Geospatial approaches to increasing the ecological relevance of Environmental Risk Assessment

Christopher M. Holmes, Applied Analysis Solutions LLC, USA; Lorraine Maltby, Sheffield University, UK;
Stuart Marshall, Consultant, UK; Jens C. Otte, BASF SE, Germany; Paul Sweeny, Syngenta, UK; Pernille Thorbek, BASF SE, Germany

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Introduction

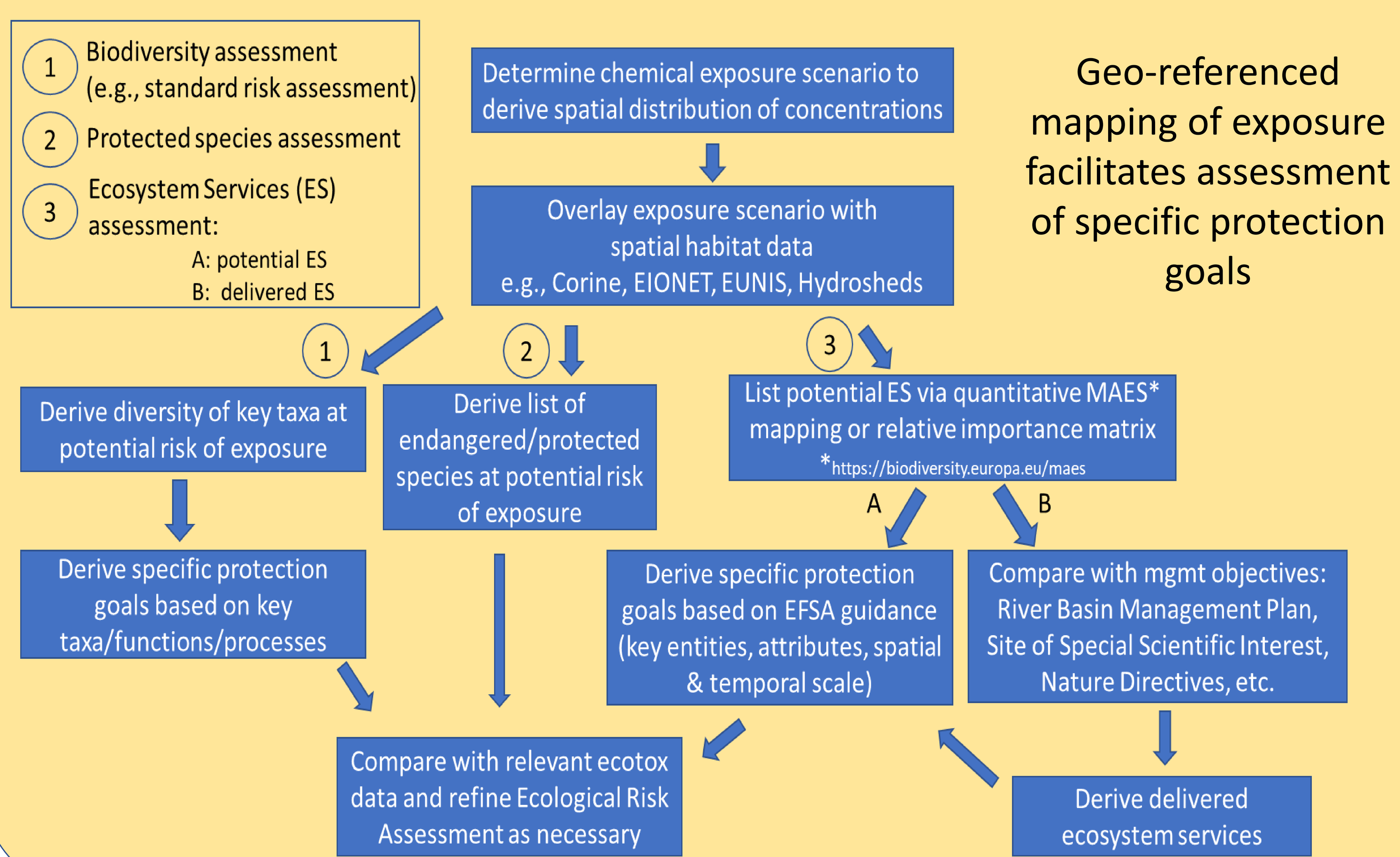
The prospective risk assessment of chemicals across all regulatory jurisdictions follows a generic approach, comparing estimated exposures to toxic thresholds designed to be protective of all species. This approach does not recognise geographic patterns of species distributions or acknowledge that particularly sensitive species may not occupy potentially exposed habitats. Therefore, risk assessments could be overly conservative and restrictive for some uses of chemicals.

Geo-referenced ecological data are becoming increasingly available at spatial resolutions applicable to chemical risk assessment, potentially facilitating enhanced environmental relevance of such risk assessments.

Greater realism in assessing additional stress due to chemical exposure could be achieved if the range of managed and unmanaged environmental typologies and their constituent biological communities were mapped and described.

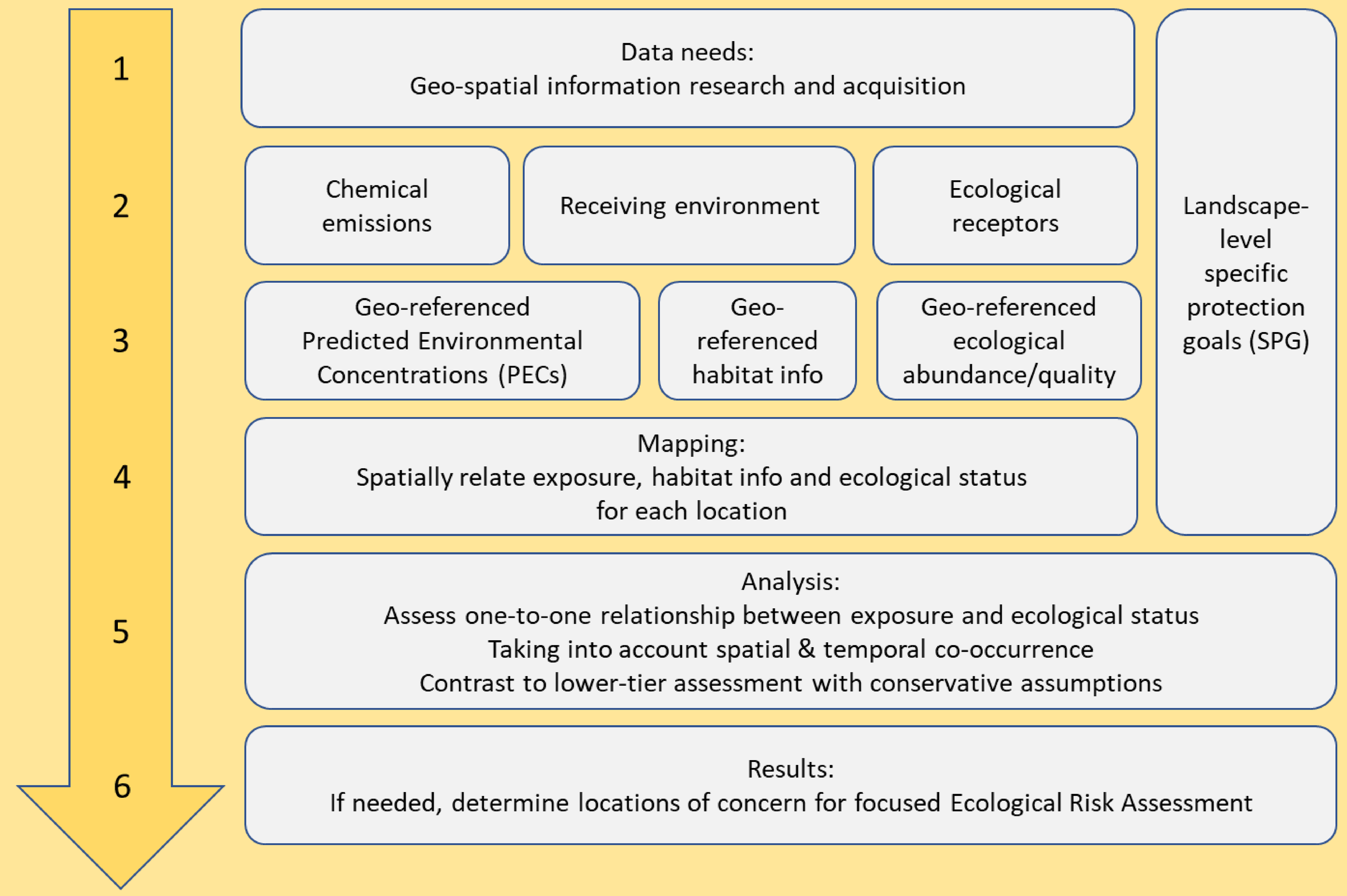
In 2017 ECETOC initiated a Task Force to investigate current capabilities in making spatially explicit chemical risk assessment (from both an exposure and effects perspective). After comprehensive research for applicable and available data, we investigated techniques and methods for combining disparate data sets using case studies, and identified some of the challenges of using different levels of taxonomic, spatial and temporal resolution in spatially explicit risk assessments.

Conceptual Framework



Geo-referenced mapping of exposure facilitates assessment of specific protection goals

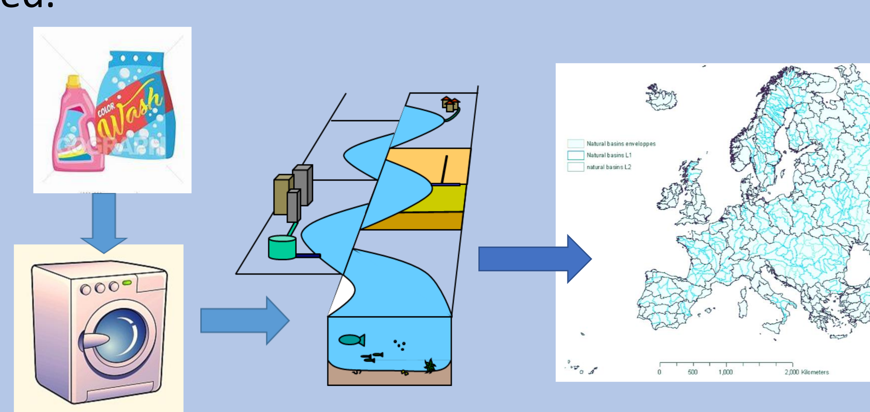
Analysis Flow



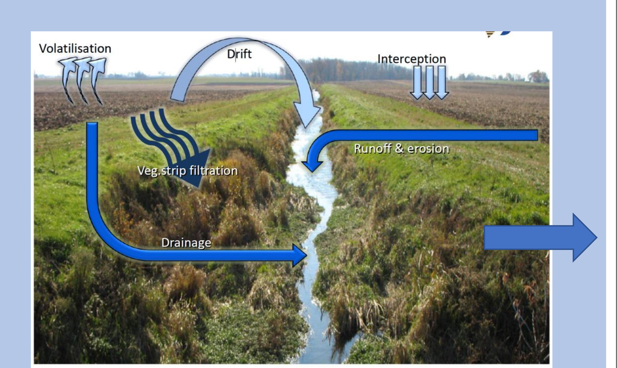
Case studies

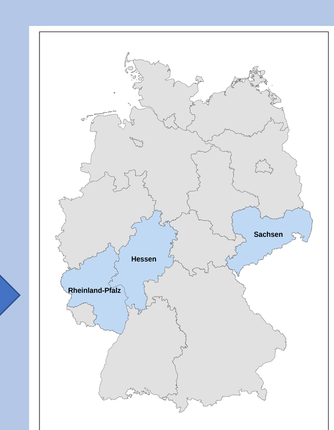
Objective: Demonstrate capability to obtain and map spatially explicit chemical exposure information and integrate with geo-referenced ecological receptor data to determine priority locations suitable for refined risk assessment. Two "proof of principle" studies were investigated.

A Pan-European exposure of freshwaters to a surfactant used in domestic cleaning products.



The aggregate risk of three Plant Protection Products (PPPs) (herbicide, insecticide and fungicide) used on three crops in Rhineland-Palatinate, Hessen and Saxony, Germany.





Conclusions

- Generation of geo-referenced data describing environmental characteristics and ecological receptors is increasing although access and utilisation can be problematic.
- Starting with the goal of developing Europe-wide datasets to use in case studies proved challenging, we needed to focus on smaller geographic areas to obtain biological data to which we could compare our estimated chemical stressors.
- We demonstrated capability for making retrospective analyses of the relationships between ecological status and chemical stressors across a wide range of spatial scales.
- In the PPP case study highlighted here:
  - these relationships do not indicate a clear cause for concern from acute or chronic exposure at the catchment scale.
  - estimated risks at field level are much greater than at catchment scale, indicating a low occurrence of potential impacts requiring further investigation/refinement.
  - the identification of small numbers of "field specific" relatively high risks might not be expected to be seen in current RA paradigms.
  - even at field level there is no clear relationship between ecological status and PPP risk, suggesting that the 3 PPPs investigated are not driving the ecological status.
- Accounting for variation in time/space of exposure and receptors could improve current regulatory risk assessment methods.
- An ECETOC Technical Report will be prepared and made available to the public when completed (http://www.ecetoc.org/publications/technical-reports/).

PPP exposure

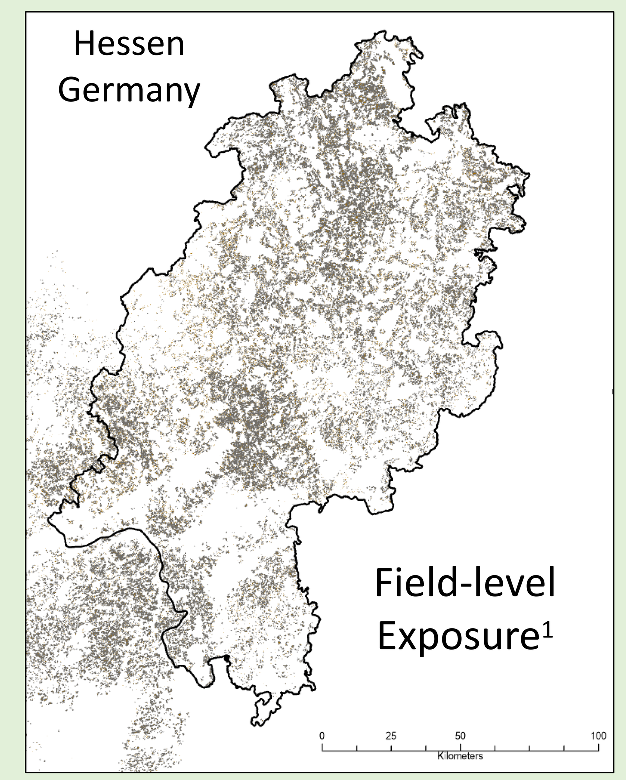
Information on environmental exposures were modelled using SYNOPS from the Julius Kühn Institute[1]. Application of 3 PPPs to 3 crops (winter wheat, winter barley and winter oilseed rape) were modelled using surveyed usage data randomly applied to individual fields. Concentrations in surface water were estimated for each field based on many factors, including soils and rainfall using standard PPP exposure models.

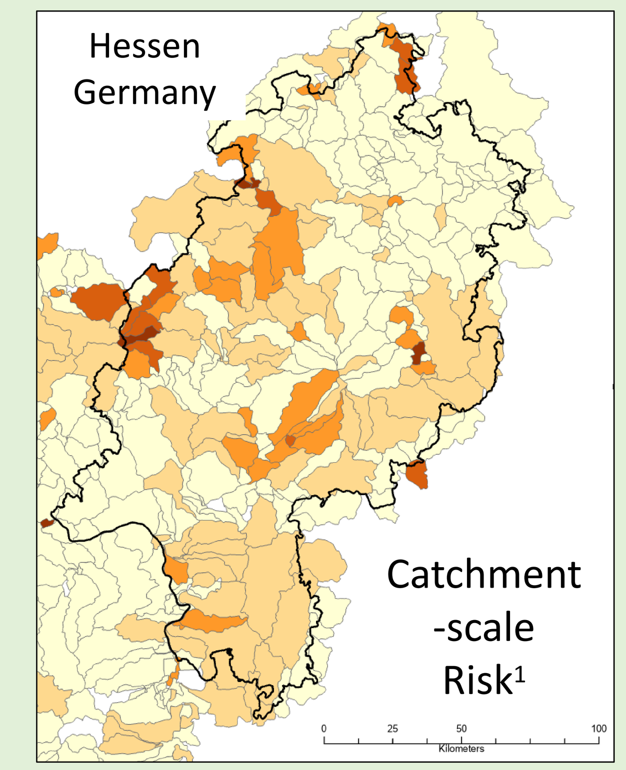
PPP risk

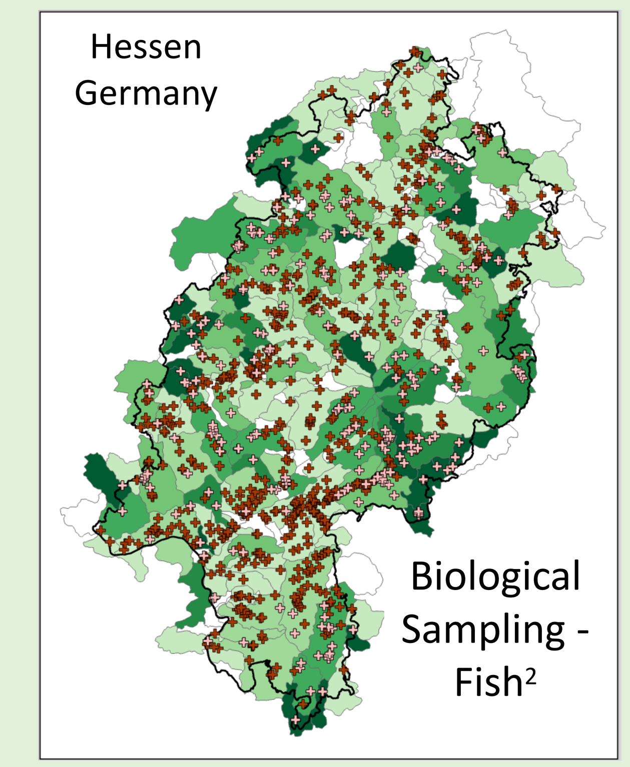
Daily field-level exposures in surface water were converted to Exposure : Toxicity Ratios (ETRs) for each PPP, and summed to an acute and chronic risk index for four taxa. The annual 90th percentile sum of risk (all 3 PPPs) for all fields within a catchment was used as an indicator of potential exposure to aquatic organisms.

Ecological receptors

Water Framework Directive ecological monitoring data for fish, diatoms, macrophytes and macroinvertebrates were kindly provided by Federal State of Hessen[2]. Attributes included location, abundance, evaluation of ecological state, as well as other scoring values. These data are highly specific in location and may reside on smaller streams not represented in continental scale data originally scoped.

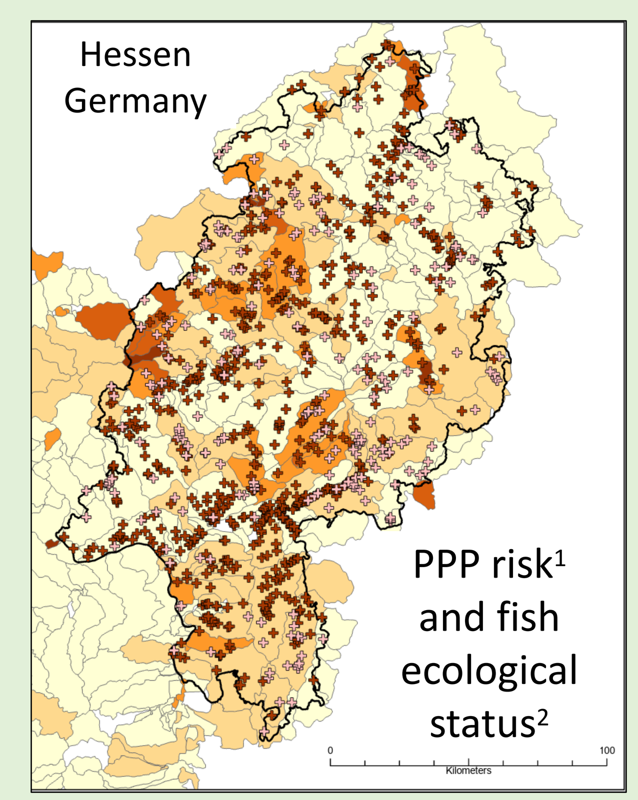


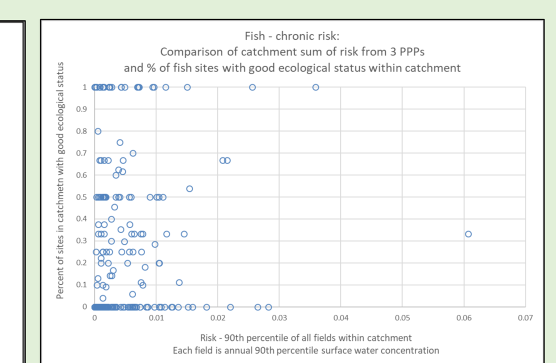




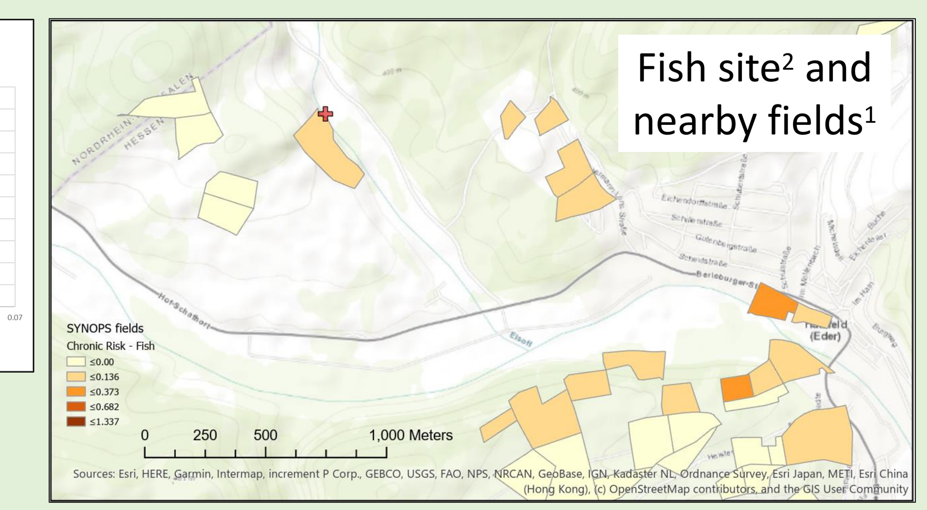
Spatially relating exposure and receptors

Spatially linking data of different scales can be challenging. In one approach we identified the proportion of sites ranked as good ecological status (ecological class 1 or 2) within each catchment, and compared to SYNOPS catchment risk. We also related each biological sampling site to the closest agricultural field (very high resolution) within 300m. We attempted to identify via statistical analysis of matched data if we could find correlations between relative exposure/risk and ecological receptors/indicators. This work is ongoing.

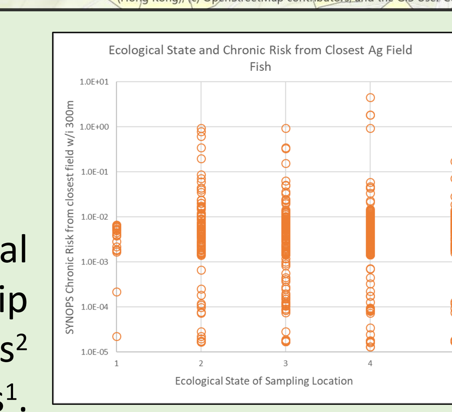




At the catchment scale, there is no strong evidence that increased PPP risk[1] is linked to reduced proportion of sites with good ecological quality[2].



Examining agricultural fields nearby biological sampling sites (fish) shows no clear relationship between ecological quality at sampling locations[2] and increased risk from PPP estimates[1].



References

1. Julius Kühn Institute (JKI), Kleinmachnow , Germany. Strassemeyer J. https://www.julius-kuehn.de/
2. Representation based on data from the Hessian State Office for Nature Conservation, Environment and Geology, Wiesbaden

For more information, contact:
Chris Holmes, Applied Analysis Solutions LLC
ChrisHolmes@AppliedAnalysis.solutions