Identification of Very Shallow Groundwater Regions in the EU to Support Monitoring

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Contents

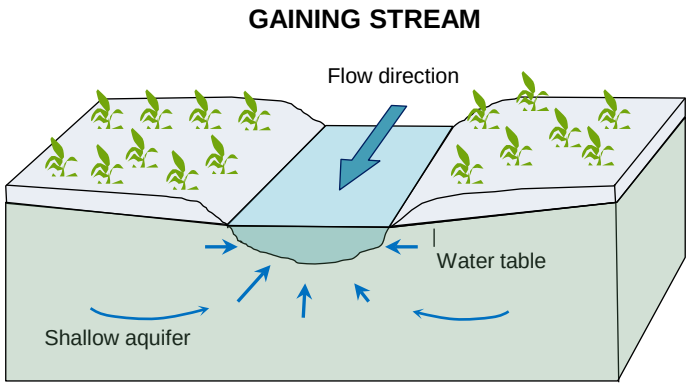
Background

- In the EU, there is increased reliance on groundwater-monitoring data to place conservative modeled estimates in context of real agricultural use.
- Continent-level monitoring data are inadequate due to limited availability, inconsistent or unknown data quality, or well placement in areas other than those where the compound has been or may be used.
- Site selection of new monitoring sites at continental scales is challenged by a lack of consistent high-resolution depth-to-groundwater (DTW) data.
- Syngenta developed a method to identify areas of very shallow groundwater that was ground-truthed in Po Valley (Italy), Hungary, and Lithuania.
- The method was extended and adapted by ARCADIS to cover the whole of EU27.

Project Requirements

- Adapt Syngenta's methodology to EU27.
- Ensure that all member states are treated uniformly.
- Provide country-specific maps displaying regions where groundwater is expected to be very shallow.
- Corroborate the data layer by performing a pilot desktop evaluation prior to field use.
- Automate workflow across EU27 to provide a data layer that could be used with other site-selection factors (e.g., crop distribution) within several weeks of initiation.

Conceptual Model

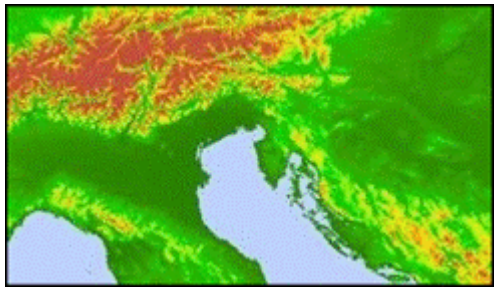


- Static water bodies, as well as gaining reaches of large rivers and perennial streams, indicate locally shallow groundwater elevation.
- DTW is likely to be very shallow within contiguous “flat” areas adjacent to significant surface-water bodies.
- DTW is typically greater beneath hills than valley bottoms.
- Similar approaches documented in the literature. (e.g., multiresolution valley bottom flatness [MRVBF] algorithm; Gallant & Dowling, 2003).
- Syngenta conceptual model vetted by ARCADIS hydrogeologists.
- Pilot approach applied to Po Valley (Italy), Hungary, and Lithuania.

Data Layer Development

Shuttle Radar Topography Mission (SRTM) 90-m Digital Elevation Model (DEM) tiles were converted to slope and constrained to flat areas (0-2%); contiguous flat areas were auto-delineated. Could be repeated with recent 30-m data.

Terrain Analysis

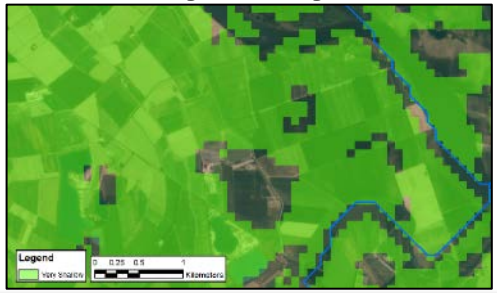


HYDRO1k (USGS 2001) queried for lakes and rivers restricted to Strahler class > 3 to use as indicators of very shallow water table locales.

Water Table Indicators

Contiguous areas of flat terrain adjacent to significant surface water features were identified via a proximity analysis.

Proximity Analysis



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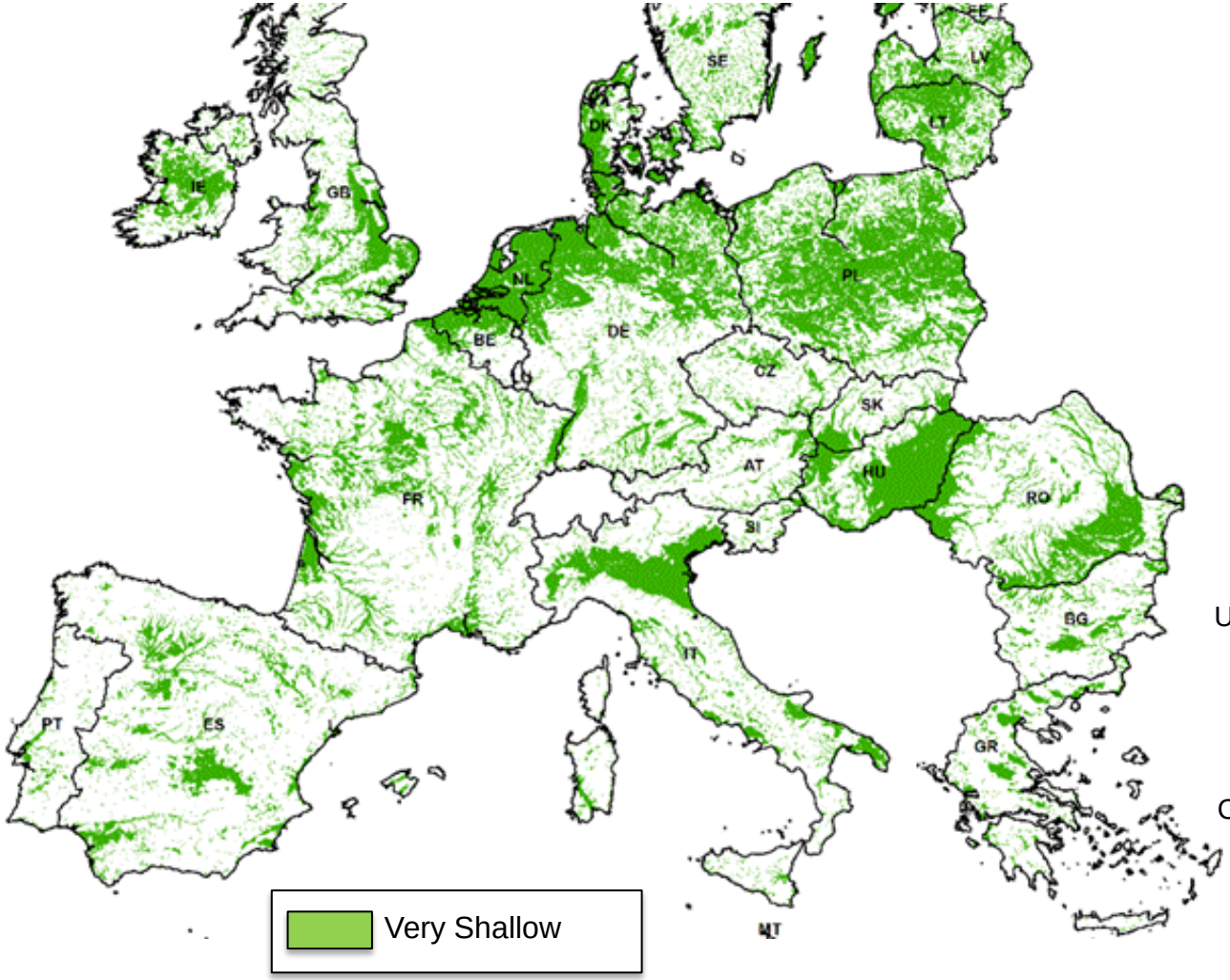
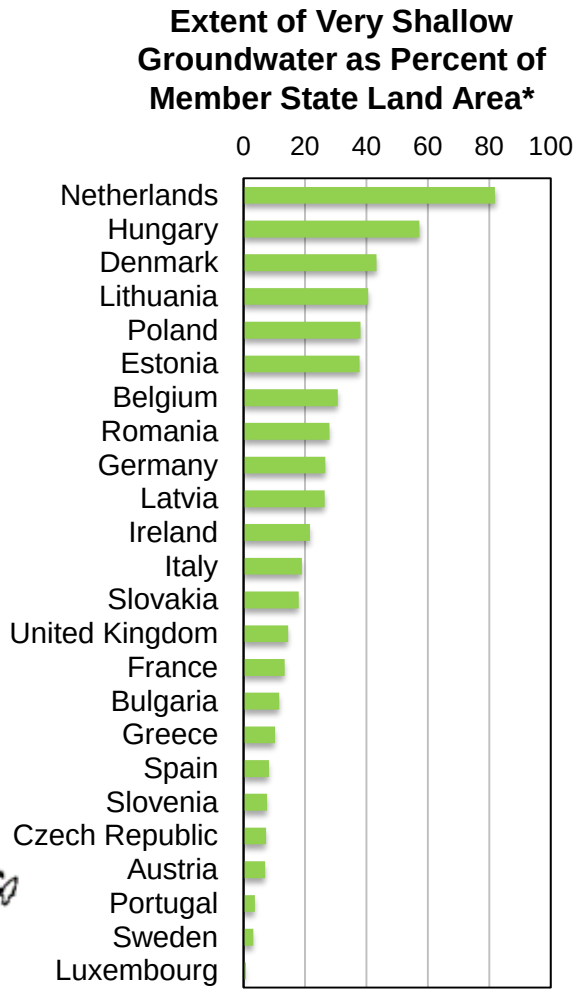
Geoprocessing Workflow

- Slope calculations based on SRTM DEM were completed in ArcGIS Spatial Analyst version 10. Total area processed = 11 948 528 km^2.
- Flat areas were delineated using the reclassify tool (spatial analyst) to derive a binary layer of flat terrain (≤ 2%).
- Contiguous flat areas (≤ 2%) were delineated by converting the raster to contiguous polygons.
- Contiguous flat areas in close proximity to selected surface-water features were identified by intersecting hydrography with contiguous flat areas and erasing non-adjacent flat areas.
- ArcPy was used to automate geoprocessing steps and to generate automated detail map outputs for in-country technical review and use.

EU27 Data Layer Characterization





Cyprus, Finland, Malta, and Croatia (2013 entry) not shown.

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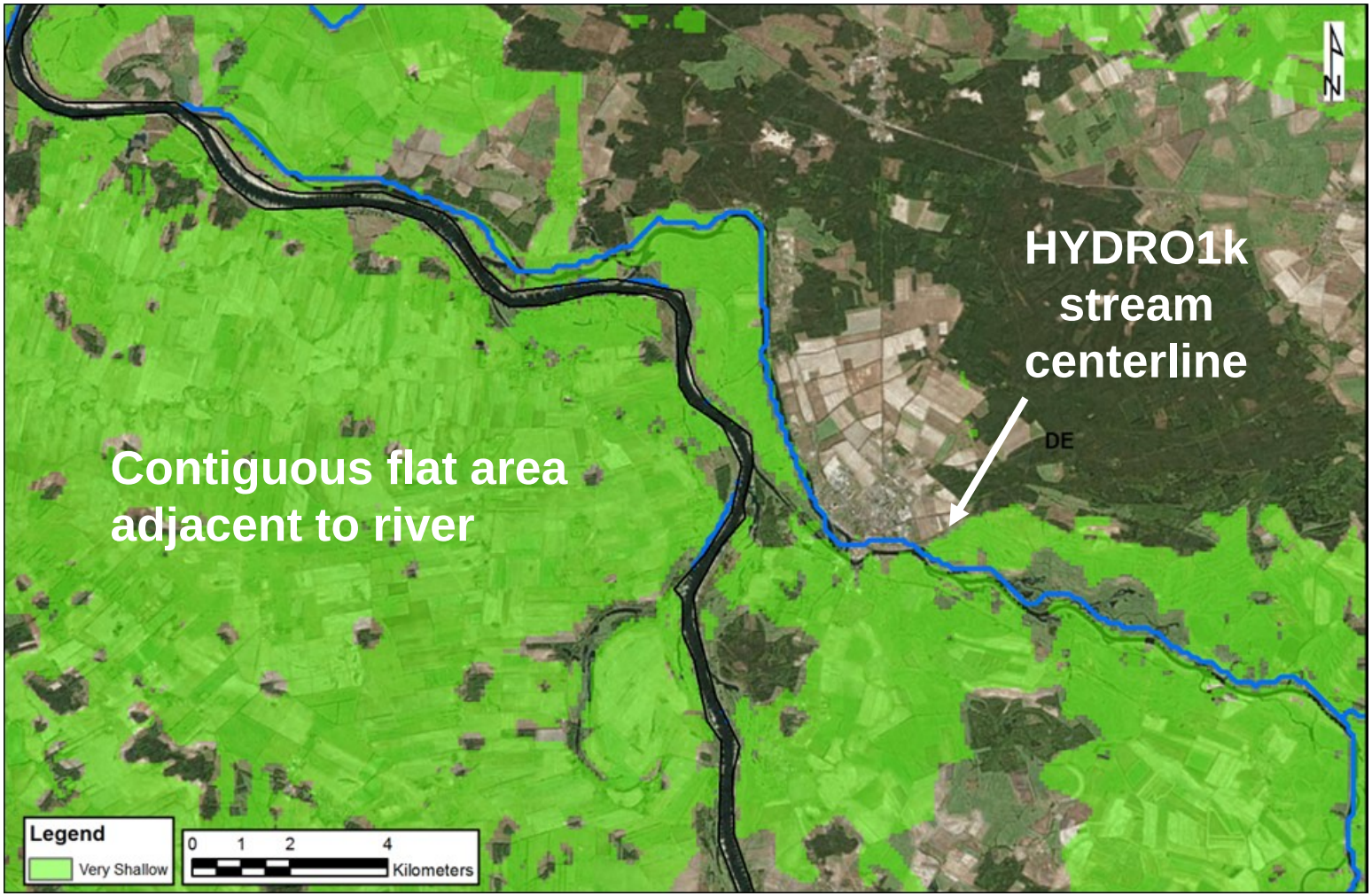
EU27 Data Layer – Detailed View



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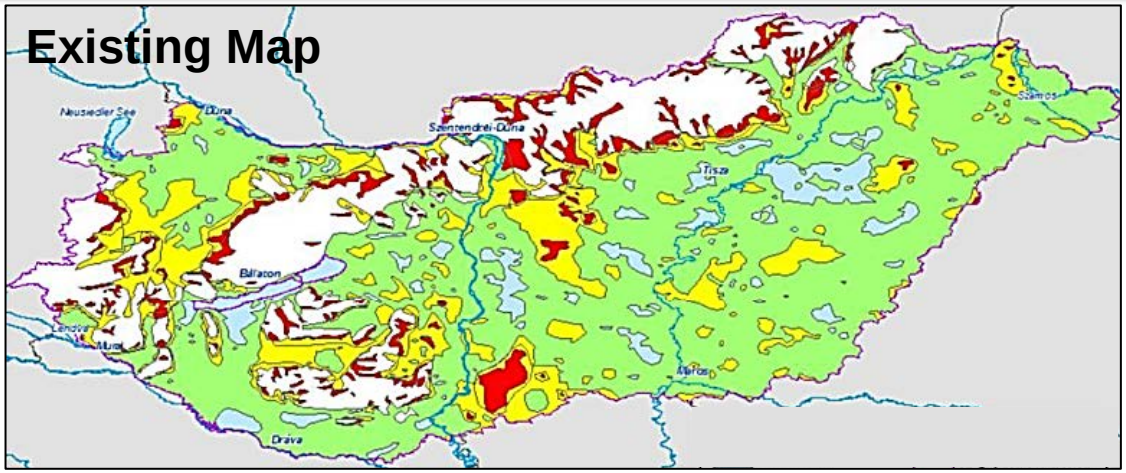
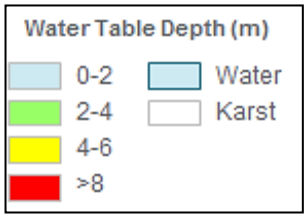
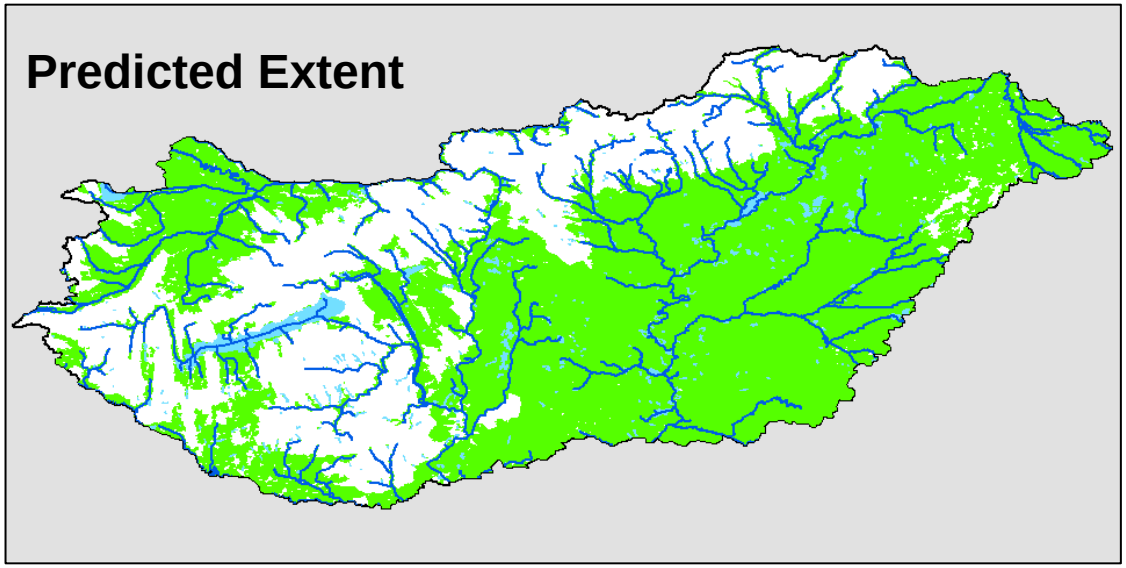
Corroboration - Hungary







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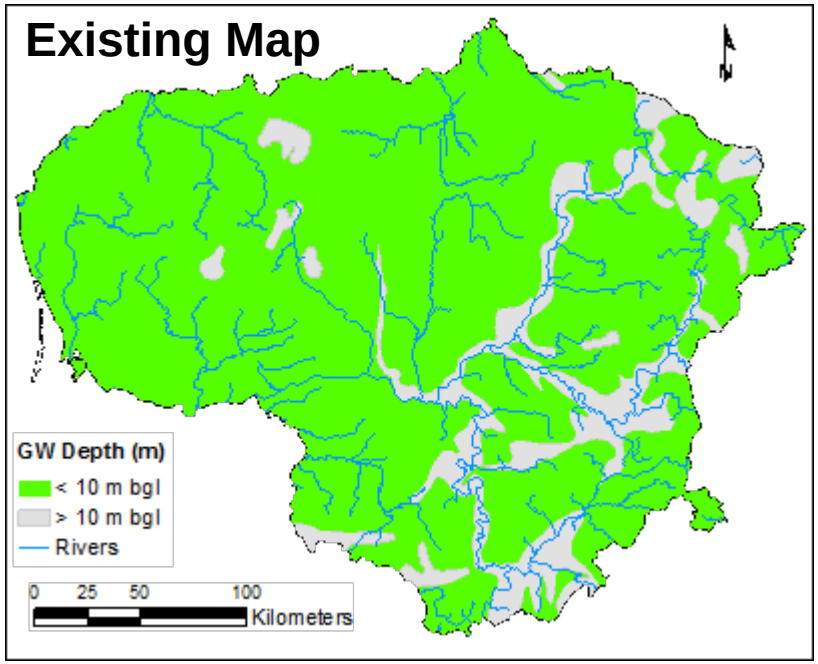
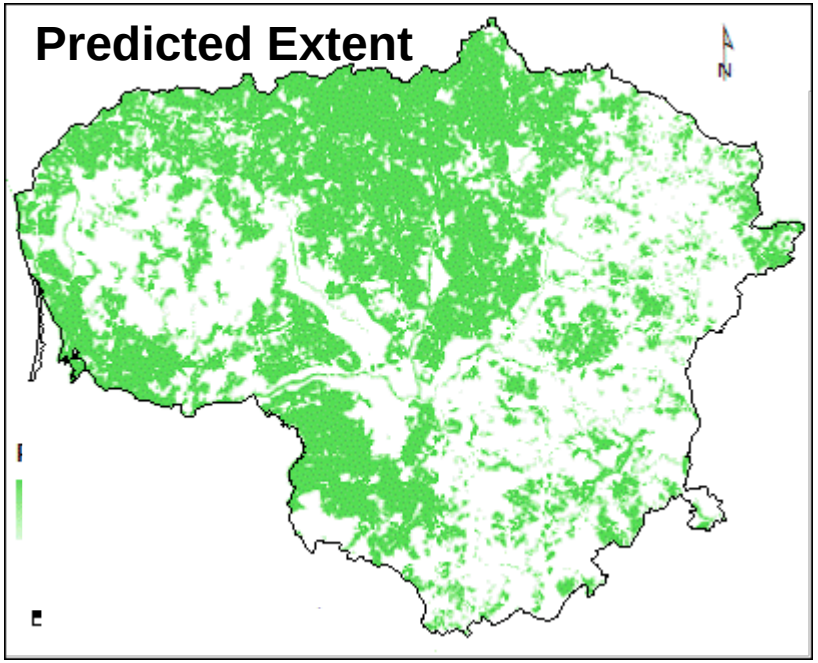
Corroboration - Lithuania



Depth to Groundwater Map from the Lithuanian Geological Survey, Department of Hydrogeology, Groundwater Report, Janina Giedraitiene, May 2011. Map digitized with an estimated accuracy of 1 km.
http://www.lgt.lt/uploads/1307619867_Geguze_2011.pdf



Very Shallow

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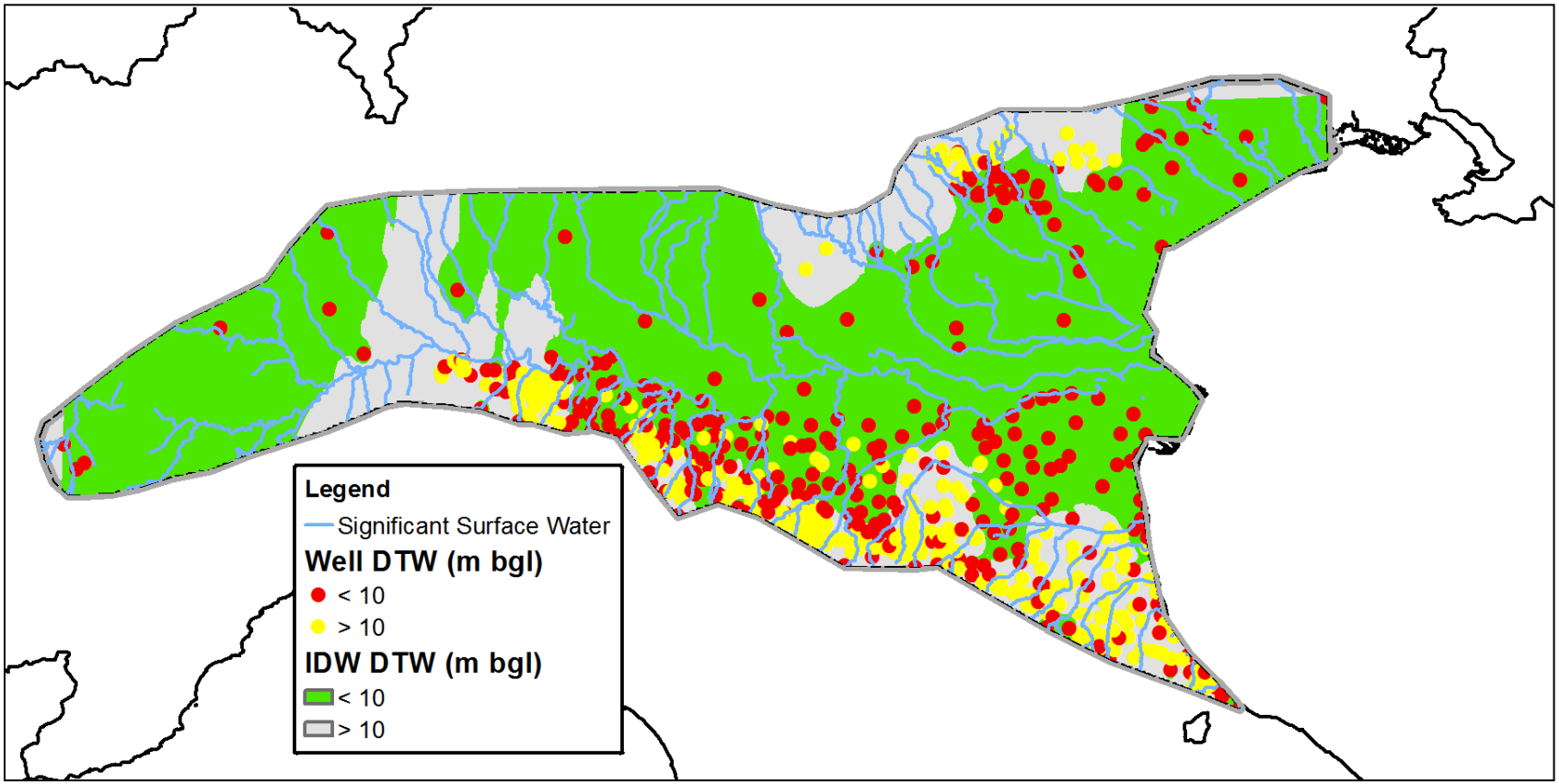
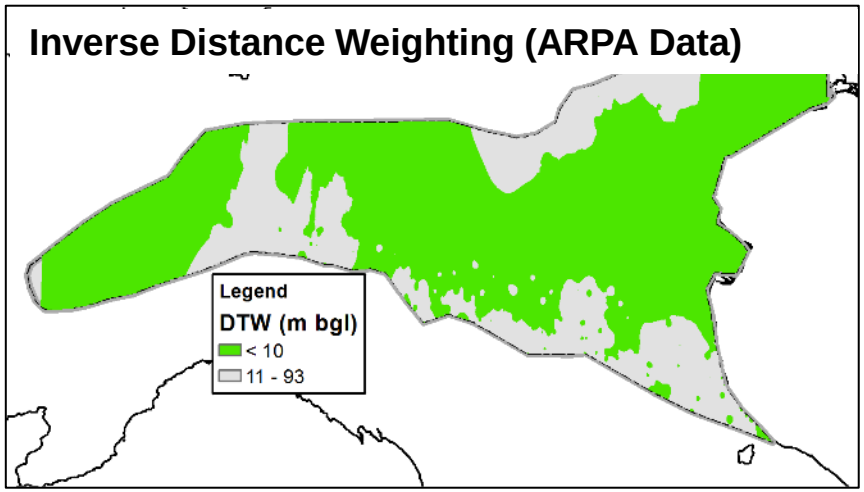
Italian Government Wells with Groundwater Elevation Measurements over 30 Years

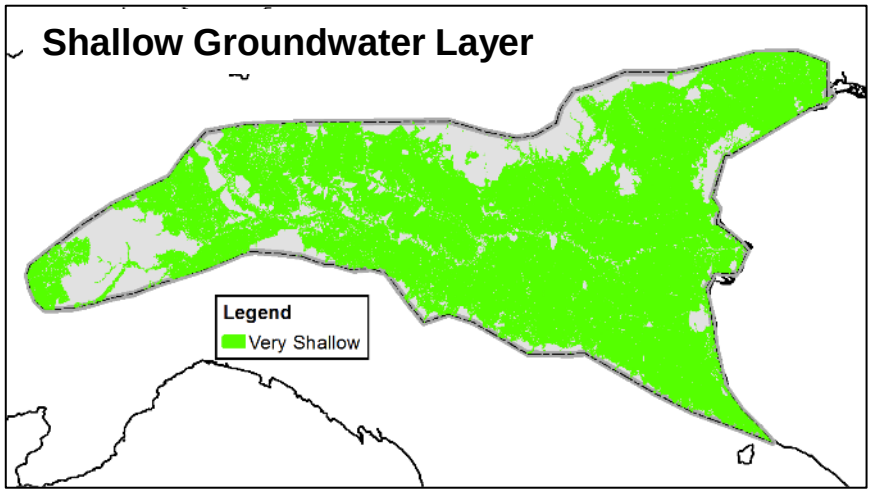


Approximate mean depth to water calculated as the difference between mean groundwater elevation and land surface elevation. DTW surface generated by inverse distance weighting interpolation (p = 2).

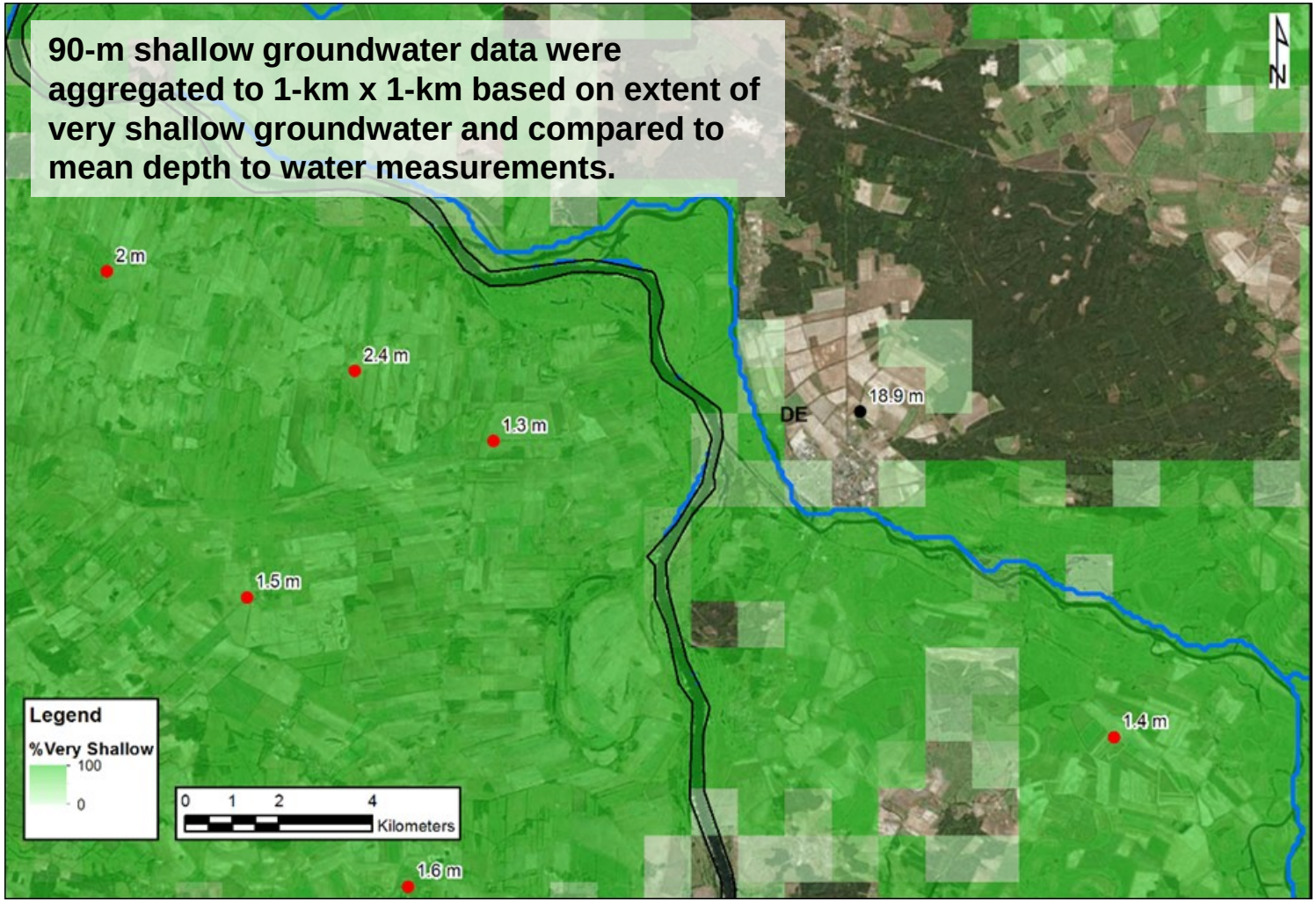
Corroboration - Italy (Po Valley)

- 75% of very shallow groundwater area agreed with DTW < 10 m below ground level (bgl) based on interpolation of measured data using inverse distance weighting.





1-Kilometer Aggregation and Corroboration



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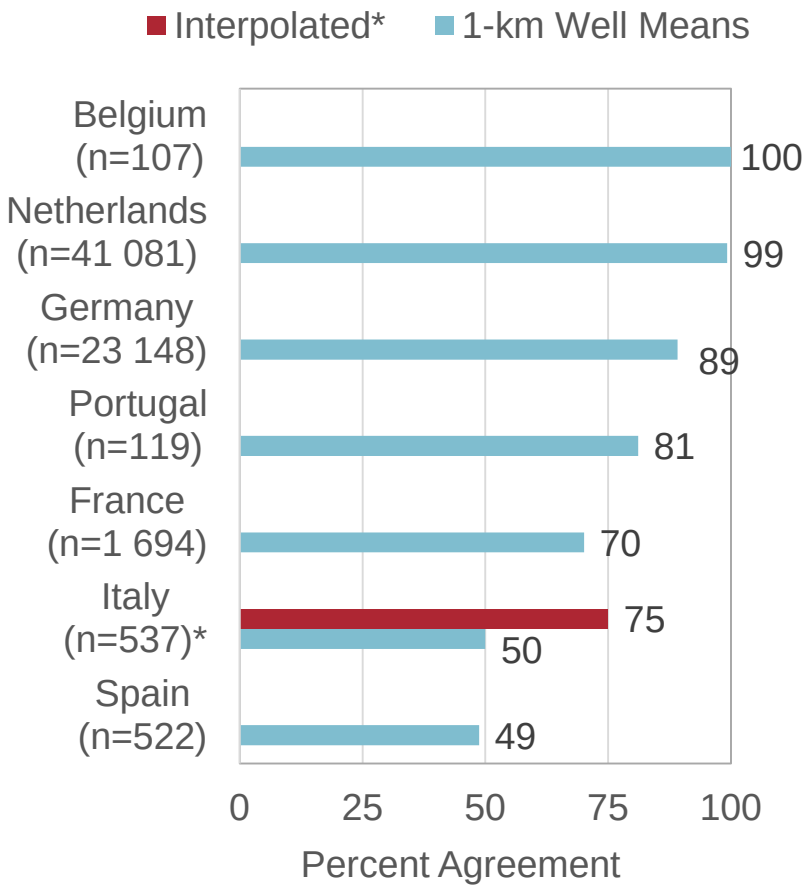
Corroboration – Groundwater Wells

- Monitoring data compiled from internal ARCADIS project databases, EU member state governmental agencies, Syngenta, and Fan et. al, 2013.
- Over 70% of very shallow 1-km cells had DTW < 10 m (except Italy and Spain).
  - Italy agreement was 75% after accounting for sampling bias.
  - In Spain, the layer tended to over-predict shallow areas and may be unduly conservative by identifying greater areas with very shallow groundwater than truly exist.



** Interpolated data for Po Valley compared to 90-m resolution very shallow groundwater layer.*

Conclusions

- Understanding where groundwater is expected to be very shallow is essential to support the types of monitoring studies needed as higher-tier support for registration of certain plant-protection products in the EU.
- The shallow DTW layer developed has been useful for targeting potential monitoring sites in areas with very shallow DTW and confirmed product use.
- Comparison of the very shallow DTW layer to actual field data on groundwater depth demonstrated its success. In the field study, 357 site visits were made with DTW exceeding 10 m bgl at only 9 sites.
- Publication of this Syngenta methodology, resulting data layer, and verification in the open literature is underway.

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