FORECASTING THE RISKS OF UNCONTROLLED DEFORESTATION IN UKRAINE

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Abstract. The forestry sector in Ukraine is currently confronted with a multitude of challenges, including the repercussions of climate change, ecological issues, economic challenges, and the consequences of military actions initiated by the Russian Federation, which have caused extensive damage to forests across the country. This highlights the necessity for research aimed at assessing threats and risks in the forestry sector, as well as evaluating the institutional capacity to ensure the sustainable development of the industry. The research was conducted in accordance with the mandate of the Temporary Investigative Commission of the Verkhovna Rada of Ukraine, which was established to examine instances of malfeasance and non-compliance with environmental safety standards in the domain of environmental protection. The *methodology* of this study is based on a risk-based approach that involves a systematic analysis of threats affecting the forest sector in Ukraine and an assessment of their impact on environmental safety. The principal instrument for data collection was an online survey of experts drawn from a range of sectors, including government agencies, local communities, research institutes, non-governmental organisations and businesses. The data was subjected to statistical analysis, including correlation and regression analysis, which enabled an assessment of the relationship between the level of threats and institutional capacity. The *aim* of this article is twofold: firstly, to identify the principal threats and risks facing Ukraine's forestry sector; and secondly, to evaluate the extent of the institutional capacity to mitigate these threats. The study identified 153 indicators that characterise threats and 102 indicators that describe the institutional capacity of the sector. Following preliminary analysis and data cleansing, a high-quality sample was constructed based on expert assessments, which helped to avoid logical errors and enhance the reliability of the results. The *results* of the study indicate that uncontrolled mass deforestation represents one of the most significant environmental threats, resulting in a reduction in the population of flora and fauna. The probability of this threat materialising was calculated to be 60.89%. The correlation and regression analysis showed that out of 102 indicators of institutional capacity, only 14 have a significant correlation with the threat of uncontrolled logging, and all 11 vulnerability indicators showed a statistically significant relationship with this threat. The key factors affecting the reduction of the risk associated with these threats are the level of bureaucratic obstacles in the performance of official duties by forestry employees and the level of bureaucracy in the provision of services to the public. The *findings* of the study indicate a relatively low level of institutional capacity within Ukraine's forestry sector. This suggests a need to improve management processes in order to reduce risks in this area. The recommendations developed based on the obtained data can be employed to devise strategic measures to guarantee environmental safety and the sustainable development of Ukraine's forestry sector.

Keywords: forest, threat, risk, uncontrolled mass deforestation, risk assessment, risk-oriented approach, institutional capacity, regression analysis.

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1. Introduction

The advancement of forestry in Ukraine necessitates a comprehensive and methodical approach to guarantee the long-term interests of society. The success of this endeavour is contingent upon a multitude of intrinsic factors pertaining to the ecological, economic and social realms, in addition to external influences that have a global impact on climate change and the exacerbation of environmental concerns. Concurrently, as a consequence of Russian aggression on Ukrainian territory, three million hectares of Ukrainian forests were damaged (Zibtsev et al., 2022), resulting in environmental damage amounting to 56.7 billion EUR (Environmental catastrophe in Ukraine: war damage has already amounted to more than 56 billion EUR). Concurrently, there are also threats of an internal nature, which are particularly subtle and necessitate comprehensive examination to ascertain their influence on the socio-economic context within the country (Korystin and Svyrydiuk, 2023a).

The authors faced this research task as part of their participation in the work of the Temporary Investigation Commission of the Verkhovna Rada of Ukraine to investigate possible facts of ineffective activities of the State Agency of Forest Resources of Ukraine, established in accordance with the Resolution of the Verkhovna Rada of Ukraine No. 2686-IX of October 18, 2022. The initial analysis, based on a comparison of state statistics data and the analytical conclusions of previous research projects, identified significant differences in the field of forestry in Ukraine according to the level of risk of their spread. These differences were especially evident in the knowledge of the problem of shadow use of forest resources, manifestations of corruption and various abuses (Korystin and Svyrydiuk, 2023a, Korystin et al., 2024). It can be concluded that the primary focus of law enforcement agencies in the forestry sector is the resolution of minor criminal offences. This is to be achieved through the implementation of preventive measures and the improvement of the socio-economic standard of living of citizens at the state level. Concurrently, the risks associated with systemic criminal threats are distinguished by an exceptional degree of pervasiveness (Korystin and Svyrydiuk, 2023a).

These conclusions led to the necessity of undertaking a specialised research project with an emphasis on a comprehensive list of threats in the field of forestry. A risk-oriented approach was employed to conduct a strategic analysis, which identified threats in the field of forestry and environmental safety in Ukraine. Furthermore, an analysis and assessment of the risks of the spread of these threats in the field of forestry and environmental safety in Ukraine was undertaken (Korystin and Svyrydiuk, 2023b).

Concurrently, an emphasis is placed on the assessment of the institutional capacity of forestry, with the objective of identifying 102 capacities of the forest industry with the aim of minimising the level of risk of the spread of threats and the implementation of the corresponding state policy (Korystin, 2023).

The sequence of activities conducted by the Temporary Investigative Commission, the findings obtained, and the necessity to enhance the efficacy of managerial decision-making prompted further research interest in a comprehensive investigation of the interrelationships between the potential for threat dissemination in forestry and the capacity to mitigate these risks, with consideration of pertinent predictive models.

2. Material and Methods

2.1. Related Works

A substantial body of research has been conducted on the utilisation and conservation of forest resources. The subject of such research is highly diverse. The issue of global deforestation was addressed by Allen, Macalady, Chenchouni, Bachelet and McDowell (2010). The study by Babst et al. (2019) examines the impact of climatic factors on tree growth. Similarly, Favero et al. (2018) investigate the potential of climate change mitigation strategies. The evaluation of ecological models is discussed by Bohn T. J., Livneh B., Oyler J. W., Running S. W., Nijssen B., and Lettenmaier D. P. (2013).

The studies of Bonan et al. (2008), Bright et al. (2014), Canadell J. G. and Raupach M. R. (2008), and Jackson et al. (2008) examine the impact of climate change on forests in the context of forest use. The following scientific works by Muukkonen et al. (2015), Peltoniemi et al. (2015), Lampilahti et al. (2023), and Kollo et al. (2023) address the geographical specificity and diversity of forest use analysis, taking into account the peculiarities and characteristic problems for different countries. The effect of grass mass on the number of litter species, plant species, humidity and climate has been the subject of significant research by a number of prominent academics. In particular, Bennett and Barton (2018), Cao et al. (2018), Spracklen et al. (2008), Teuling et al. (2017), Kulmala et al. (2020) and Li et al. (2024) have all made valuable contributions to this field of study.

A significant number of scientists, including Tharammal et al. (2019), Dubber et al. (2017), Birky (2001), Galbraith et al. (2010) and Peltoniemi et al. (2015), have provided substantial evidence to support a range of ontological foundations and have conducted extensive research into potential solutions to a diverse array of applied problems related to ecology and forestry.

The issue of forest management has been the subject of study by a number of researchers. For example, Dubber et al. (2017) and Kolström and Pitkänen (1999) have made contributions to this field of enquiry. Concurrently, a significant methodological domain within the field of management is illuminated by the contributions of Beck (1992), Luhmann (1984), and Berk R. (2017, 2018, 2021), who has directed attention towards the assessment and forecasting of risk. The relevant international standard (ISO 31000:2018) and a number of scientific publications set out important methodological approaches. Korystin and Svyrydiuk (2020), Gede Ary Suta Sanjaya et al. (2020), Faiza Ayub Syed et al. (2013), and Chiang Ku Fan et al. (2012) have contributed to the field of risk management, while RamaKoteswara Rao Alla et al. (2015) have made significant advances in the area of risk-based ranking.

2.2. Proposed Methods

2.2.1. Data Collection

The data set employed in this study was procured via an expert survey, which included experts from pertinent ministries and departments, the State Forestry Agency, the State Environmental Inspection, territorial communities, scientists, representatives of public organisations, business and trade unions. This data set reflects the professional experience and professional awareness of the respondents and the subject matter of the survey. In a previous exercise, a group of experts (up to 12 individuals) in the field of forestry engaged in a brainstorming session to identify a list of 153 indicators that characterise threats in the field of forestry. A further set of indicators (102) is used to characterise the capabilities of the Ukrainian forestry system. The questionnaires were completed online, with respondents assured of confidentiality and anonymity. This approach allows for optimal obtaining of opinions on a large number of issues from a large number of experts located at a distance. To ensure the risk assessment, each indicator was evaluated by two characteristics: "Likelihood" and "Consequences".

2.2.2. Data Cleansing

This is the stage of data cleaning and ensuring their further analytical processing based on a reliable expert sample. The formation of the sample is based on the assumption that experts may be prone to inaccuracies in their responses due to the high number of evaluation indicators and their inherent complexity. Conversely, the quality of the evaluation may be markedly compromised by the incompetence of experts or a lack of motivation to provide

substantiated responses. Such deficiencies can result in substantial errors (Korystin et al., 2021b). In order to facilitate the evaluation of indicators, researchers typically employ the use of special control questions (Goldammer et al., 2020). In order to select a reliable expert sample, the responses provided by experts were subjected to a filtering process based on the criterion of logical consistency.

2.2.3. Risk Assessment

The ISO 31000 standard (ISO 31000:2018) was employed as the fundamental methodology for risk assessment, with the corresponding authors' interpretation concerning the system of indicators (threats and capabilities), data structure, and the definition of the general expert population, as well as approaches to the implementation of individual methods and tools for data processing and analysis and interpretation of results (Korystin and Svyrydiuk, 2020).

2.2.4. Linear Regression Algorithm Forecasting

The intensification of research interest entails the pursuit of interrelationships between the risks of threat propagation in forestry and the capacities to mitigate these risks, with due consideration of pertinent predictive models. In other words, the objective is to ascertain the presence and establishment of the strength and type of connection between the independent variables (predictors, factors) and the dependent variable (Kasliono et al., 2021; Korystin and Svyrydiuk, 2021; Shahrel et al., 2021). This is achieved through correlation and regression analysis, which also encompasses the construction of mathematical models of the studied systems, the determination of the parameters of these models and the assessment of their adequacy. In consideration of the data structure, a linear regression was employed. Furthermore, data interpretation necessitates the consideration of multicollinearity, which introduces instability into the calculation procedure due to a high degree of calculation error.

3. Results

3.1. Data Collection

Consequently, a set of data delineating threats in the field of forestry was constructed on the basis of 153 indicators (Korystin and Svyrydiuk, 2023a; Korystin and Svyrydiuk, 2023b). The overall evaluation is sufficiently variable, which is also perceived as a level of sufficiency regarding the representativeness of the results. In order to distinguish and update the most significant threats in a meaningful manner, the threats were considered by

groups according to their nature, which was identified as political, economic, technological, social, ecological and legal.

In addition, the authors put forth 102 indicators delineating the institutional capacity of forest management in Ukraine. They also proposed 11 indicators of negative content, such as the level of bureaucracy or management decision-making, despite the negative consequences for forestry. These indicators are primarily concerned with the institutional vulnerability of forestry in Ukraine (Korystin, 2023).

3.2. Data Cleansing

To ensure the representativeness of the study, further analysis focused on determining a reliable expert sample. The appropriate sample limitation is carried out by checking respondents for logical fallacy. For this purpose, during the development of the questionnaire, questions were included in various sections, the logically justified answer to which was their evaluation in the "Likelihood" characteristic as "high" or "medium", but not "low", for example, "Level of shadow economy", etc. Despite the fact that after applying the filter to the general population of data, 59.13% remained, the quality of the results increased significantly. This can be seen in the example of the assessment of the threat indicator "Disruption of the ecosystem balance" and the distribution in the group of those selected according to the filter of the absence of a logical error, compared to those who did not pass this filter (Table 1). The statistical analysis of the data was carried out using the IBM SPSS Statistics package, version 25.

As can be observed, the discrepancy in the distributions is pronounced: 54.2% of the experts deemed unreliable indicated a low probability of the threat materialising, whereas reliable experts selected this option only 9.8% of the time. The "high likelihood" option was selected in 46.9% of cases. This difference is not only statistically significant (χ^2 = 33.678, p < 0.000), but also the effect size is very significant (V Cramer = 0.393, p < 0.000). A similar pattern emerges when the responses to other significant questions on the questionnaire are analysed.

Consequently, the application of logical fallacy

testing to the sample allows for the generation of statistically significant, reliable, and representative results.

3.3. Risk Assessment

A further analysis will be conducted to determine the level of risk of the spread of threats in the forestry sector of Ukraine. As previously stated, the authors have identified discrete categories of such threats (Korystin and Svyrydiuk, 2023a; Korystin and Svyrydiuk, 2023b). Consider the following group of environmental threats.

The methodology used includes a risk assessment of the prevalence of threats on a scale from 0% to 100%, with the following thresholds (Korystin et al., 2021a): above 60% – red risk zone (the most significant threats); 50-60% – orange risk zone (significant threats); 40-50% – yellow risk zone (threats that need attention); 40% – green risk zone.

Among the environmental threats, the most significant is (Figure 1) TA71 – *uncontrolled massive deforestation, which leads to a 60.89% reduction in the number of flora and fauna.*

Subsequent analysis will concentrate on evaluating the institutional capability of the forestry sector in Ukraine. A total of 102 capacity indicators were identified and subjected to assessment (Figure 2).

A calculation algorithm, which has been empirically validated, was employed to assess the ability to risk above and below a 50% threshold. The former is characterised by a positive level, while the latter is indicative of an insufficient level, which is consistent with system vulnerabilities (Korystin et al., 2021a).

Thus, in terms of risk, almost all capacity indicators are below 50%, which may indicate a low institutional capacity of the forestry sector. At the same time, this level also gives grounds to predict that in certain areas of activity, they may increase in the future, which is logical under the condition of an objective management process.

In addition to the aforementioned group of institutional capacity indicators, the indicators employed were those that characterise the processes in the forestry sector of Ukraine exclusively in a negative sense and are interpreted as direct vulnerabilities. These include the level of bureaucracy
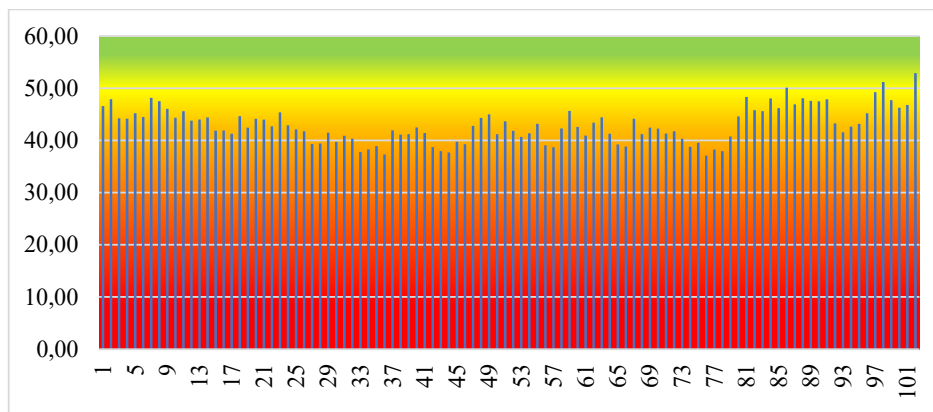
Table 1

Logical error filter analysis

Threats (Likelihood)		tp25 >= 10 (FILTER)		Total
		Not Selected	Selected	
Disruption of the ecosystem balance	Low	54.2%	9.8%	14.7%
	Medium	25.0%	43.3%	41.3%
	High	20.8%	46.9%	44.0%
Total		100.0%	100.0%	100.0%
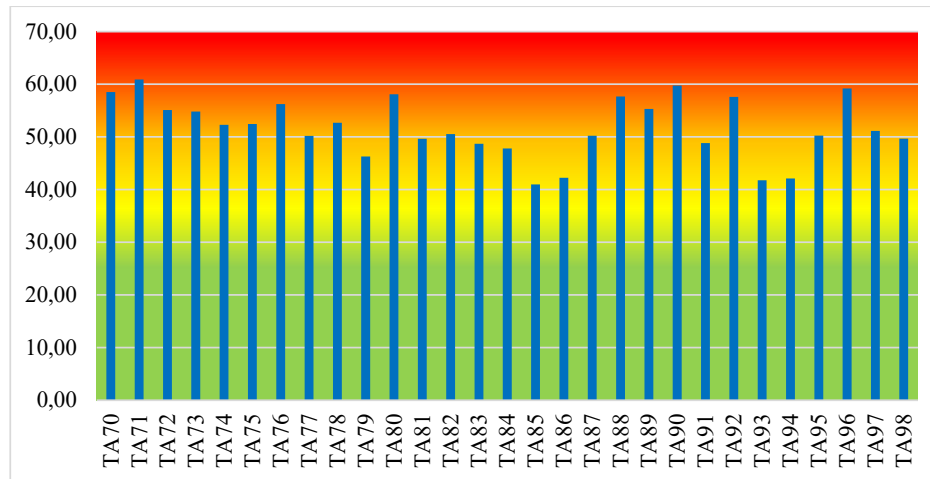
Figure 1. Risk assessment of the spread of environmental threats

Source: (Korystin & Svyrydiuk, 2023b)

Figure 2. Assessment of the institutional capacity of the Ukrainian forestry sector by risk level

Source: (Korystin et al., 2021a)

and the manner of management decision-making, despite the negative consequences for forestry (Figure 3).

Given the negative characteristic, the methodology for their assessment and interpretation provides for the inverse value of the capacity indicators, and the actual direct vulnerability is interpreted in accordance with the assessment level of 50% and above.

3.4. Linear Regression Algorithm Forecasting

An analysis of the internal factors of institutional capacity cannot be considered complete without a consideration of the descriptive statistics. It is crucial to align the identified threats to forestry with the capacity/vulnerability framework. For further analysis, the most significant threat from the environmental group was taken – *uncontrolled massive deforestation, which leads to a decrease in the population of flora and fauna,* which hypothetically has a certain statistical relationship with certain indicators of capacity/vulnerability.

Initially, the correlation analysis identifies factors that have a certain statistical relationship with this threat. Out of the total list of indicators (102) that characterise institutional capacity, only 14 have a statistically significant relationship and a certain level of effect with the threat of "*uncontrolled massive deforestation, which leads to a decrease in the population of flora and fauna*" (Table 2).

At the same time, all vulnerability indicators (11) are also characterised by a statistically significant relationship and a certain level of impact with the threat of "*uncontrolled massive deforestation, which leads to a decrease in the population of flora and fauna*" (Table 3).

In addition to the results of the research, the question of identifying the key factors influencing the threat identified by the authors and the priorities for reducing the risk of proliferation remains important. In order to achieve this objective, a suitable linear regression model was constructed using the method of stepwise inclusion, stepwise exclusion and the
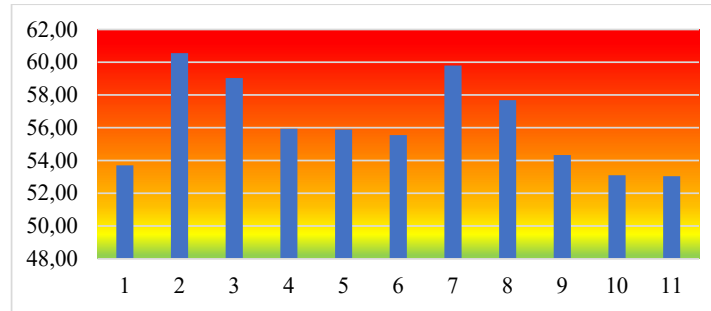
Figure 3. Assessment of direct vulnerabilities of forestry in Ukraine

Source: (Korystin & Svyrydiuk, 2023b)

Table 2
Correlation analysis of the statistical relationship between uncontrolled massive deforestation, which leads to a decrease in the population of flora and fauna, and factors that characterise the capacity

No.	CAPACITY INDICATORS	Pearson Correlation	Sig. (2-tailed)
1.	1. Efficiency of forestry activities in the sector as a whole	.158*	0,038
2.	1.4. Performance in the field of forest management	.155*	0,042
3.	2.4. Efficiency of activities at the level of forestry enterprises (branches, etc.) in the area of forest management	.212**	0,005
4.	4.2. Sufficiency level of legal regulation in the field of forestry protection	.154*	0,046
5.	4.3. Sufficiency level of legal regulation in the field of forestry protection	.154*	0,046
6.	4.4. Sufficiency level of legal regulation in the field of forestry using	.200**	0,009
7.	5.4. Provision of machinery, equipment and transport for forestry	.159*	0,040
8.	7.3. Streamlining of individual technological processes for forest protection and conservation	.167*	0,032
9.	7.4. Streamlining of individual forest management processes	.182*	0,019
10.	11. Sufficient provision of sanitary felling	.206**	0,008
11.	31. Salary level of forestry employees	.179*	0,021
12.	32. Social security level of forestry employees	.223**	0,004
13.	33. Motivation level of forestry employees	.207**	0,008
14.	35. Comfort level of the working environment for employees	.174*	0,025

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Source: (Korystin, 2023)

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REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT TA71
  /METHOD=STEPWISE Rs1 Rs5 Rs11 Rs21 Rs22 Rs23 Rs29 Rs39 Rs40 Rs49 Rs69 Rs70 Rs71 Rs73
   Rs75 Rs104 Rs105 Rs106 Rs107 Rs108 Rs109 Rs110 Rs111 Rs112 Rs113.
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Figure 4. Syntax of the linear regression model "TA71 – Uncontrolled massive deforestation leading to a decrease in the population of flora and fauna" (IBM SPSS Statistics)

identification of optimal subsets (see Figure 4 and Table 4).

The adequacy of the obtained results of the linear regression model is characterized by the statistical significance of the obtained results (Significance ≤ 0.05).

From the general list of indicators characterising the institutional capacity of the forestry system, two key predictors of reducing the risk of the threat "*uncontrolled massive deforestation, which leads to a decrease in the population of flora and fauna*" were identified based on linear regression analysis: "*The level of bureaucratic obstacles in the performance of functional duties by forestry employees*" and "*The level of bureaucracy in providing services to the public*".

Table 3

Correlation analysis of the statistical relationship between uncontrolled massive deforestation, which leads to a decrease in the population of flora and fauna, and the factors that characterise vulnerability

No.	VULNERABILITIES INDICATORS	Pearson Correlation	Sig. (2-tailed)
1.	37. Bureaucracy in the provision of services to the population	.290**	0,000
2.	49.1. The degree of bureaucratic obstacles faced by the SAFR employees in the performance of their functional tasks	.198*	0,012
3.	49.2. The level of bureaucratic obstacles in the performance of functional duties by employees of the apparatus of the SE 'Forests of Ukraine'	.180*	0,023
4.	49.3. The level of bureaucratic obstacles in the performance of functional duties by employees of territorial bodies	.235**	0,003
5.	49.4. The level of bureaucratic obstacles in the performance of functional duties by employees of interregional/territorial bodies	.198*	0,013
6.	49.5. The level of bureaucratic obstacles in the performance of functional duties by forestry employees	.322**	0,000
7.	50.1. Management decision-making, despite the negative consequences for forestry, at the level of the SAFR apparatus	.248**	0,002
8.	50.2. Management decision-making, despite the negative consequences for forestry, at the level of the SE "Forests of Ukraine"	.262**	0,001
9.	50.3. Management decision-making, despite the negative consequences for forestry, at the level of territorial bodies	.299**	0,000
10.	50.4. Management decision-making, despite the negative consequences for forestry, at the level of interregional territorial bodies	.255**	0,001
11.	50.5. Management decision-making, despite negative consequences for forestry, at the level of forestry enterprises	.264**	0,001
	**. Correlation is significant at the 0.01 level (2-tailed).		
	*. Correlation is significant at the 0.05 level (2-tailed).		

Source: (Korystin, 2023)

Table 4

Linear regression model "uncontrolled massive deforestation leading to a decrease in the population of flora and fauna" based on existing capabilities and vulnerabilities (IBM SPSS Statistics)

Coefficients[a]					
Model	Non-standardised ratios		Standardised ratios	t	Sig.
	B	Std. Error	Beta		
(Constant)	33.302	6.516		5.111	.000
The level of bureaucratic obstacles in the performance of functional duties by forestry employees	.315	.097	.257	3.228	.002
The level of bureaucracy in providing services to the public	.227	.097	.187	2.347	.020
a. Dependent variable – uncontrolled massive deforestation, which leads to a decrease in the population of flora and fauna					

Given that the regression coefficients are 0.315 and 0.227 respectively, it can be concluded that as the level of vulnerability identified by the model decreases, the risk of the threat "*uncontrolled mass deforestation leading to a decline in flora and fauna populations*" spreading will decrease.

Taking the above into account, it is possible to predict such a reduction in steps of, for example, 10% and 20% (Table 5).

4. Conclusions

The findings of this study suggest that a comprehensive assessment of threats in the field of forestry is necessary (Korystin and Svyrydiuk, 2023a). Concurrently,

the research cannot be considered as a substitute for the analysis of the institutional capacity of forestry and their descriptive statistics (Korystin, 2023). A comprehensive list of pivotal threats and distinctive characteristics of institutional capacity in the future only serves to exacerbate the complexity of decision-making processes, overwhelming decision-makers with a plethora of potential directions and activities. The further management of the forest industry and the optimisation of management processes require a more specific awareness of the potential for change in the level of threat in the field of forestry.

In order to address the issue of correspondence between the identified and assessed threats in the

Table 5
Predicting the level of threat if the level of modelled predictors changes

THREAT	Basic level	Simulated level	RISK LEVEL			
			Changing predictors			
			20 %		40%	
			The level of bureaucratic obstacles in the performance of functional duties by forestry employees	The level of bureaucracy in providing services to the public	The level of bureaucratic obstacles in the performance of functional duties by forestry employees	The level of bureaucracy in providing services to the public
Uncontrolled massive deforestation, which leads to decrease in the population of flora and fauna	60,89%	63,07 %	52,14 %		41,3 %	

field of forestry and the vulnerable components of the system, it is essential to construct an appropriate predictive model. A linear regression model is employed to ascertain the optimal relationship between a specific threat in the Ukrainian forest sector and variables representing the institutional capacities and vulnerabilities of the forest sector. Ultimately, the final version will facilitate a more efficient allocation of resources to mitigate risks, preventing the unnecessary expenditure on one resource while allowing for the targeted investment in another resource with a similar level of risk.

Applying a linear regression model, using the method of stepwise inclusion, stepwise exclusion and search for the best subsets, the authors determined the optimal dependence of the threat "*uncontrolled massive deforestation, which leads to a decrease in the population of flora and fauna*" on the variables "*The level of bureaucratic obstacles in the performance of functional duties by forestry employees*" and "*The level of bureaucracy in providing services to the public*". Concurrently, the results are defined by the preponderance of regression model indicators with exclusively adverse implications for Ukrainian forestry. The statistical value of the impact of vulnerabilities is more significant than the statistical dependence on any capacity indicator, which, in its intrinsic nature, may potentially carry a positive component.

In light of the content of the predictors, it can be concluded that the influence of "*bureaucracy*" on the development and processes in Ukrainian forestry is, in general, negative and significant.

By introducing the model and gradually adjusting the assessment level and key predictors by 20% and 40%, respectively, the risk of the threat "*uncontrolled massive deforestation, which leads to a decrease in the population of flora and fauna*" is expected to be reduced. In particular, a 20% reduction in vulnerability based on the identified predictors will reduce the risk of the threat "*uncontrolled massive deforestation, which leads to a decrease in the population of flora and fauna*" from the red risk level (63.07%) to the orange risk level (52.62%). In turn, a 40% reduction in vulnerability based on the identified predictors will reduce the risk of this threat spreading to the yellow level (41.3%).

Therefore, the efficacy of the risk-oriented methodology, coupled with the intensification of the analytical process and pursuit of optimal dependencies, offers enhanced prospects for specialists to make more informed decisions and devise effective strategies for the management and minimisation of risks. This approach can be used as a foundation for the implementation of additional security measures and the development of crisis management plans within the context of forestry.

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