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### Classification of Financial Risks in Polish Modern Forestry

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Modern forest management requires a well-founded knowledge and understanding of all the risks involved in forest management. It requires a wealth of information not only on natural hazards, but also related to the financial aspect of running a business. The most important activity in the risk management phase is to identify all the known risk areas, and on this basis, to determine the appropriate classification of risks accompanying the activities of the entity in question, taking into account the various categories of risk division. In forest management, the global risk of activities should be considered in terms of two main risks: operational risk (including natural and anthropogenic factors), and financial risk, which, in simple terms, is the consequence of decisions and economic processes in an entity's area of activity. Considering the impact of the production factors that affect the results of the activities carried out, it should be emphasized that forest management has a specific distribution of standard production factors. The forest stand plays the role of both a production resource and an object of production, and in the final analysis, represents a production effect. Any consideration of financial risk management in forest management should be carried out based on long-term analytical data series. Another factor for forests under state management is the various functions that forest management performs. Taking into account the ownership criterion cited earlier, it needs to be emphasized that the weighting of individual financial risks may vary depending on the ownership structure of forests in a given country and taking into account the ownership share of forests in the timber sales market. In conclusion, it was pointed out that, unlike other industries, financial risk management in forest holdings can be disrupted by the function of forests, as well as the strong influence in the long term of natural phenomena that have a significant impact on determining the types and ordering the degree of significance of individual risks in the process of identifying them.

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## Introduction

It is an undeniable fact that virtually all economic activity is subject to risks that affect its results and the implementation of planned ideas, concepts, or strategies. The area of financial risk impact covers entities involved in market processes, in particular, companies, financial institutions, individual investors and households [Song and Wu 2021]. Among the identified entities are forest owners and managers.

Forest resources are characterized by exposure to the risks of their activities due to the strong influence of the laws of nature and extreme phenomena of natural disasters occurring in nature [Curtis et al. 2018; Ghorbanzadeh et al. 2019; Chen et al. 2020]. In this regard, financial risks are largely derived from catastrophic risks caused by abiotic and anthropogenic risk factors. The consequences of such events are negative economic effects, which leave their mark on the implementation of the forest management plan, and thus disrupt the execution of planned economic tasks, which ultimately result in quite significant deviations in the economic account of forest owners and managers [Houng et al. 2020].

Uncertainty as to the development of such risk factors as interest rates, exchange rates, inflation levels, government policies, or the resulting economic growth and development in the past prompt business entities to be cautious, and to develop and implement appropriate strategies against the effects of risk, which will take into account its acceptable level, set a limit to the entity's exposure to risk, and transparently present methods of risk management to ensure stability and maintain further development [Siekelova et al. 2019; Wu et al. 2022]. To sum up, the risk structure in question includes: the entity, i.e. the forest owner or manager; the subject of risk in the form of the purpose of forest management, the overall forest condition and the implementation of all forest functions.

The last element of risk structure is the relationship that connects the entity to the subject, in which the entity, through its causal activities, interacts with

the subject through a conscious relational flow to try to implement a change in the subject's state. Taking into account the technological advances in forestry and timber activities that have taken place in recent decades, the problem of risk assumes even greater importance as given the current economic realities, the intermingling of different types of risk poses a very great challenge for business entities, making it significantly more difficult to identify them, while at the same time increasing the scope for potential errors in its measurement, resulting in undervaluation or overvaluation of the phenomenon.

The volatility of various risk factors indicates that the dangers arising from the emergence of new, unexplored areas of business risk should not be ignored, such as the hitherto unknown risk of hacking attacks, which can consequently lead to the destabilization of individual financial markets, and therefore such importance is attributed to the correct classification of risks accompanying the activities of a specific entity and their constant updating. Thanks to technological advances, as well as rapid information distribution channels, risk analysts have the ability to obtain the necessary numerical data and access to devices and tools that enable the development of appropriate simulations and optimization models aimed at providing messages regarding the level of risk present in the area of activity of a particular entity, and then its effective management.

The aim of this research was to study the types and levels of financial risk within the activities of forest resource managers and owners, taking into account the role played by the surveyed forest management entities in the national economy. As the public-interest entities include the managers of the State Forests National Forest Holding (PGLLP) – a Polish state forest management entity, the corresponding classification of risks also assumes a social aspect resulting from the statutory obligations imposed on the activities of such entities to guarantee the protection of property and the regularity of operation for the benefit of public administration.

- managed by the State Forests (77.3%)
- national parks (2.0%)
- gmina owned (0.9%)
- other public (0.9%)
- natural persons (17.8%)
- other private (1.1%)

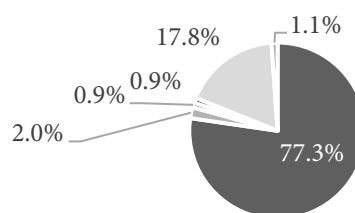


Fig. 1. Structure of forest land ownership in Poland in 2021 as of 31 December [GUS 2022]

According to the information contained in the Forestry Statistical Yearbook for 2022, published by the Central Statistical Office (GUS) [2022], the ownership structure of forests in Poland indicates the dominant role of PGLLP in forest management and the shaping of the state's forest policy, as the data presented in Figure 1 shows that more than 77% of the forest area in

Poland consists of forests managed by PGLLP, and less than 18% belongs to private individuals. The above data confirm the thesis that with regard to forest management in Poland, the main attention should be paid to identifying financial risks in the area of PGLLP activities, also taking into account the timber industry sector, which annually generates 2.5% of the Polish GDP.

**Table 1.** Economic indicators of forestry enterprises 2010-2021 (in %) [GUS 2022]

| Years | Cost level indicator | Gross turnover profitability indicator | Net turnover profitability indicator | Relation of liabilities to receivables (from deliveries and services) | Credits and loans share in short-term liabilities |
|-------|----------------------|--|--------------------------------------|---|---|
|       |                      |  | %                                    |   |   |
| 2010  | 93.4                 | 6.6                                    | 6.1                                  | 104.5   | 0.3   |
| 2015  | 94.8                 | 5.2                                    | 4.9                                  | 134.3   | 2.7   |
| 2020  | 94.1                 | 5.9                                    | 5.6                                  | 125.1   | 1.4   |
| 2021  | 92.5                 | 7.5                                    | 7.2                                  | 175.4   | 1.2   |

Data concern non-financial enterprises (legal entities) keeping accounting ledgers and employing more than 10 persons

In order to give an idea of the financial situation of companies operating in the forestry sector and providing services to it, Table 1 is used, which shows that the financial condition of these entities has improved since 2010. From the presented data, it can be concluded that in 2021 there was an increase in profitability with a decrease in the level of costs; however, along with an increase in turnover, the sub-entities belonging to this service sector recorded a significant rise in trade payables, which may translate into their liquidity ratios. It is also worth noting that companies in this sector are very cautious about using external sources of financing, which certainly limits investment opportunities in the long term, but in the short term limits the possible negative effects in the event of an imbalance in the situation of services in the forestry sector, e.g. similar to that which occurred during the COVID-19 pandemic, during which some of the work, as a consequence of the great uncertainty and temporary disruption of demand in the timber market, contributed to the short-term suspension of some of the work carried out by these entities for PGLLP.

## Materials and methods

The study of risks in the presented risk structure was referred to the entity, which in case of the Polish market

is the state forest manager: State Forests National Forest Holding (PGLLP). The subject of risk, which appears here in the form of the purpose of forest management, was determined by the level of forest condition in Poland and the level of implementation of all forest functions [Ustawa z dnia 28 września 1991]:

- ecological (protective) functions
- social functions
- production (economic) functions.

The first stage of the research was devoted to reviewing the available literature and clarifying the genesis of risk in an interdisciplinary perspective, as well as in relation to financial risk and further risks that are a consequence of its existence. The most important risk definitions are cited in the paper and their closer characterisation is discussed. In the next part of the research, the study of the risks of forestry activities and the classification of financial risks recorded in the activities of PGLLP are presented, along with an explanation of their essence and impact on the financial management of PGLLP, including the principle of self-financing and conducting activities on the basis of economic accounts. Subsequently, the authors attempted an analytical comparison of the balance sheet and profit and loss items of the PGLLP account with the previously defined financial risk

factors. The research was mainly based on the analysis of data from PGLLP's financial statements for 2021 [Directorate General of State Forests 2022b] using such research methods as: analysis of the dynamics of change, analysis of the structure of individual balance sheet and result items in the balance sheet total and total revenues, the grouping of asset and liability items in terms of the levels and types of risk, as well as the identification of sources of financial risk based on relations occurring in the data structure. In the last part, a review of risk factors and extreme economic phenomena to be assigned to a given type of financial risk within PGLLP's activities was carried out in connection with the previously conducted verification and analytical review of the individual balance sheet and result items. As a result, a synthetic summary of identifiable areas of financial risk was obtained, and on the basis of the conducted data analysis, an attempt was made to determine the levels of individual types of financial risk in the risk matrix presented in the discussion. The study used such scientific research methods as an analysis of the available literature on forestry risks, a review of economic events in the context

of the typology of financial risks, an analysis of phenomena and processes and a synthesis of the results. The study does not take into account the interaction of risks with the background of disaster phenomena with the financial risks recorded in PGLLP activities.

## Results and discussion

### 1. Literature research

The subject literature relating to issues presenting the typology of risks in forestry in the vast majority of cases devotes much more space to the analysis of risks associated with natural forces, nature and disaster phenomena, including primarily those caused by: wind [Dmyterko et al. 2015; Albrecht et al. 2009; Kilpelainen et al. 2009]; snow [Hanewinkel et al. 2009; Nykanen et al. 1997; Zachara 2006; Päätaalo 2000; Skatter and Kucera 2000]; fires [Schelhaas et al. 2003; Dziadowiec 2010; Szabla 1994; DeBano et al. 1998; Szczygieł 2012]; insect invasions [Kilpelainen et al. 2009; Forster 1998]; pathogens [Gawęda et al. 2016] and climate change [Saxe et al. 2001; Aber et al. 2001; Millar et al. 2007; Chmura et al. 2010].

**Table 2.** Literature review of risks identified in forestry activities

| <b>Risks associated with natural forces caused by</b> |   |
|---|---|
| <b>wind</b>   | Dmyterko et al. 2015; Albrecht et al. 2009; Kilpelainen et al. 2009                               |
| <b>snow</b>   | Hanewinkel et al. 2009; Nykanen et al. 1997; Zachara 2006; Päätaalo 2000; Skatter and Kucera 2000 |
| <b>fires</b>  | Schelhaas et al. 2003; Dziadowiec 2010; Szabla 1994; DeBano et al. 1998; Szczygieł 2012           |
| <b>insect invasions</b>                               | Kilpelainen et al. 2009; Forster and Storm 1998   |
| <b>pathogens</b>                                      | Gawęda et al. 2016  |
| <b>climate change</b>                                 | Saxe et al. 2001; Aber et al. 2001; Millar et al. 2007; Chmura et al. 2010                        |
| <b>Risk associated with business activities</b>       |   |
| <b>financial risk regarding forestry activities</b>   | Michalski and Adamowicz 2018; Yang 2020; Limaie 2011; Davies 2019                                 |
| <b>operational risk</b>                               | Kusiak 2007; Kocbach and Kocbach 2014   |

Studies on financial risk in the aspect of forestry activities are less frequently presented [Adamowicz and Michalski 2016; ; Michalski and Adamowicz 2018; Yang 2020; Limaie 2011; Davies 2019]. In this area, issues from the area of operational risk are much more often addressed, among others, studies on the determination of occupational risk that do not focus attention on internal fraud, human error or situations of work discontinuity [Plochmann and Hieke 1986;

Kusiak 2007; Kocbach and Kocbach 2014]. The financial risks of forest management are presented sporadically in the literature, usually in the context of a specific issue, in relation to single economic events, and systematically represent the least identified and studied type of risk among all those reported in forestry.

The classification of financial risks occurring in the financial management of PGLLP refers to the general understanding of the issue, which is risk.

According to Bernstein [1997], the word risk is derived from the Old Italian word “riscare” meaning “to dare, to have boldness.” Another interesting origin of the word risk is taken to be the word “riza” [Kaczmarek 2006], which has its roots in ancient Greek, while its meaning refers to the dangers of sailing. Many differences can be observed in the interpretation as to the meaning of the concept of risk as a consequence of the interdisciplinary nature of this phenomenon:

- the possibility that something will fail [Małkowska-Borowczyk 2012]
- taking action to take into account the danger, perceiving risk as the possibility of deviations from the expected state, both “in plus” and “in minus” as a result of events of an internal or external nature [Rudawska 2013; Szczepański 2011]
- probability of loss, at the same time imposing a burden on the affected persons regardless of their fault.

There are two concepts associated with the presented notions of understanding the essence of risk. The first, which stems from the negative idea of interpreting the phenomenon in question, is called pure risk in the literature, in the area of which the only alternative to the realization of risk is an unfavorable deviation from the assumed state [Głuchowski 2001]. On the other hand, speculative risk, within the scope of which positive as well as negative deviations from the expected end result can be expected, should be classified as risk referring to the neutral theory. In practice, risk is more often identified with the possibility of loss, i.e. the first proposal for interpreting the meaning of risk.

The differences between risk and uncertainty, which are often the subject of much confusion in the interchangeable use of these words in everyday life, should be pointed out as important in the considerations addressing risk issues. The forerunner of distinguishing these two issues is Frank Knight, who in his paper “Risk, uncertainty and profit” was the first to present the results of an analysis on the impact of risk on the economic world [1964]. Knight’s formulated theses are still valid today, and although both terms have a close relationship with the concept of actions under uncertainty, nonetheless, owing to significant differences in the meaning of these words, they should not be equated with each other.

Taking into account the categories against which the concepts of risk and uncertainty exhibit definite differences, it is concluded that there are four factors below that distinguish the meaning of these two [Niedziółka 2003]:

- measurability
- the extent of the information held
- predictions of future event scenarios
- the extent to which the consequences are linked to the decisions made.

The criterion of measurability is taken as the essential parameter distinguishing the concept of risk from uncertainty. Knight expressed an opinion, the content of which defines uncertainty as “measurable uncertainty” [Klimczak 2008], basing his thesis on the conclusion that only in the case of risk is it possible to estimate the probability with which future events will occur. It should be stated that quantifiability is a characteristic exclusively attributed to risk, and unlike uncertainty, there is a way to numerically express the occurrence of potential unexpected events through the use of probability calculus [Lange 1967]. The next important factor by which the described concepts can be distinguished is the extent of information available to decision-makers. In the case of risk, the range of data available to the subject is much broader, while any action in the area of uncertainty is characterized by a very limited range of information or no information at all. According to Hadyniak [2010], uncertainty in this dimension is perceived as the inability to predict an event due to a lack of knowledge. The ability to make predictions of future event scenarios and to obtain at least partial information on the consequences of decisions made are taken as further parameters. These factors are considered important as their role affects an individual’s awareness regarding the realization of a random variable, as well as of the anticipated consequences that the realization of a given scenario will bring in the future.

With such a rich spectrum of observations, the subject literature provides numerous definitions of the risk concept. One of them is the definition by the German philologist and linguist Duden [1989], which presents risk as a possible negative outcome of an undertaking, with which harm, loss, damage, and courage associated with the undertaking and the realized intention are connected. Krause and Borens [2009], on the other hand, express the opinion that, in a general sense, risk is perceived as the probability of an event with all the consequences, expressed through deviation from the set goal. Renn [2008], assumed that in a situation where all the activities performed by society and their nature are obvious to our consciousness, the concept of risk means the probability of an undesirable state of reality, which can be caused by natural phenomena or through human activity. The author pointed out the need to take into account three fundamental factors that have an impact on the correctness of forecasting the phenomenon in question and estimating its impact:

- events that affect the values
- the possibility of such events
- a formula that combines the two previously mentioned elements.

An attempt to define risk is presented in the content of the developed PN-ISO 9001 [2015] standard, which defines risk as the effect of uncertainty related to future events or the results of decisions made leading to loss or gain [Jadczyk and Ledzian 2016].

In case it is verified how the risk subject makes choices within its decision space, it should be stated that each subject's attitude towards risk may vary depending on the function of expected utility. Jajuga [2007] distinguishes three basic attitudes of subjects toward risk, which include:

- risk aversion
- indifference to risk
- risk propensity.

Risk aversion is an attitude that characterizes individuals who are willing to forgo future benefits and opportunities for increased profits in favor of a reduction in the scale of risk. By maintaining a pejorative attitude toward risk, the entities that prosper in the risk-affected area take an acceptable level of risk as their main criterion. However, the attitude of indifference to risk is of a different nature, in which the decisions of individual entities depend predominantly on the expected rate of return, and the level of risk plays a secondary role here. The last example of an entity's attitude to-

ward risk is the propensity to take risky actions. Entities are mainly guided by the value of a premium to compensate for the exposure to risk, and the determinant of their actions is only the category of opportunity within the limits of risk, excluding the dangers of loss.

Financial risk has a very important role in the current economic reality as it directly affects events and changes in financial markets, and its level in the global economy is an indicator of the scale of speculation that takes place in world capital markets. Financial risk once again gained importance after the subprime mortgage crisis in 2007 and the subsequent global recession [Baer et al. 2011]. Financial risk is an integral part of identifiable risks (threats) defined by the variability of unexpected outcomes that can determine the value of assets, capitals and profits [Jorion 2007]. A popular definition of financial risk was presented by Fabozzi [2009], according to which financial risk should be called a situation in which an economic entity is exposed to events that may cause a shortfall recorded in the target levels of financial measures and values. The author considers the net income per share, as well as the return on equity and cash flow value as reliable financial indices. It is noteworthy that the literature presents a number of different methods of classification of financial risks, one proposal of which is shown in Figure 2.

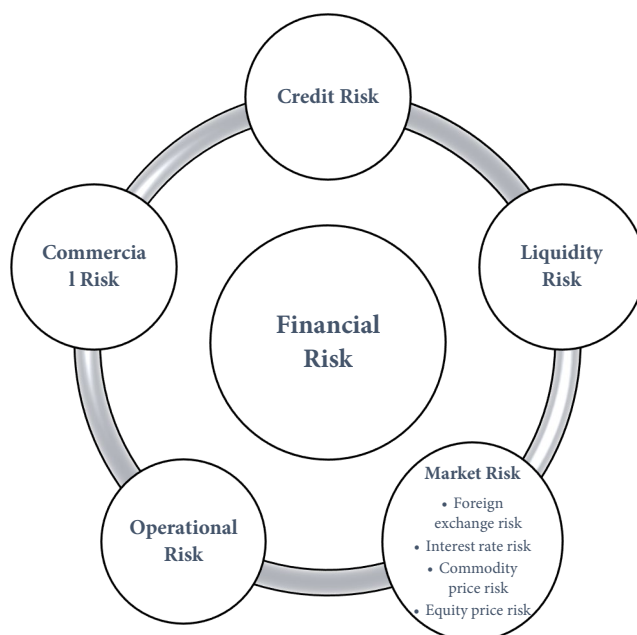


Fig. 2. Classification of financial risk in Polish literature [Jajuga, 2007, page 18]

## 2. Risks of conducting forestry activities

Taking into account the financial risk classification, which can be formulated by analyzing, among others, processes, economic events, internal regulations

adopted in forestry, including PGLLP, it should be indicated that the specifics of the industry are of significant importance in the described case. Sustainable forest management carried out by PGLLP requires the proper development and implementation

of a forest management plan, which is the determinant of further actions in the medium and long term. Adherence to the principles of forest management set forth in the Forest Law [Ustawa z dnia 28 września 1991] also involves the need to set aside adequate resources allocated annually for their proper fulfillment. Forest management, considering both productive and non-productive functions, is significantly exposed to the negative effects of a business cycle in crisis or stagnation. In the implementation of economic tasks, forestry has had to adapt to fluctuations in the level of risk as a consequence of natural disturbances, which have caused and will continue to cause an increase in the scale of financial risk. Hence, the business cycle plays a lesser role, and the change in the level of financial risk as a consequence of the growing threat of climate change is of greater importance. Certification in the conduct of sustainable forest management requires consideration of the effects of disaster phenomena and measures to minimize the risk of their occurrence by increasing the resilience of forests to reduce and prevent the impacts of disaster phenomena, e.g. by diversifying the age, species and structure of the stand [Forestry Commission 2017]. Decisions on how to shape the stand structure or how to deal with the effects of disaster events require knowledge of the types of financial risks to ensure that the cost of the measures taken does not exceed the potential loss, and that the way the timber is marketed meets the obligations of intra-community law [EUTR Regulation 2010]. In view of the above, it is necessary to identify areas of financial risk that can cause significant disruption to PGLLP's activities. Five major financial risks that threaten the financial management carried out at PGLLP have been identified:

- market risk (including: exchange rate risk, interest rate risk, stock price risk and commodity price risk)
- liquidity risk
- trade credit risk
- cost and revenue estimation risk
- legal risk.

Fluctuations in the levels of the above types of financial risk may be caused by external factors, such as catastrophic phenomena, but also through internal sources of risk, for example, inadequate rules for the sale of timber, inconsistent with market principles and the plan of economic tasks, assumptions in the preparation of annual financial and economic plans.

### 3. Market risk

Market risk is characterized by the scope and scale of impact related to the formation of market factors. The

following have been adopted as the main factors co-creating this type of risk:

- exchange rates
- interest rates
- commodity prices
- securities prices
- values of stock market indices.

According to Jajuga [2007], market risk results from price changes in financial and other related markets. The consequences of an economic entity's exposure to risk can be: positive, e.g. an increase in the exchange rate; negative, e.g. a decrease in the price of a commodity as a result of developments in the relationship between demand and supply in the market. According to the Basel Committee's position, market risk should be understood as the possibility of losses on balance sheet and off-balance sheet items resulting from changes in market prices [2005]. According to Tarczyński and Mojsiewicz [2001], this risk is expressed through exposure to loss as a result of fluctuations in the value of assets traded and held by the company. The most common division of market risk is according to the following areas of exposure [Jajuga and Jajuga 2011]:

- exchange rate risk
- interest rate risk
- stock price risk
- commodity price risk.

According to Bennet's definition [2000], foreign exchange risk should be considered a current position or a future position, or an anticipated future asset and liability, denominated in a foreign currency, which, for commercial or balance sheet reasons, must be converted into another currency at an exchange rate that has not been determined. Thus, foreign exchange risk refers to unfavorable deviations in exchange rates, which carry the cost of losing the currency held, while the scale of foreign exchange risk in a given market depends primarily on:

- state monetary policy
- demand and supply in the foreign exchange market
- the state of the economy and forecast indicators of its development.

In business entities, foreign exchange risk is involved when an entity holds foreign assets or foreign capital denominated in a foreign currency. The most sensitive to exchange rate movements are spot transactions for which no hedging in the form of derivatives has been established. The following regularities can be identified for opposite directions of exchange rate movements [Jajuga 2007]:

- currency depreciation results in a decrease in the value of domestic assets and an increase in liabilities in domestic currency
- currency appreciation results in an increase in the value of domestic assets and a decrease in domestic currency liabilities.

In PGLLP, currency risk may exist if a significant portion of timber sales transactions is carried out in foreign currencies. Nonetheless, analyzing the structure of timber recipients in terms of geography, it is inappropriate to consider a high impact of currency risk on the financial management of PGLLP; rather, in the case that in 2021 only 4.6% of the timber sold by weight was purchased by foreign recipients [Directorate General of State Forests 2021], the level of currency risk within the organization should be considered low with no indication of an increase in subsequent years. In addition, it should also be emphasized that an additional aspect demonstrating the low level of this risk is the structure of State Forests' cash, the vast majority of which is denominated in domestic currency.

This thesis is also supported by an analysis of the data in Tables 3 and 4, which present financial data on PGLLP's financial statements for 2021 [Directorate General of State Forests 2022a], through which it can be concluded that the sum of financial expenses and income, which usually reflects the effect of currency valuation, represents a small fraction of total income, which, with such a high turnover, may indicate a low proportion of transactions and bilateral items for which PGLLP would be required to make a valuation at the balance sheet date.

Interest rate risk arises from the volatility of financial markets. According to Jackowicz [1999], the decisive factor is the potential for the level of actual interest rates to differ from the subject's expectations. The Institute of Chartered Bankers [The Chartered Institute of Bankers 2001] defines interest rate risk as the result of an unfavorable change in interest rates resulting in higher interest costs or lower investment income, thus contributing to lower profits and increased loss. The extent of the impact of interest rate risk relates to interest-bearing assets such as treasury bills, bonds or money market instruments, as well as funds accumulated in bank accounts, in the case of PGLLP [Directorate General of State Forests 2022b]. When, according to the observation carried out on the basis of Table 4, a significant position in the current assets of State Forests is occupied by cash accumulated in bank accounts, the role of interest rate risk increases. Interest rate risk in the case of PGLLP expressed as a decrease in market interest rates, will result in a decrease in income from deposited funds in current accounts or short-term bank deposits. On the other hand, market

risk expressed as an increase in market interest rates will not have a material impact on the operations of PGLLP, taking into account only the fact that PGLLP's liabilities do not include liabilities from loans or other financial liabilities, which, if they occurred, would involve the risk of an increase in the cost of their financing resulting from an increase in market interest rates. On the other hand, in the PGLLP balance sheet there is a significant item for provisions for pensions and similar benefits, which represents 7% of the balance sheet total and which, in the event of an increase in market interest rates, requires valuation as at the balance sheet date by discounting the value of the future liabilities on the basis of the interest rate used for valuation - usually the market rate of return on long-term government bonds. If the market interest rate on long-term treasury bonds increases, the above provision will be revalued, resulting in an increase in salary costs due to the higher valuation of the provisions. It should be emphasized that in the case of provisions for employee benefits, the discount rate is one of many elements affecting their amount. Other important factors determining the amount of provisions for employee benefits include, among others, the employee mortality rate, the number of temporary employees, the employee turnover rate, the rate of planned salary increases for employees.

Share price risk, comes down to the securities market and price fluctuations in addition to trend directions of the respective industry sectors, indices or direct issuers. Owing to the low correlation of share price risk with the financial management carried out by PGLLP - 0.34% of equity [Directorate General of State Forests 2022b], this risk has little impact on the company's operations. This is because of the fact that PGLLP is an unincorporated entity. In accordance with the adopted accounting policy, PGLLP presents the acquired shares in long-term financial assets.

Commodity price risk results mainly from fluctuations in commodity prices on commodity markets. With regard to the study area, the timber market, where the price of raw timber is shaped, should be identified as the fundamental commodity market. The variability and magnitude of changes in timber prices are determinants of the level of commodity price risk, in a situation where almost 88% of PGLLP's revenues come from timber sales [Directorate General of State Forests 2022a]. The determinants of the risk level of timber sales prices are demand and supply shaped by decisions made at the highest level of PGLLP, taking into account the currently implemented forest management plans for individual units. The results of this study indicate that there is no correlation between a change in the price of wood and a corresponding decrease or increase in demand [Adamowicz 2010; Adamowicz and Michalski 2016].



**Table 3.** PGLLP income statement for 2021 [Directorate General of State Forests 2021; 2022a; 2022b]

|   | Item   | Year end 2021    | Year end 2020    |
|---|--|------------------|------------------|
|   |  | PLN              | PLN              |
| A | Net revenues from sales of products, goods and materials | 9 671 414 337.05 | 8 149 886 149.10 |
| B | Cost of products, goods and materials sold               | 5 136 557 487.70 | 4 450 391 521.59 |
| C | Gross profit (loss) on sales (A-B)                       | 4 534 856 849.35 | 3 699 494 627.51 |
| D | Selling costs  |                  |                  |
| E | General and administrative costs                         | 4 088 424 032.24 | 3 465 768 321.04 |
| F | Profit (loss) on sales (C-D-E)                           | 446 432 817.11   | 233 726 306.47   |
| G | Other operating revenues                                 | 449 925 131.52   | 438 440 722.11   |
| H | Other operating expenses                                 | 168 525 285.37   | 159 039 601.35   |
| I | Profit (loss) on operating activities (F+G-H)            | 727 832 663.26   | 513 127 427.23   |
| J | Financial revenues                                       | 21 234 259.26    | 22 545 781.69    |
| K | Financial expenses                                       | 13 470 987.51    | 20 187 692.82    |
| L | Profit (loss) on business activities (I+J-K)             | 735 595 935.01   | 515 485 516.10   |
| M | Income tax   | 34 275 982.78    | 27 930 019.92    |
| N | Net profit (loss) (N-O-P)                                | 701 319 952.23   | 487 555 496.18   |

Such categories of factors as the quality and species of wood raw material, clear forms of sale, and market transparency play a significant role. The strength of the price risk impact depends on the sensitivity of PGLLP organizations to fluctuations in timber prices in global markets. Less important in shaping the level of price risk is storage management, resulting from the specifics of timber hedging. Such factors as demographic changes, economic growth, environmental conditions and energy policy also influence the risk level of timber price changes [Paschalis-Jakubowicz 2012; Wieruszewski et al. 2022].

An element of PGLLP's price risk is the costs expressed in terms of the purchasing capacity for services and materials, which are reflected in the financial condition of companies belonging to the forest services sector [Kocel 2013]. Price risk in PGLLP should be estimated as high, as shown in Table 5, not only because of its importance in the national economy of Poland, but also taking into account the effect of the systemic risk of linkages with the timber industry, the realization of which may consequently lead to a wave of bankruptcies within certain economic sectors.

#### 4. Liquidity risk

Another category is liquidity risk, which is not largely related to PGLLP's operational activities, but

is instead a consequence of the results of such activities. Liquidity risk refers to the threat to the entity's ability to pay its current obligations under signed contracts, business relationships and tax obligations. Liquidity in an enterprise can be considered in the listed time series:

- up to 1 day – instant liquidity
- up to 7 days – current liquidity
- up to 1 month – short-term liquidity
- in the period from 1 to 3 months – medium-term liquidity
- in the period from 3 to 12 months – long-term liquidity.

Liquidity risk requires business entities to properly harmonize the maturity of the entity's liabilities with the repayment of amounts due by debtors. In the case of PGLLP's financial management, liquidity risk may increase resulting from the emergence of disaster phenomena effects or in the case of markets for timber, sales collapse, but also in the case of the emergence of disorders in the implementation of services provided by the forest service establishment. The main tool for controlling liquidity risk in PGLLP units should be identified as the forest fund included in the funds of the budget system [Kosikowski 2011], the main purpose of which is to compensate for shortfalls arising in the

implementation of forest management tasks, as well as those relating to the public administration of forestry. The forest fund, as well as the structure and amount of working capital, mean that the level of liquidity risk in PGLLP units should be described as low. In the presentation of the PGLLP balance sheet, the forest fund is an element of equity and has a stabilizing function, its primary purpose being to compensate for shortfalls in PGLLP units arising from different management conditions. It is worth adding that an activity frequently encountered in practice leading to a preliminary determination of liquidity risk is the calculation of liquidity ratios based mainly on two balance sheet items: short-term financial assets and short-term trade payables. By combining these ratios and interpreting their values for individual periods, it is possible to identify the liquidity risk vector of the company.

### 5. Credit risk

Trade credit risk, in the form of the deferred payment of a manipulative or commercial nature [Kubiak 2005], consists of the probability of a loss expressed in value, which is a consequence of the occurrence of events that are difficult to predict and beyond the control of the entity, leading to a decline in its financial efficiency and even bankruptcy [Rytko 2009]. Trade credit risk depends on:

- the specifics of the industry in which the company operates
- market prosperity
- the reliability and solvency of contractors.

Historically, there have been situations in State Forests when payment for wood raw material was not received on the scheduled date due to a lack of funds from the counterpart. The highest number of such cases was recorded after the economic crisis in Poland in 2001. In order to reduce the negative risk impact, the following mechanisms function in PGLLP: the payment of receivables before the release of timber – prepayment; in the case of deferred payment, the submission of collateral in the form of a bank or insurance guarantee [Directorate General of State Forests 2021]. The level of trade credit risk accompanying PGLLP's operations should be considered high, strongly correlated with the level of operational risk in the verification of collateral to the value of completed transactions, the completeness of prepayments, supported by the efficiency of IT tools for monitoring receivables. The scale of trade risk can be identified by analyzing the trade receivables indicated in PGLLP's balance sheet and by analyzing the dynamics of receivables in individual years. It may be helpful to determine the receivables turnover cycle, which represents the average number of days over the

period under review to repay receivables from counterparties. The effects of the realization of the trade credit risk will be reflected in the PGLLP income statement in the item concerning other operating costs when there are justifiable reasons to create a write-off of the receivable from a given counterparty due to the impossibility of its recovery.

Cost and revenue estimation risk can be considered based on four risk realization scenarios:

- overestimation of revenues
- underestimation of revenues
- overestimation of costs
- underestimation of costs.

### 6. Cost and revenue estimation risks

Cost and revenue estimation risks affecting State Forests' operations may result from, among others, the misidentification of needs or failure to correctly estimate them over time, unexpected legislative changes, the occurrence of unexpected economic events, a decline in demand for timber raw material, or increased pressure to carry out non-productive forest functions. It is important to make provisions for future liabilities to reduce PGLLP's financial risks.

The last legal risk is defined by Kendall [2000] as the risk associated with the possibility of incurring losses as a result of the inability of individuals and legal entities to enforce the terms of their contracts and agreements. The literature distinguishes the following types of legal risk [Kaczmarek 2010]:

- risk of over-normalizing a particular area of socio-economic life, limiting economic freedom
- risk of insufficient regulation of a particular area of socioeconomic life, leaving loopholes
- risk of the inapplicability in practice of certain legal norms
- risk of enforcement difficulties.

On the grounds of frequent changes in domestic and international law, economic entities are forced to react quickly to instability in the legal system. Fluctuations in laws sometimes arising from political initiative and from ad hoc economic or social needs lead to destabilization and misinformation for business entities. Thus, legal risk can result from insufficient adaptation or insufficiently rapid adaptation to changing regulations and legal norms by businesses. At the same time, it should be noted that too rigidly normalized conditions of the economic environment result in hindered development and the failure to fully exploit economic potential, and can sometimes be the cause of the gradual elimination of innovative investments from economic life. Nevertheless, it is worth noting that in cases of indolence on the part of authorities in the

application of law, and thus the enforcement of rulings and decisions, business entities are exposed to negative consequences in business relations with contractors who abuse or fail to comply with the law. This carries numerous consequences in the form of problems with the recovery of debts, and contractual penalties as to which proceedings have been initiated in court. In view of the above-mentioned events, appropriate cooperation with law firms of legal advisors providing substantive support in the interpretation and application of the law in practice gains in importance.

## 7. Legal risk

In analyzing the area of legal risk within the activities of State Forests, it should be stated that an additional

burden is the lack of legal personality, which is interpreted differently by some financial institutions, especially when it comes to the issue of determining the status of an entrepreneur. However, there is no doubt that State Forest units, while performing profit-making or commercial activities, also perform economic activities within the meaning of Entrepreneur Law [Supreme Administrative Court 2011]. In addition, in the case of research on the impact of legal risk in a given organization, the role of risk factors of a qualitative nature significantly increases in relation to data containing historical figures, and in recent years increasing attention is paid to the analysis of legal risk in terms of the rights and obligations to which a given unit of State Forests is entitled and obliged to fulfill.

**Table 4.** PGLLP balance sheet for 2021 [Directorate General of State Forests 2022a]

| ITEM |                        | Year end 2021     | Year end 2020     | ITEM |  | Year end 2021     | Year end 2020    |
|------|------------------------|-------------------|-------------------|------|--|-------------------|------------------|
|      |                        | PLN               |                   |      |  | PLN               |                  |
| A    | FIXED ASSETS           | 7 855 730 523.38  | 7 700 971 106.72  | A    | EQUITY                                     | 9 625 245 490.74  | 8 895 624 445.06 |
| I    | Intangible assets      | 7 811 107.20      | 8 569 036.04      | I    | Capital of resources of State Forests      | 7 708 512 302.94  | 7 317 641 784.77 |
| II   | Tangible fixed assets  | 7 745 209 123.85  | 7 589 579 836.76  | II   | Revaluation reserve                        | 353738892.99      | 358 129 735.31   |
| III  | Long-term receivables  | 1 360 367.34      | 1 119 187.05      | III  | Forest fund                                | 864 380 228.02    | 731 515 251.86   |
| IV   | Long-term investments  | 94 296 589.02     | 95 329 703.80     | IV   | Previous year's profit (loss)              | 2 705 885.44      | 782 176.94       |
| V    | Long-term prepayments  | 7 053 335.97      | 6 373 343.07      | V    | Net profit (loss)                          | 701 319 952.23    | 487 555 496.18   |
| B    | CURRENT ASSETS         | 5 211 089 348.21  | 4 302 562 435.84  | B    | LIABILITIES AND PROVISIONS FOR LIABILITIES | 3 441 574 380.85  | 3 107 909 097.50 |
| I    | Inventory              | 265 686 828.66    | 278 510 033.91    | I    | Provisions for liabilities                 | 911 821 590.66    | 810 270 698.82   |
| II   | Short-term receivables | 477 150 020.15    | 541 947 730.90    | I    | Long-term liabilities                      | 7 047 240.03      | 3 327 647.53     |
| III  | Short-term investments | 4 423 050 038.68  | 3 446 342 684.60  | II   | Short-term liabilities                     | 1 712 556 979.93  | 1 521 078 794.96 |
| IV   | Short-term prepayments | 45 202 460.72     | 35 761 986.43     | III  | Accruals                                   | 810 148 570.23    | 773 231 956.19   |
|      | TOTAL ASSETS           | 13 066 819 871.59 | 12 003 533 542.56 | IV   | TOTAL LIABILITIES                          | 13 066 819 871.59 | 12003 533 542.56 |

## Conclusions

State Forests (PGLLP) has a variable impact of factors that are a source of exposure to financial risk. Due to the specific nature of PGLLP's activities resulting from long production cycles (forest crops), phenomena with catastrophic features occurring within PGLLP's activities are important for the estimation of financial risks. In the case of PGLLP, it is possible to classify financial risks within the scope of those observed in its activity. Market risk and, more specifically, price risk, along with trade credit risk and legal risk, represent categories of financial risks that strongly affect the future activities of PGLLP entities. In a nutshell, this is a consequence of the fact that, according to the analysis of the PGLLP financial statements for 2021, trade receivables of up to 12 months have a significant share in the balance sheet total and have a significant impact on trade credit risk levels.

With regard to price risk, the dominant position on the timber market and the year-on-year increase in total revenues play a significant role.

In the context of assessing the magnitude of legal risk, the legal status of PGLLP and its role in state forestry policy play a key role. In this case, legal risk is also indicated as the responsibility of the entity to fulfil its statutory obligations properly and in accordance with the law in force, while shaping future legislative solutions that allow for sustainable and balanced forest management.

Much lower risk exposure can be attributed to liquidity risk, cost and revenue estimation and other types of market risk, such as currency risk, stock price risk, and interest rate risk. To emphasize the categories and strengths of the impact of individual financial risks in the area of State Forest activities, the risk matrix in Table 5 was used.

**Table 5.** Verification of financial risk index

| Financial risk category          | Low | Medium | High |
|----------------------------------|-----|--------|------|
| market risk                      |     | X      |      |
| of which:                        |     |        |      |
| exchange rate risk               | X   |        |      |
| interest rate risk               |     | X      |      |
| share price risk                 | X   |        |      |
| commodity price risk             |     |        | X    |
| trade credit risk                |     |        | X    |
| liquidity risk                   | X   |        |      |
| cost and revenue estimation risk |     | X      |      |
| legal risk                       |     |        | X    |

In terms of determining the overall level of risk indicated for PGLLP's liquidity, it was characterized at a low level, particularly based on the structure of balance sheet items. This is due to the perspective of taking into account balance sheet data, and not only result data (a significant level of costs are fixed costs, which provide a rationale for raising the level of this risk). Based on the above assumptions and taking into account PGLLP's liquidity risk control mechanisms, a low level was adopted for this risk.

The attempt to classify financial risks in the PGLLP area presented in this paper provides a sound basis

for future research in this area. The authors note that for a deeper analysis of the risks accompanying PGLLP's activities, it is necessary to carry out research at all three organisational levels of PGLLP in order to identify the scale and classification of risks that are relevant to the different groups of units. It should also be pointed out that in assessing financial risks in PGLLP, not only data from financial statements can be used, but also data on the aging of receivables, the settlements of individual units with the forestry fund, average timber sale prices in particular periods, etc. This research space still remains to be verified and analysed.

## References

- Aber J., Neilson R.P., McNulty S., Lenihan J. M., Bachellet D., Drapek R.J.** [2001]: Forest processes and global environmental change: Predicting the effects of individual and multiple stressors, *Bioscience*, 51 [9], 735–751. [https://doi.org/10.1641/0006-3568\(2001\)051\[0735:FPAGEC\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2001)051[0735:FPAGEC]2.0.CO;2)
- Adamowicz K.** [2010]: Cenowa elastyczność popytu na drewno na pierwotnym lokalnym rynku drzewnym w Polsce, (Price elasticity of wood demand in the primary local wood market in Poland). *Sylwan*, 154 (2): 130–138. <https://doi.org/10.26202/sylwan.2009018>
- Adamowicz K., Michalski K.** [2016]: Interakcje ryzyka w Lasach Państwowych i przemyśle drzewnym, in: Zagrożenia lasu oraz jego funkcji – przyczyny, konsekwencje i szanse dla gospodarki leśnej (Risk interactions in National Forests and the timber industry, in Threats to the forest and its functions – causes, consequences and opportunities for forest management). VIII Sesja ZSL IBL. Sękocin Stary. 15–17 marca 2016 r. p. 393–429
- Albrecht A., Schindler D., Grebhan K., Kohnle U., Mayer H.** [2009]: Sturmaktivität über der nordatlantisch-europäischen Region vor dem Hintergrund des Klimawandels-eine Literaturübersicht, *Allg Forst Jagdzeitung* [180]: p. 347–360
- Baer T., Mehta A., Samandari, H. McKinsey** [2011]: Working Papers on Risk [24]: The use of economic capital in performance management for banks, McKinsey & Company, p. 24
- Basel Committee on Banking Supervision** [2005]: Amendment to the capital accord to incorporate market risks (online), [www.bis.org/publ/bcbs119.pdf](http://www.bis.org/publ/bcbs119.pdf) [Accessed 20 July 2022]
- Bennet D.** [2000]: Ryzyko walutowe, (Currency risk). Warszawa
- Bernstein P.L.** [1997]: Against the gods - the extraordinary history of risk, WIG Press, Warszawa
- Chen J., Li Q., Wang H., Deng M.** [2020]: A Machine Learning Ensemble Approach Based on Random Forest and Radial Basis Function Neural Network for Risk Evaluation of Regional Flood Disaster: A Case Study of the Yangtze River Delta, China. *Int. J. Environ. Res. Public Health* [17], p. 49. <https://doi.org/10.3390/ijerph17010049>
- Chmura D.J., Howe G.T., Anderson P.D., St. Clair J.B.** [2010]: Przystosowanie drzew, lasów i leśnictwa do zmian klimatycznych (Adaptation of trees, forests and forestry to climate change). *Sylwan* [154], p. 587–602. <https://doi.org/10.26202/sylwan.2010033>
- Curtis P.G., Slay Ch.M., Harris, N.L.** [2018]: Tyukavina, A., Hansen M.C. Classifying drivers of global forest loss. *SCIENCE* [361], 6407. P. 1108–1111. <https://doi.org/10.1126/science.aau344>
- Davies S.** [2019]: Applying financial risk approaches to the challenge of assessing natural disturbance risks to forests. Phd, University of Edinburgh
- DeBano F.L., Neary D.G., Ffolliott P.F.** [1998]: Fire's effects on ecosystems. J. Wiley&Sons, Inc. New York, Chichester, Weinheim, Brisbane, Singapore, Toronto
- Directorate General of State Forests** [2021]: Informacja o zakupach drewna w LP przez klientów zagranicznych, Zespół zadaniowy ds. budowy utrzymania i rozwoju elektronicznego systemu sprzedaży drewna w Lasach Państwowych, [http://drewno.zilp.lasy.gov.pl/drewno/wideo\\_mrpit\\_klienci\\_zagraniczni\\_27042021\\_v2.pdf](http://drewno.zilp.lasy.gov.pl/drewno/wideo_mrpit_klienci_zagraniczni_27042021_v2.pdf) (Accessed 22 July 2022)
- Directorate General of State Forests** [2021]: Order No. 57 of 22 September 2021 on the principles of timber sales in the State Forests National Forest Holding for the years 2022–2023
- Directorate General of State Forests** [2022a]: Balance Sheet and Profit and Loss Account of PGL LP for 2021, Public Information Bulletin. <https://www.gov.pl/attachment/e055dece-afa0-4250-8575-5e53615f4ac9> (access on 10 January 2023)
- Directorate General of State Forests** [2022b]: Sprawozdanie finansowo-gospodarcze za 2021 rok (Financial and economic report for 2021). Warszawa
- Dmyterko E., Mionskowski M., Bruchwald A.** [2015]: Zagrożenie lasów Polski na podstawie modelu ryzyka uszkodzenia drzewostanu przez wiatr (Threats to Poland's forests based on a risk model of wind damage to stands). *Sylwan* [159] p. 361–371 <https://doi.org/10.26202/sylwan.2014132>
- Duden K.** [1989]; Deutsches Universalwörterbuch, Mannheim/Wien/Zürich, p. 1259
- Dziadowiec H.** [2010]: Wpływ pożaru lasu na właściwości gleb leśnych (Effects of forest fire on the properties of forest soils). Środowiskowe skutki pożaru lasu (red. Sewerniak P., Gonet S.S.), PTSH, Wrocław, p. 7–25.
- Fabozzi F.** [2009]: Finance: Capital Markets, Financial Management, and Investment Management, John Wiley & Sons, Hoboken
- Forestry Commission** [2017]: The UK Forestry Standard, Fourth Edition. Edinburgh, Crown Copyright
- Forster B.** [1998]: Storm damages and bark beetle management: how to set priorities, [in:] Grodzki W., Kniżek M., Forster B. Methodology of forest insect and disease survey in Central Europe. Proceedings, First

- Workshop of the IUFRO WP 7.03.10, Ustroń – Jaszowiec. IUFRO – Forest Research Institute, Warsaw: p. 161–165
- Gawęda P., Mokrzycki T. Skala** [2016]: Częstość i konsekwencje wielkopowierzchniowych klęsk w lasach, (Scale, frequency, and consequences of large-scale forest disasters) in: Zagrożenia lasu oraz jego funkcji – przyczyny, konsekwencje i szanse dla gospodarki leśnej. VIII Sesja ZSL IBL. Sękocin Stary. 15–17 March 2016 r., p.105–121
- Ghorbanzadeh O., Blaschke T., Gholamnia K., Aryal J.** [2019]: Forest Fire Susceptibility and Risk Mapping Using Social/Infrastructural Vulnerability and Environmental Variables. *Fire* 2019 [2]  
<https://doi.org/10.3390/fire2030050>
- Głuchowski J. (ed.)** [2001]: *Leksykon Finansów (Lexicon of Finance)*. Praca zbiorowa, PWE, Warszawa, p. 266
- GUS** [2022]: *Statistical Yearbook of Forestry 2022*, Warszawa, Białystok, stat.gov.pl (access on 2 January 2023)
- Hadyniak B.** [2010]: Przewidywalność, wartość i ryzyko (Predictability, value and risk). *Ubezpieczenia. Podręcznik akademicki*, red. J. Handschke, J. Monkiewicz, Wydawnictwo Poltex, Warszawa
- Hanewinkel M., Breidenbach J., Neeff T., Kublin E.** [2009]: 77 years of natural disturbances in a mountain forest area-the influence of storm, snow and insect damage analysed with a long-term timeseries, Can enalainen A., Peltola H. Impacts of climate change on the risk of snowinduced forest damage in Finland, *Clim Change* [99]: p. 193–209
- Huong V.D., Nambiar E.K.S., Hai N.X., Ha K.M., Dang N.V.** [2020]: Sustainable Management of *Acacia auriculiformis* Plantations for Wood Production over Four Successive Rotations in South Vietnam. *Forests* [11] 550.  
<https://doi.org/10.3390/f11050550>
- Jackowicz K.** [1999]: *Zarządzanie ryzykiem stopy procentowej (Interest rate risk management)*. Metoda duracji, PWN, Warszawa
- Jadczak R., Ledzian P. (red.)** [2016]: *Zarządzanie ryzykiem w logistyce i finansach (Risk management in logistics and finance)*. Monografia naukowa, Katedra Badań Operacyjnych Uniwersytetu Łódzkiego, Łódź
- Jajuga K. (red.)** [2007]: *Zarządzanie ryzykiem (Risk management)*. PWN, Warszawa
- Jajuga K., Jajuga T.** [2011]: *Inwestycje: instrumenty finansowe, aktywa niefinansowe, ryzyko finansowe, inżynieria finansowa (Investments: financial instruments, non-financial assets, financial risk, financial engineering)*. PWN, Warszawa
- Jorion P.**, [2007]: *Value at Risk. The New Benchmark for Managing Financial Risk*, McGraw-Hills Companies, New York
- Kaczmarek T.T.** [2006]: *Ryzyko i zarządzanie ryzykiem. Ujęcie interdyscyplinarne (Risk and Risk Management. An interdisciplinary approach)*. Difin, Warszawa
- Kaczmarek T.T.** [2010] *Zarządzanie ryzykiem ujęcie interdyscyplinarne (Risk management an interdisciplinary approach)*. Difin, Warszawa
- Kendall R.** [2000]: *Zarządzanie ryzykiem – dla menedżerów, (Risk management – for managers)*. Liber, Warszawa
- Kilpelainen A., Gregow H., Strandman H., Kellomaki S., Venalainen A.** [2009]: Peltola H. Impacts of climate change on the risk of snowinduced forest damage in Finland, *Clim Change* [99]: p. 193–209
- Klimczak K.M.** [2008]: *Ryzyko w teorii ekonomii, (Risk in economic theory)*. Master of Business Administration [6], p. 64–69
- Knight F.H.** [1964]; *Risk Uncertainty and Profit*, Reprints of Economic Classics, Augustus M. Kelley, New York
- Kocbach P., Kocbach B.** [2014]: Ocena częstości występowania boreliozy wśród pracowników leśnictwa (Assessing the prevalence of Lyme disease among forestry workers). *Medycyna Pracy, Instytut Medycyny Pacy im. Prof. J. Nofera w Łodzi* [65]
- Kocel J.** [2013]: *Firmy leśne w Polsce, (Forestry companies in Poland)*. CILP, Warszawa
- Kosikowski C.** [2011]: *Ustawa o finansach publicznych, (Public Finance Act)*. Komentarz, Warszawa
- Krause L., Borens D.** [2009]: *Das strategische Risikomanagement der ISO 31000, Zeitschrift Risk, Fraud & Governance, [4/2009]*
- Kubiak J.** [2005]: *Hierarchia źródeł krótkoterminowego finansowania przedsiębiorstwa, (Hierarchy of sources of short-term corporate financing)*. Wyd. AE w Poznaniu, Poznań
- Kusiak W.** [2007,]: *Risk assessment for the position of forester - a critical analysis of methodology and practice in State Forests, Prace Komisji Nauk Rolniczych i Komisji Nauk Leśnych. Poznańskie Towarzystwo Przyjaciół Nauk, 129–136*
- Lange O.** [1967]: *Optymalne decyzje, Zasady programowania, (Optimal Decisions, Programming Principles)*. wyd. 2 popr., PWN, Warszawa
- Limaei Mohammadi S.** [2011]: *Economics optimization of forest management, LAP LAMBERT Academic Publication, Germany*
- Małkowska-Borowczyk M.** [2012]: *Negatywna koncepcja ryzyka w teorii i praktyce zarządzania (Negative conception of risk in management theory and practice)* *Zeszyty Naukowe Uniwersytetu Ekonomicznego w Poznaniu* [235]: p. 9–21
- Michalski K., Adamowicz K.** [2018]: *Rola identyfikacji ryzyka finansowego w procesie zarządzania gospodarstwem leśnym, Acta Sci. Pol. Silv. Colendar. Ratio Ind. Lignar* [17]: p. 221–228



- Millar C. I., Stephenson N. L., Stephens S.L.** [2007]: Climate change and forests of the future: Managing in the face of uncertainty, *Ecological Applications* [17]: p. 2145–2151. <https://doi.org/10.1890/06-1715.1>
- Najwyższy Sąd Administracyjny** [2011]: Postanowienie Sądu Najwyższego z dnia 10 lutego 2011 roku, (Supreme Administrative Court, Order of the Supreme Court of February 10, 2011). Akt IV CSK 272/10.
- Niedziółka P.**, [2003]: Zarządzanie ryzykiem stopy procentowej w banku, Difin, Warszawa
- Nykanen M.L., Peltola H., Quine C., Kellomaki S., Broadgate M.** [1997]: Factors affecting snow damage of trees with particular reference to European conditions, *Silva Fennica* [31]: 193–213. <http://hdl.handle.net/1975/8519> (access on 1 January 2023)
- Päätälä M. L.** [2000]: Risk of Snow damage in Unmanaged and Managed Stands of Scots Pine, Norway Spruce and Birch, *Scand. J. For. Res.* [15]: p. 530–541. <https://doi.org/10.1080/028275800750173474>
- Paschalis-Jakubowicz P.** [2012]: Uwarunkowania strategii rozwoju Lasów Państwowych, (Determinants of the development strategy of the State Forests). CILP, Warszawa
- Plochmann R., Hieke C.** [1986]: Schadensreignisse in den Waldern Bayerns: Eine Zusammenstellung der forstlichen Literatur seit Beginn des 18. Jahrhunderts, University of Munich / Institute for Forestry, Munich, p. 30–66
- PN-ISO 9001:2015:** Quality management systems – Requirements
- Renn O.** [2008]: Risk Governance, Earthscan, Sterling, New York
- Rozporządzenie Parlamentu Europejskiego i Rady (UE)** nr 995/2010 z dnia 20 października 2010 r. ustanawiającego obowiązki podmiotów wprowadzających do obrotu drewno i produkty z drewna - Rozporządzenie EUTR, Dz.Urz.UE.L.295 z 12.11.2010 (Regulation (EU) No 995/2010 of the European Parliament and of the Council of 20 October 2010 laying down the obligations of operators who place timber and timber products on the market – the EUTR Regulation)
- Rudawska E.** [2013]: Ryzyko relacji z klientami w: Ryzyko w zarządzaniu strategicznym. Aspekty podmiotowe i przedmiotowe, (Customer relationship risk in: Risk in Strategic Management. Subject and object aspects). Wydawnictwo Uniwersytetu Ekonomicznego w Poznaniu, Poznań, p. 147–157
- Rytko P.** [2009]: Zarządzanie kredytem handlowym w małych i średnich przedsiębiorstwach (Credit Management in small and medium sized enterprises), Difin, Warszawa, p. 341
- Saxe H., Cannell M. G. R., Johnsen Ě., Ryan M. G., Vourlitis G.** [2001]: Tree and forest functioning in response to global warming, *New Phytologist* [149]: p. 369–399. <https://doi.org/10.1046/j.1469-8137.2001.00057.x>
- Schelhaas M.J., Nabuurs G.J., Schuck A.** [2003]: Natural disturbances in the European forests in the 19th and 20th centuries, *Global Change Biology* [9]: p. 1620–1633. <https://doi.org/10.1046/j.1365-2486.2003.00684.x>
- Siekelova A., Kovalova E., Ciurlau C.F.** [2019]: Prediction financial stability of Romanian production companies through Altman Z-score, *Ekonomicko-manazerske spektrum* [13]: p. 89–97. <https://dx.doi.org/10.26552/ems.2019.2.89-97>
- Skatter S., Kucera B.** [2000]: Tree breakage from torsional wind loading due to crown asymmetry, *For. Ecol. Manage* [135]: p. 97–103. [https://doi.org/10.1016/S0378-1127\(00\)00301-7](https://doi.org/10.1016/S0378-1127(00)00301-7)
- Song Y., Wu R.** [2021]: The Impact of Financial Enterprises' Excessive Financialization Risk Assessment for Risk Control based on Data Mining and Machine Learning. *Comput Econ*, <https://doi.org/10.1007/s10614-021-10135-4>
- Szabla K.** [1994]: Warunki powstawania i rozwoju pożarów, niektóre działania organizacyjne oraz aktualne zagadnienia hodowlane i ochronne na pożarzysku w Nadleśnictwie Rudy Raciborskie, (Conditions for the formation and development of fires, some organizational activities and current breeding and protection issues in the Rudy Raciborskie Forest District). *Sylwan* [6]: p. 75–83
- Szczepański M.** [2011]: Ubezpieczenia w logistyce (Insurance in logistics). Wydawnictwo Politechniki Poznańskiej, Poznań
- Szczygieł R.** [2012]: Wielkoobszarowe pożary lasów w Polsce (Large-scale forest fires in Poland). *Bezpieczeństwo i Technika Pożarnicza, Badania i Rozwój* [1]: p. 67–78
- Tarczyński W., Mojsiewicz M.** [2001]: Zarządzanie ryzykiem. Podstawowe zagadnienia, (Risk Management. Basic issues ). PWE, Warszawa
- The Chartered Institute of Bankers** [2001]: Introduction to Interest Rate Risk, Financial World Publishing, Kent, p. 5
- Ustawa** z dnia 28 września 1991 r. o lasach, Dz.U.2022.0.672 ze zm. (Act of Law)
- Wieruszewski M., Górna A., Stanula Z., Adamowicz K.** [2022]: Energy Use of Woody Biomass in Poland: Its Resources and Harvesting Form. *Energies* [15] 6812. <https://doi.org/10.3390/en15186812>
- Wu X., Tu J., Liu B., Zhou X., Wu Y.** [2022]: Credit Risk Evaluation of Forest Farmers under Internet Crowdfunding Mode: The Case of China's Collective Forest Regions. *Sustainability*, [14] 5832. <https://doi.org/10.3390/su14105832>
- Yang Y.** [2020]: Financial Risk Evaluation of Listed Forestry Enterprises Based on Factor Analysis. *Advances*

in Economics, Business and Management Research [159], Fifth International Conference on Economic and Business Management (FEBM).

**Zachara T.** [2006]: Problem szkód w lasach powodowanych przez śnieg i wiatr oraz sposoby przeciwdziałania im, (The problem of forest damage

caused by snow and wind and ways to counteract it), Sylwan [150]: p. 56–64.

<https://doi.org/10.26202/sylvan.2006023>