average response time ranged from 11 to 422 days of harvesting. An FC with only one legislative order responded in 11 days from its uptake. An FC with 9 legislative orders responded to the first legislative order in 8 days (minimal response time) while the rest of the legislative orders for this FC took up to 120 days to realize their obligations (maximum response time). Realization of legislative orders indicates that all private forest owners completed salvage logging well before official deadlines, especially after primary disturbance while FC were substantially faster (Table 7, Figure 2, Figure 3). FC were on average significantly faster than other private forest owners (Table 7).

Realization of legislative orders logically varies with elevation and forest accessibility. It decreases with increasing accessibility, particularly where it exceeds 50% (Figure 2). There are some puzzling delays at the lowest elevation, which are probably attributed to fragmented parcels, low accessibility or older owners. Fragmentation may play a role in response definition. It is not only the forest that is fragmented but also decisions. However, multiple owners in this study did not take more time to decide, so their decision-making was effective (Figure 3).

Large private forest owners had the fastest realization of legislative orders, followed by FC, as already indicated in the pilot interviews (I1, FG1). Younger private forest owners responded more quickly. Correlations of response indicators with eventual response drivers are presented in Table 8.

Geographical variables are not correlated with the response of FC. Those with high harvest quantities logically needed more time to harvest damaged wood ($p = 0.57$, $p < 0.05$) but also started significantly earlier ($p = -0.17$, $p < 0.05$). Interestingly, average response time declined with increased skidding distance ($p = -0.23$, $p < 0.05$). FC with numerous legislative orders started significantly earlier ($r = -0.35$, $p < 0.05$) and their response time for the last legislative order was significantly longer ($r = 0.42$, $p < 0.05$). The average response time of larger FC was significantly lower ($r = -0.25$, $p < 0.05$), which was already indicated by Figure 3.

However, short harvesting time was not only attributable to relatively large parcels or to the quick response, but also to other factors. For example, a higher share of subsidized pastures, indicating the active management of the FC, stimulated action (I1), while the sudden loss of an FC leader (FG2) suppressed it.

3.4 Interpretations of response indicators

All of the qualitative methods interpreted harvests and highlighted the importance of internal FC processes and their external relationships. The high variability of situations is typical in general (Bavec et al. 2021; Haller et al. 2021) and present in this study of the Postojna region, which is well exemplified by the statement »Each FC is its own story« cited multiple times (I1; FG1; Web1; FG2). The inquiry response rate was minimal (<1%), as we invited all citizens of the municipality. However, the structure of responders was balanced according to gender (53% men, 47% women), location (all local communities participated)

Table 8: Correlations between eventual response drivers. Negative values indicate efficient response.

Response drivers	Response indicators	r	Significance
Geographical variables	Altitude	Response time (average)	0.03 /
	Slope	Response time (average)	-0.03 /
Forest related variables	Amount of wood	Response time (min)	-0.17 /
	Amount of wood	Harvesting time	0.57 $p > 0.05$
	Skidding distance	Response time (average)	-0.23 $p > 0.05$
	Accessibility	Response time (average)	0.31 $p > 0.05$
Other	Number of legislative orders	Response time (min)	-0.35 $p > 0.05$
		Response time (max)	0.42 $p > 0.05$
	Number of FC members ($n_{FC} = 19$)	Response time (average)	-0.25 $p > 0.05$

and ownership (40% of respondents self-declared as forest owners). The main arguments for mobilizing the harvest were twofold: internal and external. The internal arguments were as follows: 1) ownership responsibility and income potential, motivated also by a generally expected increase in property taxes; 2) absence of alternative actors because of slow administration; and 3) different degrees of forest-related competence in FC. These were accompanied by three factors outside of the FC domain: 1) accessibility of forest; 2) share of conifers; and 3) machinery availability. Informants attribute the agility of FC to the immediate response and informed decisions. Informed decisions are part of governance, which in FC is attributed to the management board and its president, as illustrated by two statements: »Foresters on the FC management board were able to decide quickly and correctly, so that potential conflict was limited to the delivery of benefits only« and »Some FC deliberately chose new leadership according to the criteria of experience and competence, for example retired local foresters« (I1). Interdependence between FC and external decision makers was cited as influential: »Communication intensity between FC leaders and state representatives is crucial for forest management« (I2) and »There is a need to strengthen social capital with institutions« (Web 1). Indirect relationships impact efficient response, e.g. lack of professional agreement, organizational difficulties (FG1) and desired autonomy due to negative memories of the past regime (»The less intervention by external agents the better«) (FG3). All informants and methods of observation consistently defined FC governance and leadership selection criteria by 1) respect for the norm of collective benefits including minimal and subordinated personal benefits and 2) forest management competence.

4 Discussion

The decision-making process in forest management is becoming increasingly uncertain due to the effects of global warming. When land is predominantly privately owned, as is the case in Europe, the swift intervention of private forest owners becomes crucial after natural disturbances. Although numerous studies improve our understanding of forest owners, there is a lack of insight into the response of forest commons (FC), which are present throughout Europe (Casas-Cortes, Cobarrubias and Pickles 2014; De Moor 2015; Haller et al. 2021) and Slovenia (Bogataj and Krč 2014; Lawrence et al. 2021; Bavec et al. 2021)). The specific governance model of FC is critical for resource sustainability (Bodin 2017; Tucker et al. 2023), especially when natural disturbances disrupt the system. Studying the response of FC to extreme natural disturbances is interesting because FC members share land and path-dependent relationships (Gatto and Bogataj 2015; Šmid Hribar et al. 2018). They are large forest owners in the study area and in Slovenia. The share of their property type in Postojna area is three times higher than the national share (Premrl et al. 2015). Their property is not fragmented than other private properties. Furthermore, their interpretation of the extreme event was not catastrophic, in contrast to the shocking reports in the local and national media. Most members are over 60, experienced and cooperative (Bavec et al. 2021). They are not equipped for the safe and efficient mechanisation expected for large forest owners, so their high average harvest ordered by the SFS represented a sudden and substantial pressure, now documented as being realized quickly, within prescriptions, and with 56% of the operations using mechanized harvesting, which is substantial in comparison with 10% mechanized harvesting done by other types of forest owners. The local tradition of FC forest management developed through learning loops during regular ice-breaks of smaller scale therefore resulted in an effective response to the sudden large-scale challenge. FC consist of several members, organized into a group with elected leadership. The fast response of older, experienced forest owners hypothesized by de Groot, Ogris and Kobler (2018) was enhanced with new insights, even though Figure 3 underscores the fast response of young forest owners. Active FC reacted immediately, changing their initial decision from training to hiring machinery services. FC efficiently fulfilled their private and public duties (FG3; Šmid Hribar et al. 2018). Prescriptions played only a minor role (compared to de Groot, Ogris and Kobler 2018), while relatively large plots and the amount of sanitary felled spruce were important. Response was limited where plots were inaccessible and/or the internal cohesion of FC was sometimes dysfunctional. In such cases SFS enforcement could not have had an impact. Since FC prioritized conifers after the ice-break, bark beetles later caused few problems. Despite individual suboptimal response, on average past investments by FC in self-organization and governance resulted in a comparatively better harvest response to an extreme unexpected event (Table 7, I1, Figure 3).

4.1 Response drivers

The qualitative data consistently, and sometimes explicitly, suggest that social norms are the main driver of collective action of FC, which is in line with the international literature (Holt et al. 2021). The active and rapid response of FC is an interesting finding given the decades of their suppression (Bogataj and Krč 2014; Premrl et al. 2015), the general attribute of passivity of forest owners and the low public awareness of FC at the municipal (Web1), national (Bavec et al. 2021) and European level (Lidestav et al. 2017; Lawrence et al. 2020). For example, only 27% of respondents to the municipal inquiry recognized FC as private forest owners (Web 1). A redundant question in this inquiry asking who was the main driver of the response yielded responses of »ownership responsibility« (77%), which is indicative of social norms, and »income potential« (43%), which is ultimately subordinate. The SFS was cited as a minor driver but with recognition of its competence in »demanding bureaucratic procedures«. As FC have not yet been analysed in relation to harvesting behaviour, identification of their key drivers might be important for future post-disturbance strategies:

- Economies of scale (also taking into account site accessibility, location within the ice-break, proportion of spruce);
- Social relationships (internal FC cohesion in terms of trust and social capital);
- Group action and its leadership experience and competence.

This is consistent with the literature, where the environment, knowledge (competence) and social norms consistently dominate in the decision-making arguments of stakeholders (Deuffic, Arts and Sotirov 2018; Holt et al. 2021). We are unable to determine their relative importance, but they consistently support the interpretation of rapid harvesting.

As communities of practice, FC regulate forest management and relationships, both internal and external. They practice collaborative governance (Bodin 2017) and are able to mobilize experiential knowledge from past ice-breaks. They prioritize leadership quality and reputation over the number of members. Furthermore, their revived, informed and conifer-focused collective action prevented bark beetle gradation despite the high average age of FC members, their presumed lower formal education and their independence from harvesting income. This means that structural indicators do not provide the best insight into the qualities of FC.

The justifications for the active response are clearly in agreement with the theory of communicative action and practice theory (Deuffic, Arts and Sotirov 2018; Wenger 2000). Furthermore, the logics of cognition and practice described by Deuffic, Arts and Sotirov (2018) were more important than those of interest and appropriateness that support eventual conformity to imposed rules. The findings do not oppose those of another model developed in Slovenia based on individual data about forest management conceptualizations (Ficko 2019). Cross-checking the response drivers with a reverse question about barriers to active response confirmed that the activity (or passivity) of private forest owners refers to both internal and external cooperation (which may be dysfunctional), as well as to information flow. This is consistent with studies in the developing world (Magomedova 2015) that link prosocial behaviour with responses to extreme natural events.

Generally, large-scale environmental extremes represent a push that mobilizes diverse actors. The main factors influencing the response of private forest owners were norms, the environment and competence. Although competence can be problematic in a society in transition (Premrl et al. 2015; Lidestav et al. 2017; Theesfeld 2018; Šmid Hribar et al. 2018; Vasile 2019; Weiss and Nichiforel 2020), our analysis presents a vibrant rural society able to build shared meanings and actively respond. This may also be a relevant model for other European contexts (Vriens and De Moor 2020). Recognition of local joint management structures may benefit processes of adaptation to climate change. However, in Slovenia, FC are currently recognized as examples of good practice (Šmid Hribar et al. 2023) and sometimes as owners of relatively large properties, rather than as a model as proposed in the European literature (Lidestav et al. 2017; Weiss et al. 2017; Weiss et al. 2019; Lawrence et al. 2020).

4.2 Limitations of the study

The most important limitation is the fact that the sample covers less than half of private forest owners in the observed area and only part of FC. Furthermore, generalizations are limited by the high degree variation in

FC functioning. The response of FC was unevenly spread: some self-organized, while others waited for state measures or the action of neighbours. The role of the wood market and insurance was not analysed or mentioned in the qualitative observations. Collective action among co-owners after inheritance is hampered by a lack of leadership (FG2); internal cohesion may have eroded during periods of the Second World War and the undemocratic regime that followed. Competent individuals are not equally distributed and may be marginalized. We cannot draw definite conclusions about the importance of age due to a lack of these and other data on the social structure of the FC.

Non-respondents in the qualitative analysis remain a challenge for the future work. The reasons for inactivity are diverse and mostly social (emigration, alternative income, property fragmentation, lack of knowledge, poor technical equipment, irresponsibility, physical incapacity, mistrust, etc.). Inactive private forest owners remain dependent on preconditions for the activation of FC being met and on the priorities of coordinating action in each specific situation. Further analysis should compare equal sizes of individual and collective private properties and contextual analysis through systematic long-term observation.

5 Conclusions

Ecosystems and societies are increasingly destabilized by extreme weather events due to climate change. Regional empirical data on the post-disturbance forest management intervention of FC provide insights into their effective response through their immediate and rapid concerted action. They harvested damaged coniferous forest stands with machinery services well before the deadline and before other forest owners (except large individual forest owners). Iterative qualitative assessments shed light on various response drivers, including social norms of responsibility and forest management competence. This means that even if some FC remain dependent on external empowerment, most have revived the traditional collective action of FC and shifted from passive to active.

The practical implications of this analysis lie in organizational approaches in the wake of natural disasters. Professional, timely and efficient private forest owner response requires the following:

- a. Avoiding generalized measures for artificial target groups in favour of contextualized real local communities.
- b. Recognizing and supporting existing FC and the pre-conditions for their collective action.
- c. Maintaining resilience in circumstances of increased uncertainty.

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