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WINDSTORM RESTORATION EFFICIENCY USING THE KIDRIČEVO WINDSTORM (29 JUNE, 2006) AS A CASE STUDY

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Abstract

Economic efficiency is one of the many essential demands regarding the technical management of windstorms. The main goal of this paper is to analyze a hypothetical scenario in which a forest owner works independently on windstorm restoration, using his own equipment and work power. Managing windstorm damage is a difficult and dangerous task, although a potentially lucrative endeavour as our investigation shows. A windstorm represents an opportunity for instant profit for forest owners who are independent of regular forest income. Economic damage is greater and longer lasting for owners with large forest properties and for farm households, which depend on regular forest income. We compared two potential scenarios in a wind-damaged area within the 2000-2010 forestry management period. First, we include a hypothetical scenario in which the windstorm did not occur. An inventory of regular thinning as well as simulation of future events based on past dynamics was done. We also performed a second scenario in which we assumed that private owners carry out windstorm restoration alone, although in reality felling has been carried out with short-wood technology (mechanized cutting). The results section presents the possibilities to attain reasonably high yield by dealing with the consequences of a minor windstorm.

Ključne besede: storm damaged forest, windstorm restoration, scenario, production effects, gross margin, cost analysis

UČINKOVITOST OBNOVE GOZDOV PO UJMAH NA PRIMERU VETROLOMA V KIDRIČEVEM (29.6.2006)

Izvleček

Ekonomska učinkovitost je ena izmed mnogih nujnih zahtev pri tehničnem odpravljanju škode, ki jo povzročajo gozdne ujme. Glavni namen tega prispevka je analizirati hipotetični scenarij, po katerem se lastnik gozda sam, z lastno opremo in delovno silo, ukvarja z obnovo svojega gozdnega posestva po ujmi. Odpravljanje takšne škode je težka in nevarna naloga, hkrati pa tudi potencialno donosna, kot kažejo naše raziskave. Ujma je namreč priložnost za takojšen dobiček za lastnike gozdov, ki niso odvisni od rednih prihodkov, povezanih z gozdom. Ekonomska škoda je večja in dolgotrajnejša za lastnike velikih gozdnih posestev in kmečka gospodinjstva, ki so odvisna od rednih gozdarskih prihodkov. Avtorja članka sta primerjala dva potencialna scenarija v območju, ki so ga v gozdnogospodarskem obdobju 2000-2010 prizadele gozdne ujme. Najprej vključita hipotetični scenarij, po katerem ujme sploh ni bilo, in napravita popis rednega redčenja ter simulacijo prihodnjih dogodkov na osnovi dotedanje dinamike. Potem se posvetita drugemu scenariju, po katerem se z obnovo gozdov po ujmi ukvarjajo lastniki sami, čeprav je delo dejansko potekalo z uporabo tehnologije kratkega lesa oz. mehanizirane sečnje. Rezultati kažejo na možnost, da je mogoče dosegati tudi sorazmerno visok prihodek pri odpravljanju posledic manjših vetrolomov.

Key words: gozd, poškodovan med ujmo, obnova po ujmi, scenarij, produktivnost, prispevek za pokritje, analiza stroškov

INTRODUCTION AND RESEARCH OBJECTIVES
UVOD IN CILJ RAZISKAVE

Natural disasters are extreme events in nature, which cause serious threats to human social systems. In Slovenia, common natural disasters include extreme weather events. Slovenia has a high annual storm event incidence and belongs to the group of countries with the highest annual number of storm events. Mixing of air masses is a consequence of intersecting climate regions. Slovenia is a meeting point in which air from the alpine, submediterranean and continental regions are mixed together. Scientific research of floods, land-slides, avalanches, winds, dryness and frost is essential in the context of our future prosperity.

The amount of damage caused by natural disasters each year in Slovenia is around 2% of the Slovenian GDP. Oscillations are huge and sometimes damage is much higher. In 1990, after data collected by the governmental department for protection and rescue of Slovenia, the financial expense caused by flooding exceeded one fifth of the national GDP.

Potential future disasters become evident and frightening when we take a look at natural disasters in Europe in the past decade. The storms Lothar and Martin struck Europe on December 26th and 27th 1999, passing over Germany, Denmark, France, Austria and Switzerland. There was 180 million m3

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of wood on the ground, which is about 72% of regular felling in all EU countries together (FAO, 2000). Even with maximum effort invested in rebuilding infrastructure, electricity grids and in restoration of the wood chain, many companies, forest enterprises and sawmills went bankrupt.

Another significant example is the storm that damaged Slovakia. Tatra National Park was hit by the storm (northerly wind "Bory" as Slovaks call it) on November 19th 2004, between 15 and 20 in the afternoon, which destroyed 4,7 million m^3 of wood in a 330.000 ha forest region. The amount of fallen trees was nearly as high as the regular annual forest yield in Slovenia. Economic loss was about 1,5 billion € (FAO, 2005). Average wind velocity was 118 km/h, which is classified as hurricane force wind. Peak wind velocity reached 194 km/h. The windstorm in Kidričevo, Slovenia (the focus of this study), lasted for half an hour, with average wind speed reaching 18 km/h and peak wind velocity between 140 and 160 km/h (SINJUR, 2007). Significant differences between the intensity of these storms are evident.

Our purpose was to identify possible economic consequences caused by windstorms on forest stands, communications and other infrastructure based on the windstorm, which struck the Kidričevo region on June 29th 2006. The study area is mainly comprised of secondary pine (P. sylvestris L.) stands and occasional oak-white beech forests on deeper soils. Intense agricultural production is common in the area. The population density is high and numerous villages are spread along traffic lines. Stand structure in the study area is characteristic of group selection management (Forestry Management Plan, Spodnje Dravsko Polje, 2000-2010). The area is located in the "Župečja vas" municipality and composes a part of the Forestry Management Unit Spodnje Dravsko polje. Aerial photography was taken approximately one month after the windstorm (MKGP, GERKi…, 2007). The wind direction pattern on fallen trees and the damage inflicted in the area close to village Strnišče can be noted. Our research object is a horseshoe-shaped piece of forest district called Izgoni.

We examined benefit indexes in the study area, which included 55 private properties. The purpose of our research was to analyze the cost-benefit proportion of a small-scale windstorm for small-scale forest owners. We tracked indexes for ten years (2000 to 2010), which is used as the official forestry planning period in Slovenia. Mechanized cutting was used for felling damaged wood. We anticipated an option by which harvesting had been implemented by private forest owners alone.

We made a comparison of the gross margin between two scenarios. In the first scenario we assumed a regular management course during the time frame under the assumption that the windstorm did not occur. The first scenario was compared with the second scenario, where harvesting was carried out by owners alone, with their own work force and equipment. The research goal was to identify and evaluate possible values of the gross margin on sales (margin after variable cost) (NISKANEN, SEKOT 2001) at the end of the planning period for both scenarios.

METHODS
METODE

Data collection was done mostly in the field. Most of the data for analysis was provided by the Forest Service, Local Unit Ptuj. Aerial photographs of the study area were assessed with internet based digital tools (MKGP, GERKi… 2007). Statistical sampling on the windstorm affected object was performed by randomly selecting 11 of the 55 properties. We estimated that windstorm damage had varied equally across individual forest plots. This is the reason why simple sampling method for examining management indexes was used. Regularities in appearance of the affected areas have not been found.

The entire population was presented by all individual forest plots of the selected object. We selected 20% of the entire population (11 plots out of 55) with simple sampling method. The selection result can be seen in Figure 1. The owners' plots are listed anonymously with subsequent letters (Table 1). An inquiry was carried out among the chosen owners and data about the amount of fuel wood was acquired. Data about amounts and log wood quality for other wood were derived by the national Forest Service database.

A hypothetical scenario was made, in which we anticipated that private owners had carried out felling and skidding of damaged wood by themselves. This is the reason why the gross margin on sales instead of the net profit was used. The gross margin on sales (margin after variable cost) (NISKANEN, SEKOT 2001) represents the difference between incomes (sales) and production's variable costs. Labour costs are irrelevant considering that the owners carry out the work by themselves. Reforestation costs were added to total costs in the planning period. Thinning operations in the period before the windstorm were implemented by the owners.

Additionally, we analyzed total production in the 2000-2010 planning period under the assumption that the windstorm

did not occur. We assumed an average annual thinning realization from known data within the planning period. The annual average gross margin on sales was calculated from the sum of the gross margin on sales in the 2000-2006 period. We assumed the same average annual thinning realization in the ensuing 2006-2010 period. Work in difficult and dangerous conditions is usually paid based on the unit of time worked. For successful quantitative comparison of scenarios, the highest ratio of reduction of the anticipated productivity was added to basic standard times for felling and skidding in windstorm conditions.

Material costs per production unit (cubic meter) multiplied with the amount of harvested wood on a particular owner's property represent the sum of costs per one owner. Additionally, this sum was proportionally divided between plots according to the area of individual plots. Costs per one plot were acquired in this way. Market value of wood per production unit (cubic meter) multiplied with the amount of production equals total amount of incomes. Incomes per owner were also divided proportionally between plots of one owner.

There was just one owner by whom reforestation was actually realized. Values of restoration material costs for other owners were considered zero. Average restoration costs per owner were calculated from total costs in the sample. A total reforestation material cost consists of seedlings and protection nets for seedlings together. Incomes from the European Union subventions were subtracted from total material costs.

RESULTS
REZULTATI

Table 1 shows list of sample units. It is evident that in most cases one owner possesses several plots. Predicted productivity has been calculated according to production conditions on each owner's property. Bunching and skidding distance vary from plot to plot. Because of that fact, the entrance for calculation of productivity depends on the conditions on each plot. We calculated average bunching distance and average skidding distance for plots of individual private owners. As the skidding conditions are homogeneous across the whole study area, while the skidding distance varies, we used the individual private owner's properties to form skidding units.

Fig. 1: Arrangement of plots on research object (yellow labelled lots are lots selected by sampling, red - skidding trail, blue - forest road)

Table 1: Private owners with corresponding plots in sample

Preglednica 1: Zasebni lastniki s pripadajočimi parcelami v vzorcu

Plot number	Owner's plot	Area [ha]
1	A	2.3852
4	B	0.5934
5	C	0.8329
17	B	0.2050
21	B	0.5388
25	D	0.4361
26	D	0.1025
29	E	0.8776
34	E	0.2933
35	E	0.3474
45	B	0.6968

Table 2: Total quantities of wood (m^3) in sample (wood quality, ownership and tree sort) in ten year management period

Preglednica 2: Skupne količine lesa (m^3) v vzorcu (kakovost lesa, lastništvo in tip lesa) med desetletnim gozdnogospodarskim obdobjem

Owner	Conifers	Deciduous trees
A		
Saw logs	24.00	
Wood fuel		
Pulpwood	361.76	177.56
B		
Saw logs		
Wood fuel		
Pulpwood	204.14	349.34
C		
Saw logs		
Wood fuel		
Pulpwood	104.02	51.82
D		
Saw logs	28.21	
Wood fuel		2.01
Pulpwood	112.10	55.71
E		
Saw logs	16.80	
Wood fuel		5.20
Pulpwood	315.54	155.69

Forest production analysis showed that storm damaged wood was sold as pulpwood. The remaining wood listed originated from commercial thinning before the windstorm occurred.

Table 3: Material costs of forest operation before windstorm management period

Preglednica 3: Materialni stroški izvedbe gozdnih del v analiziranem obdobju pred ujmo

Owner	Felling [€/m^3]	Skidding [€/m^3]
A	2.20	2.62
E	2.79	2.90
D	2.44	1.81

We used Slovenian national standards for calculating productivity of the forest operation (Uradni list RS No.11/1999/ p. 957).

Table 4: Material costs of forest production per m^3 (anticipated restoration of windstorm)

Preglednica 4: Materialni stroški gozdne proizvodnje na m^3 (pričakovana obnova po ujmi)

Owner	Felling [€/m^3]	Skidding [€/m^3]
A	2.60	3.86
E	2.61	4.41
C	2.56	3.39
D	2.47	3.00
B	2.40	3.06

Table 5: Skidding and felling operation material costs (€ per working hour)

Preglednica 5: Materialni stroški sečnje in spravila lesa (€ na delovno uro)

Felling (chain saw)	2.92
Skidding (skidder)	13.84

Skidding and felling costs per working hour are costs taken from calculation of standards used by the local forest enterprise company (Forest enterprise Maribor).

Table 6: Wood prices (source - webpage: Spletna borza lesa: date June 2008)

Preglednica 6: Cene lesa (vir – webpage: Spletna borza lesa: junij 2008)

Wood quality	Price [€/m^3]
Sawlog (deciduous trees)	70.84
Sawlog (conifers)	55.84
Pulpwood	20
Woodfuel	29.17

Market prices for wood are average values for individual wood quality classes acquired from current data of the Slovenian internet online Wood exchange store.

From Appendix 1 to Appendix 8, starting-point data and calculated standards for the pre windstorm period can be seen.

Appendix 9 shows possible incomes for private owners prior to the windstorm period. On Appendix 10, possible incomes for private owners at windstorm sanitation can be seen. As almost all wood has been sold for pulpwood, the actual incomes do not deviate much from the obtained model figures.

EVALUATION OF ECONOMIC PARAMETERS
OCENA EKONOMSKIH PARAMETROV

Table 7 shows reliability of simple sampling results. We must point out the fact that the sample contains 11 plots and that on some plots we did not observe, prior to the windstorm, activities in the management period. Economic indexes on these plots equal zero. Arithmetic mean estimation is estimation between all sample units, including those with zero value.

Except in cases of total costs in the pre windstorm period (standard deviation=12.01; α= 0.05) and reforestation costs (standard deviation=9.79;α= 0.05), the results show reasonably good estimations. The main cause for less accurate results lies in the lack of data for individual sample units. Estimated reforestation costs are low (Table 7), which is a consequence of the fact that reforestation was made only by one private owner on just one plot. This is disturbing, as everything depends on the stands' natural renewal capabilities.

HYPOTHESIS COMPARISON
PRIMERJAVA HIPOTEZ

Comparison between scenario 2 (H2), according to which private owners carry out windstorm restoration works by themselves, and scenario 1 (H1), where no windstorm occurred, can be seen in (Figure 2). In scenario 1 (H1), the usual commercial thinning during the 2000-2010 management period is anticipated. The annual amount of gross margin on sale in scenario 1 equals the arithmetic mean of gross margin on sale for the 2000-2005 (before windstorm) period. Actual thinning realization before the windstorm period was not regularly (annually) scheduled.

Gross margin cumulative in the windstorm scenario (H2) equals:

- Sum of annual mean gross margin on sale for the pre windstorm period (corresponds with scenario 1 (H1) in pre windstorm period)
- Windstorm gross margin on sale estimation
- Sum of annual interests in the 2006-2010 period.

Results show significant cumulative rising due to the 2006 windstorm. The annual interest rate was acquired from the Republic of Slovenia Statistics Department (April 2008) and equals 7.57%. Reforestation costs were subtracted from gross margin on sale cumulative in 2006. Activities until 2010, with the exception of the stated low reforestation extent, are not planned.

The difference between the scenarios is great. It is not merely a result of the windstorms financial outcome, but also a

Table 7: Reliability of estimated economy parameters (in €)

Preglednica 7: Zanesljivost ocenjenih ekonomskih parametrov (v €)

Index	Estimation of arithmetic mean in sample	Estimation of total	Variance	Standard deviation (α= 0.05 & df=10)
Costs in pre windstorm period	33.59	1.847.68	99.58	221.87
Incomes in pre windstorm period	369.44	20.319.17	342.91	764.03
Gross margin before windstorm	335.85	18.471.49	328.36	731.62
Windstorm costs	1.060.78	58.342.90	519.11	1.156.64
Windstorm incomes	3.432.15	188.768.00	944.55	2.104.54
Gross margin in the windstorm period	2.371.37	130.425.21	782.96	1.744.52
Reforestation costs	124.87	6.868.15	301.85	672.55

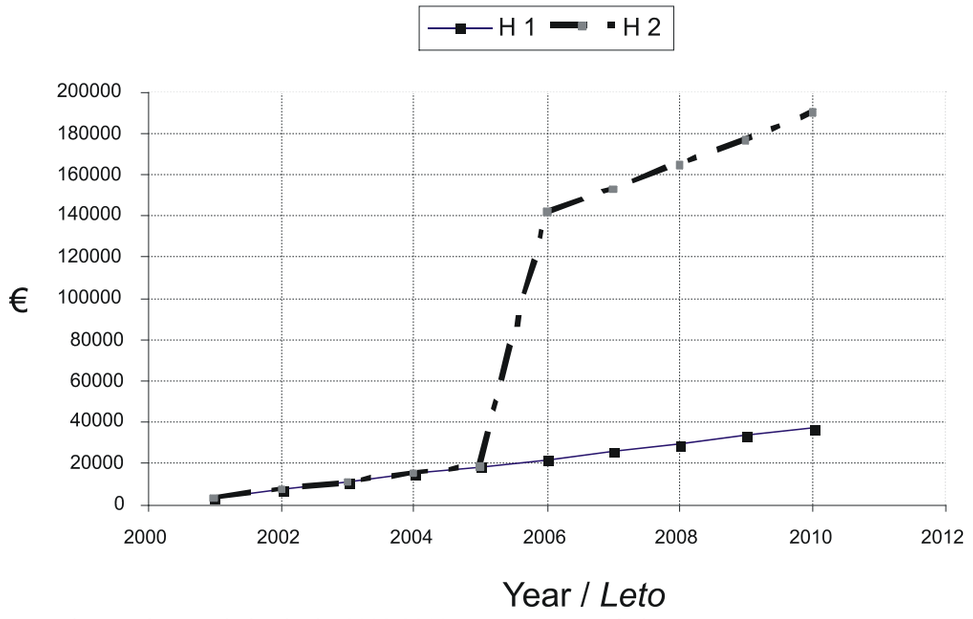

Fig. 2: Gross margin on sale cumulative in the 2000-2010 management period

Slika 2: Kumulativa prispevka za pokritje v gozdnogospodarskem obdobju 2000-2010

consequence of the fact that annual income from interests on windstorm realization is larger than sustainable annual gross margin on sale from commercial thinning. It is necessary to assign part of gross margin on sale for restoration of stands and reforestation of the struck areas. Reforestation costs are relatively high. It is prudent to ask how to renew stands. Reforestation costs are closely connected with stand renovation mode (naturally, artificially).

CONCLUSION
ZAKLJUČEK

Windstorms involve huge logistic problems (KOŠIR and KRČ, 2007; FURLAN, 1997). The extent of damage depends on numerous factors (wind speed, extent of affected forest, destruction on infrastructure, surface relief and density of traffic routes).

The windstorm studied within the framework of our research is considered moderate according to the surface extent. Surface conditions and traffic route density are favourable for felling and skidding. Almost all the surface of the research object was damaged by the storm (90% of research area). The percentage of fallen trees was 50% according to ocular estimation.

Windstorm restoration is a dangerous operation. Additionally, minimal influence of wood production on the environment has to be secured. Only experienced companies are fully capable of restoration operations in the storm-damaged forests. From an economic point of view, as our research has shown, windstorm restoration can be a short term lucrative business in given conditions, especially if restoration is implemented by private owners themselves. However, we recommend a better and easier way of restoring the affected forest areas. Private owners should hire experienced and well equipped professionals. Mechanized cutting operation is an effective as well as the safest contemporary method for storm damage restoration. Terrestrial conditions are not always favourable for using cut-to-length technology. The presented analysis could be a good example for evaluating the benefits of salvage forest operation management.

From the aspect of wood production in a single forest generation, a windstorm represents financial loss and eventual ecological degradation. Large growing stocks and long production periods are questionable forest management concepts in view of intense climate changing and frequent natural disasters. Krč and Winkler (KRČ and WINKLER, 2004) research findings point to a conclusion that contemporary, economic efficient exploitation of small diameter trees goes with production period shortening. Therefore, more valuable wood is gained in younger forest stages, with the remaining trees growing faster and attaining maturity in shorter time periods. Properly thinned forests contain trees with better mechanical stability and a lower height/diameter (DBH) ratio. With properly structured stand edges, wind resistance should be provided for.

In spite of the common belief that great economic losses are inflicted by storms, forestry shows little interest in preventive research and effective managing of storm-damaged forest. We believe that research projects like this could be useful for insurance companies. Low prices on wood markets may be a result of extensive windstorm damage. We suppose that small windstorms should not have a significant effect on wood markets. Effective operational planning for storm-damaged forests should also be of benefit for forestry companies.

In the presented research we did not deal with sustainable incomes from forests for forest owners. Generally, a scattered and fragmentary forest ownership structure in Slovenia causes a low dependence of forest owner on the owner's forest property. Forest property is not a key element for the existence of most private owners in Slovenia. On the other hand, it is very different if the private owner is highly dependent on sustainable income from the forest. In those instances, sustainability is disturbed and windstorms are a strong unbalancing factor. Oscillation caused by storms causes reduction and in many cases of sustainable absence of regular incomes from forest property. In terms of low dependence from forest incomes, which is in most instances closely correlated with the scale of property, a windstorm could be an opportunity for a short-term increase of forest incomes as shown in the presented case study.

SUMMARY

Extensive windstorms that have raged within the European Union in the past few decades show that windstorm damage presents a serious threat, till now characteristic only of the west coast of the Atlantic Ocean. The storms that hit Western Europe (1999) and Slovakia (2004) were placed in a category with hurricane force winds. Average wind speeds exceeded 100 km/h, and in a short time exceptionally large forest areas were damaged. Economic losses amounted to billions of euros. The entire national economies suffered and numerous wood processing and forestry companies went bankrupt.

The analyzed windstorm can be characterized as a microstorm compared to the previously mentioned storms. Damage was local, affecting several square kilometres around the town of Kidričevo. Economic analysis of the windstorm damage was placed in one forestry management period time frame. The central economy index, which was evaluated, was the gross margin on sale (NISKANEN, SEKOT 2001). Two anticipated scenarios of events have been stated. Under the first scenario, the affected forest owners restore windstorm damage with their own material sources and labour power and sell wood on the market. The second scenario represents possible dynamics of economy indexes through the management period with the assumption that windstorm never occurred. We were focused on a difference between the two scenarios in view of economic balance. The difference between the economic result of regular management and managing in circumstances of the storm was evaluated.

Analyses showed high short-term restoration profitability if set under given limitations. While from an accident point of view windstorm work is a highly risky endeavour, scenario 2 may be economically justified. Mechanized cutting (cut-to-length technology) is recommended where possible. In the long term, from growth and silviculture point of view, each windstorm creates economic loss. Especially affected are farm households, which are highly dependent on sustainable income from forests.

Activation of all available windstorm managing capacities is necessary when we are dealing with windstorms on a hurricane scale. Even private owners can significantly and profitably co-operate in windstorm restoration. Windstorm restoration activities should take advantage of local forestry professionals, who are well equipped, have professional manpower, and possess the necessary skills for dealing with wind-damaged forests. The analysis also showed a possibility to cover reforestation expenses from gross margin on sale.

POVZETEK

Hude ujme, ki so v zadnjih desetletjih divjale v državah Evropske unije, kažejo, da je škoda, ki jo povzročijo vetrolomi, nadvse resna grožnja, kakršna je bila doslej značilna le za zahodno obalo Atlantskega oceana. Nevihte, ki so pustošile po zahodni Evropi (leta 1999) in Slovaški (leta 2004), so bile uvrščene v kategorijo orkanov. Povprečne hitrosti vetra so presegale 100 km/h, in v zelo kratkem času so bila hudo poškodovana izjemno velika gozdna območja. Tedanja gospodarska škoda je bila ocenjena na milijarde evrov. To je bil hud udarec za kar celotna nacionalna gospodarstva, in številne lesno predelovalne in gozdarske družbe so šle kratko malo v stečaj.

V pričujočem članku analizirani vetrolom ima značilnosti mikro-ujme v primerjavi z zgoraj omenjenimi ujmami. Škoda je bila zgolj lokalna, saj je prizadela le več kvadratnih kilometrov veliko območje okoli mesta Kidričevo. Ekonomska

analiza škode, ki jo je povzročil vetrolom, je bila postavljena v okvir enega gozdnogospodarskega obdobja. Osrednji ekonomski indeks, ki je bil ocenjen med raziskavo območja, je bil prispevek za pokritje. Analizirana sta bila dva potencialno možna scenarija dogodkov. Po prvem scenariju prizadeti lastniki gozdov sami odpravljajo škodo po vetrolomu, z lastnimi materialnimi viri in delovno silo, in prodajajo les na tržišču. Drugi scenarij pa predstavi možno dinamiko ekonomskih indeksov v gozdnogospodarskem obdobju na domnevi, da ujme sploh ni bilo. Avtorja članka sva se osredotočila na razliko med obema scenarijema glede na ekonomsko ravnovesje. Ocenjena je bila razlika med ekonomskim rezultatom rednega gospodarjenja in gospodarjenja v primeru ujme.

Analize so pokazale visoko kratkoročno dobičkonosnost obnove, če poteka v danih omejitvah. Raziskava kaže, da se z vidika nezgod na delu, visoko tvegano delo, je 2. scenarij lahko ekonomsko upravičen. Mehanizirana sečnja (tehnologija kratkega lesa) je v primeru sanacije po ujmah poškodovanih sestojev priporočena povsod, kjer je pač mogoča. Dolgoročno povzroči vsaka ujma, s stališča rasti in gojenja gozda, ekonomsko izgubo. Še posebno pa so prizadeta kmečka gospodarstva, ki so v veliki meri odvisna od prihodkov, ki jim jih daje gozd.

Kadar imamo opraviti z ujmami na ravni orkanov, je treba aktivirati vse razpoložljive upravljavske zmogljivosti za odpravo škode v razdejanih gozdovih. Pomembno in dobičkonosno lahko v obnovi sodelujejo celo zasebni lastniki gozdov. V obnovitvene dejavnosti bi morali biti predvsem vključene tudi lokalne gozdarske gospodarske družbe, ki so dobro opremljene in imajo poklicno delovno silo, hkrati pa tudi strokovno znanje, potrebno za delo z gozdovi, poškodovanimi med ujmami. Analiza je obenem pokazala možnost za pokrivanje stroškov obnove poškodovanih gozdov iz prispevka za pokritje.

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Appendix 1: Variables for calculation of felling productivity before windstorm period
Dodatek 1: Spremenljivke za izračun produktivnosti sečnje v obdobju pred ujmo

Owner	Tree species	Number of trees	Net mass [m^3]	Average tree[m^3]	Class of regression
A	Coniferous	12	24.00	2.00	3
	Deciduous				
E	Coniferous	15	16.80	1.12	3
	Deciduous	4	5.20	1.30	7
D	Coniferous	25	28.21	1.13	3
	Deciduous	1	2.01	2.01	7

Appendix 2: Productivity of felling operation (pre windstorm period)
Dodatek 2: Produktivnost del, povezanih s sečnjo (v obdobju pred ujmo)

Owner	Tree species	Standard time [min/m^3]	Additional time [%]	Final standard time [min/m^3]	Productivity [m^3/8 hours]	Average productivity [m^3/8 hours]
A	Coniferous	31.18	45	45.21	10.62	10.62
	Deciduous					
E	Coniferous	38.40	25	47.99	10.00	8.36
	Deciduous	124.98	25	156.22	3.07	
D	Coniferous	38.29	25	47.87	10.03	9.57
	Deciduous	123.61	25	154.51	3.11	

Appendix 3: Variables for anticipated skidding calculation before the windstorm period
Dodatek 3: Spremenljivke za izračun pričakovanega spravila v obdobju pred ujmo

Owner	Tree species	Average tree [m^3]	Distance [m]		Bunching [min/t]	Skidding [min/t]
			Bunching	Skidding		
A	Coniferous	2.00	33.66	145.0	4.94	6.84
	Deciduous					
E	Coniferous	1.12	13.59	260.0	3.36	9.21
	Deciduous	1.30	13.59	260.0	4.01	9.21
D	Coniferous	1.13	7.36	100.00	2.70	5.91
	Deciduous	2.01	7.36	100.00	2.94	5.91

Appendix 4: Productivity calculation for skidding wood in pre windstorm period
Dodatek 4: Izračun produktivnosti za spravilo lesa v obdobju pred ujmo

Owner	Tree species	Additional time. bunching [%]	Additional time. skidding [%]	Standard time [min/m^3]	Average standard time (min/t)	Productivity (m^3/day)	Productivity (t/day)
A	Coniferous	15	8	11.97	11.97	42.21	40.10
	Deciduous						
E	Coniferous			12.57	12.72	38.23	37.73
	Deciduous			13.21			
D	Coniferous			8.14	8.19	61.01	58.62
	Deciduous		8	8.85			

Appendix 5: Variables for calculation of felling productivity at supposed windstorm restoration
Dodatek 5: Spremenljivke za izračun produktivnosti sečnje med domnevno obnovo gozda po ujmi

Owner	Tree species	Number of trees	Net mass[m^3]	Average tree [m^3]	Class of regression
A	Coniferous	303	361.76	1.19	3
	Deciduous	152	177.56	1.17	7
E	Coniferous	264	315.54	1.20	3
	Deciduous	140	155.69	1.11	7
C	Coniferous	84	104.02	1.24	3
	Deciduous	36	51.82	1.44	7
D	Coniferous	76	112.10	1.48	3
	Deciduous	42	55.71	1.33	7
B	Coniferous	162	204.14	1.26	3
	Deciduous	192	349.34	1.82	7

Appendix 6: Productivity of felling operation for windstorm restoration
Dodatek 6: Produktivnost del, povezanih s sečnjo, med obnovo gozda po ujmi

OWNER	Tree species	Additional time [%]	Final standard time [min/m^3]	Productivity [m^3/8 hours]	Average productivity [m^3/8 hour]
A	Coniferous	50	56.29	8.53	8.97
	Deciduous	50	48.62	9.87	
E	Coniferous	50	56.26	8.53	8.95
	Deciduous	50	48.95	9.81	
C	Coniferous	50	55.55	8.64	9.13
	Deciduous	50	47.40	10.13	
D	Coniferous	50	52.17	9.20	9.48
	Deciduous	50	47.85	10.03	
B	Coniferous	50	55.21	8.69	9.75
	Deciduous	50	46.31	10.37	

Appendix 7: Variables for anticipated skidding operation productivity at windstorm restoration
Dodatek 7: Spremenljivke za produktivnost pričakovanega spravila med obnovo gozda po ujmi

OWNER	Tree species	Average tree [m^3]	Distance [m]		Standard time	
			Bunching	Skidding	Bunching [min/t]	Skidding [min/t]
A	Coniferous	1.19	33.66	145.00	5.38	6.84
	Deciduous	1.17	33.66	145.00	6.32	4.45
E	Coniferous	1.20	13.59	260.00	3.29	9.21
	Deciduous	1.11	13.59	260.00	4.19	9.21
C	Coniferous	1.24	13.25	96.25	4.03	5.83
	Deciduous	1.44	13.25	96.25	3.86	5.83
D	Coniferous	1.48	7.36	100.00	2.43	5.91
	Deciduous	1.33	7.36	100.00	3.31	5.91
B	Coniferous	1.26	13.19	110.00	3.19	6.12
	Deciduous	1.82	13.19	110.00	3.65	6.12

Appendix 8: Skidding operation productivity at windstorm restoration
Dodatek 8: Produktivnost spravila med obnovo gozda po ujmi

Owner	Tree species	Additional time		Standard time [min/m^3]	Average standard time (min/t)	Productivity (m^3/day)	Productivity (t/day)
		Bunching [%]	Skidding [%]				
A	Coniferous	50	50	18.33	17.62	28.68	27.25
	Deciduous	50	50	16.16			
E	Coniferous	50	50	18.74	19.19	42.87	25.01
	Deciduous	50	50	20.10			
C	Coniferous	50	50	14.79	14.71	32.66	32.64
	Deciduous	50	50	14.55			
D	Coniferous	50	50	12.51	12.94	36.96	37.08
	Deciduous	50	50	13.82			
B	Coniferous	50	50	13.96	14.39	36.20	33.35
	Deciduous	50	50	14.65			

Appendix 9: Supposed total incomes in pre windstorm period
Dodatek 9: Domnevni skupni prihodki v obdobju pred ujmo

Owner	WOOD QUALITY	Income [∈]	Total
A	Sawlog (deciduous trees)		1,340.16
	Sawlog (conifers)	1,340.16	
	Pulpwood		
	Woodfuel		
D	Sawlog (deciduous trees)		1,634.00
	Sawlog (conifers)	1,575.25	
	Pulpwood		
	Woodfuel	58.63	
E	Sawlog (deciduous trees)		1,090.00
	Sawlog (conifers)	938.11	
	Pulpwood		
	Woodfuel	151.68	

Appendix 10: Supposed incomes at windstorm sanitation
Dodatek 10: Domnevni prihodki med obnovo gozda po ujmi

Owner	Wood quality	Income [∈]
A	Pulpwood	10,786
B	Pulpwood	11,070
C	Pulpwood	3,117
D	Pulpwood	3,356
E	Pulpwood	9,425