Digital soil mapping of the probability of iron pan occurrence in sandy podzols of South-West France

Anne C Richer-De-Forges, Nicolas N. Saby, Dominique D. Arrouays

▶ **To cite this version:**

Anne C Richer-De-Forges, Nicolas N. Saby, Dominique D. Arrouays. Digital soil mapping of the probability of iron pan occurrence in sandy podzols of South-West France. 6. Global Workshop on Digital Soil Mapping, Nov 2014, Nanjing, China. 2014. hal-02738770

HAL Id: hal-02738770

https://hal.inrae.fr/hal-02738770

Submitted on 2 Jun 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

DIGITAL SOIL MAPPING OF THE PROBABILITY OF IRON PAN OCCURRENCE IN SANDY PODZOLS OF SOUTH-WEST FRANCE

RICHER de FORGES A.C, SABY N.P.A., ARROUAYS D.

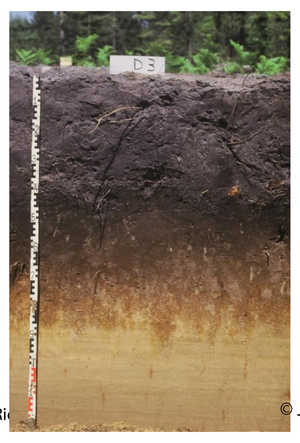
INRA, Unité InfoSol, US 1106, CS 40001 Ardon, Orléans cedex 2, France
anne.richer-de-forges@orleans.inra.fr

INTRODUCTION

The presence of iron pan limits rooting depth thus affecting available water content for plants and vulnerability of trees to storms. In some cases it may also limit the water infiltration rate and cause anaerobic conditions. The study was carried out in a region covering more than 1,150,200 ha in southwestern France: the region '*des Landes de Gascogne*'. This region is mainly covered by sandy PODZOLS containing an iron pan, called 'alios', which is generally not continuous. Iron pan is geographically distributed as little patches in the landscape, which makes its mapping difficult. Moreover, constraints about accessibility strongly limit the number and the density of field observations that can be performed. Therefore, we tested the potential of a road-side survey sampling and subsequent digital soil mapping techniques to map the probability of iron pan occurrence at a regional level.

Picture 1: podzol with alios

Picture 2: local microrelief



Picture 3: podzol without alios

MATERIAL & METHODS

STUDY AREA

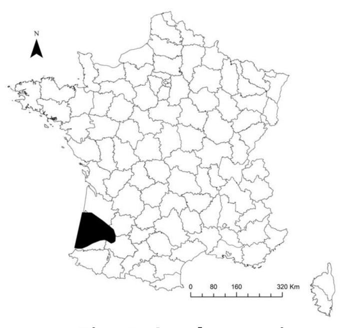


Fig. 1: Study area in 'Landes de Gascogne' (France)

The study area was located in southwestern France approximately between 43.3 and 44.5°N and 1.45°W to 0.10°E (Fig. 1). The 'Landes de Gascogne' is a nearly flat plain with elevation ranging from 0 to 256 m above sea level and slopes generally less than 0.5% (Fig. 2). The region receives about 900 mm year^{-1} of rain, and has a mean annual temperature of 12.7°C. The parent material of the soils is known as '*sables des Landes*', which originated from tertiary fluvial alluviums that were spread by successive wind erosion periods during the Pleistocene. The soils that developed from this parent material are mainly PODZOLS.

Some of these PODZOLS are characterized by the presence of a very hard iron pan, cemented by organic compounds and Al and Fe oxydes (Picture 1). The profile development is directly related to the seasonal variations of the water table. The depth and seasonal variations of the water table are mainly controlled by:

i) the distance and relative height to small valleys,
ii) an eolian micro-relief mainly consisting of a succession of low ridges and shallow troughs, ranging from about 0.30 to 1.50 m high and 10-50 m wide (Picture 2).

DATA

Field observations included 4,102 auger borings and 286 soil pits, corresponding to a mean sampling density of 0.38 observation per km². The sampling strategy corresponded mainly to a road-side survey. The presence/absence of an iron pan was registered. We transformed this information into a dummy variable (0 = soil without alios ; 1 = soil with alios). The geographical coordinates of each sampling site were recorded with an average precision of $\pm$ 5 m.

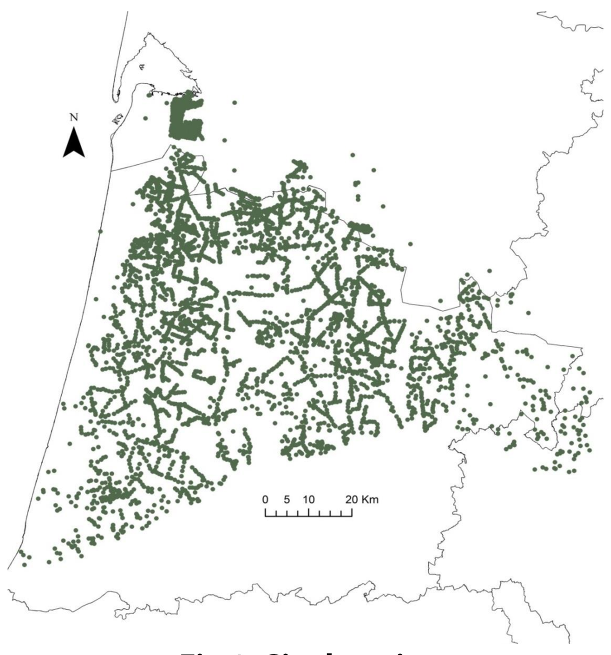


Fig.3: Site locations

We used the following co-variates :

- Classical relief attributes, as derived from a 25m resolution Digital Elevation Model:
  - Elevation (m)
  - Local slope angle (%)
  - Global curvature (curvm)
  - Horizontal curvature (curv-long)
  - Profile curvature (curv-trans)
  - Relative hydrological distance to the nearest river (m) (dppr) + mean values of dppr on 3 × 3 (dppr3_3), 7x7 (dppr7_7), 21x21 (dppr21_21) and 41x41 (dppr41_41) pixel windows
  - Relative height to the nearest river (m) (hppr)
- Corine Land Cover class (clc)

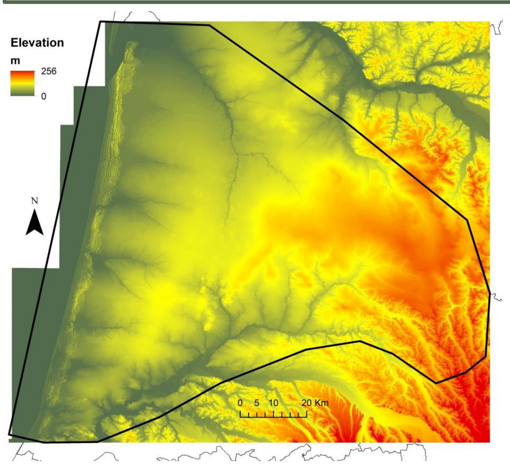


Fig. 2: elevation

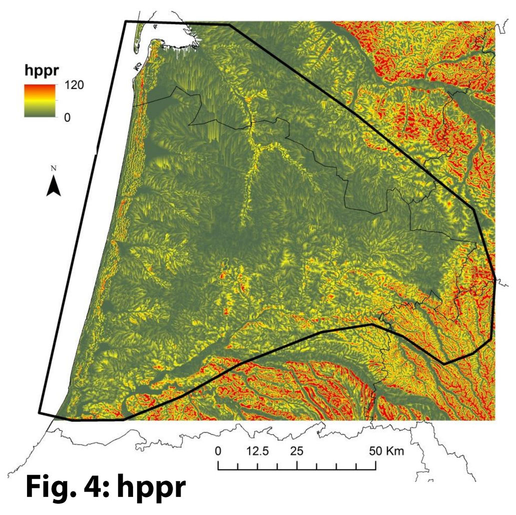


Fig. 4: hppr

MODELLING & VALIDATION

We mapped this key diagnostic soil property as proposed by Kempen *et al.* (2012). In order to map the probability of the presence of an iron pan, we calibrated a SCORPAN regression kriging model which combines a logistic regression and a variogram analysis of the residuals. Using the GSIF R package, regression-kriging model was fitted by using the fit.gstatModel function. This function runs also a stepwise selection step. Next, the probability of "presence" of the iron pan was predicted at the nodes of a grid with 250-m resolution. The map was validated with a 5-fold cross validation.

RESULTS

RELATIVE IMPORTANCE OF CO-VARIATES

The co-variates related to DEM derivatives were found the most significant for explaining the presence of iron pan (Tab. 1).

Tab. 1

	Estimate	Std.Error	z value	Pr(>|z|)	
hppr	-6.785e-02	1.073e-02	-6.321	2.60e-10	***
slope	-1.272e-01	2.935e-02	-4.333	1.47e-05	***
elevation	-4.124e-03	1.138e-03	-3.624	0.00029	***
dppr41_41	1.308e-03	2.398e-04	5.455	4.89e-08	***
clc (Forests of deciduous trees)	-1.115e+00	3.685e-01	-3.027	0.00247	**
dppr7_7	3.913e-04	1.690e-04	2.315	0.02059	*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*'

The purity of the map was 0.73.

VARIOGRAM

The variogram of the residuals exhibited a spatial structure as observed by the nugget and range (Fig. 5).

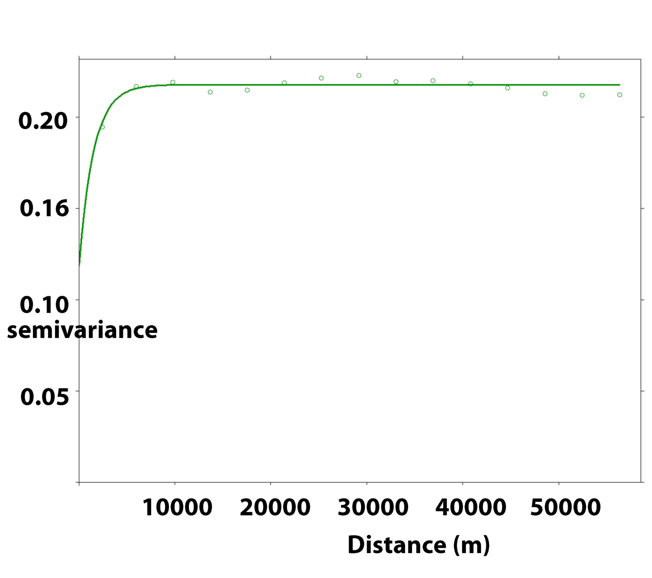


Fig. 5: variogram modelling

MAPPING

The fixed effect shows that iron pan occurrence is mainly located on rather flat areas, in interfluve position (Fig. 6). The map of the probability of iron pan occurrence (Fig. 7), shows large patches of iron pan that are not always corresponding to the fixed effect.

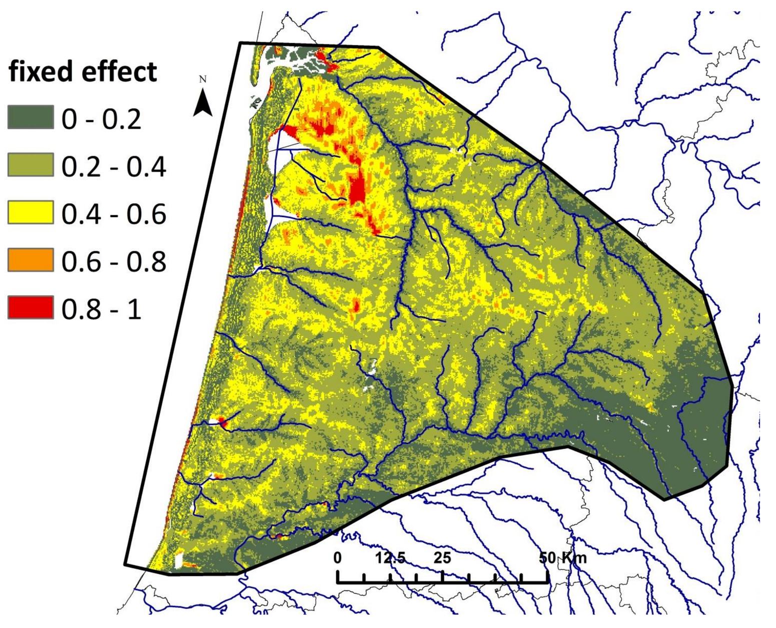


Fig. 6: fixed effect

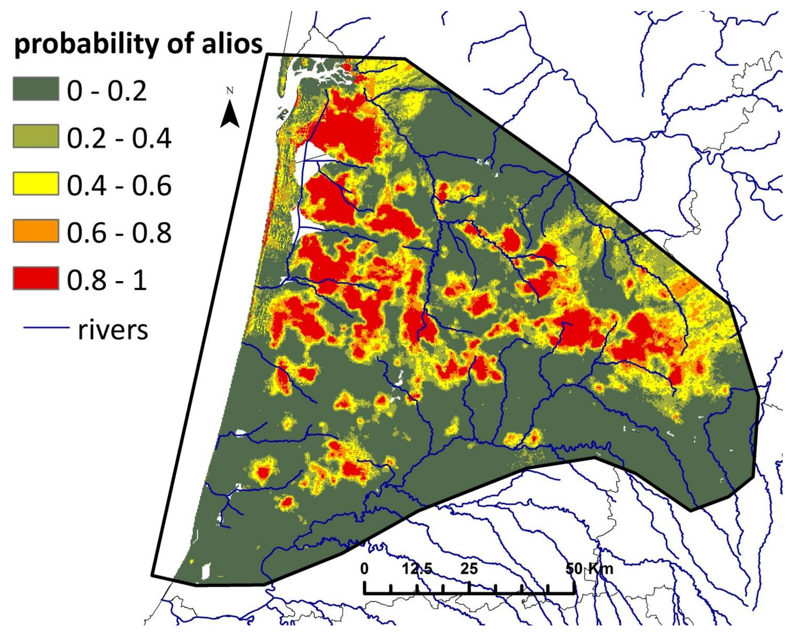


Fig. 7: probability of occurence

DISCUSSION

The final map of the probability of iron pan occurrence clearly shows that the fixed effect alone is not sufficient to map this diagnostic soil property. It suggests that the co-variates used did not allow to explain all the controlling factors of the occurrence of iron pan. This may be attributed to the fact that the resolution of the DEM we used is not precise enough to capture very local variations in the micro-relief. Moreover, the nugget effect suggests that very local variations may be encountered. However, our results demonstrate that gathering numerous field informations helps to provide a relevant regional map when combining logistic regression and geotatistical analysis of the residuals. Conversely, these results suggest that our mapping excercice may suffer from limitation related to the spatial coverage of the dataset. Indeed, in the less accessible areas where less intensive sampling was conducted we may have missed some patterns of iron pan "presence" or "absence".

CONCLUSION

The occurrence of iron pan was successfully mapped at a regional level. From a practical point of view this map could help regional planning for forestry and agriculture (e.g. choosing tree species for plantation, estimating irrigation needs of summer crop). Further work should be conducted including new potentially relevant co-variates and testing other modelling approaches to improve the prediction in this area. A next step will be the spatial prediction of the effective rooting depth as recommended by the *GlobalSoilMap* project (Arrouays *et al.*, 2014).

Arrouays D., Grundy M. G., Hartemink A. E., Hempel J. W., Heuvelink G.B.M., Hong S.Y., Lagacherie P., Lelyk, G., McBratney A. B., McKenzie, N. J. Mendonça-Santos M.D., Minasny B., Montanarella L., Odeh, I. O. A., Sanchez P. A., Thompson J. A., Zhang G. L. 2014. *GlobalSoilMap*: towards a fine-resolution global grid of soil properties. Advances in Agronomy, 125, 93-134.

Kempen, B.; Brus, D.J.; Vries, F. de; Engel, B. (2012) Updating legacy soil data for digital soil mapping. In Digital Soil Assement and beyond. Editors Minasny B., Malone B.P. & McBratney A.B. Taylor & Francis Group, 91-96 pp.

InfoSol unit
2163 Avenue de la Pomme de Pin
CS 40001 ARDON
45075 ORLEANS Cedex 2
France