Potential of machine learning in linking national airborne radiometric data to soil class mapping

Poster · January 2020

DOI: 10.13140/RG.2.2.28334.87362/1

6 authors, including:

Dave O'Leary
National University of Ireland, Galway
7 PUBLICATIONS **0** CITATIONS
SEE PROFILE

Pat Tuohy
TEAGASC - The Agriculture and Food Development Authority
28 PUBLICATIONS **90** CITATIONS
SEE PROFILE

Owen Fenton
TEAGASC - The Agriculture and Food Development Authority
213 PUBLICATIONS **2,361** CITATIONS
SEE PROFILE

Colin Brown
National University of Ireland, Galway
58 PUBLICATIONS **2,195** CITATIONS
SEE PROFILE

Potential of machine learning in linking national airborne radiometric data to soil class mapping

Dave O'Leary[1] (d.oleary1@nuigalway.ie), P. Touhy[2], P. Mellender[3], O. Fenton[3], C. Brown[1], E. Daly[1]

[1] *Earth and Ocean Science, Ryan Institute GIS centre, School of Natural Sciences, National University of Ireland Galway, Co. Galway,*
[2] *Teagasc, AGRIC, Moorepark, Fermoy, Co. Cork,* [3] Teagasc, Johnstown Castle, Co. Wexford.

Introduction:

Accurate maps of soil types at the field scale are required for many environmental and planning applications, from land use management and precision agriculture to drainage schemes and infrastructure development.

The thematic mapping of soil traditionally has been done using in-situ point sample measurements by a core or auger system (Zhang, 2017). The operator then follows a standardised classification system to place the soil sample into groups defined by the national soil classification system This method is slow, costly and subjective depending on the experience of the operator. It is difficult to create maps from point classifications as boundary conditions are rarely sampled.

More recently, the Irish Soil Information System (Irish SIS) used environmental co-variates (temperature, climate, elevation, slope etc.) alongside auger data and historical soil maps to create a national soil map to a scale of 1:250,000 (Creamer, 2018). . This however lacks the resolution at field scale and provide only a probability of any one soil group being present at any point location.

Geophysics has the potential to bridge this scale gap by using national airborne datasets combined with high resolution ground surveys (Binley, 2015). This poster highlights a potential methodology using a national airborne radiometric dataset, currently being acquired in the Republic of Ireland, with machine learning classification techniques to map soil within the Great Group classification (See Soils in Ireland Panel) in the Irish SIS.

Machine Learning Data selection and Methodology:

Figure: Dunleer ACP site with mapped soil class (Teagasc)

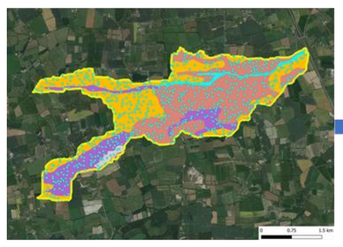


Figure: Garryduff bog site with mapped soil class

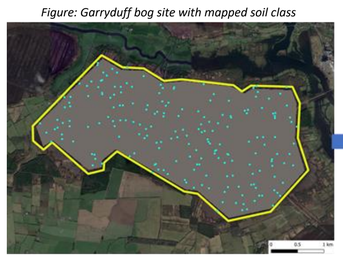
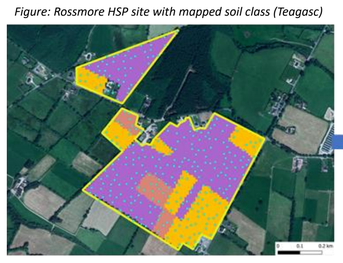
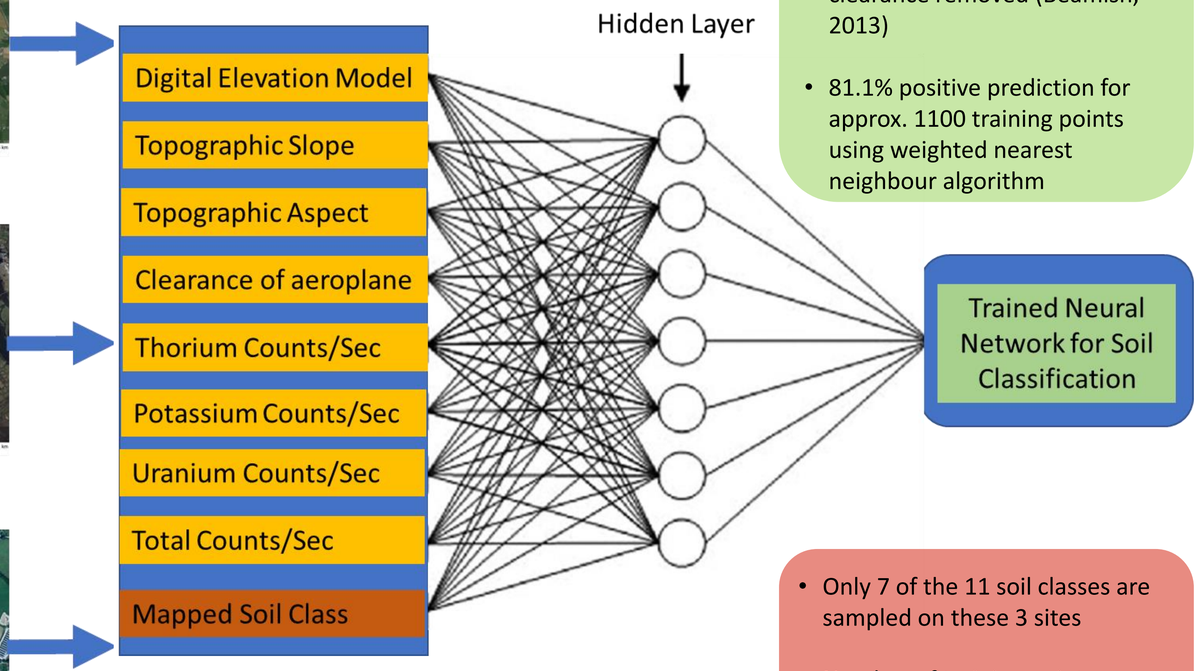


Figure: Rossmore HSP site with mapped soil class (Teagasc)





- Random training points chosen within mapped areas
- Data acquired above 180m clearance removed (Beamish, 2013)
- 81.1% positive prediction for approx. 1100 training points using weighted nearest neighbour algorithm

- Only 7 of the 11 soil classes are sampled on these 3 sites
- Number of training points per soil class are low and not evenly distributed

Application of Trained Neural Network for Soil Classification:

Figure: Dunleer Catchment Scale Neural Network Predicted Soils

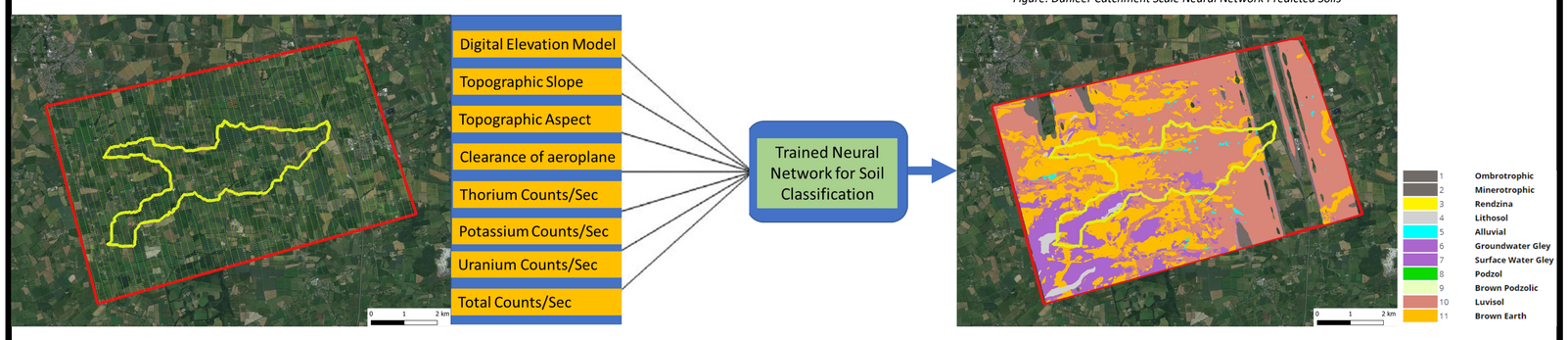


Figure: Garryduff Peat bog Scale Neural Network Predicted Soils

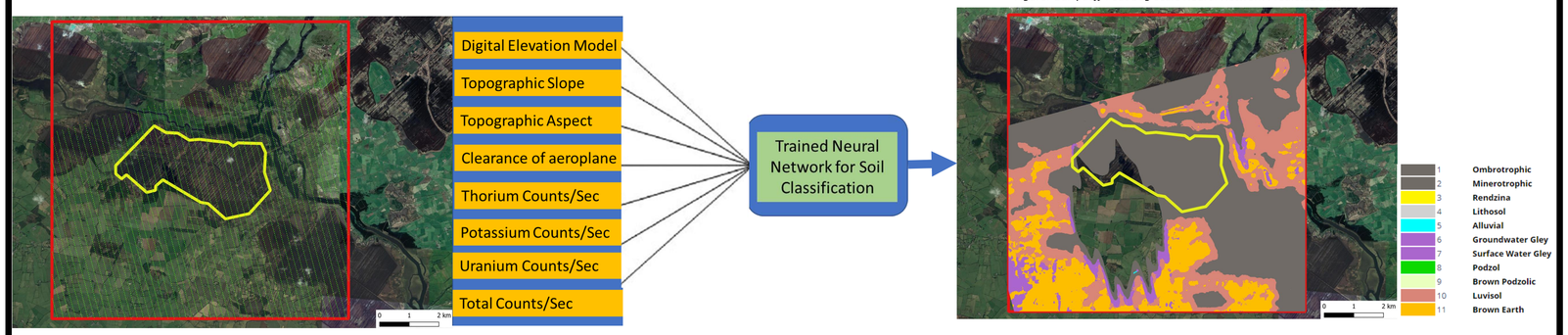
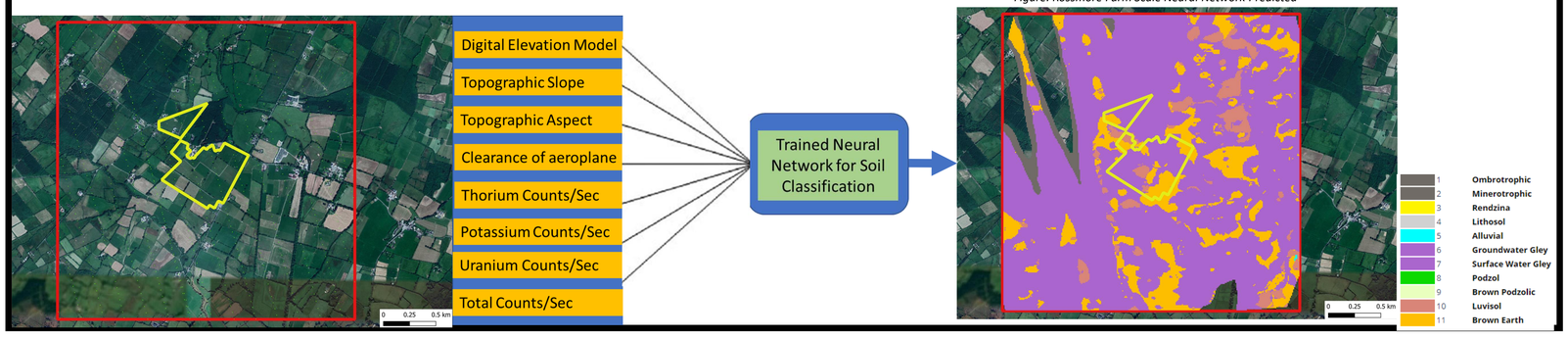


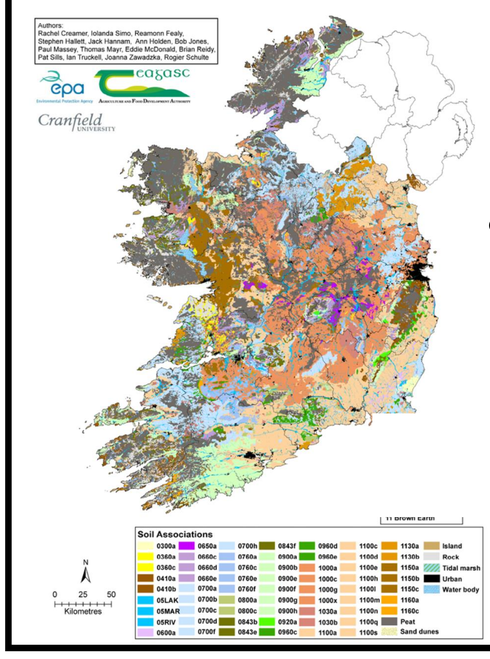
Figure: Rossmore Farm Scale Neural Network Predicted



Future work:

- More data is needed in order to better train the neural networks. Access to all ACP and HSP sites will aid in this training
- Complete ground truth on both farm and catchment scale is planned using a recently funded CMD Mini-Explorer, similar to work completed by Brogi, 2019
- Test the application of un-supervised classification (Self Organising Maps etc.)

Soils in Ireland:



Irish Soil Information System defines soils in Ireland into:

11 Great Groups (Common Soil forming conditions)
67 Subgroups (sub division of great groups)
213 Series (within a subgroup with similar horizons)

58 Associations (for mapping)
Groups of soils that commonly occur together in the landscape.
Cannot be used to describe soils in an exact location

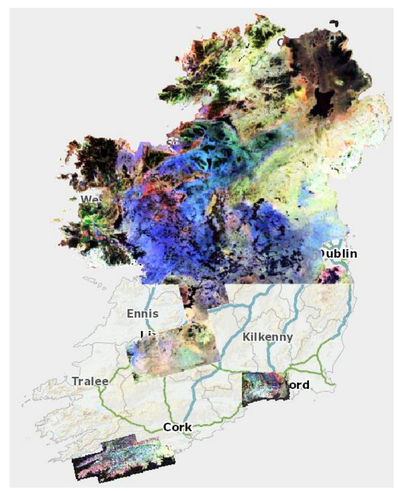
Great Soil Groups

1 Ombrotrophic peat
2 Minerotrophic peat
3 Rendzina
4 Lithosol
5 Alluvial
6 Groundwater Gley
7 Surface-water Gley
8 Podzol
9 Brown Podzolic
10 Luvisol
11 Brown Earth

National Airborne Survey:

- The Tellus Survey (GSI) is a national airborne geophysical survey
- The data that it collects included Airborne Electromagnetic, Magnetic and Radiometric data
- The Radiometric data is collected approx. every 60m along a flight line and lines are spaced 200m apart
- Radiometric surveys collect gamma radioactive decay for Thorium, Potassium and Uranium in counts per second

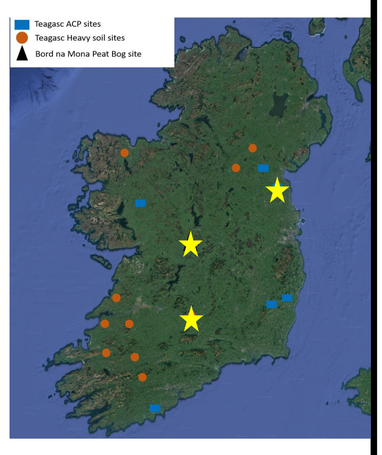
Figure: Radiometirc Ternary image from GSI showing national coverage . Red = Potassium, Green = Thorium, Blue = Uranium



Test site locations:

- The Irish Food and Agricultural Authority (Teagasc) operates a variety of field/farm programmes at several scales
- These are the Agricultural Catchment Programme (ACP) at 100's of hectares and the Heavy Soils Programme (HSP) at 10's of hectares
- One ACP (Dunleer Catchment) and one HSP (Rossmore Farm) are used in this initial study
- A third site, Garryduff, a raised peat bog operated by Bord ná Mona was also used

Figure: Map of Ireland with Teagasc ACP and HSP site locations marked. Test site locations are highlighted



Initial Ground truth:

- In September 2019, fieldwork was undertaken to determine if electrical geophysical methods could be used to identify soil types at the great group level at the Rossmore HSP site
- Electrical resistivity tomography was performed using a Dipole-Dipole array with electrode spacing of 1m, using a roll along method, for total final line length of 111m

Figure: Rossmore Farm with mapped soils and ERT Line

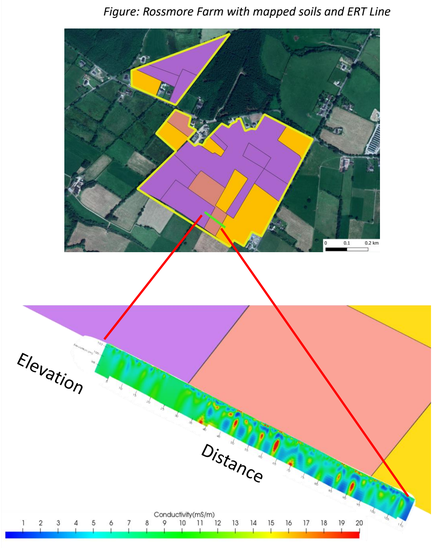
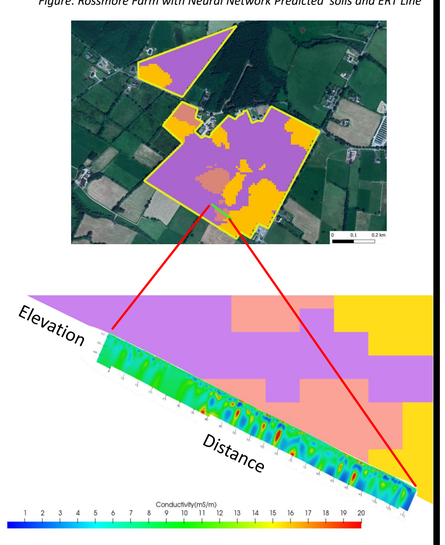


Figure: Rossmore Farm with Neural Network Predicted soils and ERT Line



- The predicted soil classes better match the ERT data
- The boundary on the left is moved closer to an obvious change within the ERT data
- Similarly on the right the boundary is moved closer to a potential boundary in the ERT data.

References:

Beamish, D., 2013, Gamma ray attenuation in the soils of Northern Ireland, with special reference to peat: Journal of Environmental Radioactivity, v. 115, p. 13-27.
Binley, A., S. Hubbard, J. Huisman, A. Revil, D. Robinson, K. Singha and L. Slater (2015). "The emergence of hydrogeophysics for improved understanding of subsurface processes over multiple scales." Water Resources Research 51(6): 3837-3866.
Brogi, C., J. A. Huisman, S. Patzold, C. von Hebel, L. Weihermuller, M. S. Kaufmann, J. van der Kruk and H. Vereecken (2019). "Large-scale soil mapping using multi-configuration EMI and supervised image classification." Geoderma 335: 133-148.
Creamer, R., and L. O'Sullivan, 2018, The Soils of Ireland: Cham, Springer International Publishing, Cham.
Geological Survey, I. (2019). "Tellus." from https://www.gsi.ie/en-ie/programmes-and-projects/tellus/Pages/default.aspx.
Teagasc. (2017). "Agricultural Catchments." from https://www.teagasc.ie/environment/water-quality/agricultural-catchments/.
Teagasc. (2017). "Heavy Soils Programme." from https://www.teagasc.ie/crops/grassland/heavy-soils/.
Zhang, G. L., F. Liu, and X. D. Song, 2017, Recent progress and future prospect of digital soil mapping: A review: Journal of Integrative Agriculture, v. 16, p. 2871-2885.

Acknowledgements:
The PhD project is fully funded by the Irish Research Council
The authors wish to thank the landowner at Rossmore farm for allowing access to their land during fieldwork

Software used: GIS Software – QGIS
Surface creator – Surfer
ERT Inversion – ResIPy + R2
Data reformat and Machine Learning – Matlab 2019a