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# FOREST REVIEW

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INTERNATIONAL SCIENTIFIC JOURNAL

International Scientific Conference "Sustainable Forestry: Fact or Fiction?"
70 years
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# PREFACE

*Dear Colleagues and Readers,*

*It is a great pleasure to announce the online publication of the first issue of volume 48 of our journal Forest Review!*

*This 2017 is a jubilee year for us. UKiM Faculty of Forestry in Skopje celebrated 70 years of its establishment, and you can read more on this in our Dean's notes on the next page.*

*Our main activities were organizing an International Scientific Conference titled "Sustainable Forestry: Fact or fiction", Solemn Academy and preparation and publication of a Monograph dedicated to the jubilee. It is our honour to invite you to see the details on the following official conference link: http://www.sf.ukim.edu.mk/UKiM_FoF_70_years.htm*

*In the meantime, enjoy reading the articles from the respected authors who published their original work and new findings related to the topics of the Conference in our Review in this and the next issue of the year!*

*Special thanks to all authors and members of Forest Review, all peer – reviewers for their reviews of manuscripts for this interesting volume and issue, all the participants and guests of the Conference, as well as to all those who have been involved not only with the Faculty of Forestry in Skopje, but also with the forest sciences in general, not just recently but through the years.*

*On behalf of the Editorial Board,*

*Asst. Prof. Dr.sc. Bojan Simovski, Editor-in-Chief*

# DEAN'S NOTE

*Respected friends of the Faculty of Forestry in Skopje and of forest sciences,*

*Jubilees are always nice occasions for celebrating individuals, institutions or events, for summarizing the past, but also occasions for presenting your potentials and your vision for the future.*

*Seventy years have passed since the establishment of "Ss. Cyril and Methodius" University in Skopje. It is an important jubilee that coincides with the jubilees and the age of the first few faculties that were the core of the establishment of the University.*

*The Faculty of Forestry in Skopje was established in 1947, immediately after the establishment of the Faculty of Philosophy in 1946, along with the Faculty of Natural Sciences and Mathematics and the Medical Faculty, thus creating the conditions needed for the birth of what will always be the first and oldest university of the country. The Faculty of Forestry in Skopje, as a unit of the former Faculty of Agriculture and Forestry, is one of those constituent members of our University, which will long retain the epithets of the largest and most successful university in Macedonia.*

*On this occasion, the Faculty of Forestry in Skopje undertook several activities for promotion of the Faculty and the University, which additionally served to promote forestry sciences in general, as well as to show appreciation to all those have been involved not only with the Faculty, but also with forestry in general. Therefore, our main activities were organizing an International Scientific Conference, a Solemn Academy and publication of a Monograph dedicated to the jubilee.*

*The International Scientific Conference was titled "Sustainable Forestry: Fact or fiction", and was held from 4$^{th}$-6$^{th}$ October, at the Faculty of Forestry in Skopje.*

*Today's forestry faces challenges and numerous environmental, social, economic and political factors. These are climate change, loss of biodiversity, carbon sequestration, new and invasive forest species, pests and diseases, land erosion and soil loss, illegal logging and timber trade, etc. The social and environmental aspects of forests and forestry seem to receive proper attention in the modern world, but is that enough? The term sustainable forestry has long been in use, but are we close to sustainable forestry in reality, or is this still only a declarative goal?*

*The conference was used as a platform to debate important issues and challenges for forests and forestry, mainly for the region, but also from a global perspective. Thus, oral and poster presentations of the latest scientific achievements were presented, while we facilitated discussion of important practical topics related to sustainable forestry through several open sessions and forums.*

*Results from more than 70 articles, including 44 oral presentations, and 32 posters were presented through the conference. Besides authors from Macedonia, authors from neighbouring Bulgaria, Serbia, Greece, Bosnia and Herzegovina, Turkey, Slovenia, Switzerland presented their work in practically all areas of forestry and related scientific disciplines: Biodiversity and conservation, Forest ecology, Forest wildlife and Game, Forests and Climate Change, Forest Governance, Forest Health, Forest Management, Forest Harvesting and Techniques, Urban Forests, Forests and Water, Forests and the Environment, and Forests and the Landscape.*

*All scientific articles and six invited keynote speeches were published in the conference Book of Abstracts which was distributed to all participants and visitors to the conference.*

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*On behalf of UKiM Faculty of Forestry in Skopje,*

*Prof. Dr.sc. Kiril Sotirovski, Dean*

*International Scientific Conference "Sustainable Forestry: Fact or fiction", 4-6 October 2017, Skopje*

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# FORESTRY SECTOR IN BULGARIA BEFORE AND AFTER THE REFORM IN 2011 MAIN CONSIDERATIONS AND INTER-SECTORIAL RELATIONS

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ABSTRACT: After the reform in 2011 the economic base for forestry functioning changed. Sector was split in six autonomous enterprises. They do their businesses like any other enterprise in the private economy. This gave capabilities to enterprises to gain profits as a result of efficient managerial decisions. All these features determine the future improvement of the entire forestry and consequent problems and the need of their solving. Current paper aims to reveal the differences and similarities of the economic base between forest sector before and after the reform in quantitative manner. To generalize the imperfections of the system and to outline the directions for diminishing their negative effect.

## 1 INTRODUCTION

The forestry sector of the Republic of Bulgaria is an economic branch that provides the raw material base for the wood processing and furniture industry. Wood and other products extracted from the Bulgarian forest are an important source of energy that is renewable, but at the same time a scarce resource. That is why, in the transition years, forestry underwent a radical reform whose ultimate goal was the establishment of a market economy in the forestry sector.

The purpose of this study is to assess the results associated with the operation of the forestry system following the 2011 reform.

The scientific object of the survey is the forestry system of the Republic of Bulgaria, and the subject includes selected indicators of efficiency in static and dynamic manner.

The main tasks of the study are:

- A brief overview of forestry developments in the country before and after 2011.
- Summarizing a methodology including indicators for the static condition and the growth and improvement itself.
- Comparing the current status profile to the previous one.
- Giving guidance on the future development of the sector.

The financial policy, considered as an element of the financial system of the state, is an integral part of the economic policy and represents a scientifically based activity of the state and private bodies of management related to the development of principles, methods and forms for the organization of financial relations [1]. There is no comprehensive, unified and clearly formulated financial policy for the forest sector in Bulgaria so far. Partial attempts are being made to create financial strategies for the development of the sector, mainly through institutional changes in order to restructure it. However, most of the changes are in two directions - ownership change and related ways of financing forestry, as well as enriching the range of forest products consumed. Until 1997, the state was the sole owner of forests. Revenues are from harvesting, hunting and offshore operations, and the management is carried out in three levels: the Forestry Committee, the Regional Forestry Directorates and forestry.

Institutional reforms in the forestry sector since 1997 will be provisionally divided into three sub-periods:

1. From 1997 to 2002 when, with the adoption of the new Forest Law in 1997, the previously functioning GHS 1958 statutes were repealed.

According to the BG, NFB bodies are:

• Regional forest management - 16 on the territory of the country, directly subordinated to NFB.

• State forests authorities (SFA) - local authorities of the forestry authority, major forestry entities, subordinated to NFB and RFB.

The economic relationship between farmers and users of forest products is changing. In the form of a timber deal, the state pays the service to the logging companies, but it can already organize the sale of wood itself [4].

2. From 2002 to 2008, when 39 Game Breeding Stations (GBS) were established in 2002 with the adoption of the Hunting and Game Conservation Law (HGCL). They are legal entities with the status of state-owned enterprises under Article 62, paragraph 3 of the Commerce Act. Unlike SFAs, GBSs are on their own economic account, through which they control the effectiveness of the advanced capital. The wood from the state forests located on the territory managed by the respective game breeding station is used by it against payment of a percentage of the selling price determined by a tariff.

The forcible deprivation of funds for production in the period 1997 - 2001 by the forestry enterprises and their centralization in 82 commercial companies led to a depreciation of the capital, to its plunder and finally to the bankruptcy of the commercial companies. Income-free timber-producing organizations have no capacity to accumulate financial resources for capitalization in forests and incentives for hired labor. At the same time, the harvesting organizations are deprived of such a financial resource for the renovation of their production equipment [4].

3. From 2008 to 2011 a major step in the reforms of the forestry sector is the adoption of the Act on Amendment and Supplement to the Forestry Law. (promulgated SG No. 49 / 29.04.2008) With this normative act the business activity is separated from the control functions of the State Agency for Forests, which carries out state policy in the field of forests, forestry, hunting and recreational fishing, as the primary budgetary spending agent. 144 State SFAs and 39 GBSs, which carry out economic and forestry activities in forests, are formed.

It creates conditions for significant changes in the use of forest resources. According to the law, the existing state forestry authorities were transformed into state-owned enterprises under Art. 62, para. 3 of the Commerce Act and

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are called state forestry holdings. This ensures the registration of SFAs and State Hunting Authorities (SHA)s under the Commercial Act as financially independent state-owned enterprises, managed on a commercial basis, but as state-owned companies, i.e. without being bankrupt. State forest holdings are entities for which the principles of budget funding are not applied. They will manage forests and land from the state forest fund as well as wildlife in their defined territorial scope. In the conditions of a competitive environment, these enterprises will self-finance their revenues, and from the realized profit they will be able to accumulate funds for investment in forests [5].

Some more recent researches [3] provide a closer look at the managerial opportunities and problems for the contemporary forest system. They outline the main characteristics of the new system:

• creating of 6 State Enterprises in field of forestry;

• creating the possibility for State Enterprises and their units (SFE and SHE) to implement management activities (harvesting and forestry works);

• dividing control functions and management functions between Executive Forestry Agency and State Enterprises;

• improvement of management of all property type of forests.

## 2 MATERIALS AND METHODS

The current study implements statistical approach to outline the differences between previous and current system. Some recent [2] and not so studies investigate some indices for economic condition and growth. They give an information about the current condition and problems. Current study improve the analysis with assessment of the statistical significance of the quantitative result during the last few years after the reform.

The main approaches are following:

- Basic indexes for the period 2005-2010 and 2005-2011
- Basic indexes for the period 2011-2015
- Student and Fischer tests for mean equality and variances difference.

Testing is undergone through placing the null hypothesis that there are no statistically significant difference between means of the main economic indicators before and after the reform. The time subseries are tested for variances inequality.

Empirical data are derived from the Eurostat database.

Some basic economic indices have been used in order to outline the situation and the economic efficiency of the sector.

## 3 RESULTS

The overall state of the Bulgarian Forestry can be comprehensively presented by the profitability and relative indicators for the results per output produced. Indicators are shown on fig.1.

Real labor costs are significantly increasing. In the sector, since the beginning of the reform, the view is that wages are one of the few emerging indicators. The problem is that they outstrip the other indicators. Gross value added per cubic meter follows the long-term trend, so any change cannot be considered to have occurred in that direction. In the previous forest management systems, wood was used for own consumption - heating, etc. Now it's all about the market. It is significantly lowering the FTA per cubic meter. The industry is deprived of means of production. Multiple intangible assets with indirect production were purchased. Proof of this is the increase in fixed capital formation at the expense of buildings and facilities.

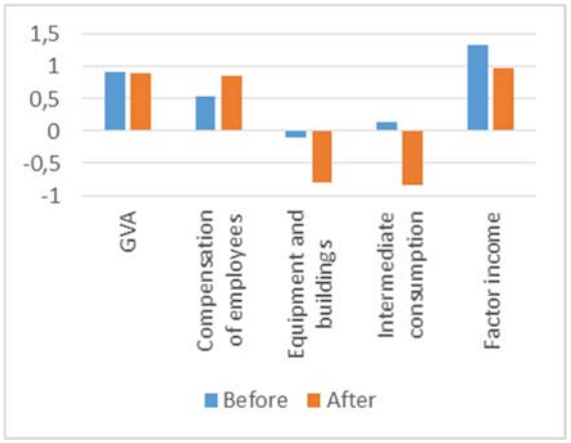


**Figure 1:** Main economic indicators per $m^3$

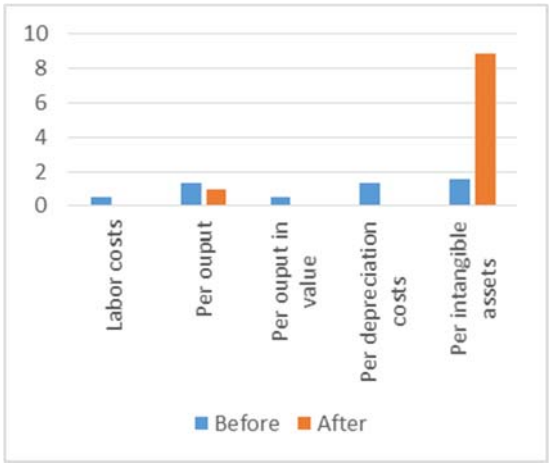


**Figure 2:** Profitableness, %

Profitableness indicators (fig. 2.) are some of the best to characterize what is happening in a business system. Although they sometimes require further clarification, they show in depth the relationship between the factors of production and the economic result in the country's forestry. Again, a significant drop in results over previous periods. Exporting most of the activities outside the forestry system has led to a decline in economic performance.

After being informed about the profitability is crucial to assess whether the processes are independent. The process of economic earnings, investments or costs can be treated like independent processes if the reform really contributed to the changes. Otherwise the reform has done nothing but forcing the forestry authorities to do the best they can in the situation year by year.

Data in (Table I) reveal that in fact nothing has changed significantly. Despite the transformations of the system it remains in inner essence the same. Scarce investments in new equipment has leaded to nothing new, but the worsening the profitability. Mechanisms for value

adding are the same. Many of the indicators have risen but this is the result of the external factors not the system ones. Taxes increased which made sector more dependent on the government policies. From state-owned companies, forestry enterprises have become pseudo-private ones fighting on the free market and paying taxes like private enterprises. With one great difference – entrepreneurship is not a feature of the main managers. They remain only bureaucratic-like employees.

**Table I:** Statistical significance and connection to the last year's transformation- improvement or not

| Processes - results | t-test (p-values) | | F-test (P - values) | Improvement |
|---|---|---|---|---|
| | New state of old processes | Creation of new processes | | |
| Changes in inventories | 0,1196 | | 0,8964 | No |
| Compensation of employees | 0,0010 | | 0,0947 | Yes |
| Consumption of fixed capital | 0,0004 | | 0,4734 | Yes |
| Factor income | 0,0130 | | 0,5040 | Yes |
| GFCF - equipment and buildings | 0,6357 | | 0,0721 | No |
| Gross fixed capital formation (excluding deductible VAT) | 0,5265 | | 0,0825 | No |
| Gross value added | 0,0139 | | 0,4820 | Yes |
| Intermediate consumption | 0,0052 | | 0,7379 | No |
| Net entrepreneurial income | 0,0296 | | 0,4323 | Yes |
| Net fixed capital formation (excluding deductible VAT) | | 0,277 | 0,0279 | No |
| Net operating surplus and mixed income | 0,0592 | | 0,6513 | Yes |
| Net value added | 0,0156 | | 0,4649 | Yes |
| Other gross fixed capital formation | 0,3892 | | 0,5422 | No |
| Other taxes on production | | 0,055 | 0,0034 | No |
| Output of forestry and connected secondary activities | 0,0071 | | 0,6373 | Yes |

## 3 CONCLUSION

The forestry sector, and in particular forestry, needs to reform the "reformed" with a focus on productivity. The lost link between the quality of the factors of production, the payment of the costs of their use and the results of the same must be restored. The study confirmed the thesis that real reforms in the economic sense were not actually made. Investments in own primary assets are of direct importance and should be increased. The inclusion of all extraction, transportation and subsurface functions into the woods to the forestry business will provide higher margins, revenues to cover current costs and reserves for future investments.

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# ENLARGEMENT OF THE PINE PROCESSIONARY MOTH (*THAUMETOPOEA PITYOCAMPA*) RANGE IN BULGARIA

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ABSTRACT: The pine processionary moth (*Thaumetopoea pityocampa*) was established for the first time in Bulgaria in 1906. From 1951 to 1972, the average attacked area amounted to 5163 ha. Its gradual increase began at the end of the 20th century when the affected area enlarged over five times. The attacks of the pest occurred in the region of its natural range where deciduous forests were replaced by *Pinus nigra* and *P. sylvestris* plantations. Since 1999, an expansion of *T. pityocampa* has been observed in the central part of Bulgaria. The species has extended its range by 46 km into the east with an average of 2.6 km a year along the southern slopes of the Balkan Range and Sredna gora Mt. In recent decades, the negative economic, environmental and social impact of the pine processionary moth has increased in the country. In high population densities, the pest is a serious defoliator in pine plantations. In addition to the direct economic losses, the pest has a hazardous effect due to its potential to cause an allergic and toxic reaction in humans and animals in recreational forests and forest parks. The success of the pest's spreading into new geographical areas requires favourable climatic conditions and presence of large areas afforested with *P. nigra* and *P. sylvesrtis*. Among the biological factors, the egg parasitoids appear to be the most important regulators of the pest number.
Keywords: *Thaumetopoea pityocampa*, expansion, pest, pine plantations, Bulgaria

## 1 INTRODUCTION

The pine processionary moth, *Thaumetopoea pityocampa* (Denis & Schiffermüller, 1775) (Lepidoptera: Notodontidae) was established for the first time in Bulgaria in 1906 by catching a male specimen in a light trap near Sofia [7]. One year later, a nest with *T. pityocampa* caterpillars was found in the region of Belovo [2]. Until the first half of the 20th century, a large number of new localities were established in Bulgaria and reported without any data about the size of attacked areas and population density in different biotopes [2, 3, 4, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31].

Since 1951, the specialized divisions of Forest Agency have carried out yearly monitoring on pest attacks and damages on forest vegetation. The obtained data allow the economic significance of *T. pityocampa* in pine forests, as well as the dynamics of its numbers and attacked areas, to be established.

Numbers of authors have determined the ecological niche of the species' development, defined by the impact of certain climatic factors: lethal winter temperatures -16 °C [6] or -24 °C [34]; realized feeding threshold and activation temperature [1]; required number of favorable winter days allowing the completion of the caterpillar development [15].

The aim of this paper is to examine the impact of some biotic and abiotic factors on pine processionary moth attacks and to establish the enlargement of its range since 1951.

## 2 MATERIAL AND RESEARCH METHODS

Data for the size of attacked by *T. pityocampa* areas in Bulgaria in the period 1950-2016 were taken from Forest State Agency (http://www.iag.bg/docs/lang/1/cat/6/index). The information about the areas attacked by the pest in zones of its expansion in the central part of Bulgaria was kindly provided by Forest Protection Station in Plovdiv. Climatic data were obtained from the public website (https://www.stringmeteo.com/synop/bg_climate.php).

The larval instar structure of *T. pityocampa* by regions was determined by checking all caterpillars from 10 nests in each investigated site. The caterpillars from each individual nest were placed in 75% ethanol. In the entomological laboratory of Forest Research Institute – Sofia, the larval instar was determined by the epicranium size [34].

## 3 RESEARCH RESULTS AND DISCUSSION

### 3.1 Expansion of *Thaumetopoea pityocampa*

The pine processionary moth is distributed in the mountains of Southern Bulgaria – Rila, Pirin, the Rhodopes, Osogovo, the Central Balkan Range, Sredna gora, along the valleys of the rivers Struma, Mesta, other smaller rivers and in the pine plantations of the hollows and the high plains of the western part of the country. It has not been found in the eastern part of Southern Bulgaria (Fig. 1). In the vertical respect, the species occurs at an altitude of up to 1200 m with northern exposures, and of up to 1350 m in Pirin Mt.

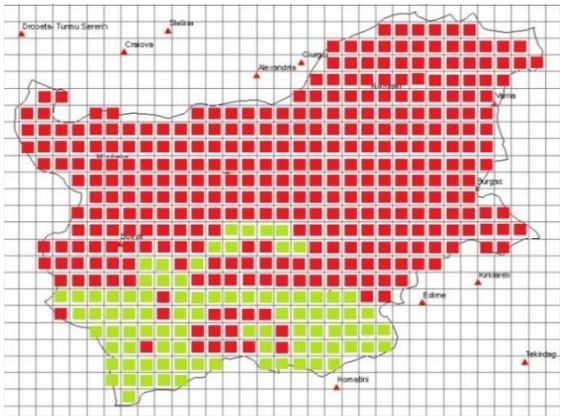


**Figure 1:** *Thaumetopoea pityocampa* range in Bulgaria

In 1951, the areas attacked by the pine processionary moth were 6800 ha (Fig. 2). Until 1972, they appeared to remain unchanged – an average of 5163 ha for the period 1951-1972. After that period, there was a gradual increase in their size: in 1979, they were 19 000 ha, 1982 – 30 000 ha, with a maximum in 1998 – 39 127 ha. For the 1973-2017 period, the average attacked area was 22 929 ha, that is an increase of 4.4 times compared to the preceding period. The number of fluctuations and the reduction of the areas attacked were mainly due to the aerial treatments, carried out

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with varying intensity through the years, with bacterial and biotechnical substances based on diflubenzuron.

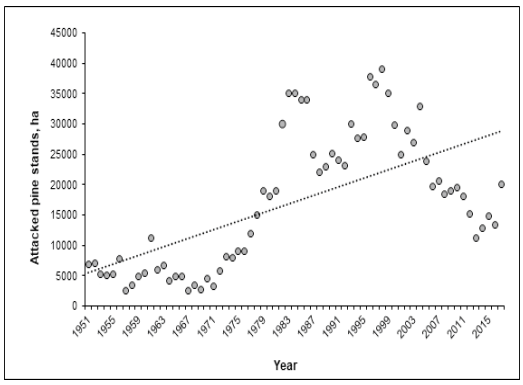


**Figure 2:** Pine forests infested by pine processionary moth

The average value of *T. pityocampa* attacks occurred in 1977-1999 period (27 282 ha), is 5.3 times more than in 1951-1972 period (Fig. 3).

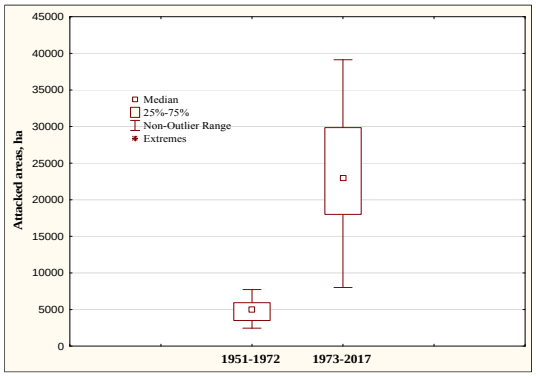


**Figure 3:** Pine forests infested by *Thaumetopoea pityocampa* during the periods 1951-1972 and 1973-2017

In the 66-year period (1951-2017), the pine processionary moth marked two stages in its expansion. After 1972, the attacked areas increased multiple times, but only within the limits of its range. The second stage appeared in 1999, when it topped the mountainous hills near the town of Kalofer and become to enlarge its area toward east. In the subsequent 18 years, the pest aggressively expanded its range (Fig. 4), infesting the pine stands on the southern slopes of Balkan Range.

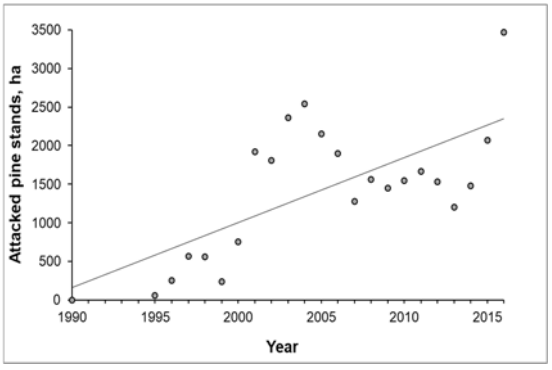


**Figure 4:** Pine forests attacked by *Thaumetopoea pityocampa* in Central Bulgaria

In 2017, the pine processionary moth was already registered in the region of town of Maglizh. For the period 1999-2017, it has moved to the east at an aerial distance of 46.3 km, or at an average annual pace of 2.6 km.

3.2 Factors determining the expansion of *Thaumetopoea pityocampa*

The presence of available trophical base of the pine processionary moth is one of the main factors for the range expansion of the species. The pine plantations in Bulgaria are 880 995 ha, from which 64% are *P. sylvesrtis*, and 36% - *P. nigra*. The predominate part of pine forests (88%) grow in Southern Bulgaria, where the pine processionary moth occurs. With an annual average of around 30 000 ha attacked, the available surface area of pine forests is a potential foundation for the pest expansion in the zones of its distribution.

The strong increase of the areas attacked in the 1972-1998 period was due to the afforestation carried out at a scale large for Bulgaria after 1960, primarily with *Pinus nigra* and *P. sylvesrtis* plantations (Fig. 5), most frequently on terrains with a southern exposure.

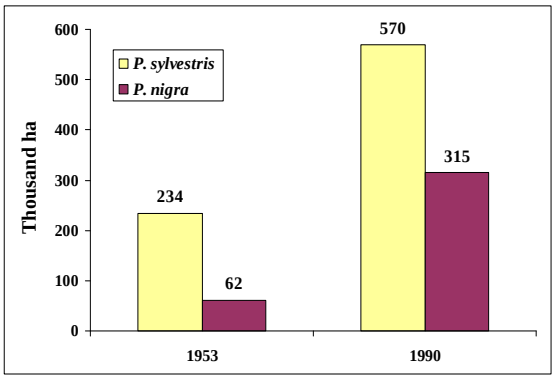


**Figure 5:** *Pinus sylvestris* and *P. nigra* areas in 1953 and 1990

The *P. sylvesrtis* plantations increased 2.5 times from 233 507 ha in 1953 to 569 793 ha in 1985, most of them being within the regions of the pine processionary moth distribution. In the region of Kardzaly (the Eastern Rhodopes), they increased 10 times in that period, in Kyustendil region - by 344%, and in Plovdiv region – by 240%. The same trend is observed for *P. nigra*. From 62 062 ha in 1953, they reached 314 612 ha in 1990. In Plovdiv, Kardzaly, and Kyustendil regions they increased by 310%, 272% and 174%, respectively [10].

The other main factors involved in range expansion of *T. pityocampa* are presence of appropriate climatic conditions. The low winter temperatures of below -16 ˚C are lethal for the pine processionary moth caterpillars [6, 34]. The climatic data from 1977 to 1991 showed that at varying frequencies during the period there were days with minimum temperatures below this norm in the area of the species distribution [12]. In this period, such temperatures were registered in 3 years in Southern Bulgaria, whereas in Northeastern Bulgaria (Shumen) and Northern Central Bulgaria (Pleven) they were 5 and 9 years, respectively. In this regard, Northern Bulgaria, particularly its central part, has a more distinct continental climate that is less suitable as a potential area for *T. pityocampa* expansion.

The other factor determining the survival of the species is the number of favourable days for larval feeding during

the cold period (November-February) - days with daily temperatures above +9 °C and night temperatures above 0 °C [1]. In the region of Sandansky (Marikostinovo vill.), the favourable for feeding days in some years reached up to 46, unlike Sofia region (Staro selo vill.) – 8 days, where larval mortality reached up 86% [15].

The climatic peculiarities determine the critical conditions for *T. pityocampa* development in Bulgaria. Nevertheless, the species is successfully developing and even expanding the area of its distribution. This is due to two main biological characteristics of the species. The first one is the presence of pupal diapause, when a part of the population remains in the soil for several years, overcoming the extreme conditions [5]. A field study showed that after the first year, 37% of the pupae remained in diapause.The second one is the specificity of its phenology. Summarizing data for various regions in Europe, North Africa, and the Near East, Schmidt [21] pointed out that the caterpillars go down in the soil for pupation from February but mostly in March and first half of April. In some regions in Bulgaria, an earlier hatching was observed, when the development of the larvae ended before the coming of winter, and they hibernate in the soil [33, 34]. Studies in mid-winter (January) showed that in the region of Hisarya (Central Bulgaria), 50% of the caterpillars hibernated in the soil, while in the Eastern Rhodopes the hibernation in the soil was 10-30% [13, 15]. In Central Bulgaria, an extended period of emergence has also been established [14].

The age structure of the caterpillars proves the great diversity in the phenology of the pine processionary moth in the various regions of the country. In the region of Sandansky (Southwestern Bulgaria), 25 September 2017 was the beginning of larval hatching, which is similar to that in Tassos Island in Greece. At this time in Central Southern Bulgaria, the caterpillars were already in 3-rd instar and in the Kirkovo region in the Eastern Rhodopes - in 5-th (final) instar (Fig. 6). This is an important adaptation peculiarity of the species, by which it overcomes the severe winters with lethal temperatures of below -16 °C or the insufficient number of favourable for feeding days.


**Figure 6:** Age structure of the caterpillars from the various regions of Bulgaria, by 25 September 2017; A – Sandanski Region (Southwestern Bulgaria); B – Maglizh Region (Central South Bulgaria;) C – Kirkovo Region (the Eastern Rhodopes Mt.)

In addition to abiotic factors, some biological factors also have a deterrent effect on population density of *T. pityocampa*. Egg parasitoids play a substantial regulatory role. The relative share of the parasitized eggs in individual habitats can reach 44%, and in individual egg batches – up to 89%. Seven egg parasitoids have been found in Bulgaria, the dominant ones being *Ooencyrtus pityocampae* (Mercet, 1921) (Hymenoptera: Encyrtidae) and *Baryscapus servadeii* (Domenichini, 1965) Hymenoptera: Eulophidae). The role of predators is insignificant; the eggs destroyed by them rarely exceed 1% [9, 11]. A virus was isolated from dead caterpillars from Southwestern Bulgaria [8, 32], and in an experiment carried out in laboratory conditions the mortality rate reached 90% [32]. However, there are no reports of epizooties observed in natural conditions.

3.3 Economic importance of *Thaumetopoea pityocampa*

The pine processionary moth has a substantial negative economic importance in Bulgaria. The stands attacked decrease in growth by height and diameter, become physiologically weak and susceptible to attacks by xylophages and diseases. This insect species, as well as the other two representatives of genus *Thaumetopoea* in Bulgaria (*T. processionea* and *T. solitaria*) are allergens hazardous for humans and animals (Fig. 7).

**Figure 7:** Allergy caused by *Thaumetopoea pityocampa*

The presence of the pine processionary moth reduces the recreational functions of forests. Unfortunately, it has already been found in city parks and SPA resorts of the country, such as Sandansky, Velingrad, the Tyulbeto Park near Kazanlak, Dupkata near Ivaylovgrad etc.

## 4 ACKNOWLEDGEMENT

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# MARKET RESEARCH AND BUSINESS MODELS FOR SUSTAINABLE FOREST MANAGEMENT IN BULGARIA

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ABSTRACT: To be competitive and to be able to support sustainable forest management forest enterprises need effective business models to offer certified products. The article analyses the results of marketing research carried out in two important forest regions in Bulgaria. It aims to identify and characterize potential markets for certified wood. The current status of forest certification in the country is presented. Business models are developed to meet the market needs.
Keywords: sustainable development, forest certification, marketing research, economic analysis

## 1 INTRODUCTION

Forests are multifunctional, serving economic, social and environmental purposes. Of all nature resources in Bulgaria the forests present the biggest share and primary importance. They offer habitats for animals and plants and play a major role in mitigating climate change and other environmental services. The societal benefits of forests, including for human health, recreation and tourism, are high, but often underestimated. Bulgarian forests have essential contribution to rural development and for many regions they are the only source of financial revenues. Forest biomass is currently the most important source of renewable energy for the country. Forests also provide a large range of other products, such as cork, resins, mushrooms, nuts, game and berries.

To deliver these benefits in a balanced way it is necessary to ensure sustainable forest management.

For the purposes of this paper we use the definition for sustainable forest management, developed by Forest Europe in 1993 and subsequently adopted by the Food and Agriculture Organization (FAO) of the United Nations: "The stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems."

Forest certification is a voluntary instrument, which uses a set of standards to evaluate and validate the practices of forest management. It ensures and promotes economically viable forest management, in compliance with social standards, while protecting the environment. Forest certification is a direct economic instrument to ensure the sustainable use and management of forest resources.

European market for wood products is becoming increasingly sensitive to consumer demand for certified products. There are clear market opportunities in this direction for Bulgarian companies. Since the certification requires the practices in forest management to meet regulatory requirements, this could become an important addition to the supervisory and regulatory functions of the state. Moreover, it will improve transparency and governance in the sector.

At the same time to be competitive and to be able to support sustainable forest management forest enterprises need effective business models to offer certified products.

The here presented paper analyses the results of marketing research carried out in two important forest regions in Bulgaria. It aims to identify and characterize potential markets for certified wood. The current status of forest certification in the country is presented. Business models are developed to meet the market needs.

## 2 FOREST CERTIFICATION IN BULGARIA

In Bulgaria the forest territories are around 37% of the country's territory. Approximately 67 % of them are broadleaved forests. Bulgaria is the third richest in biodiversity country in Europe. There are 3 National parks, 11 Nature parks and more than 700 protected areas in the country.

Forest certification in Bulgaria is a voluntary instrument, which is administered by the evaluation and validation of the practices of forest management using a set of standards.

Forest certification system aims to ensure and promote economically viable forest management, in compliance with social standards, while protecting the environment. Forest certification is a direct economic instrument to ensure the sustainable use and management of forest resources.

The certification verifies that the management of forest territories is carried out in an open manner, balancing environmental, economic and social benefits.

Lately worldwide users of timber and forest products began to look for evidence that the timber and forest products on the market are certified. In this sense, forest certification occurs as a potential market mechanism to promote better forest management. Forest certification gives an opportunity for product differentiation based on reduced product impact on the environment. In the future we could expect steadily growing demand of products from well-managed forests.

In this respect sustainable management will improve competitiveness and will create jobs, particularly in rural areas, and at the same time will ensure the protection of forests and the provision of ecosystem services.

In Bulgaria there are two forest certification systems offered on the market – FSC and PEFC. Currently FSC is the preferred one and with more than 130 users. PEFC is still not very well known and spread as there are only 3 companies certified according to it for chain of custody.

FSC shares the EU Commission's broad goals of setting up a better global timber trade and governance system. It promotes sustainable forest management, improves forest governance and supports sustainable consumption.

Certification bodies award forest management (FM) certification to those forest managers or owners whose

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practices meet FSC Principles and Criteria. As it is shown on the figure below FM certification rose from 1,084 certificates in 2012 to 1,462 certificates in 2017. This is a significant 35 per cent rise over five years.

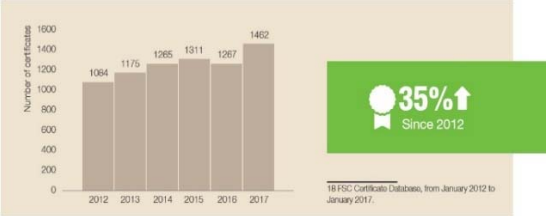


**Figure 1**: Evolution of FSC FM certificates, 2012–2017

There are 19 forest management enterprises, which have received the FSC forest management certificate in Bulgaria. There are 807 833, 80 ha of certified forest territories which represent 19% of the total forest territory of the country. On fig. 5 is shown how the FSC certified territories are growing during the years. The first two certificates were awarded in 2006. As it could be seen on the graphic there is a tendency of growing interest to the certificate over the past few years. At least another three forest management enterprises are under certification procedures.

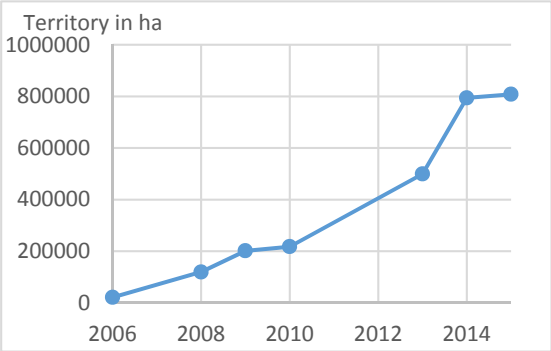


**Figure 2:** Changes of FSC certified forest territories

On fig. 3 is shown the distribution of FSC territories according to ownership. Most of the forest management enterprises are state owned forest territories - 98 %. There is only one certified municipality. The private sector is represented only with one company, which owns relatively small territory of forest plantation. In this respect the forest certification is considered as a state policy in Bulgaria at the moment.

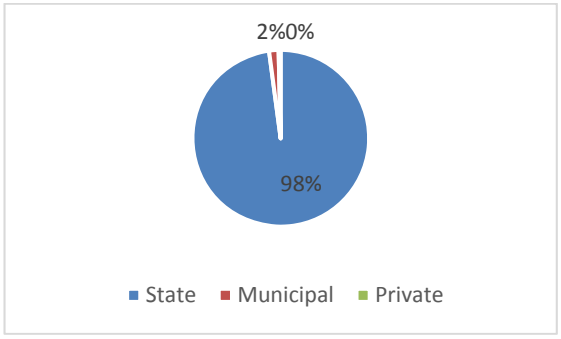


**Figure 3**: Distribution of FSC certified forest territories according to ownership

Table I shows how in terms of CoC certificates European countries show significant growth, with Romania adding over 225; this was followed by Russia (more than 130), Latvia (89), Ukraine (82), and Bulgaria (70). The percentage increase in CoC certificates in Bulgaria is 49% and only in Ukraine we could see a higher increase.

**Table I:** FSC CoC certificates: Countries with highest growh, 2015–2017

| Country | FSC CoC certificates 2015 | FSC CoC certificates 2017 | Percentage increase in CoC certificates (%) |
|---|---|---|---|
| Ukraine | 66 | 148 | 50 |
| Bulgaria | 61 | 131 | 49 |
| Thailand | 63 | 117 | 37 |
| Romania | 297 | 523 | 33 |
| Russia | 295 | 428 | 21 |
| Latvia | 217 | 306 | 19 |
| India | 255 | 354 | 18 |
| Mexico | 93 | 128 | 17 |
| Lithuania | 197 | 270 | 17 |
| Serbia | 104 | 141 | 17 |
| Viet Nam | 396 | 532 | 16 |
| Portugal | 162 | 217 | 16 |
| Turkey | 190 | 249 | 15 |
| Estonia | 186 | 242 | 14 |
| China | 3,799 | 4,841 | 13 |
| Slovenia | 171 | 216 | 13 |
| Poland | 1,186 | 1,466 | 11 |
| Spain | 696 | 844 | 10 |
| Bosnia and Herzegovina | 258 | 312 | 10 |
| Indonesia | 203 | 241 | 9 |

Source: A review of Forest Stewardship Council® (FSC®) market developments, statistics, and trends. January 2017

FSC has commissioned two studies to collect data and develop deep insight into the market needs of their stakeholders. Collectively, these studies show that certificate holders and members believe the brand does offer consumers a clear sign that their organizations are serious about responsible forest management, with 80% saying that FSC creates a positive corporate image. They also show that 85% regard FSC certification as credible proof of timber legality, giving them confidence that the timber they source really is from responsibly managed forests. The staff knowledge in the same survey is also rated highly.

The authors have made a market research among 15 (79% of all) of the FSC certified forest management enterprises in Bulgaria. The main aim of the research was to determine the grade of satisfaction of the users and the main benefits which the certificate brings.

Market access is the key direct financial benefit of certification. It is closely linked to the recent phenomenon of market globalization. Only 47% of Bulgarian certified forest management enterprises recognize this benefit. The certificate brings new customers to 60% of the interviewed companies. In 40% among the researched cases there is a sales increase among current customers. The most valued benefit is the improved reputation and company status. 87% of the participants in the research share that they feel better attitude among society and partners. FSC has given the opportunity for price increase of certified products only to 20% of the enterprises. 60 % of the interviewed report employee satisfaction. The others share that they

have experienced difficulties to implement the new procedures among the employees. The FSC certification has secured a constant market share during the market shrinkage over the past few years for 73% of the companies.

## 3 MAJOR FINDINGS FROM MARKETING RESEARCH AMONG POTENTIAL BUYERS OF FSC CERTIFIED WOOD

There is an evidence that market strategies for certified forest products need to be developed at national level to support and encourage sustainable forest management.

The authors have carried out a marketing research to determine the demand of certified wood. The research was part of a scientific project funded by Forestry University, Sofia. Two regions were selected in which the two forest enterprises owned by the Forestry University operate – Pazardzhik and Montana regions. The main aim of the research was to help the forest enterprises to successfully position their products and support a decision making regarding FSC certification.

The selected regions are important forest regions for the country. The major findings from this research could be used by any forest enterprise.

The research is made by interviews with woodworking companies from the selected regions, which were essential timber buyers. The interviews were carried out with the help of questionnaire.

The purpose was to determine the following:

- FSC recognition
- FSC certified wood consumption
- Interest in buying certified timber
- Willingness to pay the price

Altogether were made 15 interviews. The results from the two regions differ significantly. The main reason is in the different characteristics of the companies operating there.

In the region of Pazardzhik operate numerous micro to small enterprises. Their main market is Turkey where the quality requirements are relevantly low. The main species used in this region are conifers as spruce, fir and pine. The interest in timber coming from sustainably managed forests is low and it was very difficult to find companies willing to participate in the research.

In the region of Montana operate less but bigger enterprises. The main species used is beech and seldom conifers and poplars. Most of the companies export into EU. A clear interest towards FSC certified timber is defined.

On fig. 4 is shown how companies recognize the FSC brand.

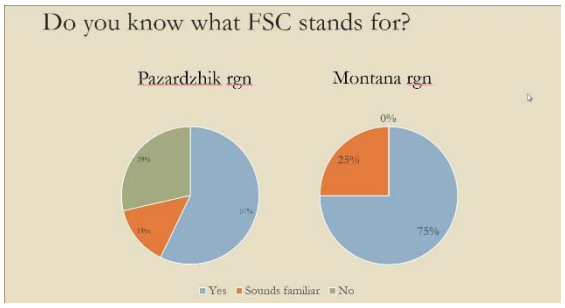


**Figure 4:** FSC brand recognition in the studied regions

A little more than 30% of the studied companies are certified to FSC CoC and are already buying certified timber.

On fig. 5 is shown the willingness of the studied companies in buying certified timber.


**Figure 5:** Willingness to buy FSC certified wood

In the region of Pazardzhik there is still lack of recognition of FSC brand and low interest in FSC certificate showed by big part of the companies, which are numerous. At the same time over 70% of the studied enterprises declared willingness to buy certified wood. Most of them are not ready to pay price which differ significantly to the current prices.

The main reason for the low interest in FSC certified wood in this region is the fact that the major part of the companies work for the Turkish market where the certificate is not required. In the future is expected this situation to change and the companies realize that.

In the region of Montana there is a clear interest in the certified timber. A major part of the woodworking companies are exporting to EU where a certificate is required.

Overall around 75% of the studied enterprises are showing willingness to buy certified timber, most of them on the condition that the price does not change significantly.

The bellow business model could be suggested based on the results of the marketing research.

**Table II:** Business model how successfully to market FSC certified timber

| **MARKETING MIX ELEMENTS** | BUSINESS MODEL |
|---|---|
| **PRODUCT** | FSC brand should be use to distinguish the timber products and gain market advantage. |
| **PLACE** | While the local enterprises remain the main market, new markets should be defined and entered where there is a lack of certified wood supply. |
| **PRICE** | For the moment only small price increase could be accepted. |
| **PROMOTION** | Public relations should be used to promote the certification and to foster positive reputation. Campaign among local citizens is important to raise awareness about the certificate. |

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The main marketing strategy of the forest enterprises adopting the FSC FM certificate should be to use the FSC brand to distinguish their products, which will give them a competitive advantage and will help them in case of market shrinkages.

Furthermore they should enter new markets where there is a demand of products from sustainably managed forests and not enough supply.

Regarding the price, it should not differ significant from the market price of not certified products as the companies would not be ready to pay it.

Important part from the successful business model is to use actively public relations to demonstrate to the local public sustainable forest practices and build positive reputation.

## 4 CONCLUSION

Currently FSC is the preferred forest certification system in Bulgaria. FSC shares the EU Commission's broad goals of setting up a better global timber trade and governance system. It promotes sustainable forest management, improves forest governance and supports sustainable consumption.

Market access is the key direct financial benefit of certification. It is closely linked to the recent phenomenon of market globalization. The research shows that only 47% of Bulgarian certified forest management enterprises recognize this benefit.

There is an evidence that a marketing research is needed to determine the specifications of certified wood market and to develop strategies for certified forest products to support and encourage sustainable forest management.

An official survey of FSC shows that the percentage increase in CoC certificates in Bulgaria for the last two years is 49% and worldwide only in Ukraine we could see a higher increase. This suggests that the demand of certified timber will increase in the country.

As a part of scientific project, commissioned by the Forestry University in Sofia, the authors have carried out a marketing research among woodworking companies in two important forest regions in the country.

The results show that the recognition and the interest in FSC certificate in the two regions differ significantly. The main reason is in the different characteristics of the companies operating there. In the one, where there are working numerous small companies processing conifers and operating on the Turkish and domestic market nearly 30% of the examined enterprises do not even recognize the FSC brand.

The main reason for the low interest in FSC certified wood in this region is the fact that the major part of the companies work for markets where the certificate is not required. In the future this situation is expected to change.

In the other region there is a clear interest in the certified timber. A major part of the woodworking companies are exporting to EU where a certificate is required.

The research show that overall around 75% of the studied enterprises are showing willingness to buy certified timber, the majority on the condition that the price does not change significantly.

The main marketing strategy suggested by the authors to the forest enterprises adopting the FSC FM certificate is to use the FSC brand to distinguish their products, to enter new markets and to offer the certified products at price similar to the market price, which the companies are ready to pay. An important part of the suggested business model is to use actively public relations to promote the impacts of the certification and to foster positive reputation.

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# DETERMINATION OF THE OPTIMAL DENSITY OF FOREST ROADS FOR SKIDDING BY METHOD OF MINIMAL COST

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ABSTRACT: This paper presents the methodology for theoretical determination of the optimal density of skidding roads by method of minimal cost skidding of wood assortments. Whit research is developed a model of skidding with a tractor Ford 5600 in real work in mountainous conditions in the Republic of Macedonia. An analysis is made of all the costs that are made in the phase of skidding and the costs of building and maintaining skidding roads. The optimal density of the road network for skidding is calculated using differential estimations from the total costs for skidding. In this research, a connection is made between the density of the skidding roads and the volume of wood to be used when managing the forests. This paper reviews the impact of already built skidding roads on the environment as a factor that must be considered when choosing the optimal density of skidding roads. In a situation where the horse skidding in the forest practice is gradually abandoned, there is a need of displacement with mechanization for skidding. Hence, the determination of the optimal density of skidding roads Gdp and the optimal distance between skidding roads Rdp represents a useful tool in the designing of skidding roads in practice.
Keywords: skidding roads, optimal density, tractor, minimal cost, forest.

## 1 INTRODUCTION

Secondary transport is an activity by which the wood that had been cut in the forest is transported to the temporary depot.

There is a specific solution for secondary transport when skidding with a tractor or similar skidding devices of transport, for which in order to move on the terrain without performing great violation of the surface, an adequate skidding road network needs to be built.

The cases when great violations and damages in the Macedonian forests have been made because of inadequate analysis of the secondary road network optimization are not rare.

In praxis, the analysis of the optimal building of skid roads should be considered as a whole, with both an economic and ecological solution (Demir M. [8]).

Seen from an ecological viewpoint the optimal density of skidding road network means building as less unproductive roads as possible, by which the usurpation of the forest surface would be reduced. When designing the skidding roads there must be measurements for protection from land erosion of the forest soil and the road foundation. In the end, conservation and protection of the skidding roads from destruction and erosion processes need to be done.

The optimization of the secondary road network viewed from an economic viewpoint means finding a relation between the skidding costs and the skidding roads costs at which there would be minimal costs per unit product.

This means that with a mathematical calculation before the designing of the skidding roads were determine the optimal density of the skidding roads, i.e. the optimal distance of the skidding roads in the area.

There is also an extra analysis of the influence of more parameters which affect the solution: the relief, the wood allowable which is planned for a cutting, the effect of work with a particular skidding means of transport with a specific technology of work.

Input parameters when planning the skidding roads are both the existing road infrastructure, as well as the planned truck road network according to the general plan for forest opening (Pentek T. [26]).

Bearing in mind all these parameters and principles the designer approaches towards designing a secondary plan for forest opening.

The results that are achieved with the mathematical calculations are refer to an ideal model, but at the real planning there will be a deviation from the results.

The minimum cost method have the shortcomings because are not included parameters such as: protective function, social, tourist, recreational, agricultural and others.

## 2 MATERIALS AND METHODS

In this study the basic methodology is established on differential estimations i.e. determining the minimal costs which are made during the phase of skidding of wood assortments, in order to determine the optimal density of skidding roads in the mountain regions of Republic of Macedonia. The basic theoretical model is taken from the research of (Akimovski R. [1]) as well as scientific research on: (Segebaden G. [33]), (Akimovski R. [2]), (Jeličić V. [13]), (Lovric N., [21]), (Bojan S. [5]), (Krč J. [15]), (Jeličić V. [14]), (Picman, D. [29]), (Chung W. [7]), (Krč J. [16]), (Danilović M. [10]), (Trajanov Z. [22]) and (Lepoglavec K. [20]).

In the field, different models have been researched depending on: the type of assortments which are a subject of skidding (firewood and technical wood), as well as the determination of the influence of the factor 'gradient of the terrain' in relation to the optimal density of skidding roads. At the gradient of the terrain there are models of cable winching of wood assortments in increase and in fall, and there is also a model of cable winching of wood on flat terrain with a deviation of $\pm$ 5% of the terrain gradient. The slope of the terrain is determined using the Abney level (clinometer).

During the research, as fixed parameters we considered the following: the costs that are made at the skidding of wood assortments, the training of the staff, the influence of the skidding means of transport, as well as the use of the assortment method as one of the most included technology of work in the forest practice in the Republic of Macedonia. The basic model that was considered at the estimations refers to the average use of the volume of wood of 300 $m^3$/ha in the period of a

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hundred years where the assortment structure is 50% firewood and 50% logs.

During this research we used the adjusted agricultural tractor Ford 5600, produced in 1985. The tractor is equipped with a warping drum, type Maxwald A516-50, the rope has a length of 100 meters. The skidding with the tractor is performed by four workers. One of them steers with the tractor, another is at the warping drum, and the other two pull the rope from the warping drum to the load, prepare the load and help with the unload.

The input parameters that have been used in these estimations are achieved by direct measurements on the terrain, as well as using an appropriate literature and scientific findings from this area. Comparable research from this problematics has the authors: (Bekar D. [4]), (Samset I. [32]), (Bojanin S. [6]), (Krpan A. [18]), (Krpan A. [19]) and (Pentek T. [25]).

The use of the method of differential estimations is considerably made easier by using the contemporary software tools from the field of mathematics. On this occasion we used the program Wolfram Mathematica 8. Despite the fast estimations it can perform, this program also enables us to create graphic displays which are used in the chapter 'Results'.

The direct costs, on which depends the determination of the skidding roads density, are related to: the costs of building and maintaining the skidding roads and the costs of the wood assortments cable winching to a skidding road. The other skidding costs have no influence on the optimal density of the skidding roads, which is why they are not considered in this analysis.

The costs for skidding roads are estimated with the following equation (1):

$$Tdp = \frac{Cdp\,1 \cdot Gp}{Q} + \frac{codp\,1 \cdot Gp \cdot tod}{Q} \quad (1)$$

In the equation the symbols have the following meaning:
*Tdp* – total costs for skidding roads
*Gp* – density of the skidding roads at one hectare
*Cdp*1 – costs for building one metre skidding roads
*Codp*1 – costs for maintaining one metre skidding roads
*tod* – duration time for maintaining the skidding roads
*Q* – volume of wood which is used for a period of a hundred years at one hectare.

The costs for the wood assortments cable winching are estimated with the following equations (2):

$$Tpr = \frac{Tden_{pr}}{n_{pr}} \quad (2)$$

In the equation the symbols have the following meaning:
*Tpr* – The costs for the wood assortments cable winching
$Tden_{pr}$ - direct costs per day when skidding with a tractor
$n_{pr}$ - daily norm for skidding with a tractor

The data about the time needed for cable winching of the wood assortments with a tractor is achieved by terrain research. The achieved data has been mathematically estimated by means of regressive analysis. It is presented as function (3) for driving with the load (going) and function (4) for driving without the load (returning):

$$fode_{pr} = a_{pr} \cdot dd_{pr} + b_{pr} \quad (3)$$

$$fvra_{pr} = c_{pr} \cdot dd_{pr} + d_{pr} \quad (4)$$

$A_{pr}$, $b_{pr}$, $c_{pr}$, $d_{pr}$ - parameters of a linear function for a tractor
$dd_{pr}$ – skidding at a distance

If we replace the analytical form for estimation of the norm, the equation (5) would be acquired:

$$Tpr = \frac{Tden_{pr} \cdot x}{\frac{(T - T_{pz}) \cdot k_{pr}}{fode_{pr} + fvra_{pr} + Tu_{pr} + Tr_{pr}} \cdot qtov_{pr}} \quad (5)$$

In the equation the symbols have the following meaning:
x/(1-x) – coefficient of the area which is being skidded in increase or in fall
T - working hours during the day
Tpz - preparation-finish time
$k_{pr}$ - coefficient for exploitation of the working hours at the skidding with a tractor
$Tu_{pr}$ - time necessary for loading the tractor
$Tr_{pr}$ - time necessary for unloading the tractor
$qtov_{pr}$ – size of the load of the tractor

Considering that at the wood assortments cable winching with a tractor various work effect at different cable winching operations, such as cable winching in increase, cable winching in fall, cable winching of logs and cable winching of firewood, could be achieved, various work norm during the work day could be achieved as well. A need arises for the equation (6) to be completed for different skidding operations depending on the estimations. Such model has been elaborated on in the paper (Trajanov Z. [23]). For the purposes of this research estimations have also been made for cable winching on flat terrain of logs and firewood.

$$Tsum = Tpr + Tdp \quad (6)$$

2.1 Optimization of the skidding road network

The optimal density of the skidding road network is estimated using differential estimations from the total costs for skidding transport, separately for every mode. The equation (7) is used for estimating the optimal density of the skidding road network.

$$\frac{DTsum}{DGdp} = 0 \quad (7)$$

2.2 Input parameters for estimating the optimal density of skidding roads

The maintaining of the skidding roads necessary to be conducted during the whole cycle of forest management. No matter what type of (main) regeneration cutting in the forest we are discussing about: selective cutting or clean cutting. Because in the whole cycle there is a necessity to create previous cultivating (thinning) cuttings as well as to conduct protective measures in the forest. Forest roads with a lower quality are needed for such activities. The quality of the roads at certain parts of the cutting areas would be considerably improved at the performance of the main or the final cuttings.

With these researches the average costs for building the skidding roads are 1,2 Euro/m. The costs for the skidding roads maintaining about the researched period are 4 Euro/m (1 Euro = 61.7 Denars). The average direct costs per day for skidding with a tractor are 79.64 Euro. The estimated working hours during the day are 480 minutes at which the preparation-finish time is 30 minutes. The coefficient of exploitation of the working hours for skidding with a tractor is 0.7.

$$Tpr = \frac{Tden_{pr} \cdot x}{\frac{(T - T_{pz}) \cdot k_{pr}}{fode_{pr} + fvra_{pr} + Tu_{pr} + Tr_{pr}} \cdot qtov_{pr}} \quad (5)$$

Based on terrain research of the time needed for wood assortments cable winching with a tractor, a regressive analysis has been developed according to the equations (3) and (4).

**Table I:** Index values for cable winching with a tractor in increase and in fall

| cable winching | *apr* | *bpr* | *cpr* | *dpr* | *tupr* | *trpr* | *qtovpr* |
|---|---|---|---|---|---|---|---|
| *op* | 1,06 | 31,58 | 2,52 | -7,59 | 335 | 72 | 1,1 |
| *ou* | 1,35 | 21,42 | 0,99 | 7,40 | 335 | 72 | 1,1 |
| *tp* | 1,22 | 21,88 | 2,19 | 26,68 | 70 | 57 | 0,5 |
| *tu* | 1,48 | -6,73 | 1,02 | 13,65 | 70 | 57 | 0,5 |
| *txop* | 1.25 | 6.02 | 0.85 | 11.02 | 70 | 57 | 0,5 |

Table I shows the index values of the linear functions for the time needed for cable winching, as well as the average data of the time needed for loading and unloading the wood assortments, and data about the average size of the load. The results are comparable to the research of (Krstevski K. [17]).

The data about the same parameters for cable winching of wood assortments on flat terrain or nearly flat terrain with a deviation of (± 5%) of the horizontal gradient are presented in Table II.

**Table II:** Index values for cable winching with a tractor on flat terrain

| cable winching | *apr* | *bpr* | *cpr* | *dpr* | *tupr* | *trpr* | *qtovpr* |
|---|---|---|---|---|---|---|---|
| *oxop* | 0.89 | 35.87 | 1.11 | 27.9 | 335 | 72 | 1,1 |
| *txop* | 1.25 | 6.02 | 0.85 | 11.02 | 70 | 57 | 0,5 |

Because there weren't any significant differences, the time needed for loading and unloading the wood assortments and the data about the average size of the load are considered as average.

By means of differential estimation, i.e. by estimating the first statement of the total time for skidding of all the wood assortments, we have estimated that the value of *xt* is 0.36. This means that the skidding would be most optimally done if 36% of the wood allowable which gravitates towards the upper road to be skidded in increase, and the rest of 64% to be skidded on the lower road, i.e. in fall. The values are taken from the research of (Trajanov Z. [24]). With horizontal skidding on flat terrain the wood allowable which is placed on 50% of the surface that is the closest is skidded towards one road, and the rest towards another

## 3 RESULTS AND DISCUSSION

### 3.1 Estimations of the cable winching costs and skidding roads

The results from this study are in connection to the costs of wood assortments cable winching and the costs for building and maintaining the skidding roads. The model itself, as well as the use of software for calculating mathematical operations enables us to analyze all the input or accounting parameters.

The total costs for cable winching with a tractor are estimated according to the equation (5). The total costs for building and maintaining the skidding roads for the period of research are estimated according to the equation (1). The summary costs from the achieved results are presented in Table 3. Comparable research has the authors: (Robek R. [31]), (Valeria O. [3]), (Sokolovic Dž. [25]), (Enache A. [12]), (Đuka A. [15]), (Pičman D. [30]), (Petković V. [28]) and (Walter W. [35]).

**Table III:** Cable winching costs and skidding roads in relation to the density of the skidding road network (general model)

| *Gp [m/ha]* | 20 | 40 | 60 | 80 | 100 |
|---|---|---|---|---|---|
| *Tdp [euro/ $m^3$ ]* | 0,37 | 0,73 | 1,11 | 1,48 | 1,84 |
| *Tpr [euro/ $m^3$ ]* | 3,64 | 2,54 | 2,18 | 1,98 | 1,89 |
| *Tsuma [euro/ $m^3$ ]* | 4,00 | 3,27 | 3,28 | 3,46 | 3,72 |

Graphic display of the summary costs for cable winching of wood assortments and the costs for skidding roads at the basic model is presented in Figure 1. The optimal density of the skidding roads happens at the point where there are minimal summary costs.

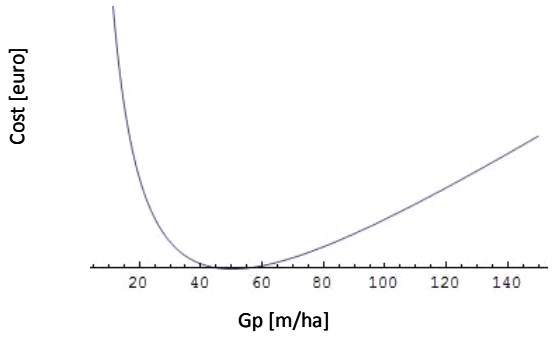


**Figure 1**: Summary costs for skidding roads and wood cable winching

In Figure 2, with a 3D model, one can see the relation of the costs (axis *z*) to the density of the skidding roads (axis x) and the quantity of the wood allowable which is used in the period of 100 years (axis y). On this graphic display one can notice the tendencies of the optimal density of the skidding roads. The lower fields are the zones with low costs connected to the optimal solution, whereas the upper zones are more inadequate solutions in relation to the density of the skidding roads.

With a small quantity of used wood allowable the zone around the optimal density is sharper, whereas with a greater quantity of used wood allowable the zone around the minimal costs is drastically milder. Thus, one should be more careful in determining the optimal density of the skidding roads with a small quantity of

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used wood allowable i.e. with a small density of the skidding roads. The situation in Austria is similar (Walter W. [35]).

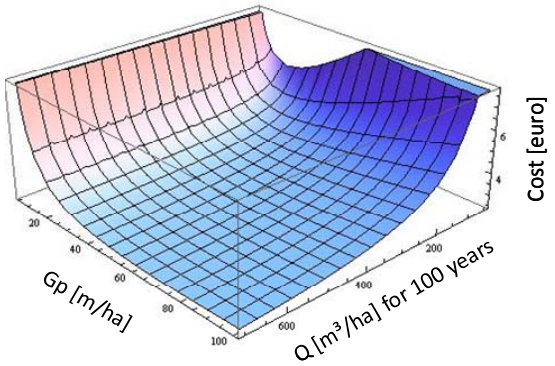



**Figure 2:** Density of the skidding roads in relation to the used wood allowable and the costs that appear in the phase of skidding

A great display of a certain factor can be presented with a 2D diagram by displaying the zones with a tendency of the summary costs varying.

The influence of the factor x (a fraction of the area which would be skidded in increase) is shown in Figure 3. The least costs are made when the density of roads is from 35 to 55 m/ha when skidding in fall. With increasing the length of the area which is being skidded in increase, as well as with distancing from the optimal density of the skidding roads, the summary costs are also rising.

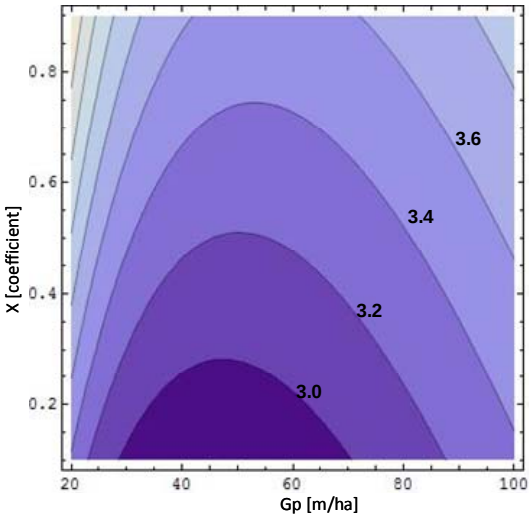



**Figure 2**: Zones of costs (in euros) in relation to the density of the skidding roads and factor x (a fraction of skidding in increase)

The influence of the portion of firewood in the production structure is presented in Figure 4. The least costs are made when the density of roads is from 25 to 65 m/ha when there is only production of firewood. With increasing the portion of technique wood allowable, as well as with distancing from the optimal density of the skidding roads, the summary costs are also rising.

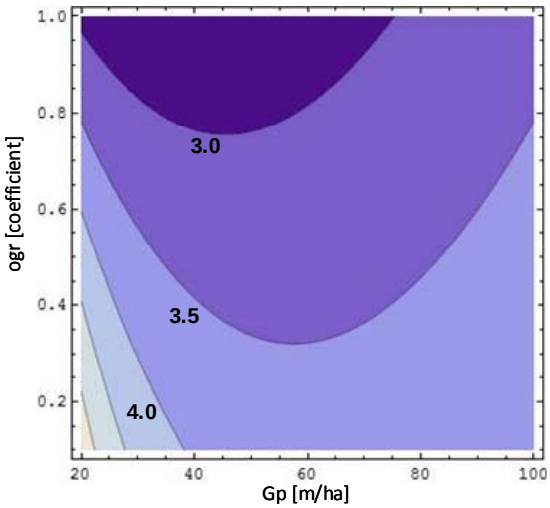



**Figure 3**: Zones of costs (in euros) in relation to the density of the skidding roads and the quantity of firewood in the wood production

The influence of the used wood allowable for a period of a hundred years is shown in Figure 5. The least costs are made when the density of roads is from 40 to 100 m/ha at the highest use of the wood allowable per unit area. Such results has been elaborated on in the paper (Pičman D. [30]). With reducing the used wood allowable in the period of a hundred years and with distancing from the optimal density of the skidding roads, the summary costs are rising.

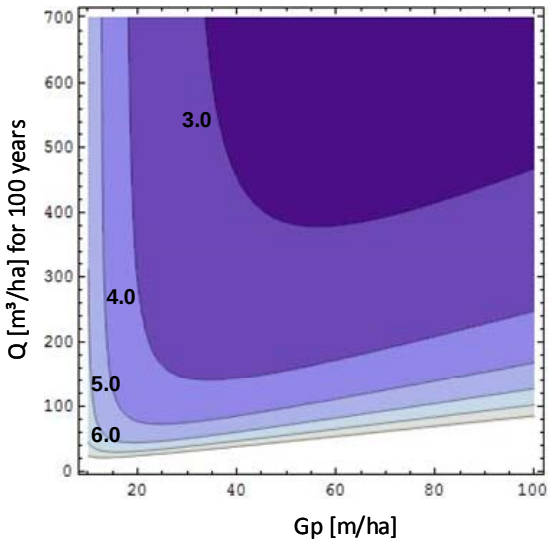



**Figure 4**: Zones of costs (in euros) in relation to the density of the skidding roads and the quantity of wood that is used in a period of a hundred years

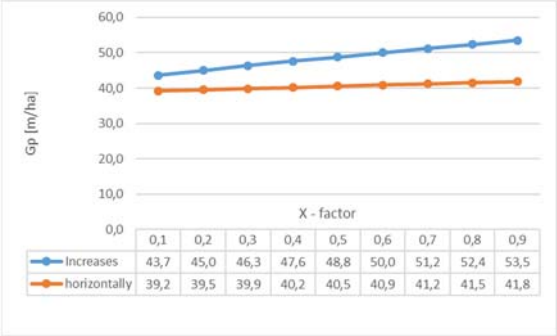
3.2 Differential estimations of the first statement from the sum of costs

Absolute correct results about the optimal density of the skidding roads are acquired by means of differential estimations of the first statement from the sum of costs. Thus according to the equation (7) with an estimation of the first statement from the sum of costs one can acquire density of the skidding roads of 48.82 m/ha. This density refers to the used wood allowable of 300 $m^3$/ha in a period of a hundred years, with an ideal cable winching of assortments in increase x=0.36 and with an equal

portion of firewood and technical wood when skidding wood assortments.

With the change of these parameters the optimal density would change as well. Changes also appear in a situation when the skidding is done on flat terrain or with small deviations of the horizontal line ± 5%.

The influence of the factor x (a fraction of the area which would be skidded in increase and in fall) has been calculated about a situation of cable winching in increase and in fall, and about another situation when the assortments are cable winching horizontally. The results achieved are presented in Figure 6.

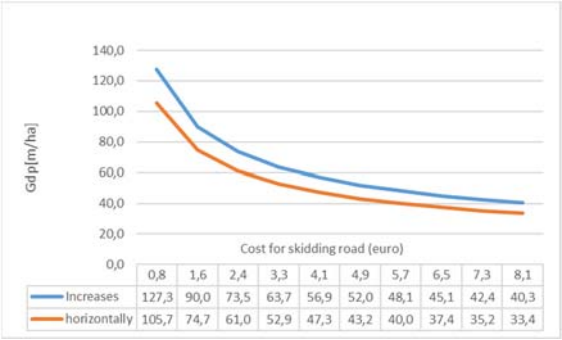



| | 0,1 | 0,2 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 |
|---|---|---|---|---|---|---|---|---|---|
| Increases | 43,7 | 45,0 | 46,3 | 47,6 | 48,8 | 50,0 | 51,2 | 52,4 | 53,5 |
| horizontally | 39,2 | 39,5 | 39,9 | 40,2 | 40,5 | 40,9 | 41,2 | 41,5 | 41,8 |

**Figure 5**: Optimal density of the skidding roads in relation to the factor x (a fraction of skidding in increase)

Figure 6 shows that with the increase of factor x the density of the skidding roads also increases. There is smaller optimal density of skidding roads when cable winching horizontally.

Figure 7 presents the influence of the total costs for building and maintaining the skidding roads in relation to the determining of the skidding roads optimal density. This density refers to the used wood allowable of 300 $m^3$/ha in a period of a hundred years.




| | 0,8 | 1,6 | 2,4 | 3,3 | 4,1 | 4,9 | 5,7 | 6,5 | 7,3 | 8,1 |
|---|---|---|---|---|---|---|---|---|---|---|
| Increases | 127,3 | 90,0 | 73,5 | 63,7 | 56,9 | 52,0 | 48,1 | 45,1 | 42,4 | 40,3 |
| horizontally | 105,7 | 74,7 | 61,0 | 52,9 | 47,3 | 43,2 | 40,0 | 37,4 | 35,2 | 33,4 |

**Figure6**: Optimal density of the skidding roads in relation different cost for skidding road

From the Figure 7 in diagram one can see that the trends for optimal density remain identical also in the case of skidding on flat terrain, and the values of the optimal density are smaller. Numerical data are given in the table in Figure 7.

Figure 8 presents the influence of the quantity of firewood with various use of the wood allowable in relation to the optimal density of the skidding roads. The calculations refer to cable winching in increase and in fall.

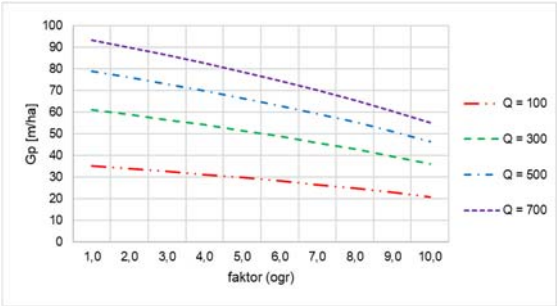



**Figure 7**: Optimal density of the skidding roads in relation to the portion of firewood in the production with various use for a period of a hundred years (analysis of skidding in increase and in fall)

Figure 8 shows that with increasing the quantity of firewood, as well as with smaller use of wood allowable, the optimal density of the skidding roads is smaller. With increasing the portion of the technical wood allowable, the optimal density of the skidding roads increases, and with increasing the wood allowable which is used for the researched period, the optimal destiny of the skidding roads also increases.

Figure 9 presents the influence of the quantity of firewood with various use of the wood allowable in relation to the optimal density of the skidding roads. The calculations refer to cable winching on flat terrain.

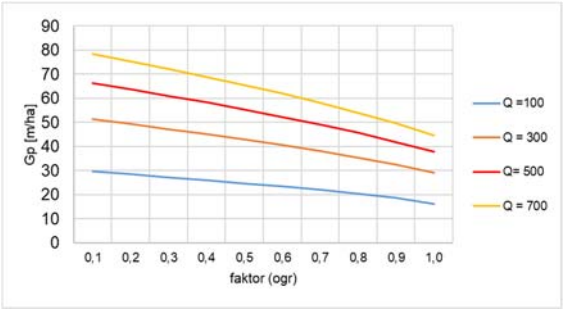



**Figure 8**: Optimal density of the skidding roads in relation to the portion of firewood in the production with various use for a period of a hundred years - Q (analysis of skidding on a flat terrain)

Figure 9 shows that the trends remain identical also in the case of cable winching on flat terrain, only that on flat terrains in all situations the optimal density of the skidding roads is smaller compared to the cable winching in increase and in fall.

## 4 CONCLUSIONS

In this study the results are closely connected to: the technical characteristics of the skidding means of transport, the team that works, the natural conditions, as well as the general and legal costs which appeared at the moment of research. With the change of these circumstances there would also be changes in the results.

With the model of displaying the costs that appear in the phase of wood cable winching, as well as the costs for skidding roads, and with the use of zonal graphic displays the trends and tendencies of certain parameters are well presented. Absolute correct solutions about the optimal density are acquired with differential estimations (first

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statement of the summary costs). Thus, at the model that had been researched an optimal density of skidding roads of 48.82 m/ha was determined.

With a small quantity of used wood allowable, the zone around the optimal density is sharper, and with a greater quantity of used wood allowable the zone around the minimal costs is drastically milder. Thus, in practice, one should be more careful in determining the optimal density of skidding roads with small quantity of used wood allowable, i.e. with small density of skidding roads.

In regard to the economic effects, one would make a smaller mistake if in percentage terms a skidding road network with a bigger density is built, compared to the same percentage of smaller density where greater financial losses would happen.

The results achieved about the optimal density of the skidding road network under 50 m/ha with the model of skidding only with the researched tractor would not be taken into consideration because of the technical characteristics of the comber which has a pulling rope of maximum 100 m.

With these analyses it must emphasized that we mathematically estimate an ideal model at which the roads are parallel and regularly placed in the area. Considering the fact that in mountain conditions such model could not be set up, these estimations have the purpose to determine the optimal distance between the skidding roads. That is to say, the expert people who would do the secondary opening of the forests are given a tool that they can use at their work. In reality this estimating density would be stressed with the density of the skidding roads which are unproductive by any reason.

Comparable research and results has the authors: (Sokolovic Dž. [25]), (Krstevski K. [17]), Pičman D. [30] and Walter W. [35].

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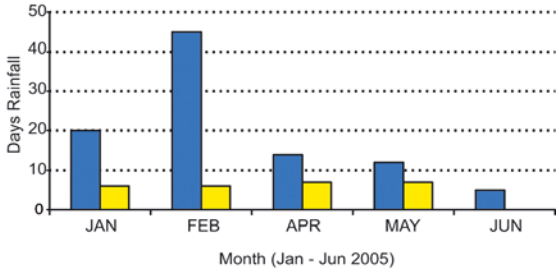


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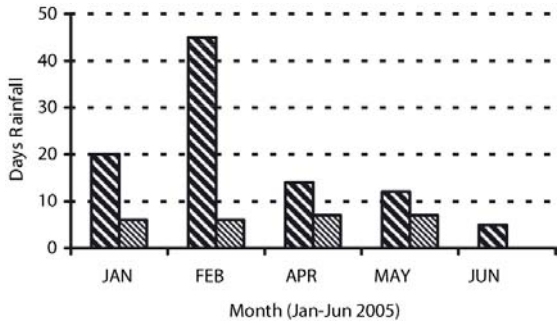


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Tabular presentation of data is an easy way to condense many items. Tables must be numbered in bold Roman numerals (e.g. **Table I**), and have a reference in the text. Captions should be as clear as possible, for an easy comprehension of the tables.

**Table I:** Overview of biomass resources available

| Biomass Sources | Quantity | Moisture | Residue |
|---|---|---|---|
| Sewage Sludge | 1.86 | 1.73 | 1.40 |
| Septage | 0.32 | 0.28 | 0.16 |
| Fruit Pulp | 3.78 | 3.89 | 4.02 |

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