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THE DRAINAGE SYSTEM EFFICIENCY OF THE MOLIDVIS PEATLAND, FAGARAS MOUNTAINS

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The drainage system efficiency of the Molidvis peatland, Fagaras Mountains

Ruben Iosif

The drainage system efficiency of the Molidvis peatland, Fagaras Mountains. Identifying the elements which indicate the presence of active peat, such as the associations of *Sphagnum* ssp., *Carex* ssp., even pools and ponds which persist through out most part of the year, determined us to test the efficiency of the Molidvis swamp drainage system, in the Fagaras Mountains. In order to drain the swamp, in the late 1960, 3022 m of channels were excavated, with depths above 2 m and 2575 m secondary channels, with depths up to 1 m. Considering the ratio between the total length of the channels and the entire surface of the Moldvis meadow (65 ha with poorly water drainage), we have a density of approximately 85 m/ha. Still, the high value of this indicator does not confirm the efficiency of the drainage system. The purpose of our study is to test the efficiency of the Moldvis peatland drainage system, using statistical methods . The most important result is connected to accepting the hypothesis referring to the lack of correlation between the ground's morphologic parameters and the distance between the channels, and also to explaining the consequences of this fact.

Key words: Molidviş peatland, drainage system, slope, profile curve, correlation.

Efficacité du drainage des tourbières Molidvis dans les Monts Fagaras. L'identification des éléments qui indiquent la présence des tourbes actives, comme les associations *Sphagnum* ssp., *Carex* ssp., les tourbillions et les étangs qui persistent la plupart de l'année, nous ont determines à mettre a l'épreuve l'efficience du système de drainage du marais Molidvis, le massif Fagaras. Pour le drainage du marais, à la fin des annés 1960 out été excavés 3022 m de canaux d'une cavité au-dessus de 2 m et 2575 m de canaux secondaire, d'une cavite jusqu'à un métre. En rapportant la longueur totale des canaux à la superficie des marais Molidvis (65 hectares avec du drainage déficitaire de l'eau), resort une densité d'environ 85 m/ha. Cependant, le valeur augmentée de la densité n'exprime pas l'efficience du système de drainage. Le but de l'étude est de démontrer l'efficience du système de drainage du marais Molidvis, en utilisant les méthodes statistiques. Le plus important résultat est lié de l'acceptation de l'hypothèse concernant l'absence de la correlation statistique entre la distance des canaux et les paramèters morfologiques du terrain que l'explication des consequences de ce fait.

Mots clés: la tourbière Molidvis, système de drainage, la pente, la courbure en profil, la corrélation.

1. INTRODUCTION

The large capacity to retain water of the *Sphagnum* peats of Molidvis led to the construction of a water drainage system toward the Vidraru Lake, through the Limpedea headrace [1]. This also made possible adding approximately 65 ha of wetland into the agricultural system.

The technical parameters of the surface drainage systems are determined by standardized methods which offer information regarding their efficiency based on the length, depth, density, and average slope of the channels, and average slope and profile curve of the terrain [2], [3]. The profile curve represents a morphometric indicator which expresses the behavior of the flow on the slope, based on the shape of the versant. On the

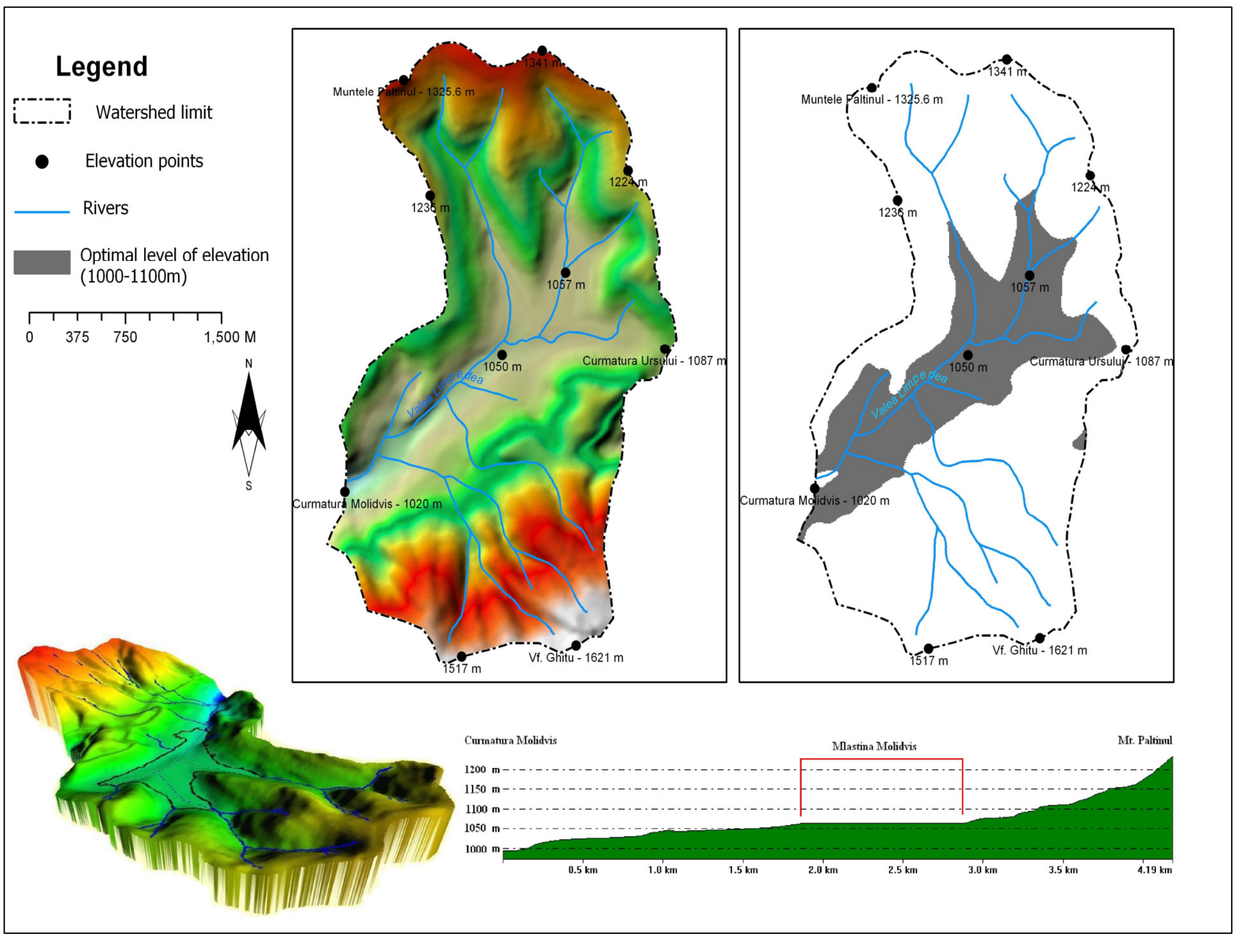

Figure 1 – Study area: D.E.M. with optimal level of elevation; a 3D view of the Limpedea River Basin and a longitudinal profile (Data source: Military topographic maps, 1:25000)

convex shaped versants we have an accelerated flow, and on the concave ones a slower flow [4].

The research niche that the present study is trying to fill is determined by the lack of detailed analysis of a digital elevation model (D.E.M.) which can provide us critical information about the natural drainage inside a basin [5].

The research in hydrotechincs rarely include spatial analysis of this type and for researchers from other areas (e.g. hidrology), they still remain a major challenge.

The purpose of our study is to explain the efficiency of the drainage system using statistical correlation between the technical parameters of the drainage system and morphometric parameters of the Moldvis peatland in the Fagaras Mountains.

2. STUDY AREA

The Molidvis swamp is situated in the center of the superior basin of Limpedea river, left-side tributary of the Arges river. This basin is placed north from Ghitu Mountains, between the Curmătura Moldviş, which separates it from the Vidraru Lake catchment area and Curmatura Ursului, which make the transition to Valsan river basin [6]. An artificial water catchment area of 8.12 km^2 was built 2km downstream from the swamp, the river flow obtained to supply Vidraru Lake is of only 0.16 m^3/s [7] (Figure 1).

The geological conditions as well as the morphological and morphometrical land parameters allowed a peatland to form alongside the river. The uplift of the metamorphic rock structures of Ghitu-Cozia Mountains and the sinking of the Miocene heterogenous conglomerates is what enabled the deposit of impermeable sedimentary formations (an essential condition in swamp genesys), like the Oligocen-Miocen clay rocks, which determined the decomposition of peat deposits [8], [3].

It's basin depression structure, opened only by the Limpedea Valley gorges also determines the functioning of a certain microclimate, with frequent thermal inversions, which led to the descent of the *Picea abies* forest down to 1060 m. Thus, the climate parameters achieve perfect conditions of forming oligotrophic swamps [3].

The characteristics of this swamp places it in the category of the south-east Carpathian ones, oligotrophics, with surfaces varying between 10 and 50 ha, at altitudes up to 1050 m. The average annual temperature is of approximately 5°C, and the average annual precipitations are slightly over 1000 mm [9]**.** Doniţă et al. (2005), consider the structure of such a swamp (R5409), as being one typically oligotrophic, formed on terrains with poor water drainage, especially in the rainy months. The grassy layer is constitued of

Drosera, Carex and *Rhynchospora* associations (up to 20 cm high), and the peat moss carpet is dominated by *Sphagnum* associations.

The largest changes in the structure and functionality of this habitat were triggered by the construction of a drainage system, designed to collect the water surplus from the versants strings. Nowadays, the strings from the southern versant of the Molidvis intermountain depression are being collected by six secondary channels with lengths between 22 and 303 m. All the channels begin at the base of the versant , next to the *Picea abies* forest and they are connected with the main channel, which is 1479 m long. The emissaries from the northern versant are gruped in two microbasins with numerous torrential organisms, especially on the deforested versants: the north-west one, with a main collector channel 798 m long, drained as soon as it enters the low slope sector and five other secondary channels, their purpose being to drain the water from the versants which

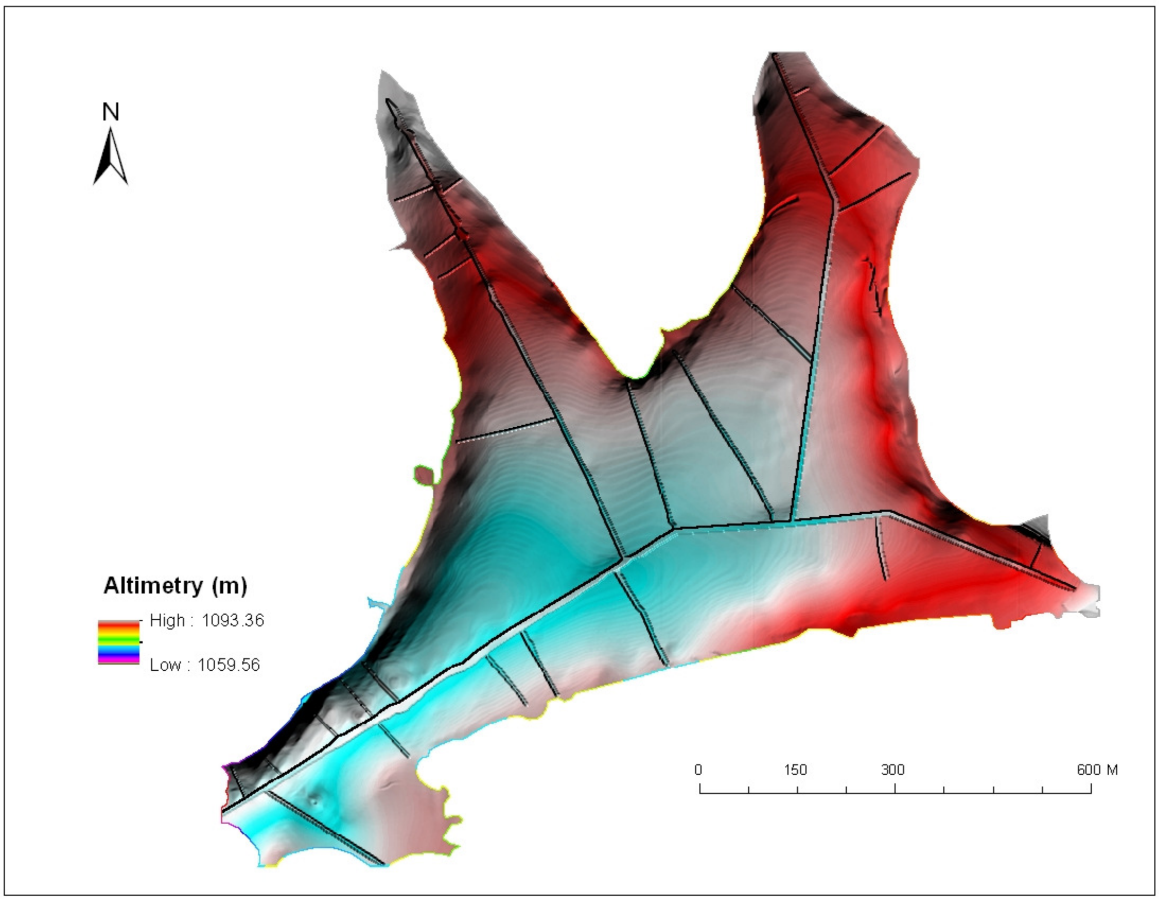

Figure 2 – D.E.M. after subtracting the depths values from a channel raster using map algebra

are directly linked to the Molidvis meadow; the north-eastern one is drained using the same principle, by means of a main channel, 743 long and seven other secondary channles. To all these add five smaller channels that are designed to drain the river out of the swamp.

3. METHODS

The analysed data were obtained either from direct field measurements, using GPS Garmin model GPSMap60CSX, or through the ulterior processing of the data extracted from topographic maps, and orthophotos. Digital elevation model was created by interpolating the altimetric data extracted off the area framing plans, at a scale of 1: 5000, made by I.G.F.C.O.T. in Stereo 70 prejection with a 5 m equidistance, and was used to calculate the average slope and curvature values for each parcel using the extract by mask tool.

Map algebra was used to add the values of the channels depths to the D.E.M., resulting a new raster, closer to the reality, which was later used in the analysis (Figure 2, *supra* note).

We then created a model using the ArcGis Desktop 9.3 program, in order to convert raster into points; then we applied a randomized selection on 35 points for each of the 27 parcels, using the random point tool. We continued the model for the resulting 945 points using the extract multi values to points tool. The gathered data has a non-normal distribution, so we used the Spearman correlation coefficient . We analysed the correlations between the length (m) and slope (%) of the channels, and between the distance between the channels (m) and the slope (°), respectively the average profile curve (radians/1m) of the parcels contained between those channels [10], [11], [12]. All the statistical analyses was realized using the SPSS 13.0 program for Windows, by carrying out the following steps:
a) we calculated the average of the variables, the standard deviation and other elements of descriptive statistics;
b) we tested the data distribution, both visually and using the Kolomogorov – Smirnov normality test;

c) we calculated the non-parametric Spearman *rho* correlation coefficient in order to test the statistical hypotheses.

4. RESULTS

A simple visual analysis of the drainfage system, but especially of its placement over a D.E.M. of the Molidvis peatland, may lead us to the idea that the longer sectors of the channels have the highest slope. This occurs because it spreads across multiple altitude levels. However, the statistical analysis indicates the opposite. The channels' slope decreases along with the increasing of their length. The correlation between the two elements is small, but statistically significant (rho = -0.45, p=0.014).

The longest channels (segments 1, 4, 5) have an average slope smaller than 2% (Table. 1), and they drain the central sectors of the swamps, having a longitudinal disposition, in the same flow direction as the mainstream. The shortest channels have the highest slope and they are perpendicular on the flow direction of the mainstream, having average slope values up to 7 %.

The distance between the channels, another important parameter in designing drainage systems, is a variable that doesn't depend on the average values of the slope and profile curve, within the parcels separated by the respective channels (Figure 3). This could be the main reason for which the Moldvis peatland system is not efficient.

An efficient drainage system should be designed considering the average slope and the profile curve of the terrain. Thus a fairly

Table 1. Technical parameters of the Molidvis peatland drainage system (Field measurements)

Channel segment ID	Length (m)	Slope (%)
1	**838.8**	**0.73**
2	330.3	1.53
3	310.3	3.07
4	799.1	2.91
5	501.7	1.43
6	242.4	3.69
7	56.6	4.02
8	54.5	4.57
9	79.3	3.21
10	77.0	2.59
11	85.6	1.57
12	159.3	1.59
13	60.6	5.05
14	66.4	2.75
15	64.0	1.89
16	40.1	**7.53**
17	243.5	2.12
18	307.2	1.60
19	172.1	1.83
20	**26.4**	1.40
21	117.3	4.40
22	126.7	4.75
23	50.3	7.05
24	98.9	2.13
25	167.1	2.16
26	120.4	4.17
27	104.5	4.19
28	77.9	7.33
29	216.2	4.08
Mean	192.91	3.28
Stdev	204.92	1.83

strong correlation is expected to be found between the distance between the channels and the values of the average slope and average profile curve within the parcels separated by the respective channels (Figure 4).

The correlation between the curvature and the distance between the channels is statistically insignificant (rho=0.082, p=0.34). However, there is a weak negative correlation between the slope and the distance between the channels (rho=-0.37, p=0.028).

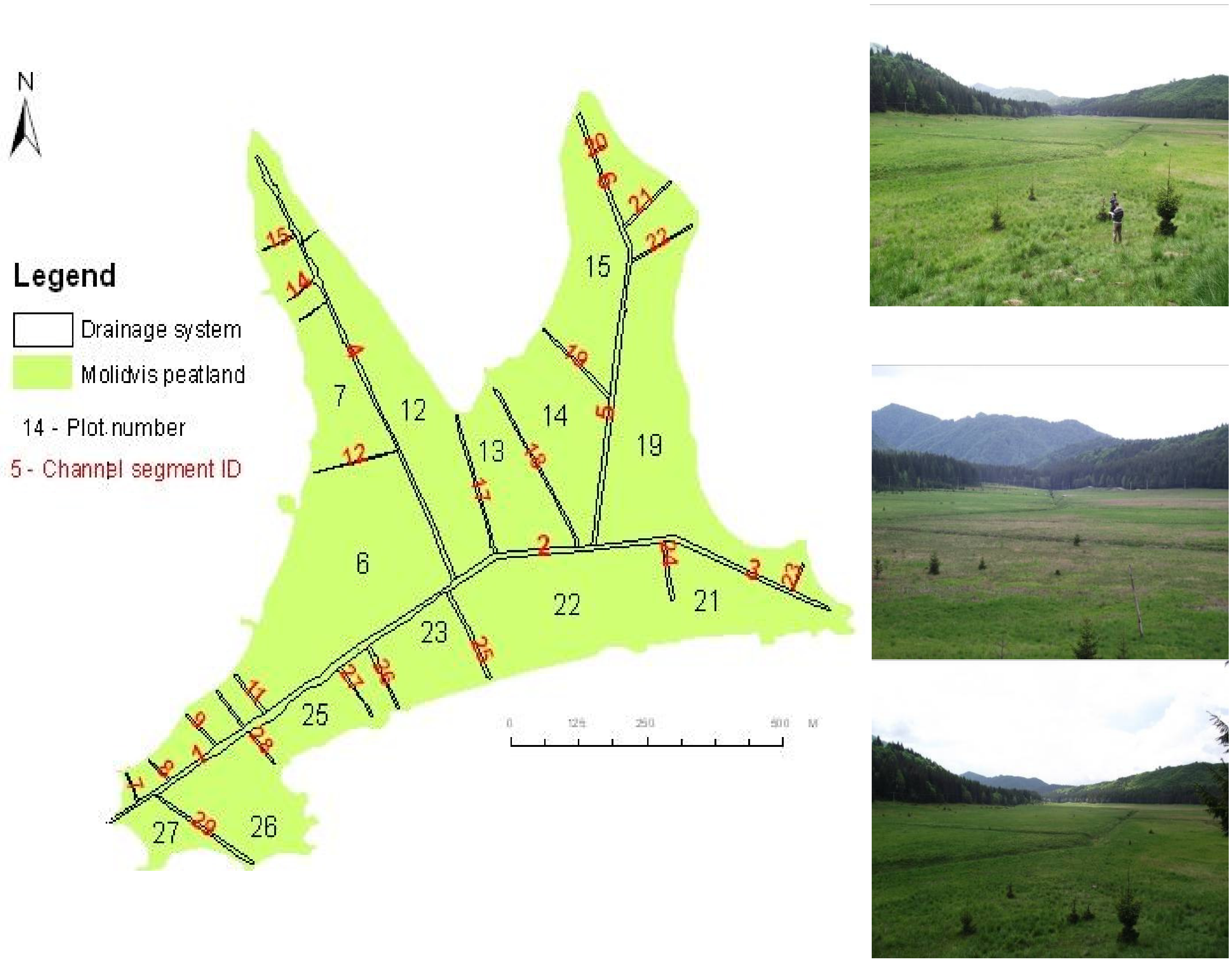

Figure 3. Molidvis peatland drainage system (Spatial data source: Orthophotomap, 1:5000; Photos Iosif Ruben, June 2011)

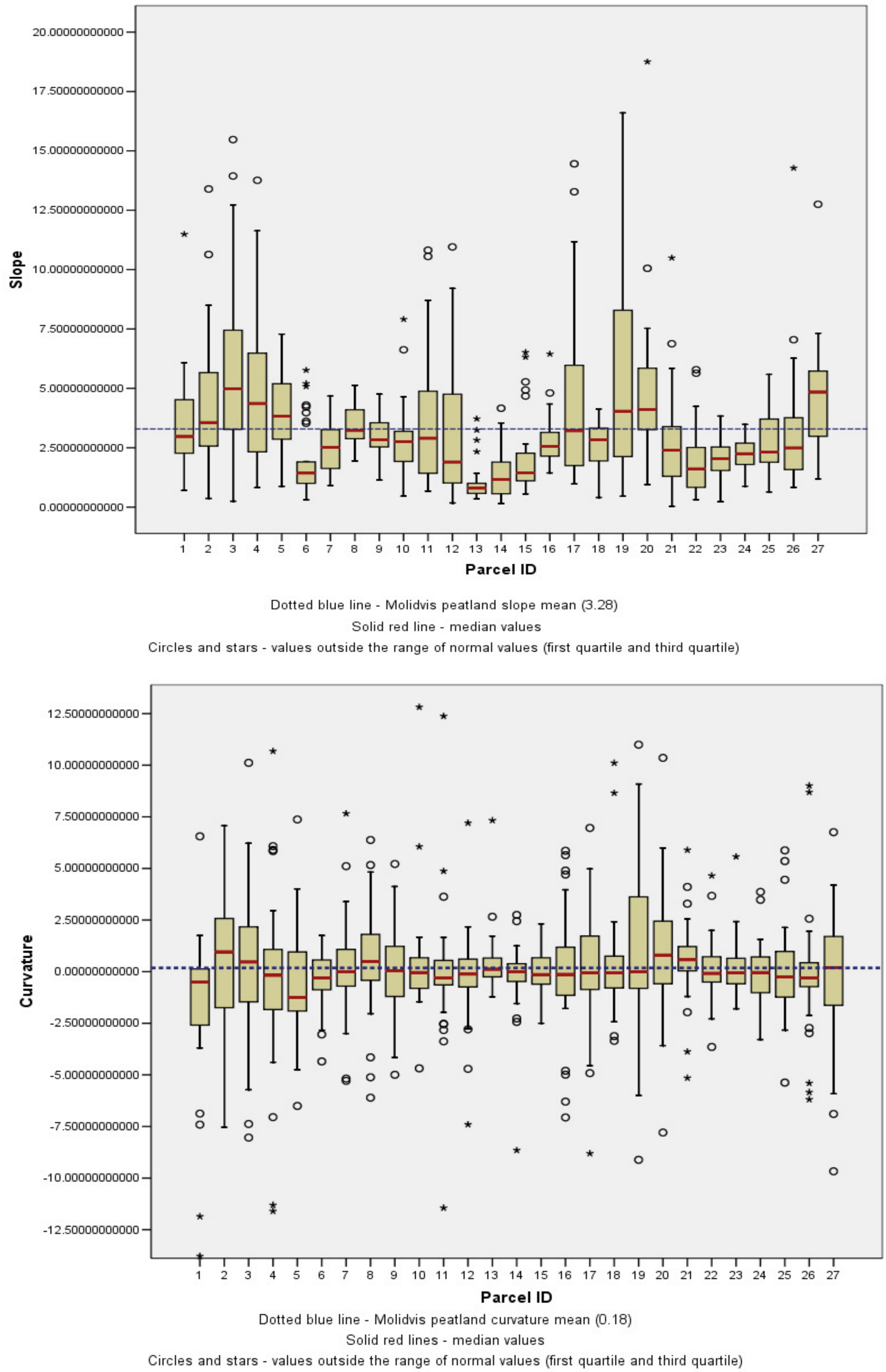

Figure 4. Molidvis peatland morphometric parameters for each 27 parcel of the drainage system

5. DISCUTIONS

The most important result of the study consists in the testing the efficiency of the drainage system of Molidvis swamp, by rejecting the hypothesis which states that there should be a strong correlation between the morphometric variables (slope and profile curve) and the technical parameters of the channels. The necessity to prove the drainage system's efficiency began from field observations regarding the presence of active peat even in artificial drainage conditions. We identified markers (Figure 5) like *Sphagnum* hummock, *Carex* associations, ponds, and the trees species distribution is obviously influenced by the persistent underground moisture. These aspects can represent a theme for further studies.

Statistical correlation represents an useful tool, as it replaces the opinion of experts, which can easily make wrong inferences. As a short recapitulation of the statistical method used, we suggested a technical error in designing some of the drainage channels, by only taking into consideration the position of the strings, and neglecting the lateral flow which occurs rapidly into the moss carpet and the quantity of water retained by the peat soil. In conclusion, a higher density of the channels in areas with reduced slopes and on concave shaped sectors would have been more efficient.

Figure 5. Active peatland indicators (Photos by author, May-June 2011): A- *Picea abies* inhibited by moss carpet; B – Pond ; C – *Sphagnum* ssp; D – Panoramic view of study area (note the stunted trees)

The limitations of the study consist in the lack of data regarding the peat layer, its distribution, its thickness, the groundwater level etc.

As to consequences of the lack of correlation tested in this study, we mention: trees species (e.g. *Picea abies*, *Betula pendula, Betula pubescens*, *Salix* ssp.) inhibited by the moss carpet, especially in the swamp sectors in which the artificial drainage is not efficient; the persistence of ponds throughout the year; the perpetuation of the peat deposit process at larger distances from the channels and the fact that it ceases at smaller distances.

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