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Applying Electrical Resistivity Tomography Method to Investigate the Impact of Large Ungulates on Wildlife Areas in Terms of Soil Compaction

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Abstract- The study was conducted in two main areas, are: Slovakia and Bialowieza Bison Park in Poland. We applied Electrical Resistivity Tomography (ERT) method to investigate the impact of large ungulates on wildlife areas in terms of soil compaction. We Measured two sites (high disturbed and undisturbed) in each plot. ERT data were processed through using the RES2DINV whin Geoelectrical Imaging (Geotomo Software), then we analysed the resistivity colours by using the Volfram Mathematica. Our results demonstrate that high disturbed plot sites have a higher electrical resistivity values (tones) than undisturbed sites and vice-versa. ERT method can be categorized among a useful method for investigating the impact of ungulates on soil in terms of compaction.

Keywords- Electrical resistivity tomography, Soil compaction, Disturbed site, Undisturbed site.

I. INTRODUCTION

Ungulates depend mainly on grasses, shrubs and trees for their food. Food productivity connects directly with quality of soil subsurface and its physical properties (particle density, bulk density and porosity). Therefore, using ERT method can cover large distance in short time and no laboratory process needed rather than other methods for collecting soil samples (for example core method), it needs field tools, carry samples to laboratory, long laboratory process and takes time to get results. ERT is non-destructive method without digging can show the subsurface properties [6]. ERT method has been already used in different contexts such as: groundwater exploration, bedrock depth, soil horizon thickness, agronomy specially identifying more compacted areas…etc. [6]. In addtion, [1] reported that researchers have focused on their studies of soil dry density and bulk density through conducting the soil electrical resistivity measurements.

In this study, we only focus on qualitative (categorical variables) traits (impact, medium impact, or no impact in terms of compaction) vs. factors (such as a degree of animals disturbance whether high, or non-disturbed).
The purpose of the study was to investigate the impact of large ungulates on wildlife areas by using ERT method, in order to insight us whether there is an impact of ungulates on subsuface of the soil in terms of compaction or not.

II. MATERIAL AND METHODS

A. Study areas

The study was conducted on two main locations in central and eastern Europe. First one represented by Carpathians which itself includes three study sites distributed on most parts of Slovakia, are: (1) Topolčianky Game Reserve (Bison Park: 48°27'50" N and 18°20'28" E) in the north, (2) Bukovina (Budca-Boky: 48°34'08.19" N and 19°01'16.99" E) in the middle, (3) the Poľana Region (Iviny: 48°37'08.19" N and 19°23'50.77" E) in the middle as well. The second location represented by the Bialowieza National Park (Bialowieza Bison Park) in Poland.

B. Electrical resistivity method

Reference [8] explained the relationships between wire resistivity (ρ) and electric resistance (R), as presented in following equation:

$$R = \rho \frac{L}{A} \qquad \text{.................................. (1)}$$

Where R is the wire electric resistivity (Ω), L is the length of wire (m), and A is the wire cross-sectional area (m^2).
Replacing Ohm's law (V = I.R) which refers to relationships between Volage (V), Current floe (I) and Resistance (R). Then the resistivity can be as following:

$$\rho = \frac{A}{L} \cdot \frac{V}{I} [\Omega m]. \qquad \text{......................... (2)}$$

Electrical resistivity tomography (ARES device, GF Instruments,s.r.o. version 4.7) was applied for imaging sub-surface of the investigated soils. We carried out ERT measurement in different plots: Topolcianky Bison Park, Buca-buky, Iviny, and Bialowieza Bison Park, in order to insight us whether there is an impact of ungulates on subsuface of the soil in terms of compaction or not. The length of the cable used 47 m; one meter distance between electrodes.

Figure 1: Electrical resisitivty device (right) and electrical resistivity measurement along highly disturbed profile (left).

C. Data Evaluation

Electrical resistivity tomography data were processed by the using of RES2DINV whin Geoelectrical Imaging (Geotomo Software). A software program (RES2DINV) can show subsurface two-dimensional resistivity model from the data collected through electrical imaging measurement [2].

To confirm our visual investigation of resistivity based on colours, we analysed the resistivity colours in order to identify which colour is dominant (according to electrical resistivity scales), by using Mathematica, version 10 (Volfram Mathematica).

III. RESULTS AND DISCUSSION

As we described before, Electrical Resistivity Tomography method was applied for imaging sub-surface of the soil. ERT has great ability to show the image of the soils, therefore we carried out ERT measurements in different plot sites with different degrees of animal disturbance, in order to insight us whether there is an impact of ungulates on subsuface of the soil in terms of compaction.

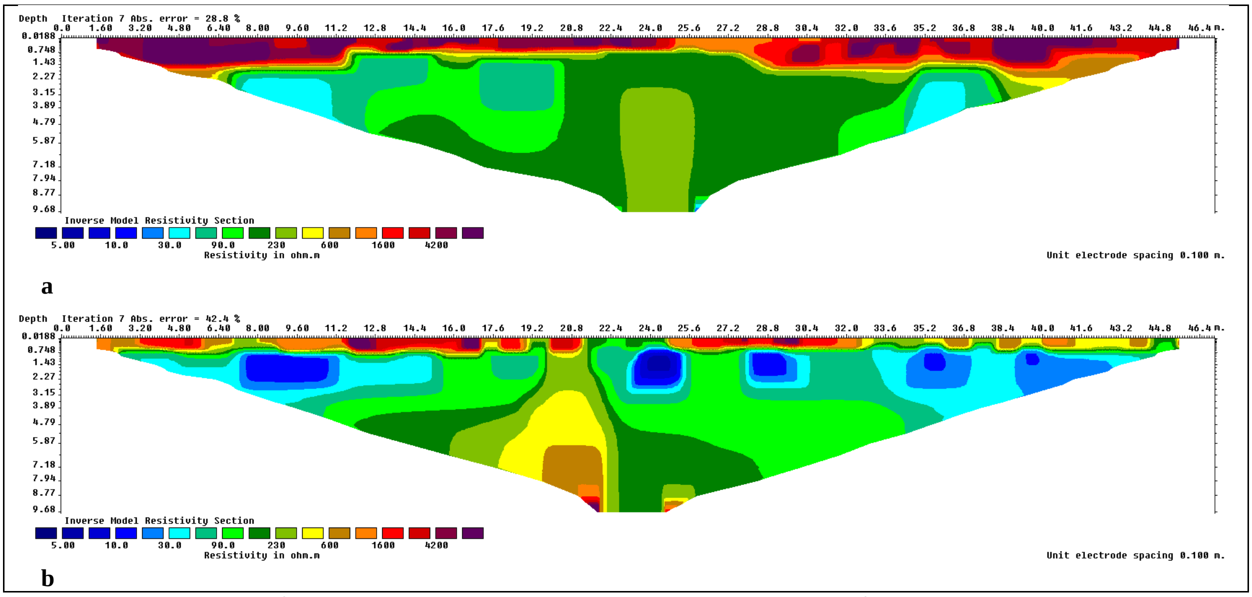


Figure 2: The visual results of soil electrical resistivity tomography (Ohm. m) along 2 profiles at plot Bialowieza Bison Park; (a) is inside the Bison Park where the soil is highly disturbed by the bison, (b) is outside the Bison Park (undisturbed plot site).

Our investigation of subsurface of the soil based on electrical resistivity tomography images showed us the differences in resistivity among investigated plot sites. By looking at the picture of each plot site individually in terms of electrical resistivity, clearly showed that the plot site with the high disturbed revealed intensity of high tones (red, brown, and yellow) which represent high resistivity (Fig. 2a). The undisturbed site (Fig. 2b) the resistivity tones intensity on the subsurface is less than occurred on the high disturbed site. Figure 2 (highly disturbed site), the dominant colour is violet, whereas Figure 4 (undisturbed site) shows dominance is for light brown. Figure 2 shows the electrical resistivity value of violet colour (up to 4200 Ohm. m) is higher than resistivity value of brown colour (which ranged from 600–1600 Ohm. m). Therefore, highly compacted soil has higher resistivity than less compacted.

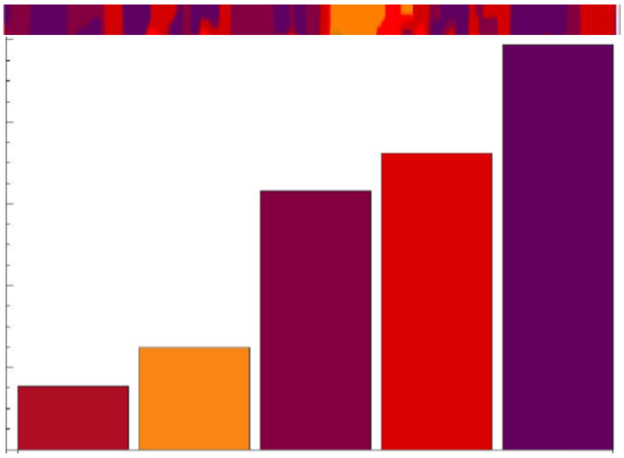


Figure 3: Dominant colours of the plot Bialowieza Bison Park at highly disturbed site; the slide is soil surface (depth 50 m), colours analyses of Figure 2a.

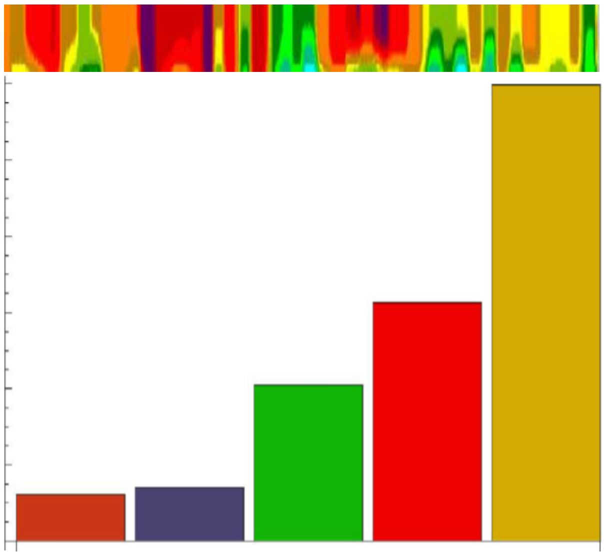


Figure 4: Dominant colours of the plot Bialowieza Bison Park at undisturbed site; the slide is soil surface (depth 50 m), colours analyses of Figure 2b.

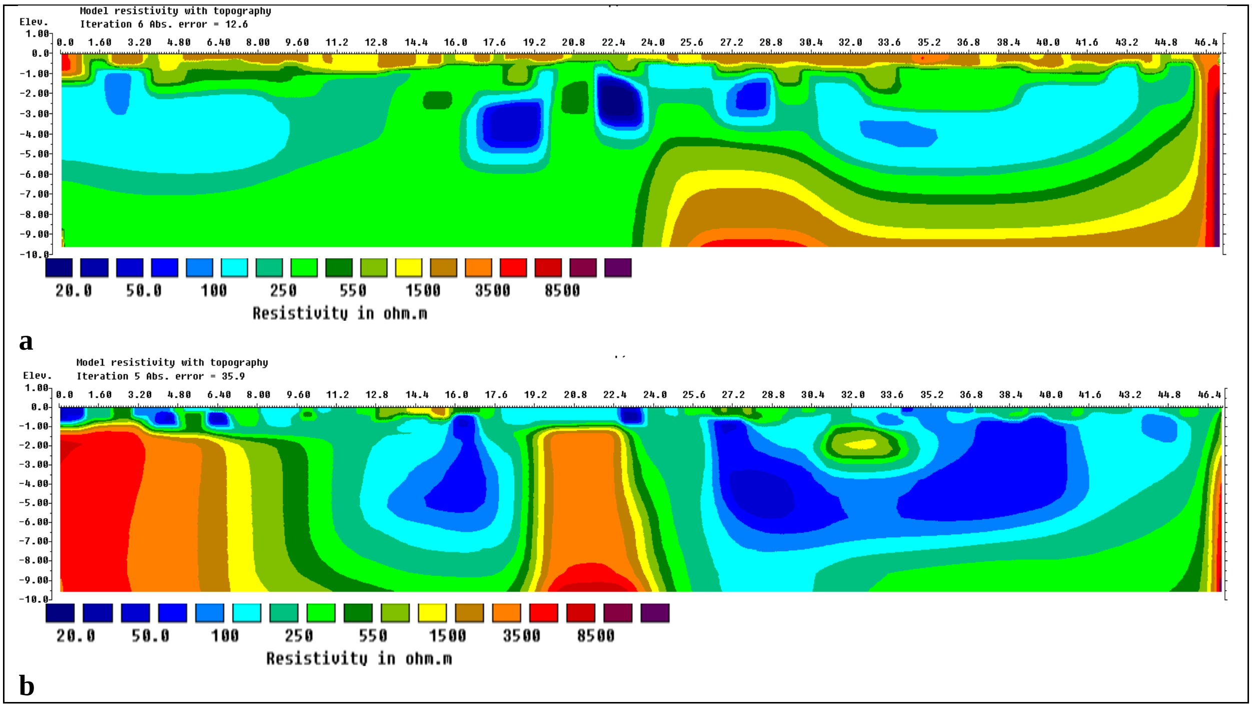
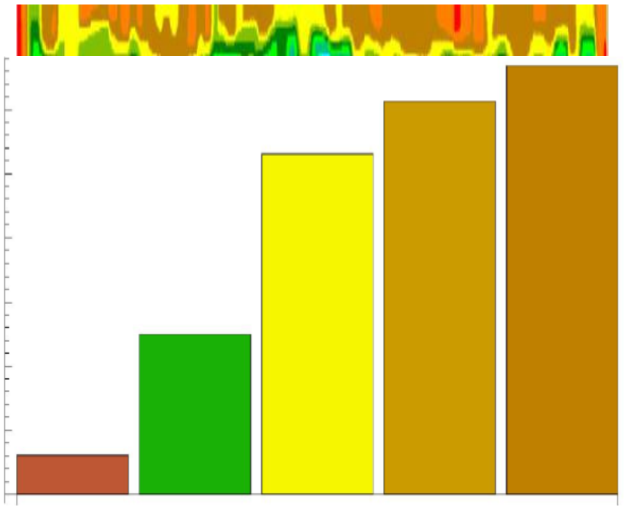


Figure 5: The visual results of soil electrical resistivity tomography (Ohm. m) images along 2 profiles at plot Topoľčianky Bison Park; blue and green tones indicate low resistivity, while red, brown and yellow tones represent high resistivity; (a) is inside the Bison Park where the soil is highly disturbed by the bison, and (b) is outside the Bison Park (undisturbed plot site).

Electrical resistivity tomography measurement was implemented in the plot Topoľčianky Bison Park which includes two different plot sites: inside and outside the Bison Park which we consider them as high disturbed and undisturbed, respectively (Fig. 5).

Electrical resistivity tomography measurement images revealed that at the high disturbed site (Fig. 5a) appears on the subsurface high resistivity tones (red, brown, and yellow), whereas undisturbed plot site the low tones (blue and green) which indicate low resistivity are clear (Fig.5b). Furthermore, the dominance colour in the disturbed site of the Topoľčianky Bison Park is for dark brown (Fig. 6), its resistivity value in Fig.5is up to 1500 Ohm. m it's quite higher than dominant colour (green) of undisturbed site (Fig. 6), which has a value of only about 100 Ohm. m (Fig. 5).



Figue 6: Dominant colours of the plot Topoľčianky Bison Park at highly disturbed site; the slide is soil surface (depth 50 m) colours analyses of Figure 5a.

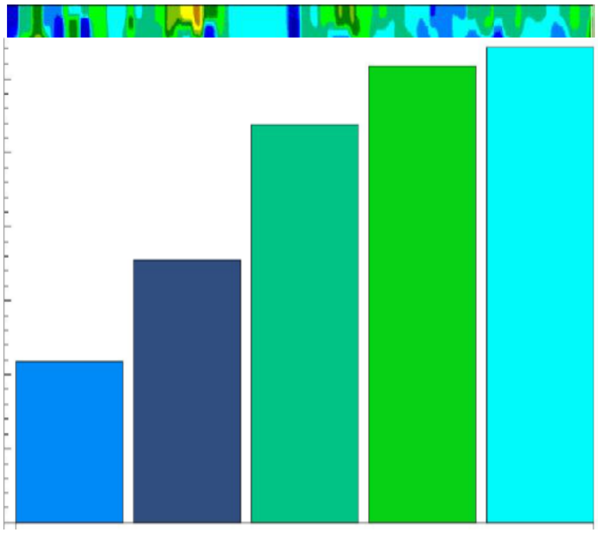


Fig. 5.14: Dominant colours of the plot Topoľčianky Bison Park at the undisturbed site; the slide is soil surface (depth 50 m) colours analyses of Figure 5b.

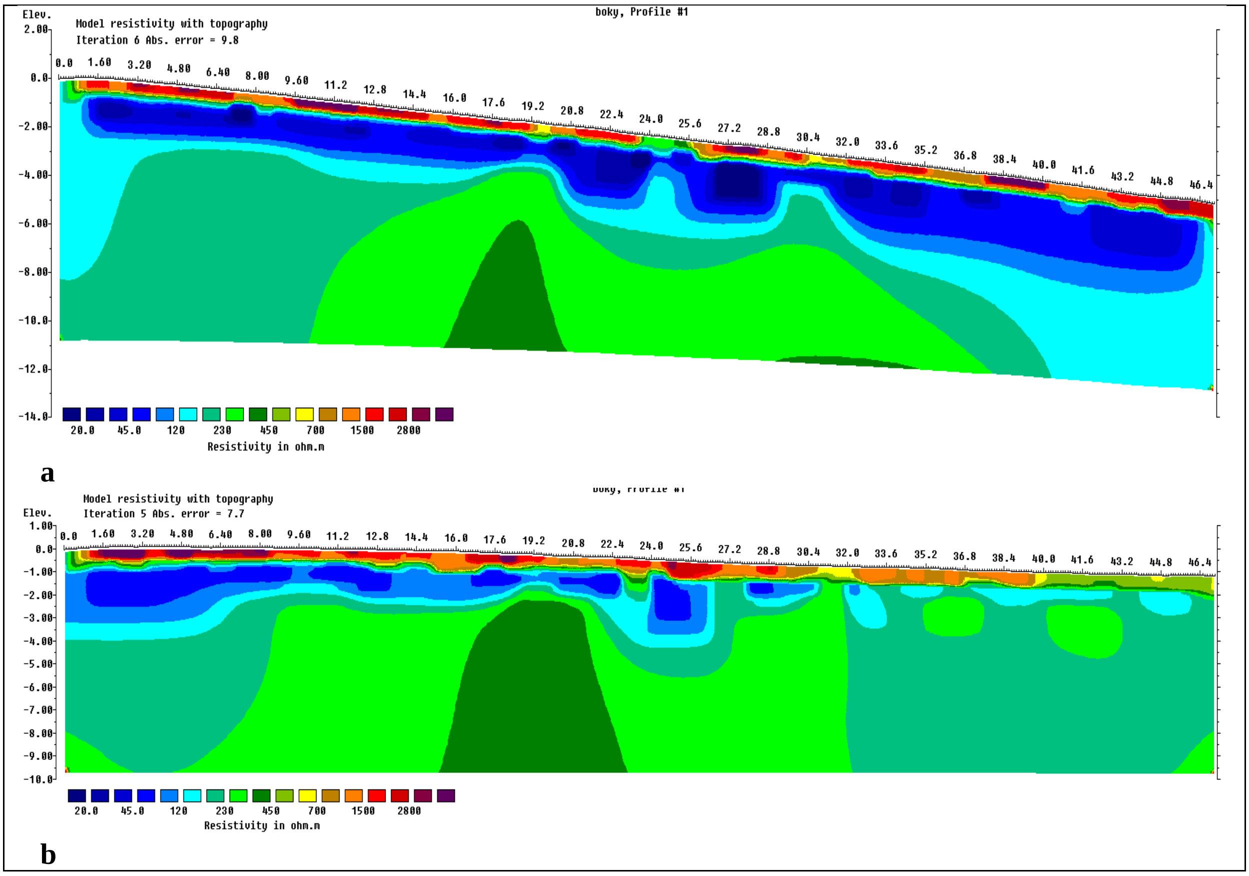


Figure 7: Soil electrical resistivity (Ohm. m) images at plot Budca-Boky; 0 m position is located at edge of the mud pit where animals use it for cooling; the highest animals disturbance appears at first 3 m, and then gradually disappear when we are getting farther from the center (mud pit); (a) electrical resistivity section from the edge of mud pit along the slope and (b) line from the edge along non-slope section.

Subsurface image of the (Fig. 7a) shows that horizontally homogenous, high valued electrical resistivity along all the section (from high disturbed till undisturbed). Reference [3] mentioned that differences between two sites (undisturbed and breeding area) according to all soil properties such as (compaction and bulk density, saturation capacity, fine soil,..etc) were significant, except for electrical conductivity. Similarly, [7] found that three grazing treatments in terms of electrical conductivity were similar, as well [4] found that no differences between grazing treatments. However, on the other hand, Figure 7b laterally is heterogeneous in terms of resistivity values, from the edge (0 m in the direction of 47 m) appears high, medium, and low resistivity tones, respectively. The result of Figure 7b correspond well with our expectation that higher animals disturbance could have higher resistivity which resulting due to compaction of the soil caused by animals trampling.

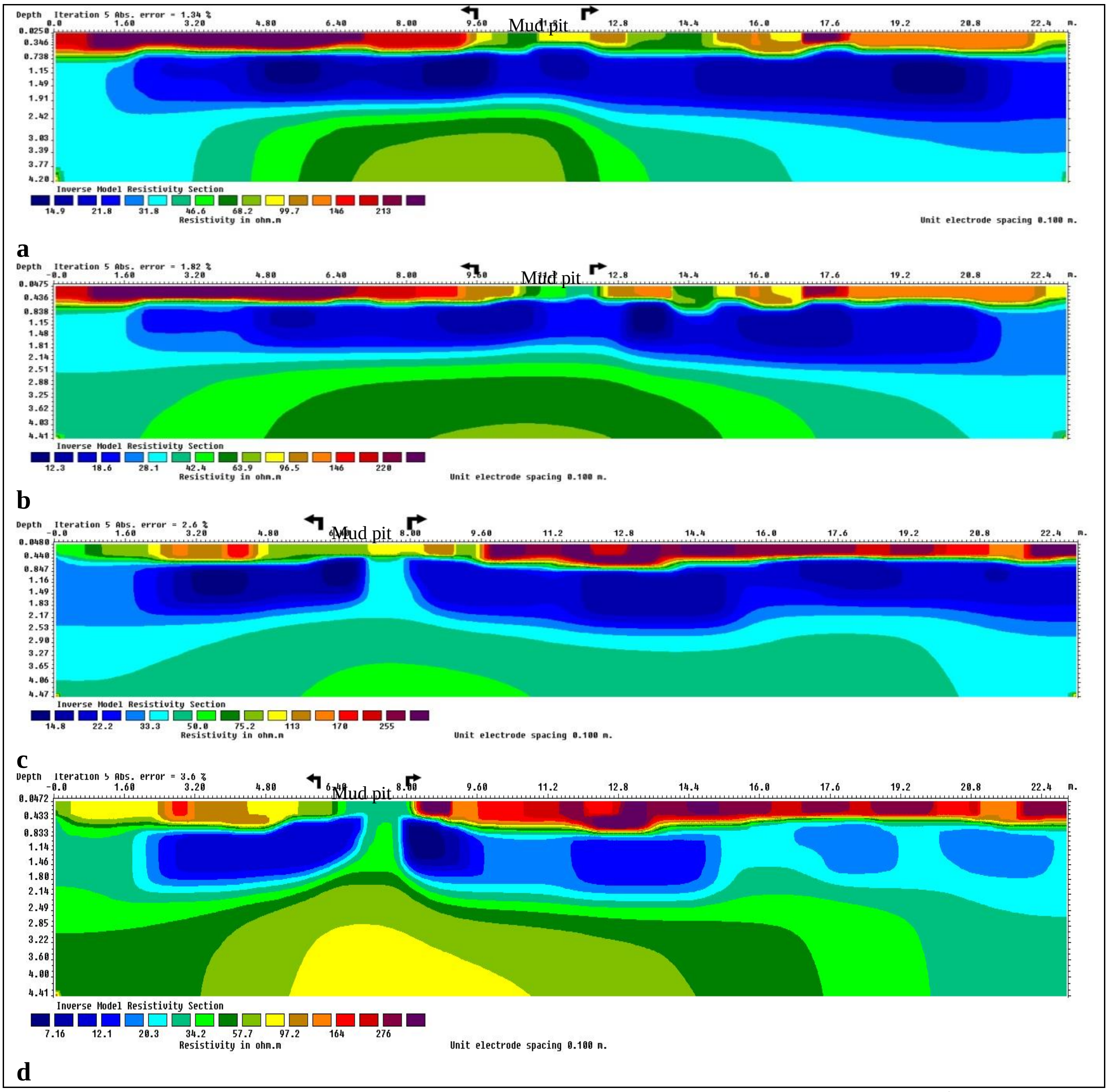


Figure 8: Soil electrical resistivity (Ohm. m) images had taken in plot Iviny; the distance between arrows is hole of mud pit; arrows show directions of animal disturbance; (a) electrical resistivity image across slope and at the edge of the pit, (b) across slope and through the pit, (c) along slope and at the edge of the pit, and (d) along slope and through the pit. The left arrows of profiles **a** and **b** show the direction of more open space with some big trees, while the right arrows show the direction of intensive young trees; arrows of profiles **c** and **d** show the opposite of **a** and **b**.

Electrical resistivity of the mud pit (Fig. 8) is relatively higher when the electrodes were mounted on the edge of the pit (Figs.8a and 8c) than mounted directly through the pit (where the soil is fully saturated) (Figs. 8b and 8c). Electrical resistivity of soils is known to depend on moisture status of the soil. Reference [5] reported that soil resistivity depends type on soil, soil texture (clay content in particular), and water holding capacity. In geotechnical field, more dry density increases soil resistivity and reduces soil water content [1].

Obviously, the sections of more open space with big trees have a higher electrical resistivity values than other sections with the young and intensive trees. Animals usually after cooling in a mud pit they look for some big tree trunks to scrabble their bodies and/or to scratch tree trunks by antlers in case of deer.

IV. CONCLUSION

We have Applied Electrical resistivity tomography method in order to confirm our expectations that large ungulates trampling could affect subsurface of soil, because electrical resistivity has the ability to capture and visualize the impact of wild ungulates and can be used in other different fields. Ungulates have clear impact on subsurface of soil in terms of compaction.

Our results demonstrate that highly disturbed plot sites have a higher electrical resistivity values (tones) than undisturbed sites and vice-versa, as ERT method revealed. Therefore, electrical resistivity tomography method is useful tool for identifying animal impacts on soils in terms of compaction. To supplement these findings, additional studies are suggested relative to the determination of an optimal number of animals can be kept in breeding area or pasture.

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