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"Sustainable Forestry: Fact or Fiction?"
70 years
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ANALYSIS OF THE CONNECTION BETWEEN SPATIAL FACTORS WITH TWO TYPES OF FORESTS IN THE CEMERNICA FOREST MANAGEMENT UNIT, BOSNIA AND HERZEGOVINA

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ABSTRACT: The paper presents two types of forest in the area of management unit Cemernica in terms of preservation. Namely, all the forests were divided into two types, primary and modified. In the primary type we included all high forests with natural restoration, other types (coppice forests, culture...) we included in modified type. The results of the logistic regression showed what affects the position of these two types of forest. For this purpose, we included in the analysis the basic topographic variables (altitude, inclination and exposure) as well as the spatial units (the distance of the department from the settlement and the distance of the department from the nearest forest road). An analysis of the position of primary and modified parts shows that increasing the distance from the settlement increases the likelihood of the presence of primary forests, while parts of the forests that are closer to the forest roads are better preserved due to the higher traffic density in the parts of better preserved forests.
Keywords: primary forest, modified forest, logistic regression.

1 INTRODUCTION

Forests of beech, fir with spruce are most widespread in Bosnia and Herzegovina. Beech and fir with spruce community in Republic of Srpska measures the area of 21.3037 ha [10]. In the area of Cemernica, forests of beech and fir with spruce (*Piceo-Abieti-Fagetum*) represent the largest economic and ecological significance. Forest preservation is the result of human activity in the form of exploitation and care of forest stands. The reason for the deviation of the present state of the forest from the well-preserved ones is primarily the consequence of the input and expansion of conifers and other invasive species on inappropriate sites for them. Irregular shelterwood system of management is prescribed system for management in the area of Cemernica management unit [3]. Forest stands that are managed represent a typical selection structure which shows that forest stands are managed by the selection.

The extent to which the forest is preserved is linked to the forest's openness, habitat potential and historical facts. Given the current state of vegetation, growing conditions and tree species, in the area of Cemernica the following categories are present: high beech forests; mixed forests of fir and spruce; mixed forests of beech, fir and spruce; degraded beech forests; cultures of black and scots pine; low beech forests; coppice forests of sessile oak and other areas suitable and unsuitable for management. High beech forests and mixed forests of European silver fir and beech with Norway spruce cover the biggest part of Cemernica, that is 48,28 %. From economical point of view, they represent the most important and best preserved forests. According to the data from FAO classification [2] forest stands are divided into: primary, modified natural, semi-natural, productive plantation, protective.

High beech forests; pure stands and mixed stands of fir and spruce; mixed forests of beech and fir and spruce are marked as primary. Other parts of management unit are classified into group of modified forests. A smaller number of research was done on a similar topic. Bončina and others [5] analyzed the connection of salvage cutting with orography factors during period of 1979-2006, after natural disasters (wind, snow and insect's invasion). The correlation on Pokljuka on the area of 9627 ha is shown.

The works shows the following: If there is a connection between primary and modified parts of management unit with basic topographic and environmental factors: Openness with forest roads and topography (altitude, inclination and exposition)?!.

2 MATERIAL AND METHODS

2.1 Study area

Management unit Cemernica is located in the middle part of Republic of Srpska (Figure 1). It spreads from 44^0 27' 09'' to 44^0 34' 44'' north latitude. Total area of management unit is 12.353 ha. According to the forest management division, management unit Cemernica belongs to forest- management area of Cemernicko. Research area is located on altitude of 240 to 1339 m [7]. The terrain is very diverse. Most of the areas are with inclination exceeding 50 %. Those are the parts around Velika and Mala Cemernica and parts around bank of river Vrbas.

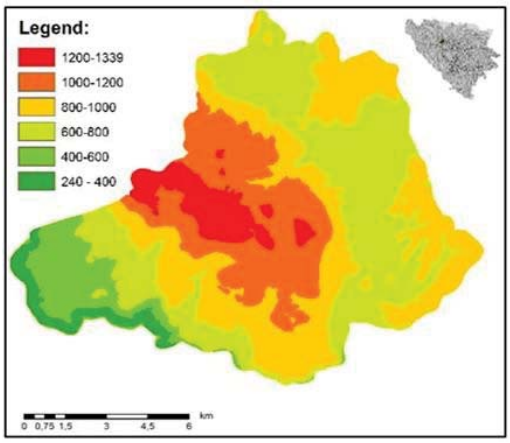

Figure 1: Location of the research area and altitude

According to ecological zoning of vegetation of Bosnia and Herzegovina [9], Cemernica is located within Knezevo area, western Bosnia limestone-dolomite area and area of the inner Dinarides. Cemernica can be considered as a typical Dinaric mountain in the geological sense. The mountain is entirely chalk formation. The pedogenetic strings that are present on the limestone are orthent-kalkomelanosol-kalkokambisol- luvisol [4].

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Table I: Variables used for modelling (primary-0; modified-1)

	Variable	Variable type	Description of the variable	Candidates for modelling
Site-characteristic variables	INC	continuous	Inclination (˚)	-
	ELV	continuous	Elevation (m)	-
	ASP	continuous	Aspect	included
	DFR	continuous	Density of forest road (m)	-
	DFP	continuous	Distance from the populated place (m)	included
	DRR	continuous	Distance from the forest road (m)	included
Past events	PAM	0/1	0 – primary forests 1 - modified forests	included

2.2 Method and analysis

The connection between primary and modified parts of management unit Cemernica from the point of view of topography (altitude, inclination and exposition) and spatial units (traffic density, distance to the settlement and distance to the nearest truck road) (Figure 2) were analyzed with logistic regression analysis [1]. All the variables analyzed were obtained at departmental level.

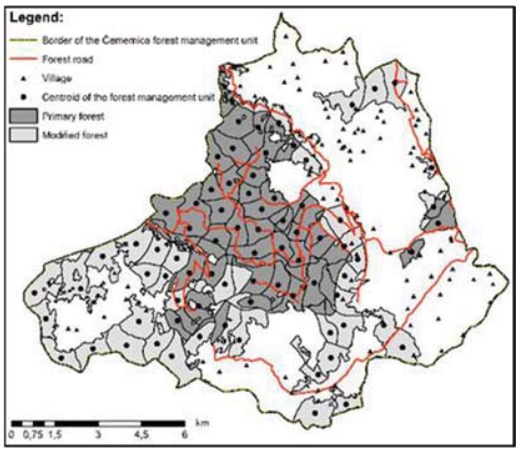

Figure 2: Research area

Topographic data were got from DEM (digital terrain models) with resolution 30 x 30 m. For each department we calculated: average elevation ELV (m); average inclination INC (0); exposure ASP (flat, N, NE, E, SE, S, SW, W, NW). The analysis included the following environment data: density of roads DFR (m/ha); distance from populated places DFP (m); distance from the forest roads DRR (m). These variables were calculated by using the programme package ArcGis 10.4.1.

In the first step, we calculated the density of the forest truck roads for each department separately. The second phase was determining centroid of each department on the map. We calculated the distance of the nearest road to the centroid of each department. In the third phase, we made a new layer with marked settlements in the management unit of Cemernica.

In this example we also calculated the distance of the nearest settlement to the centroid of the department. As a variable, in the binary logistic regression analysis we included two types of forests in relation to the preservation (0-primary; 1- modified).

Primary forests include high beech forests, pure and mixed forests of fir and spruce, and mixed forests of beech, fir and spruce. Other parts of Cemernica, such as coppice forest, forest culture and degraded forests were included into modified ones.

At the very beginning of the analysis we excluded some of the variables from analysis, due to the emergence of multilinearity. We checked this with correlation analysis. All variables that had less *Spearman's coefficient* from 0,6 were included into analysis. In this example we excluded altitude and the density of forest roads. With a t-test, we checked whether there was multilinearity between other variables. We excluded inclination from further analysis. Other variables (Table I) are included in binary logistic regression.

3 RESULTS AND DISCUSSION

The results showed that the best-preserved parts occupy about 48 % of the entire area of the management unit of Cemernica. These are primarily high beech forests, as well as pure and mixed forest stands of beech, fir and spruce. Other parts of the management unit occupy 52 % of the area. Forest cultures, coppice forests and other areas that are suitable and unsuitable for afforestation were classified into another form of forest stands that is modified forests.

Growing stock is one of the important indicators that shows us the productivity and the quality of the stands. Namely, high forests have more stocks compared to other breeding forms. In the research area of Cemernica according to the data from the forestry base for 2008, the average growing stock for high forests is 410 m3/ha and for other breeding forms 322 m3/ha. In this example, we can confirm that the high forests are better preserved than other categories. The reason for bigger area is that in that part of the management unit there are also parts especially in the southern part that are inaccessible for management due to the field configuration itself.

With logistic regression analysis, we checked whether the extent of forest preservation depends on accessibility (density of forest roads, distance to the nearest road and settlement) and topographic scale (altitude, inclination and exposition). In terms of preservation, we distinguished two types: primary (0) and modified (1). Results show that only two variables are statistically significant ($p < 0,05$). These are the distance of the department to the nearest forest road and the distance of the department to the nearest settlement.

Table II: Results of logistic regression

Variables		β	Wald Chi-Square	p
INC	Inclination	-	-	-
ELV	Elevation	-	-	-
ASP	Aspect	-0,2505	0,082	,774
DFR	Density of forest road	-	-	-
DFP	Distance from the populated place	-0,0013	8,893	,003
DRR	Distance from the forest road	0,0028	5,876	,015

All other variables were excluded from the analysis due to the occurrence of multicollinearity. The values of the regression coefficients are shown in Table II.

For an independent variable, the distance of the departments from the settlement (DFR), the value of the beta coefficient is (β = *- 0,0013*). The negative value of the regression coefficient means that increasing the distances of the settlements from the departments increases the probability of occurrence of the protected forests that is primary categories. As for the proximity of the forest roads (DRR) to the department, the results are slightly different. In this example, the values of the beta coefficient are positive ($\beta = 0.0028$), which means that the parts of the management unit Cemernica that are closer to the forest paths are better preserved.

The analysis showed that two variables (the distance of the departments from the settlement and the distance of the departments from the forest roads) significantly influenced the occurrence of unexplored forests (forest culture, coppice forest, etc.), while the other analyzed variables were not statistically significant. We showed in Table II that by increasing the distance from the settlement and the probability for the presence of the protected forests increases as well. Naturally, at a greater distance from the settlement, the intensity of the forest use by the inhabitants is lower. The improper use of the forest in this example is taken over by professional foresters. The parts of the management unit that are closer to the forest roads are surprisingly better preserved. The reason for this is that the density of the forest roads in the areas where the protected forests are located is bigger.

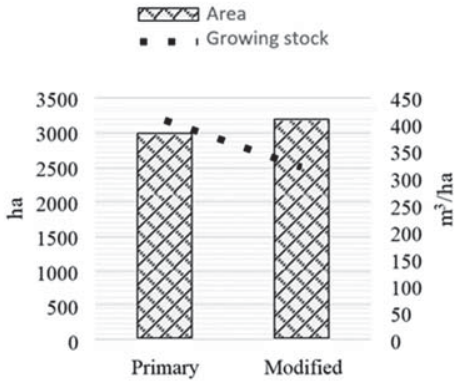

Figure 3: Growing stock and research area

4 CONCLUSION

- 48 % of the area of Cemernica management unit is occupied by category of primary forests that include high forests of beech, fir and spruce. The average growing stock of these forests is 410 m3/ha.
- Other parts marked as modified parts occupy 52 % of total area of management unit.
- The results showed that only two variables affect the presence of primary forests, that is the distance of the departments from the settlements and the distance of the departments from the forest roads.
- Bigger distance of the settlement from the department positively affects the presence of better protected forests. The reason for this is the lower intensity of the utilization of the forest by the inhabitants.
- The distance of the departments from the forest roads slightly differently influenced preservation of the forest stands. Even though the stands that are farther away from the roads should be better preserved, the results of the analysis are the opposite. The reason for this is the higher density of roads on parts of forest stands that are better preserved.

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