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SOIL VULNERABILITY MAPS FOR PREDICTIVE PURPOSES IN DECISION MAKING PROCESSES FOR POST-ACCIDENT RECOVERY IN SPAIN

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Post-Emergency Situation

- Large areas of agricultural land may be affected by restrictions, due to accumulation of RN in soils → impact in the production and way of life of affected population
- For an adequate and realistic optimization of the protection, the design and planning of the recovery strategies → must take into account the LOCAL SPECIFICITY
- Fukushima accident has highlighted this need → the mapping of contamination and soil characteristics has helped to identify those areas with higher levels of soil-to-plant TF and where treatment with agricultural countermeasures is feasible and effective

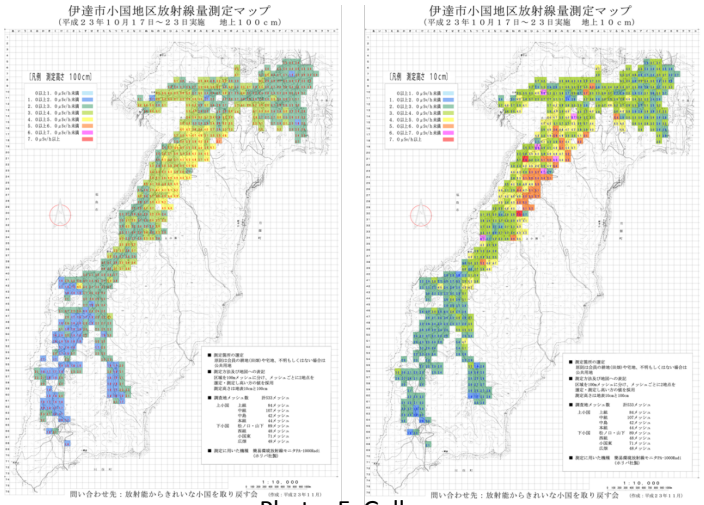
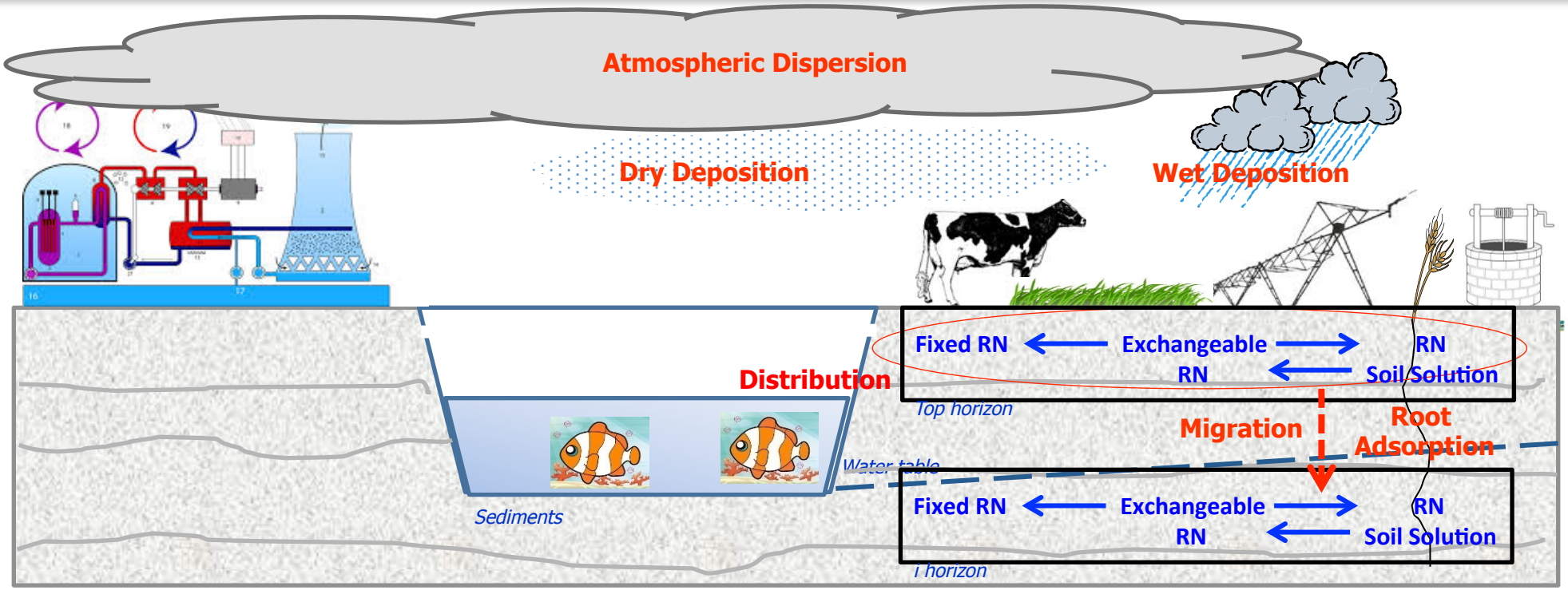


Photo: E. Gallego

Post-Emergency Situation: Local specificity



Information and site specific parameters:

- Behavior and fate of RN in soils
- Soil uses and agricultural practices
- Dietary habits of affected population

Different scales of local specificity: first step REGIONAL (within Europe)

No Chernobyl deposition on Spanish soils: the parameter values obtained from contaminated soils in Europe, were not sufficiently representative of our soils and climate:

Radiological Vulnerability of Spanish Soils in case of a Nuclear Accident

- Objective: to develop a methodology to asses the potentiality of Spanish soils, according to their specific properties, to transfer ^{137}Cs and ^{90}Sr to the population.

- Potentiality, defined as Radiological Vulnerability, allows the categorization of Spanish soils by means of indexes representing, qualitatively, the maximum to minimum transfer capacity, identifying the areas of most concern.

- Predictions help to prioritize rehabilitation areas, in the decision-making processes for post-accident recovery.

Radiological Vulnerability of Spanish Soils

Identification of soil processes of interest

- Infiltration (F)
- Water Retention (H)
- Physico-chemical retention (FQ)
- Nutrition Status (K, Ca)

Methodology Development

- Food Chain (FC)
- External Irradiation (EI)

Characterization of Spanish Soils

- Literature review of soil profiles
- Data compilation in a DB

Soil Vulnerability Indexes Estimation

- Spatial Distribution of Vulnerability Indexes

SOIL VULNERABILITY MAPS

General behavior of ^{137}Cs and ^{90}Sr in soils

Physical behavior

^{137}Cs and ^{90}Sr:

- Entrance with water
- Migration in soil solution

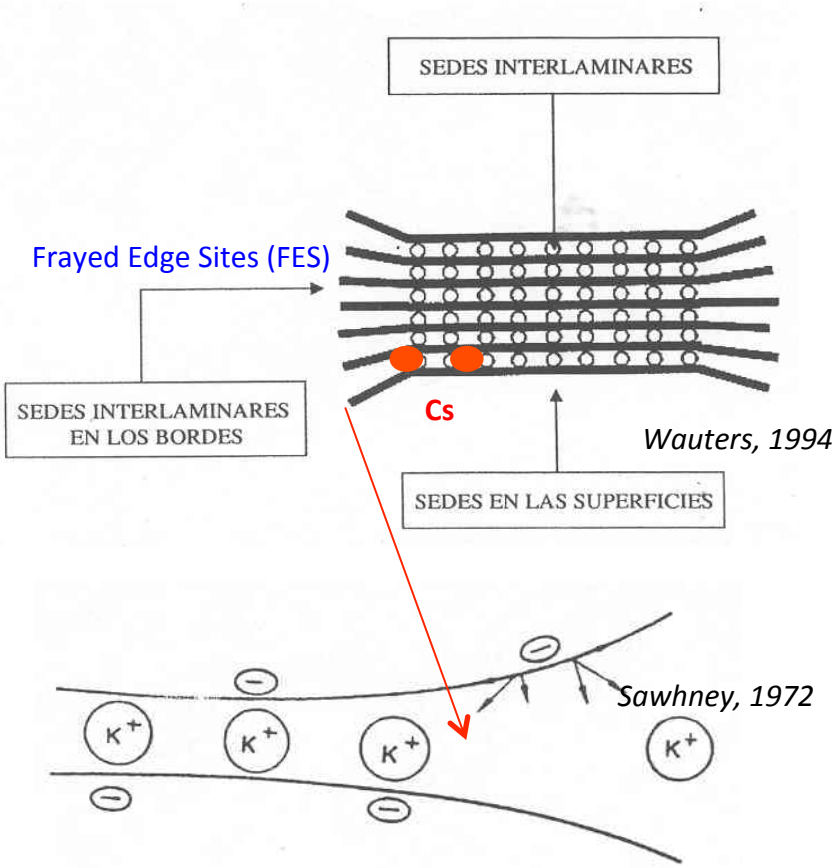
Physico-chemical behavior

^{137}Cs:

- Fixed in irreversible way when adsorbed in the selective, and small in number, frayed edge sites (FES) of micaceous clays (illite)
- Competes with K

^{90}Sr:

- Not fixed; takes part in exchangeable reactions
- pH conditions its solubility
- Competes with Ca



Wauters, 1994

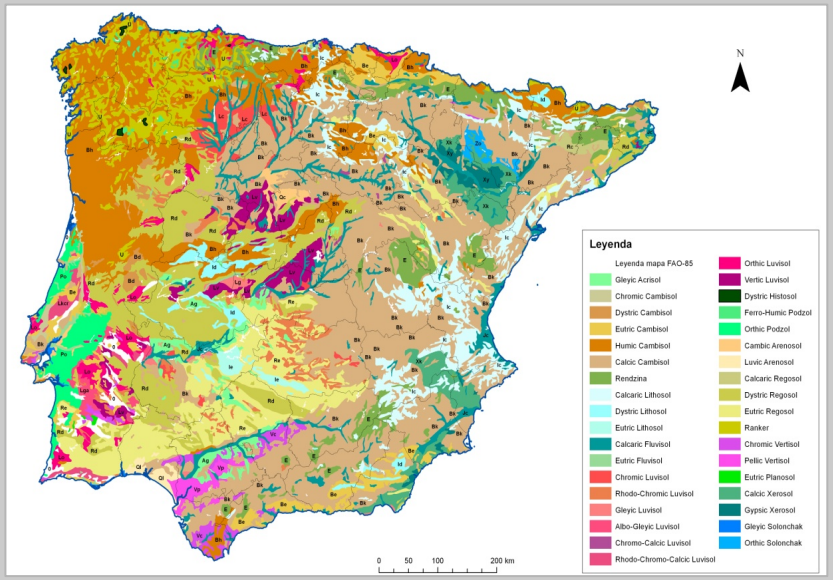
Sawhney, 1972

Methodology Development

Vulnerability Indexes for food-chain	IF_FC	IH_FC	IFQ_{Cs}_FC	IFQ_{Sr}_FC	IK_FC	ICa_FC
Soil processes	Infiltration rate	Water retention	Cs:Physico-chemical retention	Sr:Physico-chemical retention	K status	Ca status
Soil properties	Texture, Structure, Dominant clay type	Texture, Structure, Porosity, Water capacity	Texture, CEC clay	pH	Exch. K content	Exch. Ca content
Reference parameter 60 cm depth	F (mm/h) (top layer)	R (mm/cm)	CEC (cmol/kg)	pH	K (cmol/kg)	Ca (cmol/kg)
Minimum	F≤1,0	R≤2,0	Clay2:1 non exp	pH>7,5	K>1,00	Ca>10,0
Low	1,0<F≤5,0	2,0<R≤3,0	Clay 2:1 exp	6,5<pH≤7,5	0,50<K ≤1,00	5,0<Ca≤10,0
Medium	5,0<F≤20,0	3,0<R≤4,0	Clay 1:1	5,5<pH≤6,5	0,25<K ≤0,50	2,0<Ca≤5,0
High	20,0<F≤50,0	4,0<R≤5,0	Peat	4,5<pH≤5,5	0,10<K≤0,25	1,0<Ca≤2,0
Maximum	F>50,0	R>5,0	Sand	pH≤4,5	K≤0,1	Ca≤1,0

Maximum vulnerability: at higher infiltration rates and higher water retention, Cs: sandy soils (no fixation) and minimum K status / Sr: low pH and minimum Ca status

SPANISH SOIL PROFILE DATABASE



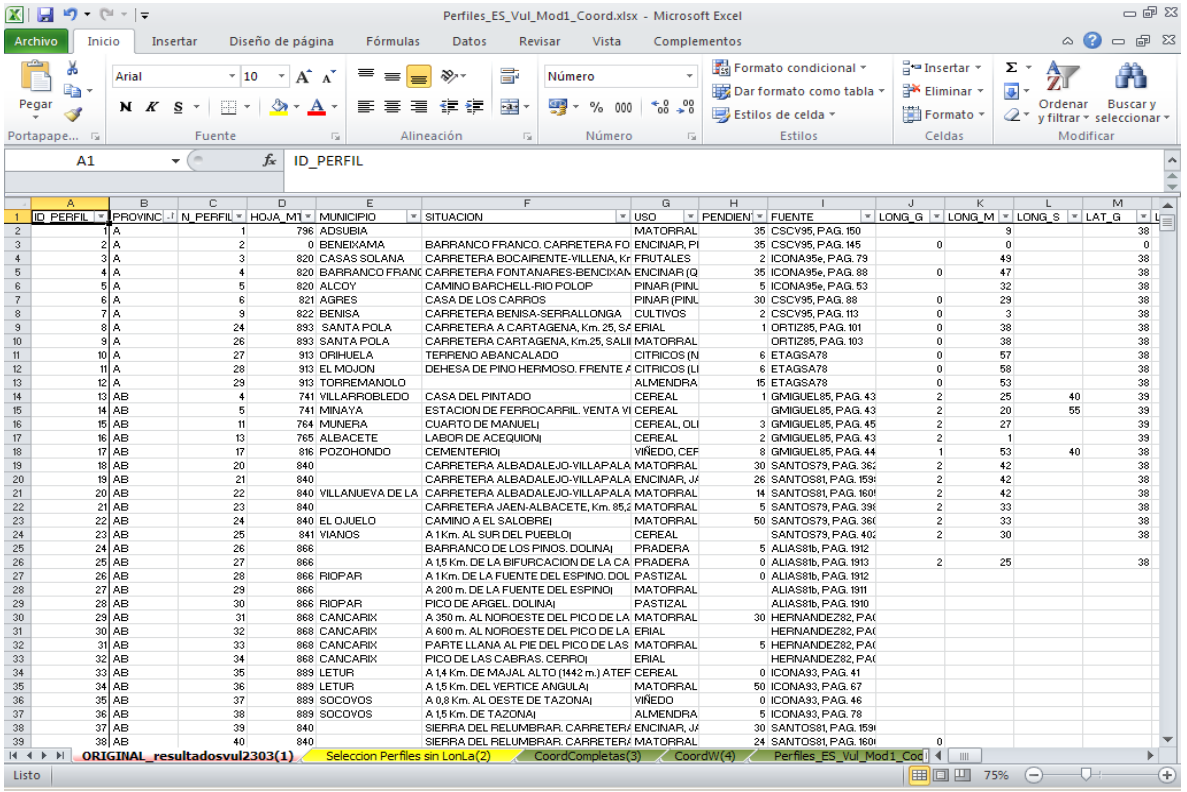
2014

2.177 SOIL PROFILES

↓

1.657 Complete for estimations

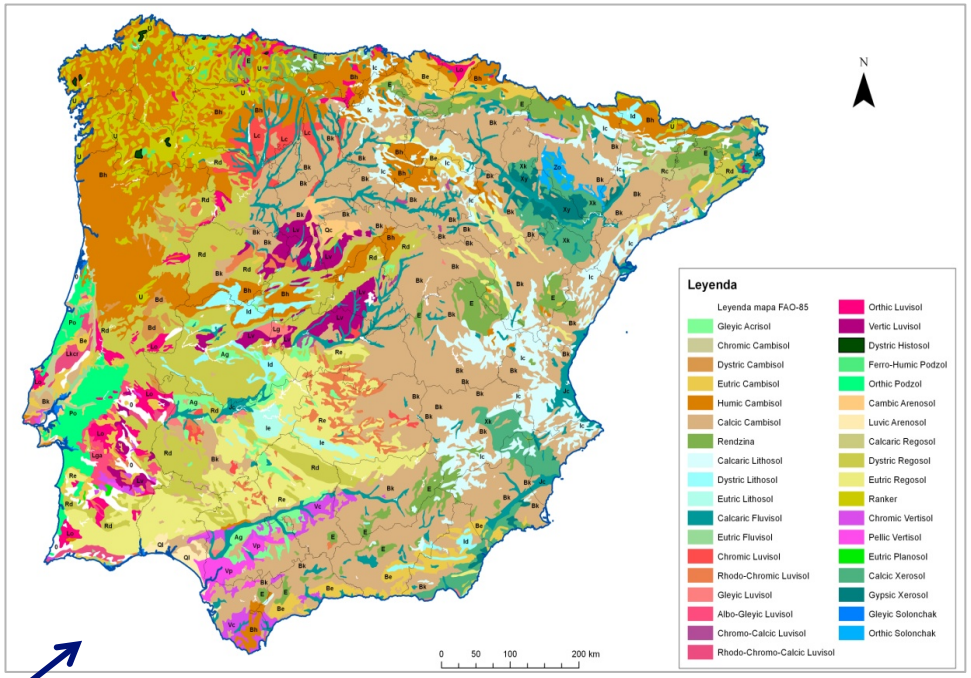
Literature review, data compilation and processing to standardize, units, coordinates, nomenclatures, ….



BASE MAP TO REPRESENT THE VULNERABILITY INDEXES

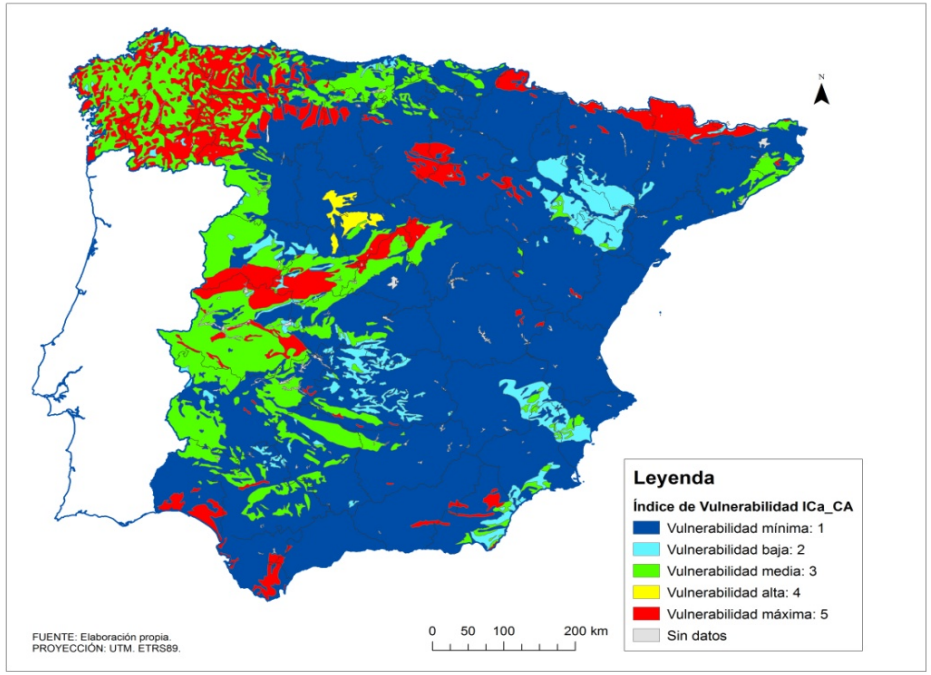
1ST EDITION:
Soil Map of the CEC (Commission of the European Communities, 1985), scale 1:1.000.000.

2ND EDITION:
Soil Geographical Data Base of Europe: **SGDBE v.3 (EC, 1995)**, scale 1:1.000.000



Spatial distribution based on the SMU (Soil map units) of SGDBE v.3

Results: Individual Vulnerability Maps



ICa_FC

Calcareous soils → min values

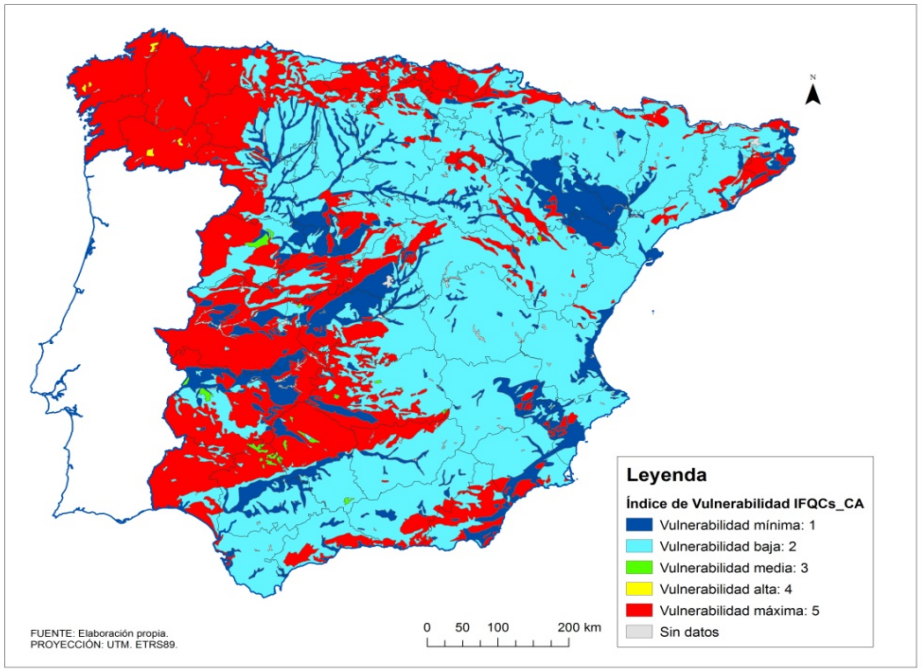
Acidic soils, with lower pH and Ca status → higher values

IFQ_{Cs}_FC

Clear difference between lithologies:

Acidic: coarse texture, Cs not fixed → max values

Calcareous: clayey texture, different type and percentage → min values

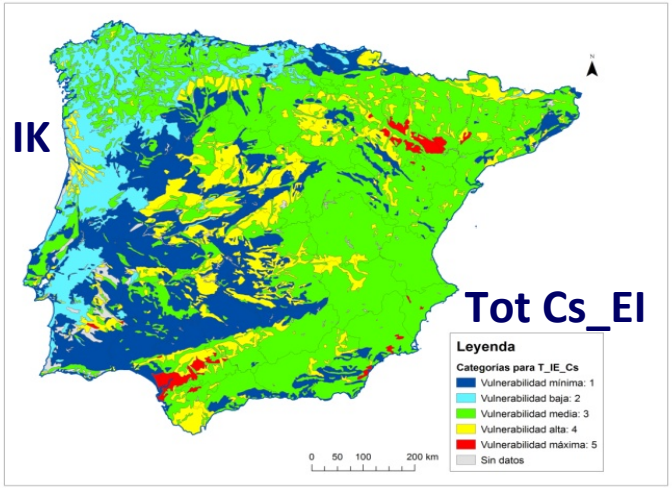


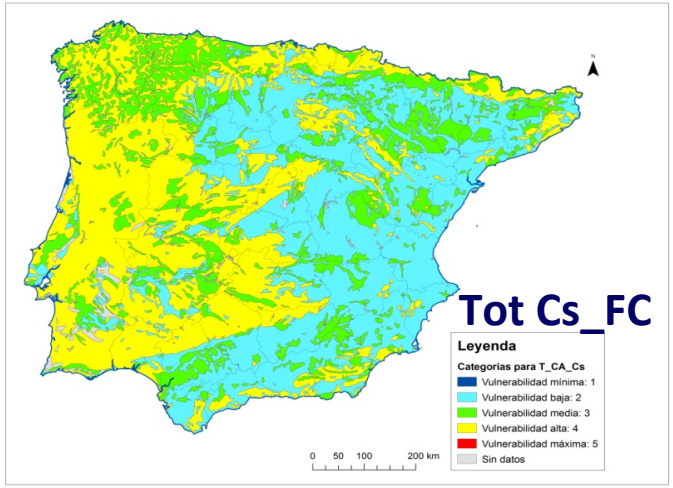
Results: Global Vulnerability Maps

GLOBAL VULNERABILITY MAPS: combination of individual indexes

Tot Cs_EI = IF + IH + IFQCs

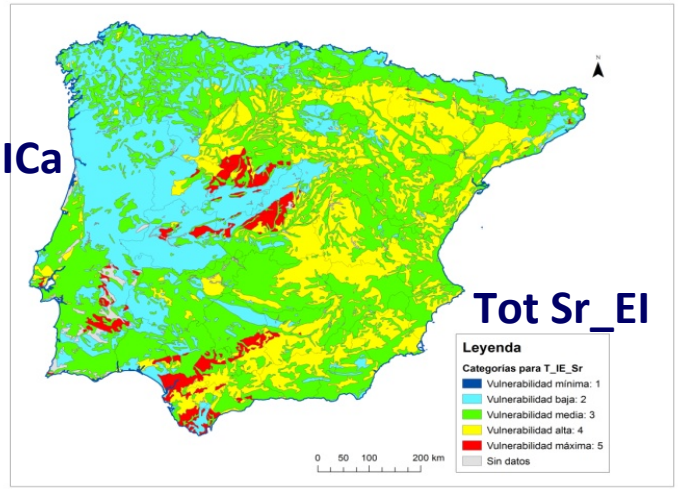
Tot Cs_FC = IF + IH + IFQCs + IK

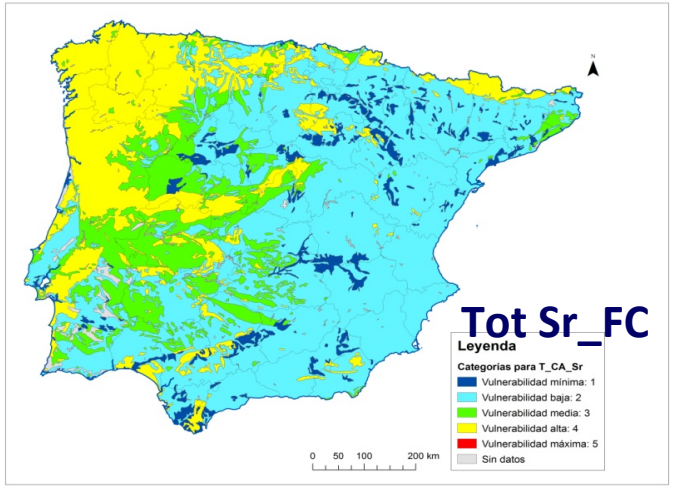




Tot Sr_EI = IF + IH + IFQSr

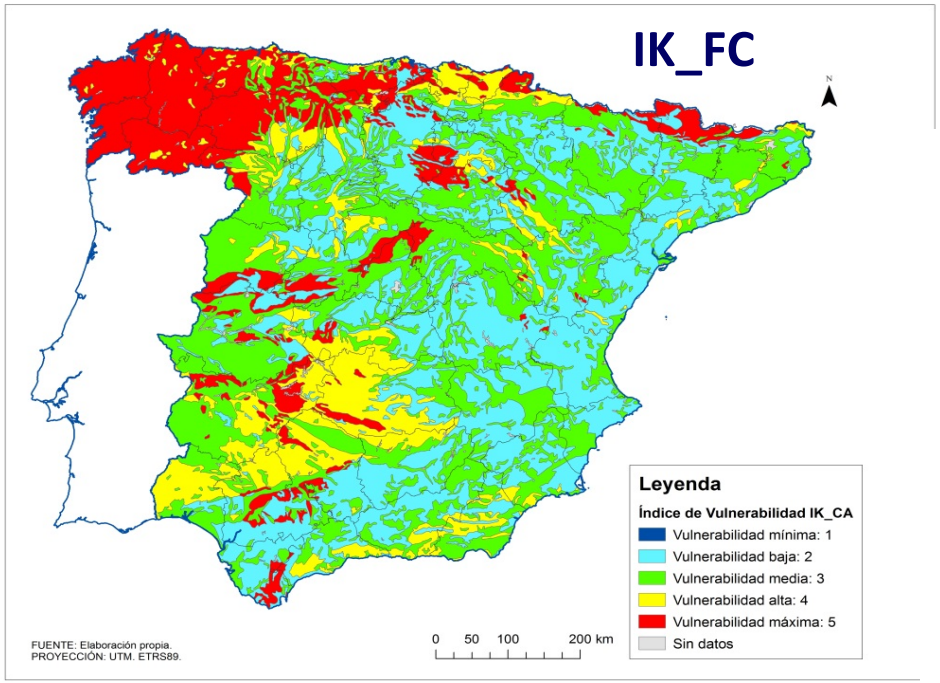
Tot Sr_FC = IF + IH + IFQSr + ICa

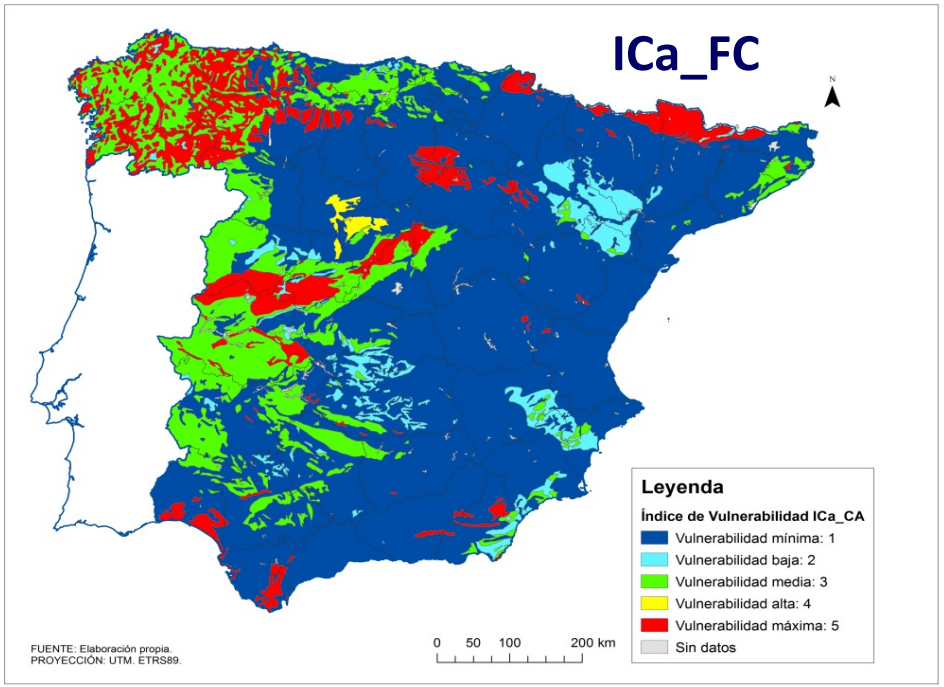




Case study: K fertilizer application and liming

Vulnerability maps regarding K and Ca status, identify those areas were rehabilitation is a priority. Case study on the application of K fertilizer and liming to decrease the potentiality to transfer ^{137}Cs and ^{90}Sr:





Case study: K fertilizer application and liming

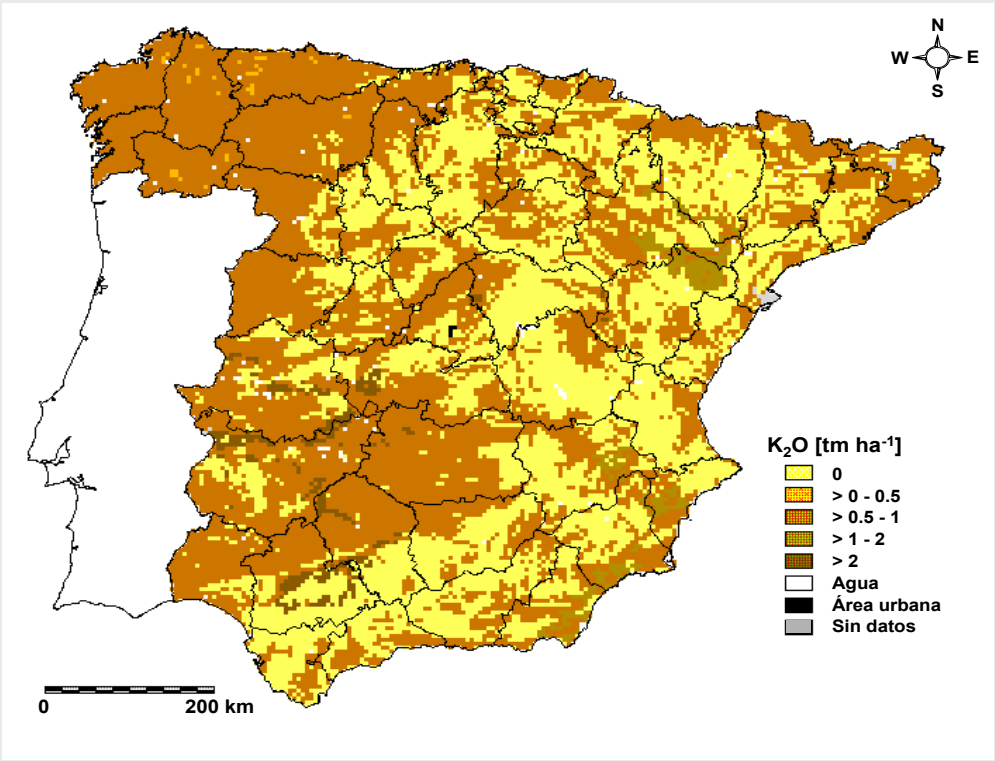
From the nutritional status on K and Ca, the application of K fertilization and liming is assessed under two assumptions:

- *Standard agricultural practice: correcting the deficiencies of K and Ca in soils.*
- *Agricultural countermeasure: applying the quantities of K and Ca that reduce to minimum values the soil vulnerability.*

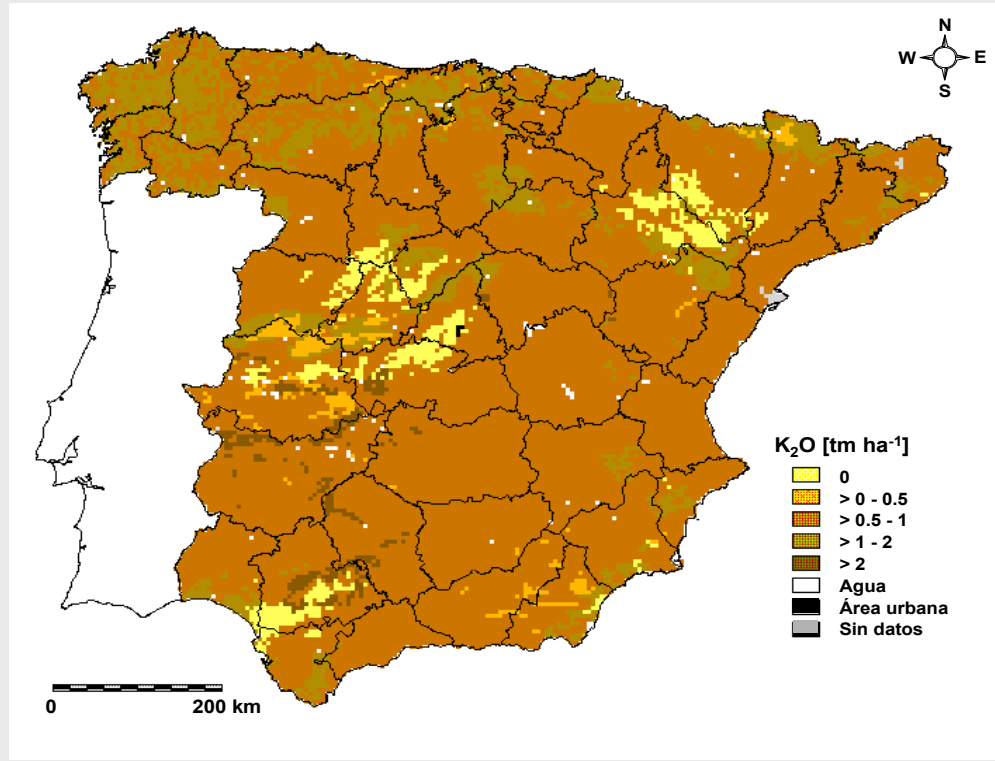
- Only the decrease of the potentiality of transfer of RN is taken into account.
- No other factors such as machinery, costs, side effects, …, are considered.
- The total quantities (tm ha^{-1}) to be added are estimated without considering their distribution with time.

Potassium fertilizer

Standard agricultural practice

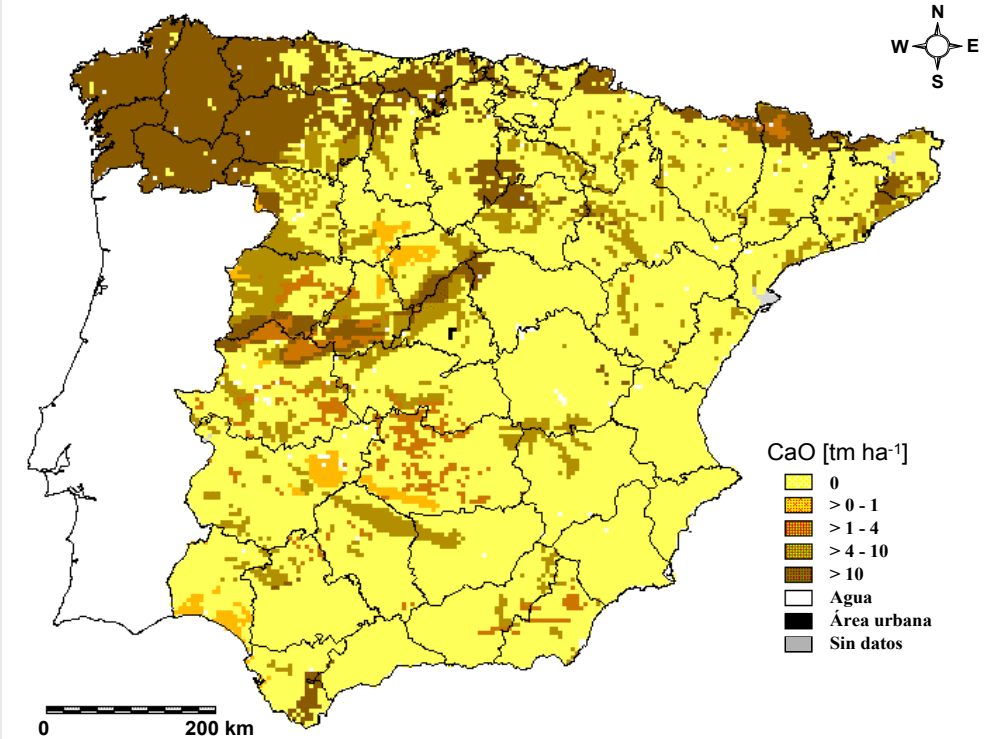


Agricultural countermeasure

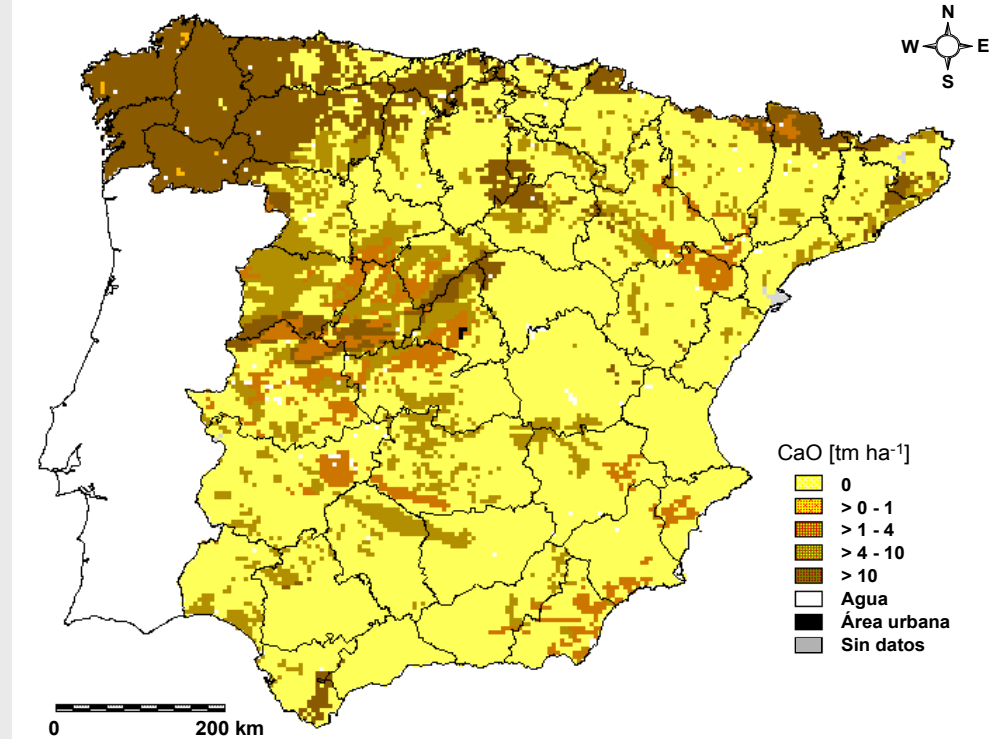


Liming

Standard agricultural practice

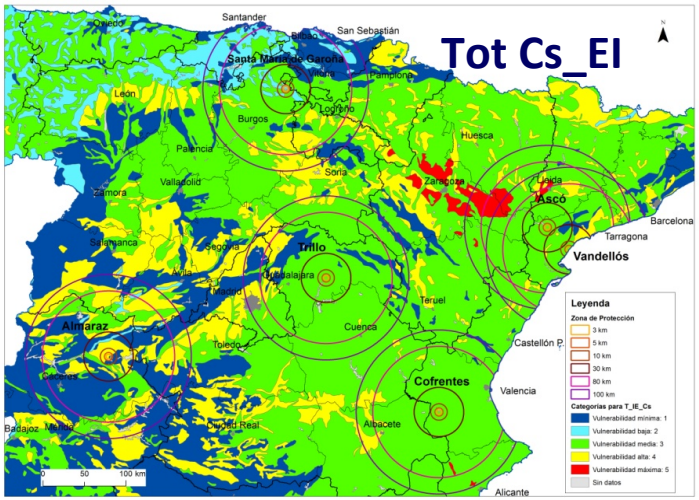


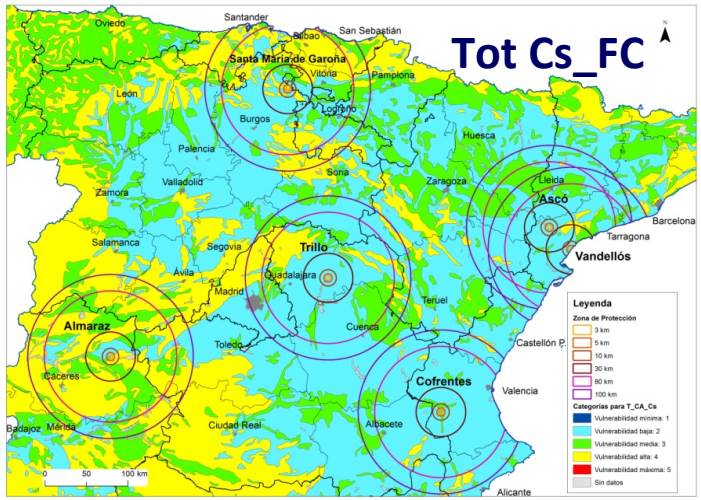
Agricultural countermeasure

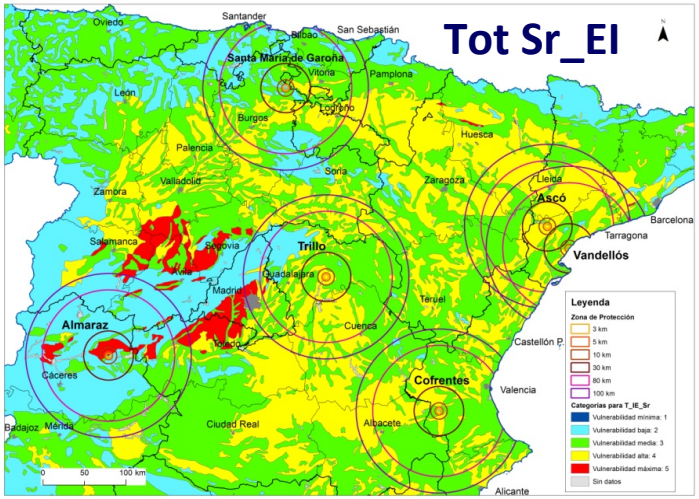


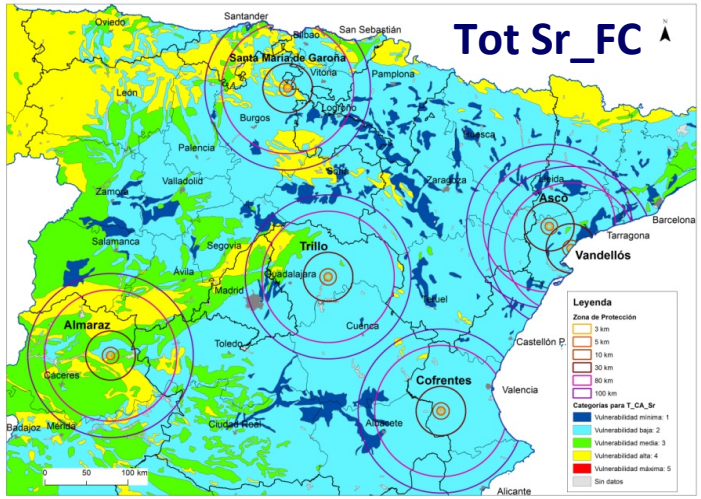
Increasing the local specificity: NPP_EPZs

Increasing the local specificity to the EPZs of NPP, will require more data to increase the reliability of the vulnerability assessment?



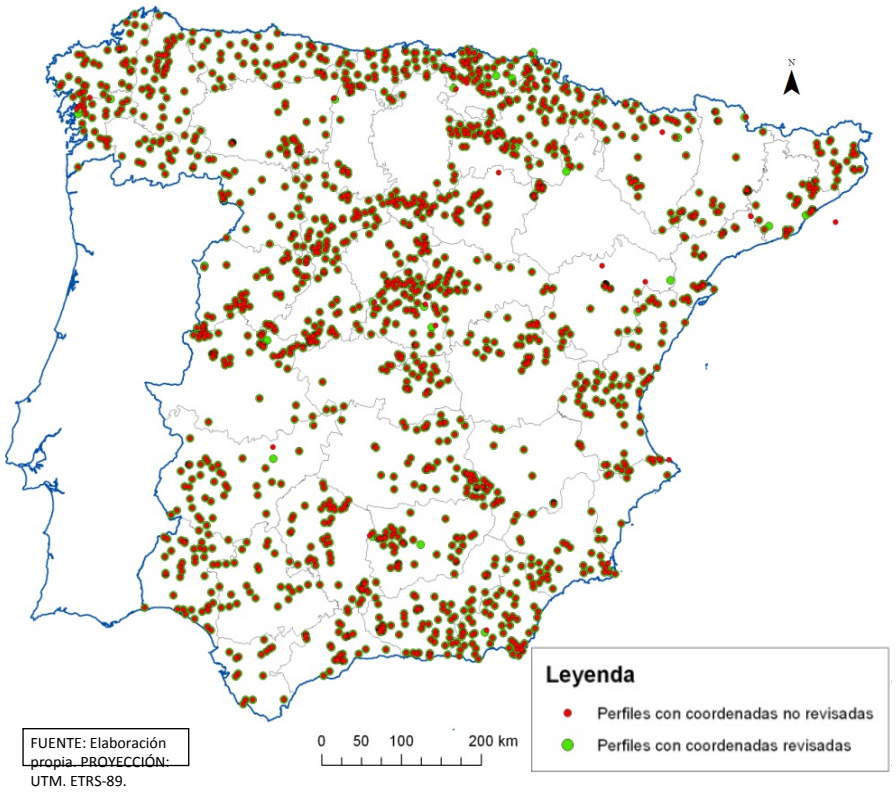




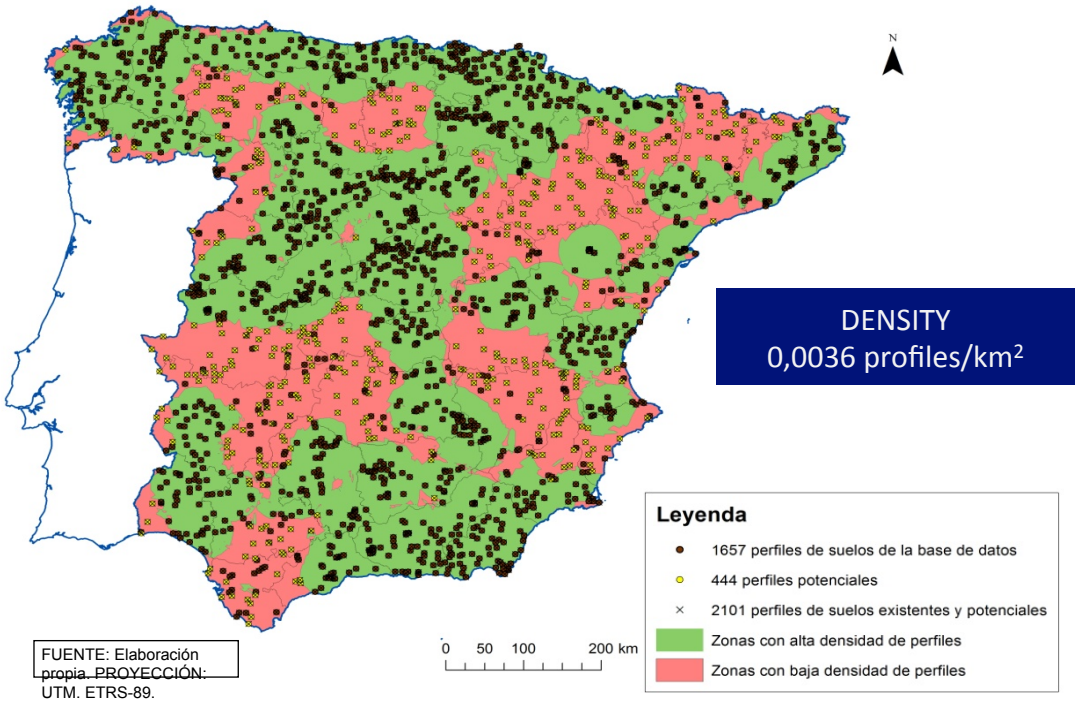


Increasing the local specificity: NPP_EPZs

Location of the 1.657 soil profiles at 1.000.000 scale, to asses the vulnerability in Peninsular Spain

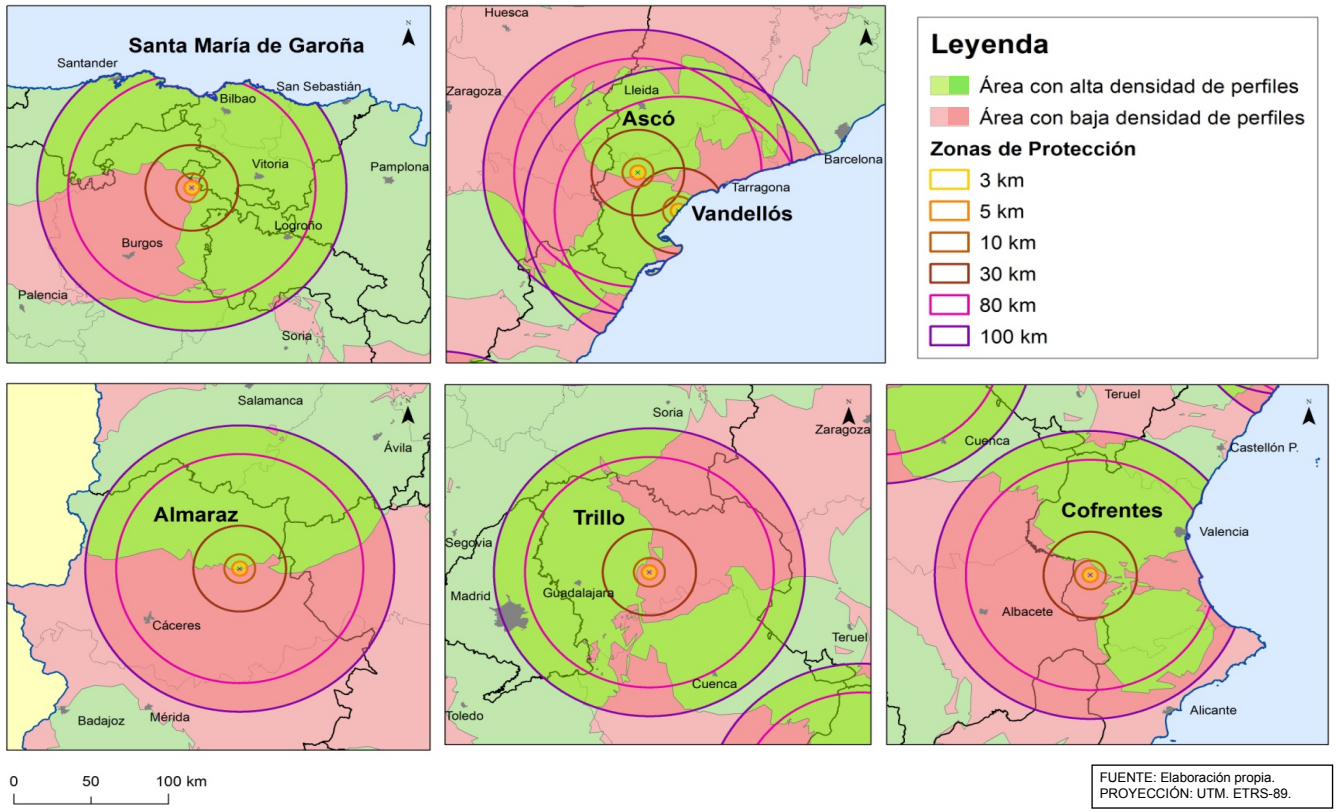


Distribution and density analysis to determine if the information is enough to assess the vulnerability in the surroundings of NPP



Increasing the local specificity: NPP_EPZs

Identification of areas with high and low profile density → to balance the soil characterization, some green areas will need a reduction of soil profiles and pink ones will need more soil profiles



Conclusions

- The methodology developed, estimates the radiological vulnerability of Spanish soils, according to their specific properties.
- The results, in form of vulnerability maps, show the trends of the behavior of ^{137}Cs and ^{90}Sr, allowing to prioritize rehabilitations areas in the decision-making processes.
- A case study regarding the vulnerability due to nutrient status, allows to plan the K fertilizer and liming applications to reduce the vulnerability.
- Increasing the local specificity scale, will require more detailed parameters and information to improve reliability.

THANK YOU FOR YOUR ATTENTION!