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Cover – management (C-factor) of the Petrohan Training and Experimental Forest Range

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Abstract

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The results for the cover management coefficients (C-factor), obtained on the territory of the Petrohan Training and Experimental Forest Range, are presented in this study. Their values were mapped and spatially represented using GIS tools with software ArcMap, version 10.2. The highest vegetation effect was determined for the stands with high productivity mark and density, where the C-factor values vary from 0.001 to 0.004. They cover 92.6% of the total forestry range area. The territories, occupied by agricultural vegetation (game fields), low-yield and low-density stands, as well as the forest areas not suitable for tree species, are characterized by the lowest soil protection efficiency and coefficients of 0.340, 0.090 and 0.041, respectively. The obtained results for the soil protection role of the vegetation cover allow to determine the estimated quantities of eroded soil and assess the actual risk of sheet water erosion on the respective territory.

Keywords: soil erosion; C-factor; mapping; forest territory

Introduction

The steep slopes and climatic conditions in the mountainous territories are a prerequisite for the formation of high erosion potential of the surface runoff. The natural protection of soil from erosion processes is mainly due to the complex influence of the vegetation cover. Its protective functions mainly result in reduction of the surface runoff, decreased energy of raindrops from the above-ground part of the plants and protection from destruction and removal of soil material from the forest litter and roots.

The erosion control by the vegetation cover (canopy cover, ground cover, plant residues and roots) is defined as C-factor by the Universal Soil Loss Equation (USLE). It is estimated as a coefficient as the ratio of the soil loss from land cropped under specified conditions to corresponding loss under tilled, continuous fallow conditions (Wischmeier,1960; Wischmeier & Smith, 1978). The high effect of vegetation cover is characterized by coefficients, low absolute value coefficients.

In Bulgaria, the research in this field began in the second half of the last century (Biolchev, 1953; Dzhingov, 1969, 1983; Tsvetkova-Lazarova, 1980; Kitin, 1988; Krumov, & Malinov, 1989; Krumov, 1995; Onchev et al., 1988). Biolchev (1975) determined that forest belts have a high water-regulating effect. Coefficients for runoff-reducing and soil-retaining efficiency of grass and forest belts were proposed by Malinov (1999). The assessment of soil protection indices of the vegetation in the country based on the land distribution by the types of permanent use was performed under the Project PHARE-MERA (Stoev et al., 1997). The C-factor is determined for 8 classes of land cover in the CORINE classification – farmlands, forests, pastures, vineyards, orchards, rare vegetation, burnt lands and other agricultural lands. The watershed territories of the Struma River basin are determined by the adapted methodology for graded assessment of erosion factors according to Onchev (1983), with the application of the USLE model (Martenson et al., 1998; Marinov., 2009). Malinov and Ilieva (2015) presented for the first time the adapted methodology of C-factor assessment according to Wischmeier and Smith (1965, 1978) for the mountain areas in the country.

The recent studies apply the Revised Universal Soil Loss Equation (RUSLE) and Modified Universal Soil Loss Equation (MUSLE) methodologies for estimation C-factor as a set of 5 sub-factors for the influence of the vegetation cover, dead forest litter, and root system (Meyer, 1984; Renard et al., 1991, 1997; Karpilo & Toy, 2004; Zhou et al., 2008; USDA-ARS, 2013; Panagos et al., 2015). Similar studies for sub-factor assessment have started in the country in connection with the validation of the RUSLE and MUSLE models (Project, 2018).

The application of GIS and mapping C-factor in mountain areas provide the opportunity to perform timely analyzes in order to assess the risk of erosion processes occurring in case of land use change. In this context, the information provided by the geographic information systems (GIS) is a basic requirement to analyze the changes in vegetation cover and the respective consequences.

The aim of the present study is assessing and mapping the cover-management values (C-factor) of the vegetation cover on the territory of the Petrohan Training and Experimental Forest Range.

Materials and Methods

The research subject is the vegetation cover on the territory of the Petrohan Training and Experimental Forest Range, Montana District (Fig. 1). It serves for a number of purposes, connected with the implementation of scientific and research activities and experimental application of the best contemporary forestry practices as well as for practical training of students and PhD students of the University of Forestry.

The territory of the Petrohan Training and Experimental Forest Range is located between 23°04’ and 23°13’ eastern longitude and 43°14’ northern latitude. The terrain of the forest range is typically mountainous, with steep slopes, deeply incised river valleys and steep minor ridges (Regional Forestry Development Plan of Berkovitsa and Varshets Municipalities, 2016). Regarding the climatic conditions, the territory is characterized by specific mountain climate – lower temperatures, significant cloudiness and intensive rainfall, high relative humidity and prolonged snow cover. The terrain and climatic conditions are a prerequisite for the high erosion potential on the forest range territory.

The predominant soil type is Cambisols. It is characterized by high acidity (Malinova, 1996). This is typical for the soils of the Balkan Mountains and is assessed as stable over a 30-year observation period (Karatoteva et al., 2016; Tzvetkova, et al., 2016). Under the influence of erosion processes, in some regions were formed the Regosols (Malinova, 2016).

The main tree species is the European beech (*Fagus sylvatica* L.), which has good water-regulating and protective functions. The percentage of the deciduous species is 89.3% of the total tree species distribution, and the share of the coniferous species is 10.7%. No active development of both sheet and rill water erosion of soil has been observed on the forest range territory. Landslides and slips occur very rarely in case of heavy torrential rains in the valleys with very steep banks. The total area of the research subject is 7290.4 ha, 6215.9 ha of which are state property. The forested area represents 6752.4 ha (92.6%), non-timber production area 534.0

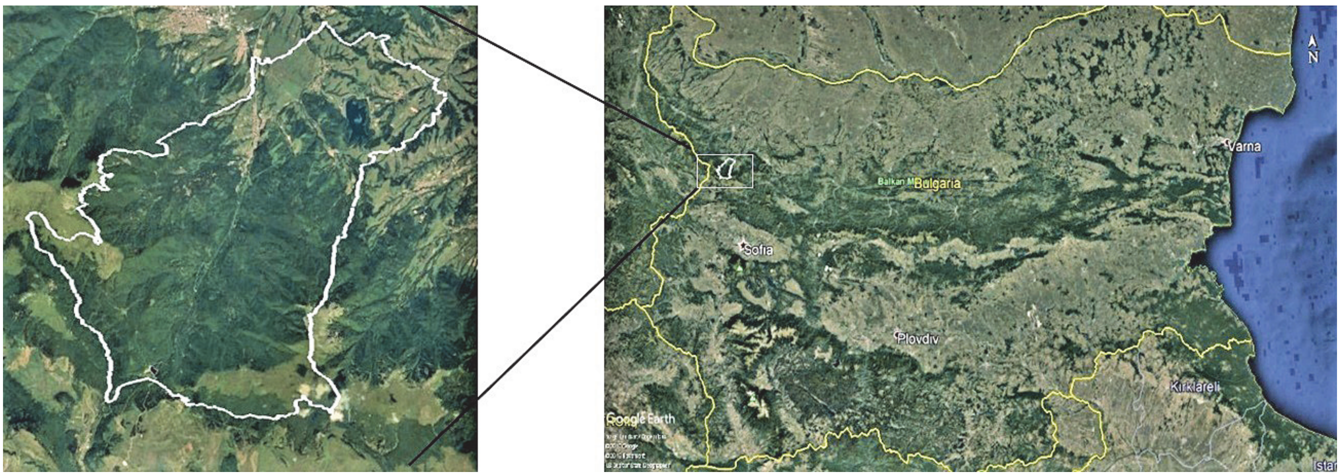

Fig. 1. Research subject – the Petrohan Training and Experimental Forest Range

ha – 7.4%. The listed crops and plants (with a density from 0.1 to 0.3 inclusive) occupy 3.5% of the total area – 217.3 ha. The unafforested timber production area represents 4.0 ha unafforested forest area. The unafforested non-timber production area is 516.5 ha or 8.2% of the total area. From this area 277.2 ha (4.5% of the total area) is occupied by meadows, 74.3 ha (1.2 %) is occupied by rock slides; 48.3 ha (0.8%) are clearings; 35.5 ha (0.6%) are forest areas that are not suitable for tree species, occupied by scarce tree, shrub and grass vegetation (Forest Management Project of the Petrohan Training and Experimental Forest Range, 2005).

A part of the non-timber production areas (grasslands, meadows, nurseries, game fields, etc.) is used for harvesting various non-timber forest products. Another part is technologically necessary for the production process – roadways, roads and clearings, etc., and a third part is unusable for forestry activities – forest areas not suitable for tree species, unafforested areas, quarries, rock slides, etc.

The C factor values are determined at the expert level (Table 1) according to the methodology and assessment scale for mountain areas (Malinov & Ilieva, 2015). The following data at the level of forest sub-section from the Forest Management Project has been used to determine the C-factor of the vegetation cover on the territory of the Petrohan Training and Experimental Forest Range for:

➢ Plantations with forest vegetation – forest canopy plantations of artificial origin, coppice and seed plantations of different density and productivity mark;

➢ Grass and shrub vegetation – meadows and game meadows, grasslands, natural pastures, forest areas not suitable for tree species, unafforested areas, plantations of artificial origin and game fields.

Table 1. C-factor values in mountain territories (Malinov & Ilieva, 2015)

C-factor	Characteristics of the forest stands	
	Productivity mark	Density
0.001	I and II	from 0.7 to 1.0
0.002	III and IV	from 0.7 to 1.0
0.003	V	from 0.7 to 1.0
	I and II	from 0.4 to 0.6
0.004	III and IV	from 0.4 to 0.6
0.009	V	from 0.4 to 0.6
0.020	I, II and III	up to 0.4
0.090	IV and V	up to 0.4
	Grass and shrub vegetation	
0.003	Meadows, game meadow, grasslands, etc.	
0.011	Unafforested areas, plantations of artificial origin	
0.041	Forest areas, not suitable for tree species	
0.340	Game fields	

The areas, marked as road, water areas, landing site, forest nursery, rock slide, yard, canal, quarry, wetland, parking, rocks, roadways and forest areas not suitable for tree species, are not subject to the assessment. They are defined as unclassified territories and represent 2% of the total forest range area.

The C-factor values were mapped and spatially determined using Geographic Information Systems (GIS) tools in software program ArcMap, version 10.2. During the mapping process the areas, smaller than 0.1 ha, were added to the adjacent larger areas with the respective C-factor value. As a result, the total number of sub-sections in the Forest Management project was reduced to 2425.

Results and Discussion

The map of C-factor values of the forest territory of each sub-section was developed by using GIS (Fig. 2). The data was summarised and represents the factor areal distribution. The results, presented on Fig. 3, show the distribution of C-factor of different vegetation cover in the forest range. The C-factor values for 84.4% of the Petrohan Training and Experimental Forest Range area vary from 0.001 to 0.003. These areas are mainly occupied by forest stands with high productivity mark and density. The areas with C-factor values of 0.001, representing 38.7% of the total area, are best protected.

The vegetation cover, characterized by C-factor value of 0.004, also has high erosion control efficiency. It occupies a territory representing 8.2% of the forest range area. The remaining vegetation cover groups have an insignificant spatial distribution with the respective C-factor values, as follows: 0.6% with C – 0.009; 0.1% with C – 0.011; 3.6% with C – 0.020; 0.6% forest areas not suitable for tree species with C – 0.041 and 0.3% with C – 0.090. The vegetation cover of game fields is characterized by the lowest effect on soil erosion, C-factor 0.34 as only 0.1% of the forest range area is occupied by them.

Data about the number of sections with equal C-factor is presented on Fig. 4. The results reveal that from a total number of 2425 sub-sections, 883 are characterized by very high effect of the vegetation cover (C – 0.001). The forest stands with C – 0.002 on the territory of 524 sub-sections, with C – 0.003 in 507 sub-sections and those with C – 0.004 in 218 sub-sections also provide very high protective functions. The remaining vegetation cover groups (C – 0.009; 0.011; 0.020; 0.041; 0.090; 0.340) have a lower soil-protective function on the territory of 122 sub-sectors in total. Of them, the lowest numbers (6 sub-sections) are stands with lower productivity mark and density – C-factor value of 0.041.

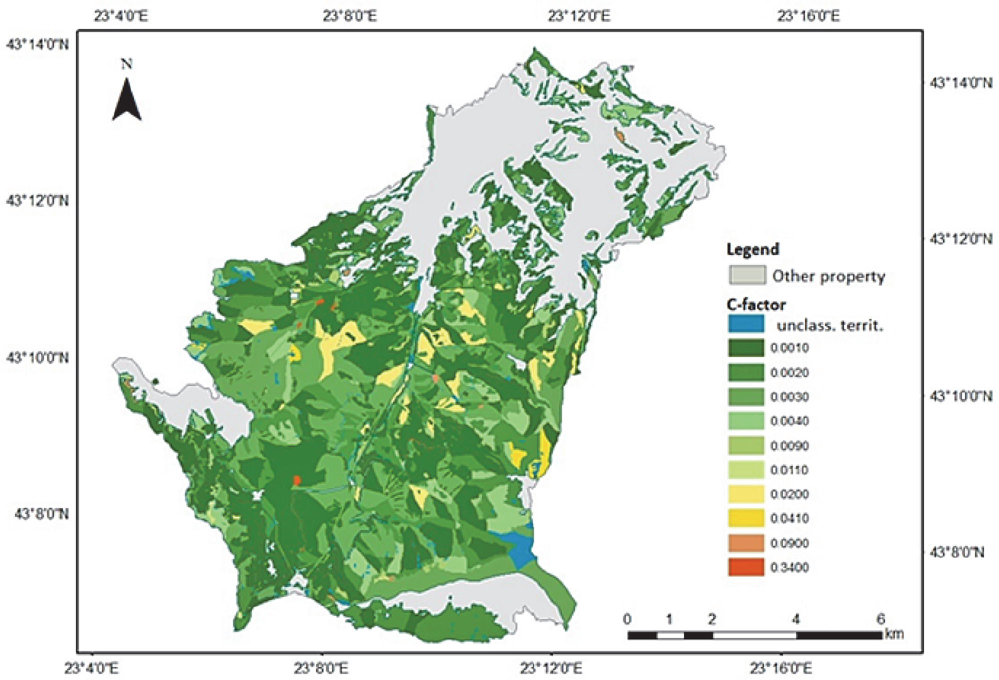

Fig. 2. Map of C-factor on the Petrohan Training and Experimental Forest Range territory

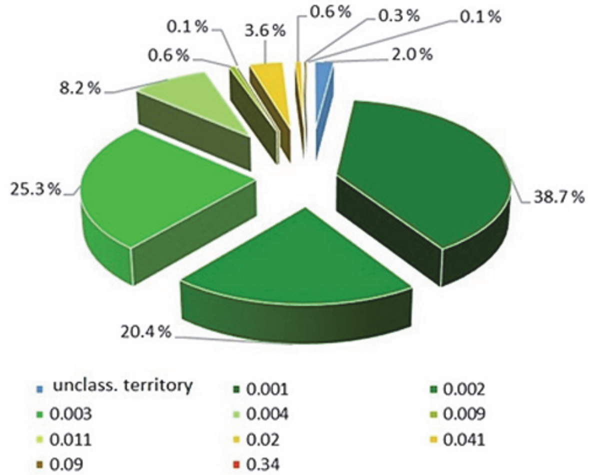

Fig. 3. C-factor distribution on the Petrohan Training and Experimental Forest Range territory

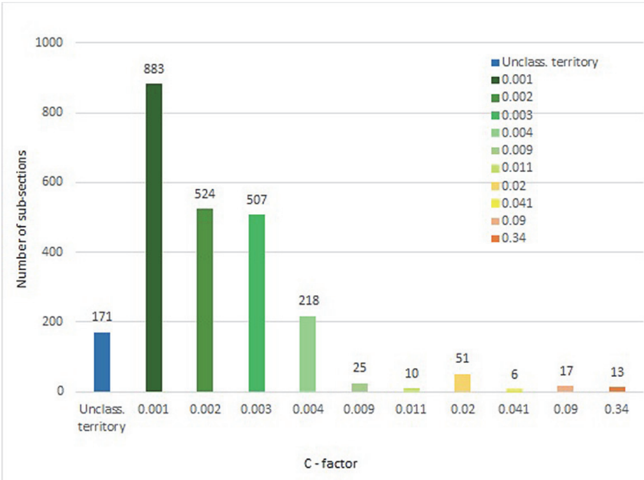

Fig. 4. C-factor distribution by sub-sections of Petrohan Training and Experimental Forest Range

Conclusions

The results show that the vegetation cover on the territory of the Petrohan Training and Experimental Forest Range have potential to control soil erosion. Mapping C-factor provides detailed information about distribution of the vegetation cover at the sub-section level. The stands with high productivity mark and density provide the most effective protection. They are characterized by C-factor values ranging from 0.001 to 0.004. Regardless of the erosion potential of the terrain and climate, the lack of intensive processes of sheet and rill soil erosion is due to the high soil protection efficiency of the stands on 92.6 % (1900 sub-sections) of the forest range territory. The obtained information can be applied to predict the actual erosion soil losses. This will provide an opportunity to optimize erosion control practices for sustainable management of the soil resources on the territory of the Petrohan Training and Experimental Forest Range.

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References

Biolchev, A., (1953). Mountain erosion and fight against it (Bg).

Biolchev, A. (1975). Water-regulating, colmation and anti-erosion action of forest and grass belts. *Scientific Proceedings*, Higher Institute of Forestry, *XX*, 63-69 (Bg).

Dzhingov, A. (1969). Studies on the water-regulating and anti-erosion role of sub-mountain pasture from the region of Sredna Gora used for hay and pasture. *Pochvoznanie i Agrohimia*, *4*(2), 105-114 (Bg).

Dzhingov, A. (1983). Studies on the water-regulating and protective role of the grass vegetation on eroded areas. Doctoral thesis, "N. Puskarov" Institute of Soil Science and Agroecology, Sofia (Bg).

Forest Management Plan of the Petrohan Training and Experimental Forest Range (2005), 412 p (Bg).

Karatoteva, D., & Malinova, L. (2016). Macro and microelement contents in soil from some grassland landscape of „Central Balkan" national park. *Bulgarian Journal of Agricultural Science*, 22 (4), 580–583.

Karpilo, R. D., Jr & Toy, T. J. (2004). RUSLE C-factors for slope protection applications. *Proceedings of America Society of Mining and Reclamation,* 995-1013.

Kitin, B. (1988). Studies on the hydrological and anti-erosion role of coniferous forests. Habilitation thesis, Higher Institute of Forestry, Sofia (Bg).

Krumov, V. K. (1995). Protection of soil from erosion by compacted cultivation of oriental tobacco on highly-eroded areas in the Southwestern Rhodopes. Dissertation for awarding the educational and scientific degree of PhD, "N. Puskarov" Institute of Soil Science and Agroecology", Sofia, 141 p (Bg).

Krumov, V. & Malinov, I. (1989). Erosion efficiency of naturally restoring vegetation on heavily eroded pasture areas. *Pochvoznanie i Agrohimia*, *24*(5), 75-79 (Bg).

Malinov, I. (1999). Study of the water soil erosion on a slope with built bank grass and forest belts. PhD Dissertation, "N. Puskarov" Institute of Soil Science, Sofia (Bg).

Malinov, I., & Ilieva, D. (2015). Determination and mapping of the C-factor and actual risk of sheet water erosion in the Central Balkan National Park. Digital Book of Proceedings of the International Conference "Soil and Agrotechnology in a Changing World", Sofia, pp. 436-442 (Bg).

Malinova, L. (1996). Study on the technogenic impact on the soil at Petrohan Regional Station. *Forestry Idea*, 4, Sofia, pp. 51-60 (Bg).

Malinova, L. (2016). Regosols in "Central Balkan" National park. *Bulgarian Journal of Agricultural Science, 22* (1), 21-25.

Marinov, I. Ts. (2009). Research and Assessment of Erosion in Some Regions of Southwest Bulgaria, Abstract of Dissertation for acquiring title Doctor of Agricultural Sciences, Forestry University, Sofia, 70 pp. (Bg).

Martenson, W., Marinov, I., Gergov, G., Malinov, I., Mandev, A., Stefanova, V. & Nikolov, I. (1998). Study of the erosion in the Struma River watershed. Final Report. PHARE Framework Contract – Enviroment, OSS № 9 (Bg).

Meyer, L. D. (1984). Evolution of the universal soil loss equation. *Journal of Soil and Water Conservation*, *39*(2), 99-104.

Onchev, N. (1983). Prediction of the water surface erosion in Bulgaria and optimization of anti-erosion measures. Zemizdat, Sofia (Bg).

Onchev, N., Rousseva, S., & Petrov, P. (1988). Indirect methods for estimation of K- and C-values of the Universal Soil Loss Equation. *Proc. of the International Symposium on Water Erosion, 19-24 Sept. 1988, Varna*, pp. 101-107.

Panagos, P., Borrelli, P., Meusburger, K., Alewell, C., Lugato, E., & Montanarella, L. (2015). Estimating the soil erosion cover-management factor at the European scale. *Land Use Policy*, *48*, 38-50.

Project Prediction of erosion soil losses and assessment of the suitability of agricultural lands for effective economic and anti-erosion use (2018). "N. Pushkarov" Institute of Soil Science, Agrotechnologies and Plant Protection, Agricultural Academy, Sofia (Bg).

Regional forest development plan of the Berkovitsa and Varshets municipalities (2016) (Bg).

Renard, K. G., Foster, G. R., Weesies, G. A., McCool, D. K., & Yoder, D. C. (1997). Predicting soil erosion by water: a guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE), Vol. 703, Washington, DC: United States Department of Agriculture.

Renard, K. G., Foster, G. R., Weesies, G. A., & Porter, J. P. (1991). RUSLE: Revised universal soil loss equation. *Journal of Soil and Water Conservation*, *46*(1), 30-33.

Stoev, D., Malinov, I., Dimitrov, V., Rashkov, S., Stephanova, V., & Nickolov, I. (1997). Land Degradation Mapping. PHARE –

MERA Project – Bulgaria. Final Report. Joint Research Centre ISPRA. Ministry of Environment, Bulgaria.

Tzvetkova, N. D., Malinova, L., Bezlova, Doncheva, M., Petkova, K., Karatoteva, D., & Venkova, R. (2016). Soil Contamination in Forest and Industrial Regions of Bulgaria. In: Soil Contamination – Current Consequences and Further Solutions. Chapter 7. 127–158. Online ISBN 978-953-51-2816-8, Print ISBN 978-953-51-2815-1. Edited by Marcelo L. Larramendy and Sonia Soloneski, DOI: 10.5772/62589 web of science ISBN: 978-953-51-2816-8. Print ISBN: 978-953-51-2815-1.

Tsvetkova-Lazarova, E. V. (1980). Anti-erosion efficiency of some agrotechnical measures in the cultivation of corn. PhD Dissertation, "N. Pushkarov" Institute of Soil Science, Agrotechnologies and Plant Protection, Sofia (Bg).

USDA – Agricultural Research Service Washington, D.C. (2013). Revised Universal Soil Loss Equation, Version 2 (RUSLE 2).

Wischmeier, W. H. (1960). Cropping-Management Factor Evaluations for a Universal Soil-Loss Equation 1. *Soil Science Society of America Journal*, *24*(4), 322-326.

Wischmeier, W. H., & Smith, D. D. (1965). Predicting rainfall erosion losses from cropland east of the Rocky Mountain. Washington, USDA, *Agriculture handbook*, *282*, 47.

Wischmeier, W. H., & Smith, D. D. (1978). Predicting rainfall erosion losses – a guide to conservation planning. *Predicting rainfall erosion losses-a guide to conservation planning. USDA Agricultural Handbook* , No. 537.

Zhou, P., Luukkanen, O., Tokola, T., & Nieminen, J. (2008). Effect of vegetation cover on soil erosion in a mountainous watershed. *Catena*, *75*(3), 319-325.

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