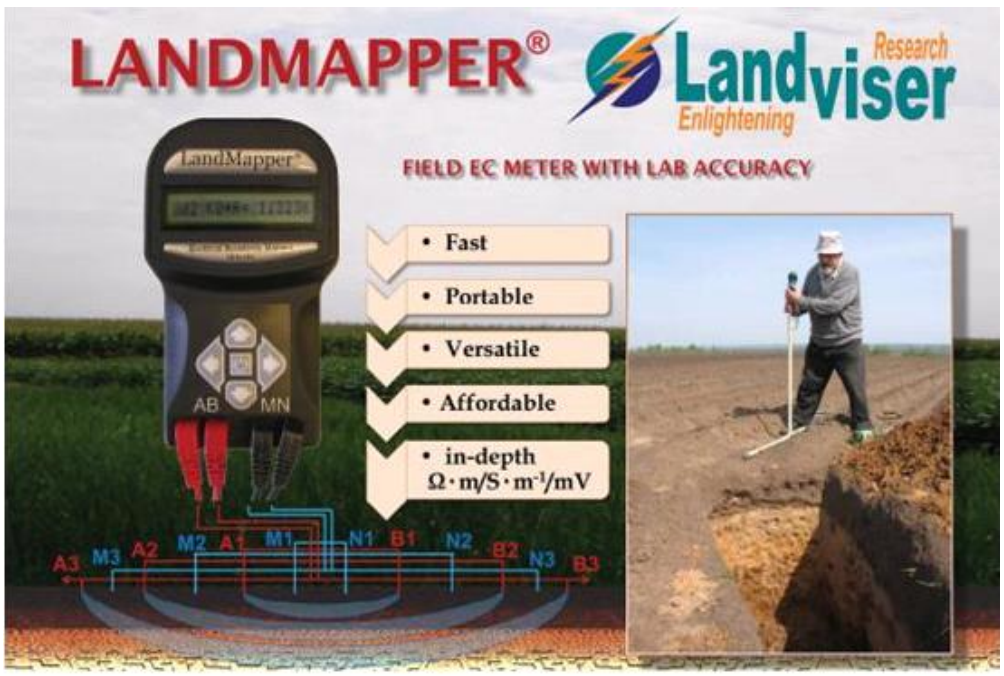
Applications of LandMapper handheld for near-surface soil surveys and beyond

On-the-go sensors, designed to measure soil electrical resistivity (ER) or electrical conductivity (EC) are vital for faster non-destructive soil mapping in precision agriculture, civil and environmental engineering, archaeology and other near-surface applications. Compared with electromagnetic methods and ground penetrating radar, methods of EC/ER measured with direct current and four-electrode probe have fewer limitations and were successfully applied on clayish and saline soils as well as on highly resistive stony and sandy soils. However, commercially available contact devices, which utilize a four-electrode principle, are bulky, very expensive, and can be used only on fallow fields. Multi-electrode ER-imaging systems applied in deep geophysical explorations are heavy, cumbersome and their use is usually cost-prohibited in many near-surface applications, such as forestry, archaeology, environmental site assessment and cleanup, and in agricultural surveys on farms growing perennial horticultural crops, vegetables, or turf-grass. In such applications there is a need for accurate, portable, low-cost device to quickly check resistivity of the ground on-a-spot, especially on the sites non-accessible with heavy machinery.

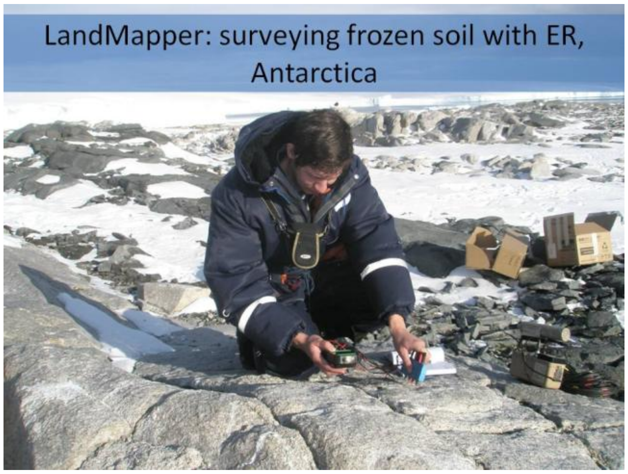
Four-electrode principle of EC/ER measurements



Our equipment utilizes well-known four-electrode principle to measure electrical resistivity or conductivity, as shown in the figure. LandMapper® measures potential difference ($\Delta\varphi$), which arises between two electrodes (M and N), when electrical current (*I*) is applied to other two electrodes (A and B). The increase of the distance among four electrodes in a set allows measuring resistivity of deeper layers, f.e. probe of A2M2N2B2 reaches deeper than A1M1N1B1. In theory, electrical resistivity (*ER*) of a material is defined as follows: $ER = \frac{A\Delta\varphi}{LI}$

where *L* is the length of a uniform conductor with a cross-sectional area *A*. A/L is a geometrical coefficient (K), which is easily calculated for different in-situ electrode arrangements and laboratory conductivity cells. LandMapper® calculates electrical resistivity using formula: $ER = K\frac{\Delta\varphi}{I}$. The direct digital output of the device is electrical resistivity in Ohm m. Those can be converted automatically in electrical conductivity (S/m) inside LandMapper® ERM-02 by using reciprocal of the measured resistivity: $EC = \frac{1}{ER}$. Thus, the measured results may as well be presented in convenient for Canadian soil scientists form of soil electrical conductivity (EC), which is routinely used to evaluate salinity of soils and irrigation water. However, EC can be used in many more applications than just soil salinity! Also ERM-02 can output natural electrical potential (EP) of soil and plants, which has some specific applications (*over*).

Applications of EC/ER technology in soil studies



Mapping of soil properties highly influencing density of mobile electrical charges (measured EC/ER strongly correlates with those properties *in-situ*):

1. Soil salinity
2. Soil texture (i.e. silt, sand and clay contents, working formula needs to be developed)
3. Coarse fragment content and depth to bedrock
4. Depth to limiting layers like clay and plough pan (wastewater - leaching fields)
5. Groundwater depth - capillary rise extent in profile
6. Correlations between soil EC maps and yield maps for many crops were established
7. Depth and extent of permafrost.
8. Pollution detection - depth and limits (pollution during oil and gas mining, for example)
9. Location and stability of karsts and carbonate sink holes.
10. Mapping of soil disturbance and search for hidden objects (drainage pipes, urban underground communications, forensic and archaeological applications).
11. Estimating depth of peat deposits during prospecting and locating methane accumulations in natural bogs and swamps.

Monitoring processes where only one soil properties changes:

12. Soil water content changes
13. Monitoring fertilizer uptake and other solute transport in soils (f.e. during phytoremediation)
14. Monitoring of freezing-melting processes in soil
15. Mapping and monitoring leakage from the retention ponds and sewage ponds, and underground oil storage tanks.

Applications in **soil genesis** studies. Majority of Canadian soils developed under downward leaching and typically feature the elluvial horizon with very high resistivity.

16. The thickness of horizons, the degree of eluviations and soil profile organization can be evaluated either without digging soil pits or by quick checking EC on the walls of soil pits.
17. Measuring of soil vertical and horizontal anisotropy non-destructively.

Special **applications beyond soil** studies:

18. Forestry – in addition to evaluating all important soil properties of forest soils, monitoring ER of a growing tree can indicate wood quality and if plant is stressed (also electrical potential is especially useful in plant health studies as non-penetrating electrodes can be mounted on surface of herbaceous plants).
19. Evaluating and monitoring stability of the roads (seasonal, gr avel, asphalt, on permafrost or landslides, etc.).
20. Measuring integrity of underground electrical cables and pipes (and soil corrosive properties).
21. Monitoring charge-recharge processes in membrane resins in water purification plants or consumer distillers.
22. ….?