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T A Č R Tento projekt je spolufinancován se státní podporou Technologické agentury ČR a Ministerstva životního prostředí v rámci **Programu Prostředí pro život.**

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SS02030018 - Centrum pro krajinu a biodiverzitu

Možné způsoby podpory biodiverzity hmyzu v zemědělské krajině a monitoringu změn hmyzích společenstev

Michal KNAPP (et al.)

Midterm konference DivLand – Litomyšl 13. 3. 2024

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Perspective

Ecologically-Informed Precision Conservation: A framework for increasing biodiversity in intensively managed agricultural landscapes with minimal sacrifice in crop production

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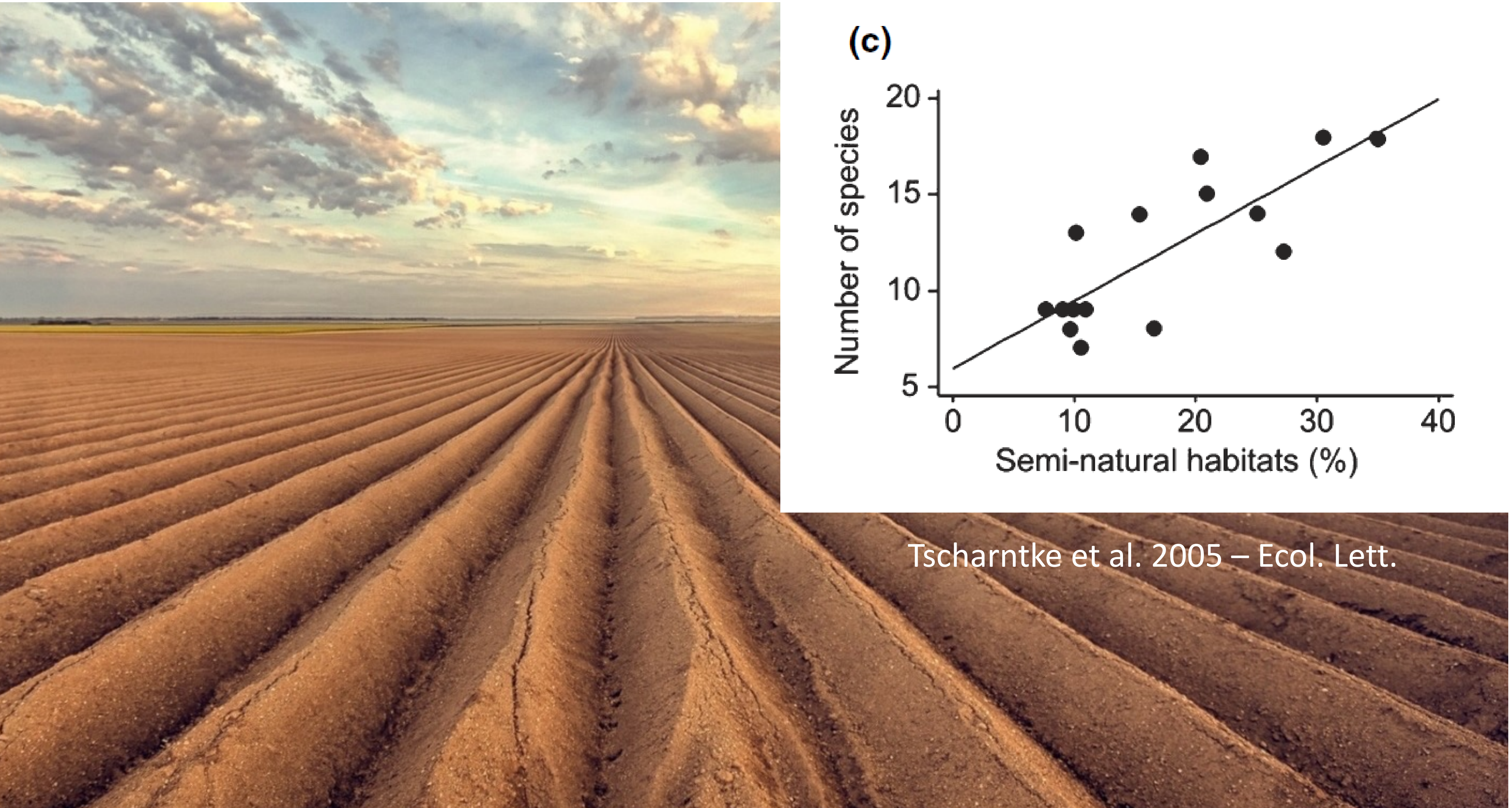
ABSTRACT

Conservation actions are urgently needed to tackle biodiversity loss in intensively managed agricultural landscapes. Production lands are usually heterogeneous and contain low-yield areas that can be set aside for biodiversity conservation without serious yield losses. Here, we introduce Ecologically-Informed Precision Conservation, a framework that integrates yield mapping and ecological theory to select the best areas to create new set-asides while ensuring high crop yields at the farm/landscape level. Long-term yield maps can be generated using globally available satellite data and basic information on field/farm crop yield from farmers. Ecological principles are then used to select the subset of areas with the highest potential for biodiversity conservation by prioritising those that increase connectivity, maximise habitat heterogeneity and decrease landscape grain size. The created non-crop habitats can be permanent and thus ensure biodiversity support over time. In addition, agricultural management efficiency can be enhanced by improving field shapes. The framework provides the basis for a practical, user-friendly tool that informs all interested stakeholders on how to rationalise existing agricultural landscapes using already-existing farming systems and available technologies. High cost-effectiveness from an economic and conservation perspective, along with the creation of heterogeneous non-crop habitats, make our framework a promising solution to re-design agricultural landscapes.

Agricultural intensification … fine mosaic of small fields, meadows, woodlots, orchards and linear structures was transformed into …

… large blocks of arable land (heavily sprayed with various agrochemicals) almost without any non-crop habitats



Tscharntke et al. 2005 – Ecol. Lett.

Nature Restoration Law

For people, climate, and planet

22 June 2022
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Over **half of global GDP depends on nature** and the services it provides. **Construction, agriculture, food and health** sectors all highly depend on it

More than **75% of global food crops depend on pollinators**

40% of the world's land is degraded. Costs associated with soil degradation in the EU already exceed EUR 50 billion a year

Our global food systems are responsible for **80% of deforestation, 70% of freshwater use** and are **the single greatest cause of terrestrial biodiversity loss**

We need to establish new non-crop habitats in a clever way (to maximise biodiversity benefits and minimise yield reduction)

comment

Check for updates

Digital agriculture to design sustainable agricultural systems

The global food system must become more sustainable. Digital agriculture — digital and geospatial technologies to monitor, assess and manage soil, climatic and genetic resources — illustrates how to meet this challenge so as to balance the economic, environmental and social dimensions of sustainable food production.

Bruno Basso and John Antle

Fifty years ago, many people doubted the ability of the world to feed itself. While food security remains a challenge for the poorest people, the global food system has been so successful in producing cheap food calories that today three-times more people in the world are obese than underweight due to malnutrition[1]. The current food system is able to do this largely because of crop and livestock production technologies that produce and deliver more food calories to more people than was previously thought possible. But agriculture's contributions to greenhouse gas emissions, water pollution and biodiversity loss show that major agricultural systems are on largely unsustainable trajectories[2]. As Schramski et al.[3] point out, changing the way we produce and use energy in agriculture as well as the rest of the economy must be an important part of meeting the sustainability challenge. However, it seems unlikely that a development pathway for a human population approaching 10 billion could be achieved with less total energy use. And since some environmental costs will be associated with increased energy use and a substantially larger human population, achieving a more sustainable development pathway will involve managing trade-offs in complex natural and human systems among economic, environmental and social dimensions of human well-being[4]. It now appears likely that moving agriculture towards a more sustainable development pathway will depend largely on crop agriculture, particularly if the sustainable human diet is to be largely based on plant-based foods. This will involve trade-offs associated with the demands such a pathway will place on land, water and genetic resources in many parts of the world[5].

The best hope for meeting the challenge of sustainable agricultural development lies in the ongoing process of innovation now taking place using modern genetic and information technologies to increase agricultural productivity while balancing economic, environmental and social outcomes associated with agriculture and the food system. Genetic improvement is a necessary but not sufficient part of this strategy, as we learned in the Green Revolution of the twentieth century, because environmental outcomes depend on how crop production is managed at the field scale as well as its interactions with ecosystems across the landscape. Much attention has been paid to the key role that data acquisition plays in improving crop management — but improvements in system performance will come about only when agricultural science can make effective use of these 'big data'. Improved data and analytics will need to be incorporated with agronomic science, that is, what we call digital agriculture (DA) — a set of digital and geospatial information technologies that integrates sensors, analytics and automation to monitor, assess and manage soil, climatic and genetic resources at field and landscape scales.

So-called precision agriculture (PA)[6] began to be implemented in the early 1990s ostensibly to increase profitability and reduce the environmental impact of crop-based systems by applying variable inputs according to spatial variability of crop growth[7]. However, there is little evidence as yet demonstrating widespread economic and environmental benefits of precision management technology[8]. Like many mechanical technologies, the economic benefits appear to be greatest for larger farms that can spread their fixed costs over many acres, and that can reduce labour costs through automation. Thus, profitability and adoption in the United States is highest among larger farms, with profitability only slightly higher on average among adopters, and input use only marginally lower on average, consistent with the finding of minimal environmental benefits from PA as currently implemented[8]. One explanation for the failure to achieve more substantial and widespread improvements in environmental performance is the lack of effective policies to incentivize the implementation of technologies such as PA in ways that achieve their promise of environmental improvement. For example, in the US Midwest, both surface and groundwater quality continue to be severely impacted by high levels of agricultural chemical use and pollution caused by surface runoff and leaching to groundwater, despite a variety of policies implemented since the 1980s to reduce soil erosion and runoff[9].

A related explanation for the failure of DA to deliver on its promises is that, thus far, algorithm developers for precision management have lacked the data and computational tools needed to convert complex geospatial information on soil and plant status into appropriate crop management actions. Misinterpretation and misuse of data appears to be a consequence. For example, many farmers utilize precision technology to apply more nitrogen (N) fertilizer to low-yielding portions of rain-fed fields in the hope of increasing yields, rather than less N to avoid fertilizer losses through leaching and runoff of N that crops cannot use. This tendency is compounded by apparent conflicts between farmers' goal to maximize economic returns, and the objective of input suppliers to maximize sales of inputs. Thus, ironically, precision management tools may result in lower economic and environmental sustainability if not used appropriately.

Recent research suggests that improvements in DA technology could transform these trade-offs into the win–win synergies that were envisioned for PA, and also help re-design agricultural landscapes for sustainability[10]. Given the inherent variability in climate, soil and topography, appropriate assessments of yield variability to make more informed decisions require at least several years of data[10]. New methods of analysing spatial-temporal data from satellites or yield-monitor data from farmer machinery can produce yield stability

NATURE SUSTAINABILITY | VOL 3 | APRIL 2020 | 254–256 | www.nature.com/natsustain

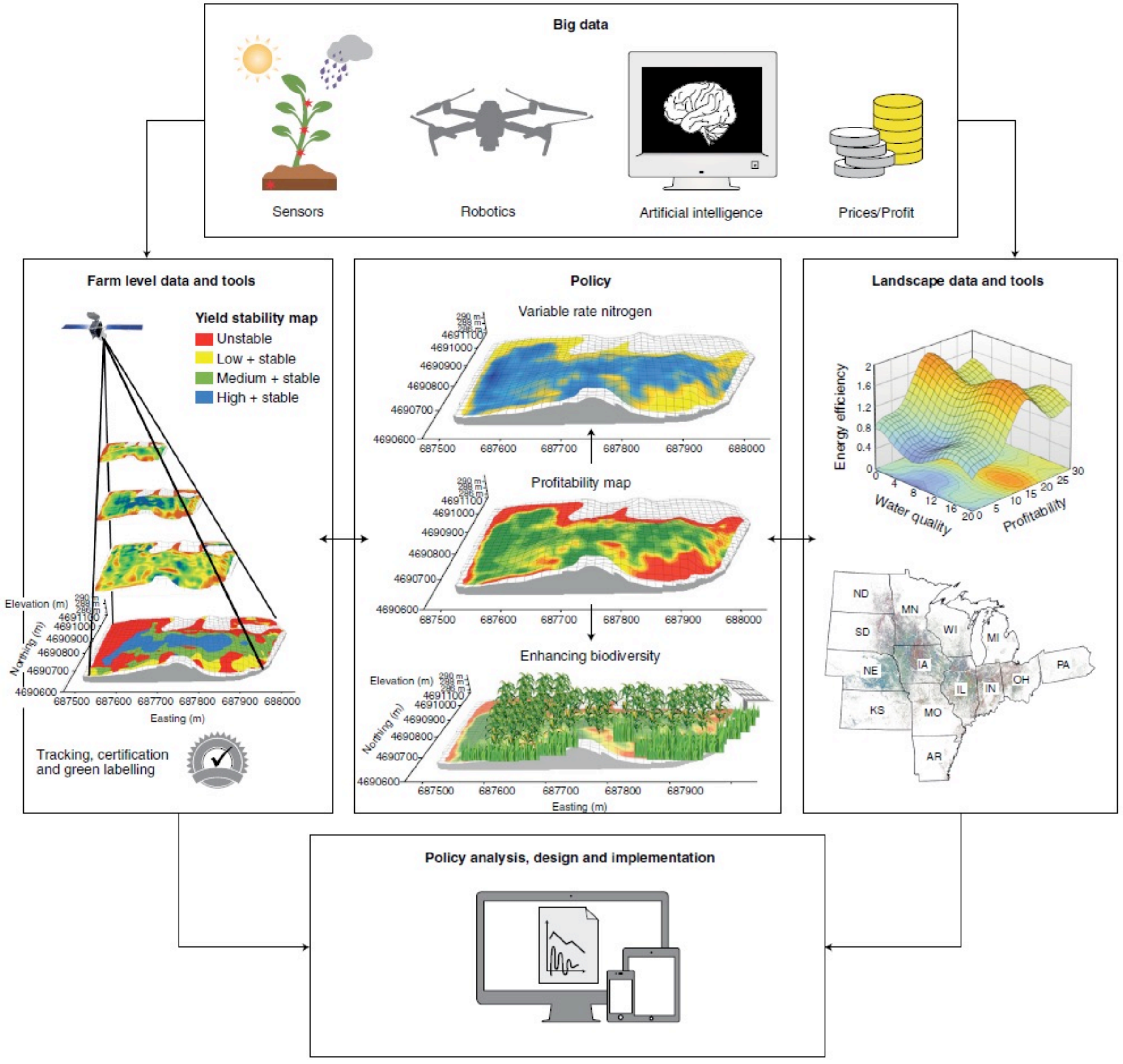
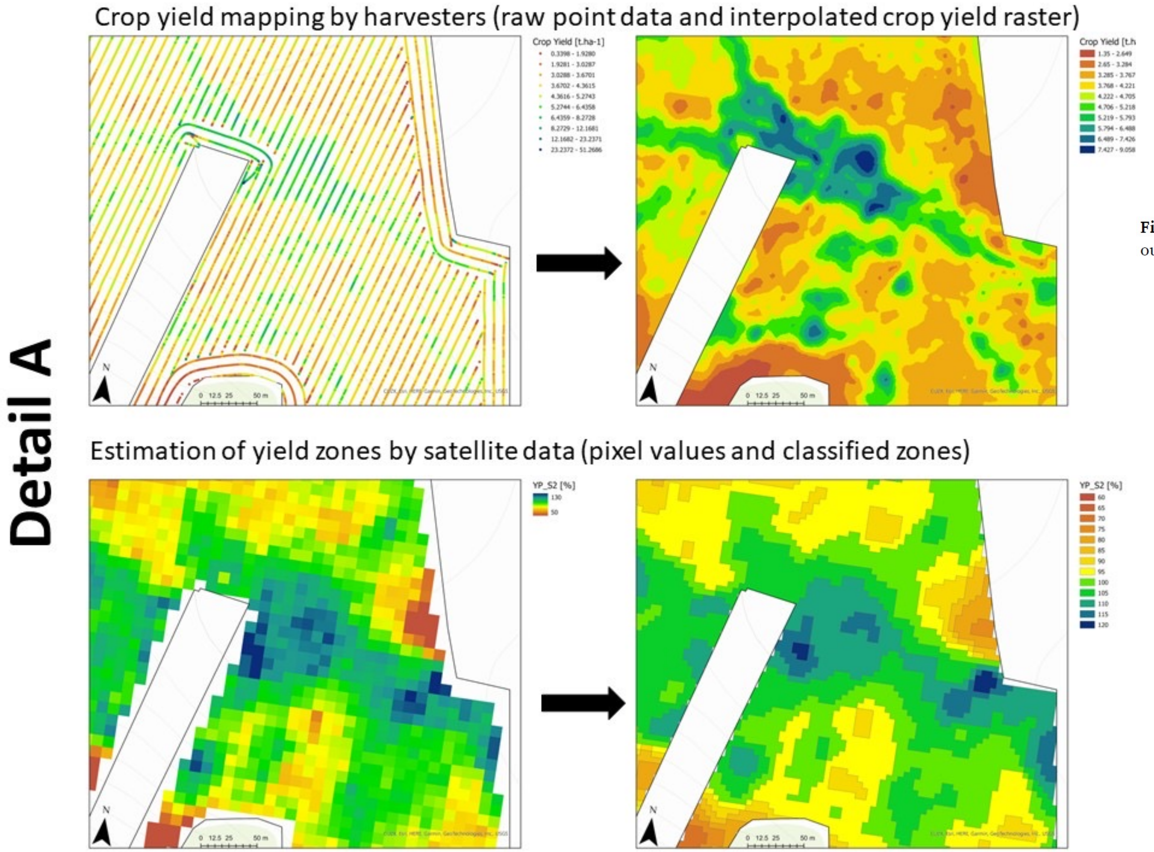


Fig. 1 | **DA in agricultural systems.** DA can be used to design and implement sustainable agricultural systems at farm and landscape scales.

Direct measurements vs satellite data



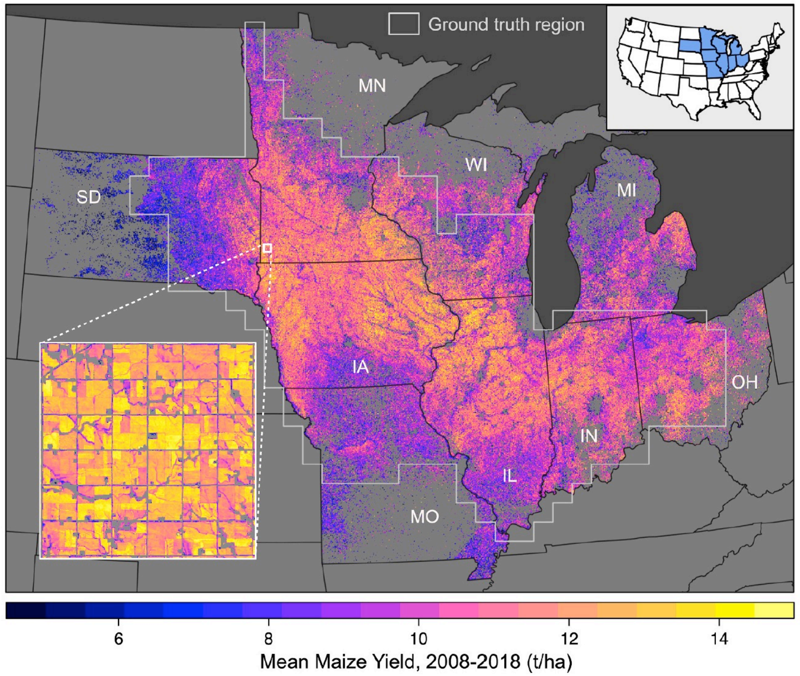
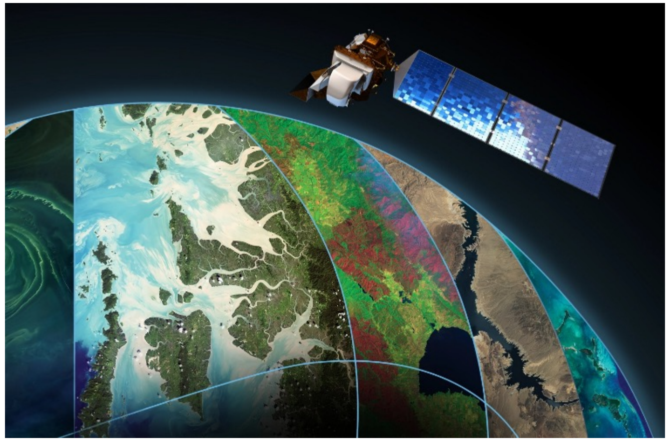


Fig. 1. Study area and mean 2008–2018 yields. The extent of the ground truth data from yield monitors used to evaluate alternative yield mapping approaches is outlined in gray (see also Fig. 2). Mean yields for the larger nine-state study region were generated by applying the preferred SCYM model to Landsat satellite data.



How to satisfy stomachs, farmers and biodiversity

- Setting-aside just a small proportion of arable land
- Optimising field shapes to increase efficiency of agricultural management
- Employing ecological theory to establish high-value non-crop habitats

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RESEARCH PAPER

Soil Use and Management WILEY

Infield optimized route planning in harvesting operations for risk of soil compaction reduction

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Abstract
Soil compaction is a major problem in arable farming mainly caused by the intensive traffic of heavy machinery. It affects negatively soil and crop development. Even though the first wheeling is considered the most damaging, repeated traffic deteriorates further the soil and subsoil even up to irreversible conditions. Intelligent infield traffic planning in the form of optimized route planning is one key option to mitigate soil compaction. Currently, no comprehensive evaluation of the benefits of such methods exists. In this paper, a harvest logistics optimization system was employed to evaluate the effectiveness of optimized route planning in reducing traffic by generating simulated operational data and comparing it to a set of six recorded fields ranging in size (2–21 ha) and shape. For the evaluation, simulated and recorded data for each 12 × 12 m grid cell within the fields were compared by analysing three variables, that is, traffic occurrences, accumulated traffic load and maximum traffic load per grid cell. The results showed a reduction of the total number of traffic occurrences with a field size weighted mean of relative differences of 9.8%. A reduction of 5.6% for the accumulated traffic load, and an increase of 4.0% for the maximum traffic load. Repeated traffic was reduced in four of the six fields. Even though optimized route planning is not directly intended for traffic reduction, it can notably contribute to such mitigation efforts and adds an extra element to the overall farm strategy for soil compaction mitigation.

Basic ecological rules to increase biodiversity in intensively managed agricultural landscape

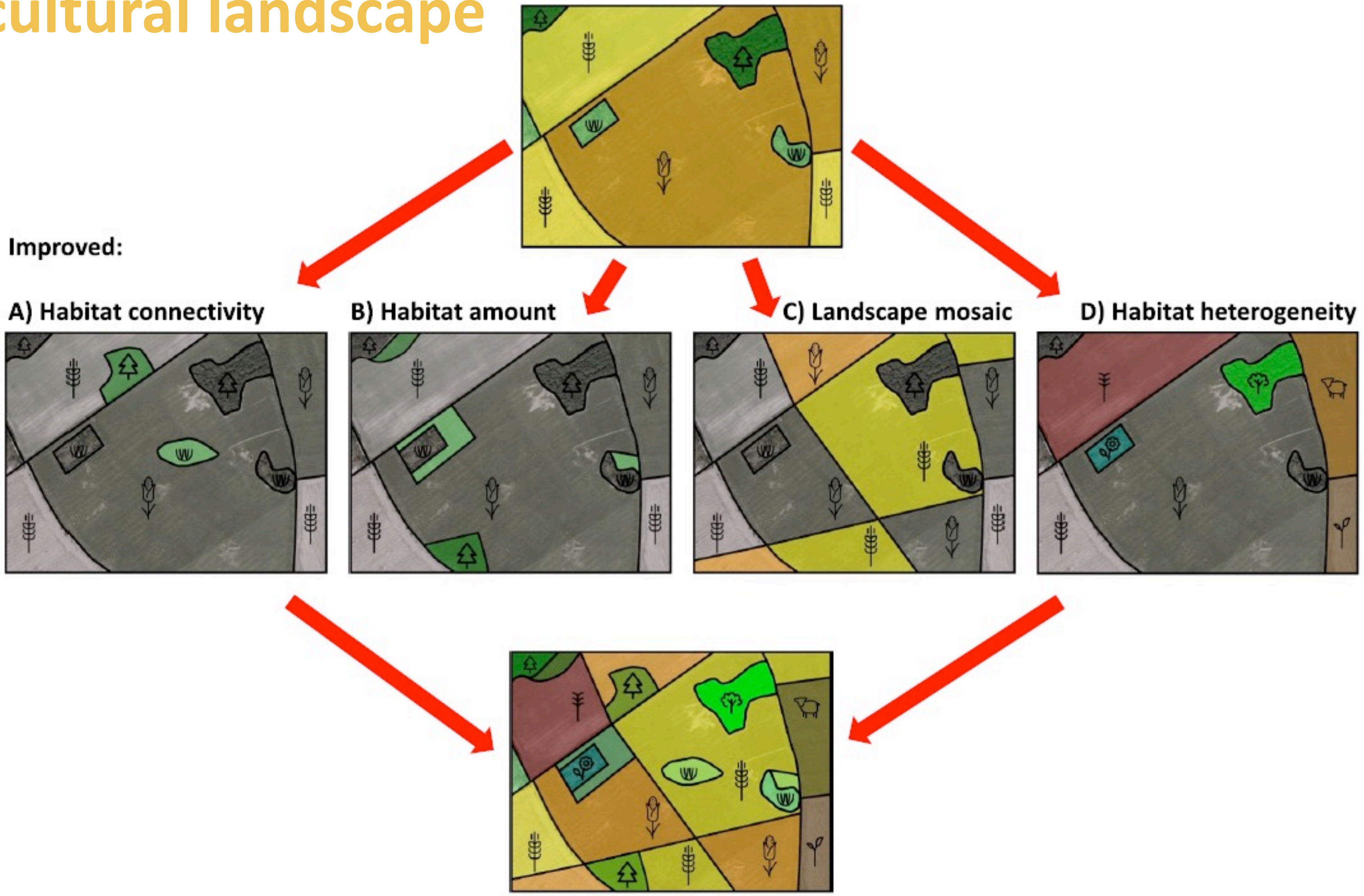


Fig. 1. Visualisation of the main ecological principles that can be applied to improve agricultural landscapes for biodiversity. The upper panel shows an original landscape where the biodiversity value can be enhanced by increasing habitat connectivity (A; adding new set-asides that act like stepping stones) or habitat amount (B; enlarging existing non-crop habitats), decreasing grain size (C; splitting cultivated fields, creating thereby more edges), or increasing habitat heterogeneity (D; new habitat types and crops are introduced to the landscape). Modifications made in panels A-D are highlighted in colour. The bottom panel represents an ideal scenario where all these principles are applied simultaneously.

How we can combine yield maps, field shape analysis and basic ecological rules to improve agricultural landscapes

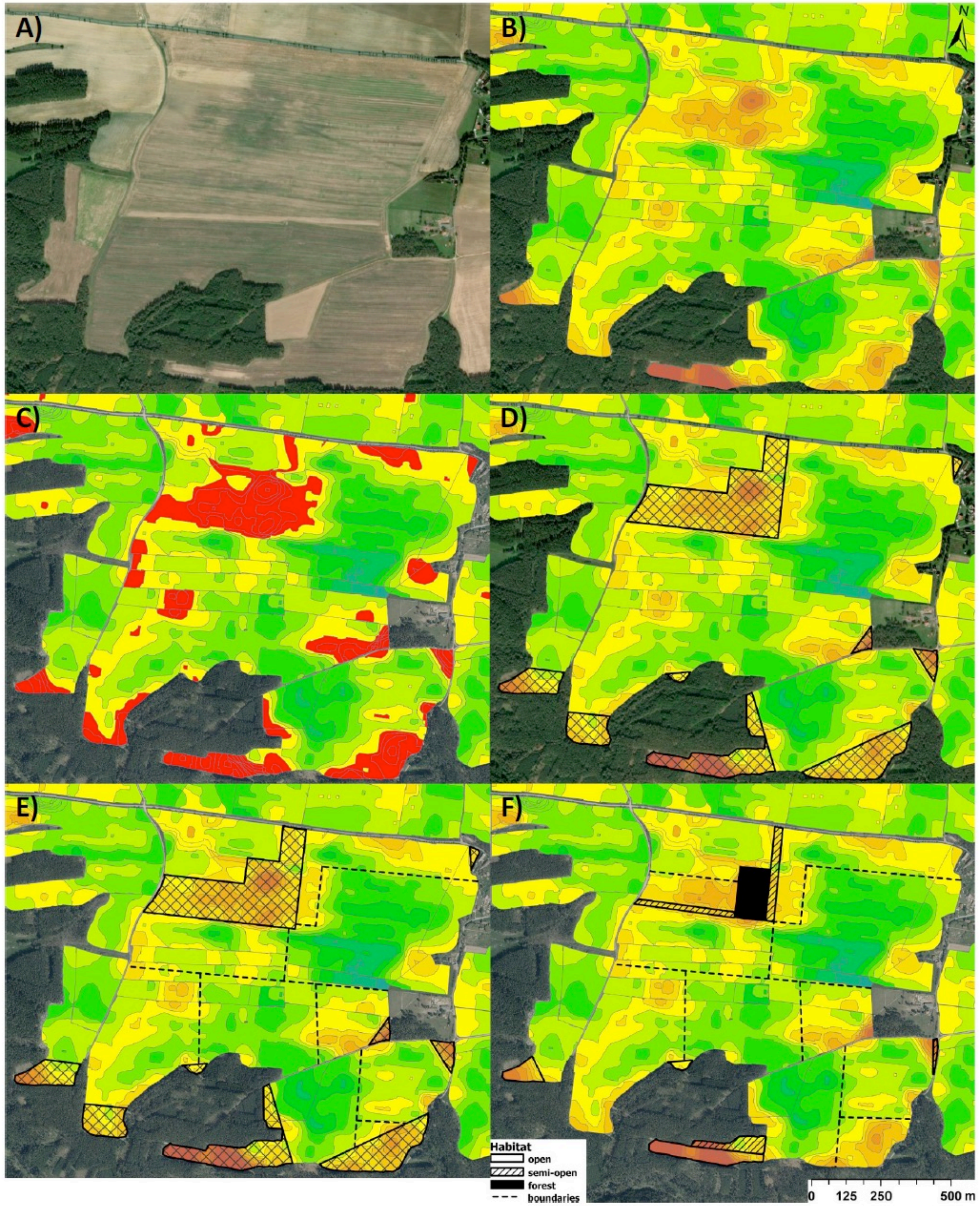


Fig. B2. Step-by-step example of landscape rationalisation using the Ecologically-Informed Precision Conservation (EIPC) framework. Panel A shows the current situation in a focal landscape (aerial photography). Panel F represents optimal solution generated for the focal landscape using the EIPC framework. Colours (green to brown) in panels B–F indicate yield distribution within the model landscape; darkest green equals to 140 % and darkest brown equals to 50 % of average yield. Red areas in panel C indicate 25 % of arable land with the lowest yield potential. See the text in Box 2 for more details on each step of the EIPC framework.

Our framework can be easily transformed into a user-friendly tool/application (algorithm-based automation)

ZEMĚ II
Program na podporu aplikovaného výzkumu Ministerstva zemědělství 2024–2032

e-planner

- About E-Planner
- User guide
- E-Planner tool
- Next steps
- About UKCEH
- Acknowledgements

+ Choose maps to display

+ Basemap options

+ Layer transparency

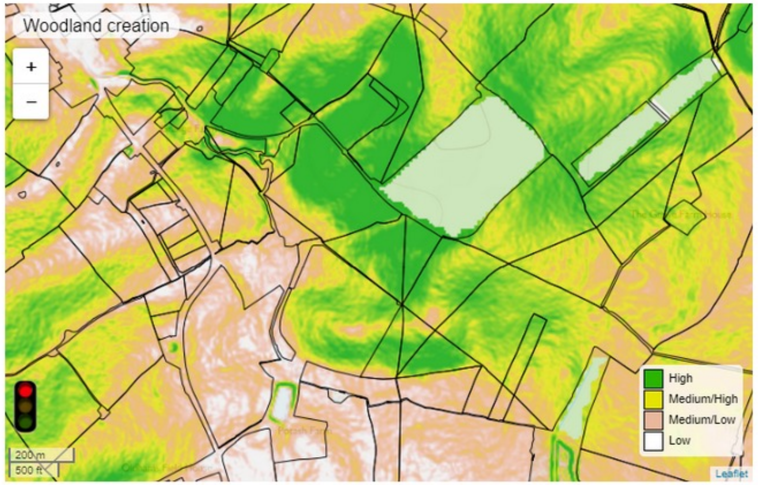
UK Centre for Ecology & Hydrology

e-planner

Welcome to E-Planner! E-Planner has been developed by UKCEH to help farmers and other land mangers identify the most suitable places for different environmental management options via easy to use, interactive maps. E-Planner is free to use and covers the majority of agricultural land in GB.

The tool uses environmental datasets to produce maps of the relative suitability of land for different environmental outcomes. E-Planner currently maps relative suitability for these options:

- **Water resource protection** (buffer strips and cover crops)
- **Woodland creation** (planting of trees on-farm)
- **Sown winter bird food** (wild bird seed margins)
- **Flower-rich pollinator habitats** (flower margins and grassland restoration)
- **Wet grassland restoration** (restoring wet grassland and floodplain meadows)



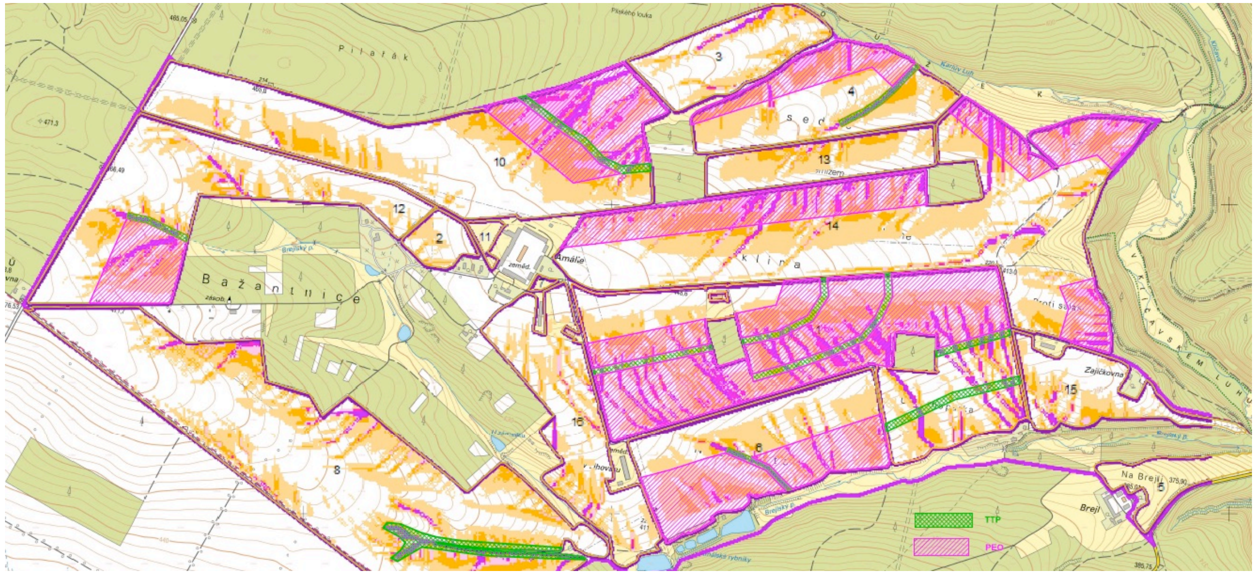
Suitability is based on topography, soils, nearby habitats, landscape features etc. Suitability is then presented as easy to explore 'heat maps' for a chosen area or farm, making it simple to compare the most suitable option for a given area or to identify the most suitable location for a specific option.

E-Planner is intended to support farmer decisions by presenting complex environmental data in an easy to interpret way. But it cannot take the place of local knowledge and therefore does not suggest an 'optimum' solution. We suggest the following workflow:

1 **Make an assessment**
Think about what you want to do. Use precision agriculture data (e.g. yield maps) or your own knowledge to identify less productive or difficult to farm areas. Consider options you might choose.

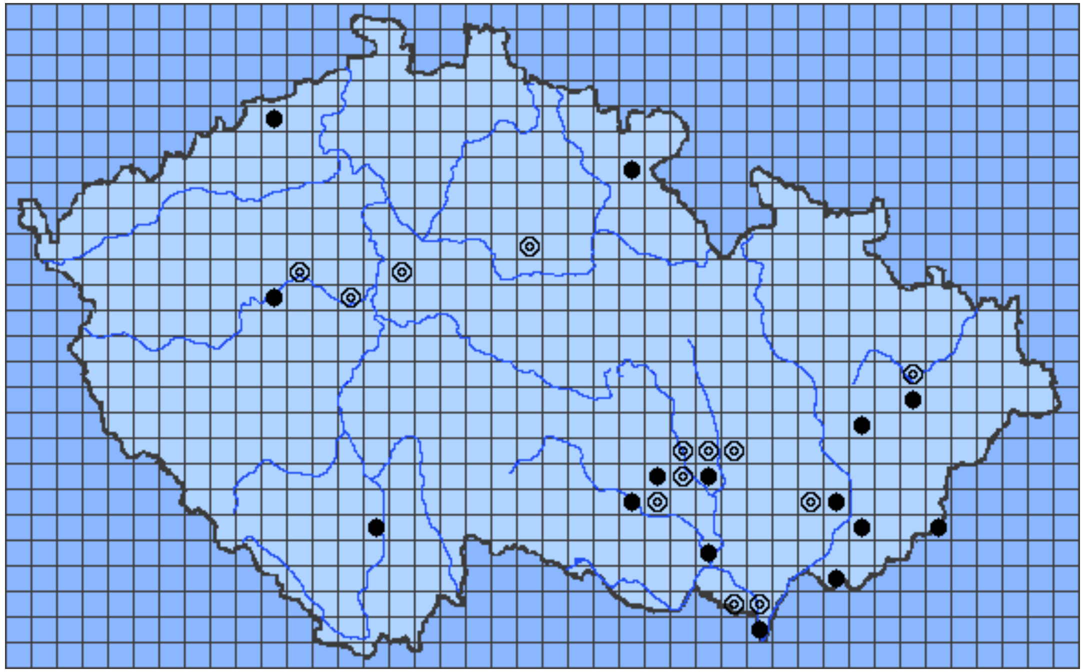
Our framework can be easily further developed

- Erosion risk analysis
- Water quality effects
- Consideration of agricultural practices
- Inclusion of local/national politics/targets (e.g., to decrease arable field size)
- **Inclusion of local specifics (e.g., conservation priorities, focal species/habitats)**



Limitations of the proposed framework

- Data availability (mandatory yield reporting)
- Biological knowledge (local species pool, optimal non-crop habitat management etc.)
- Socio-economic limitations (e.g., land ownership impeding land-use changes)
- And a lot of other small issues



iNaturalist

Systematic insect monitoring in the Czech Republic

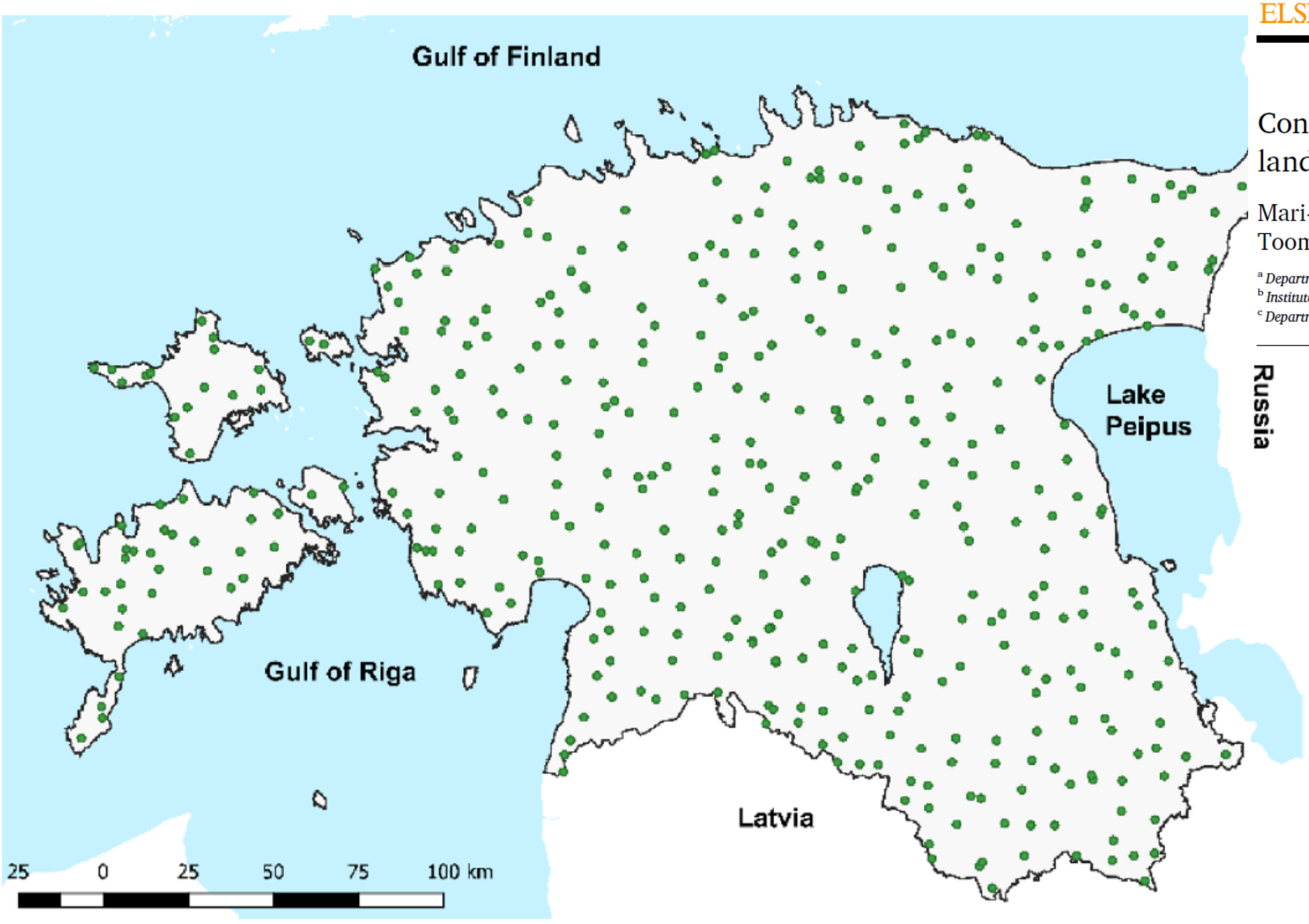


Fig. 1. Map showing the distribution of study sites in Estonia, Northern Europe.

Forest Ecology and Management 462 (2020) 118002

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Conserving woodland butterflies in managed forests: Both local and landscape factors matter

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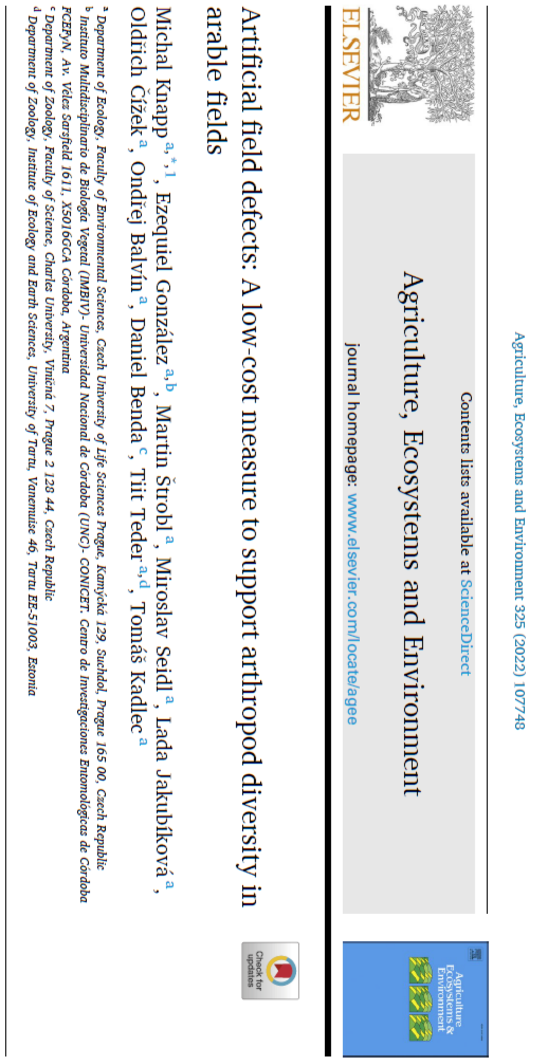
Systematic insect monitoring in the Czech Republic




Systematic insect monitoring in the Czech Republic



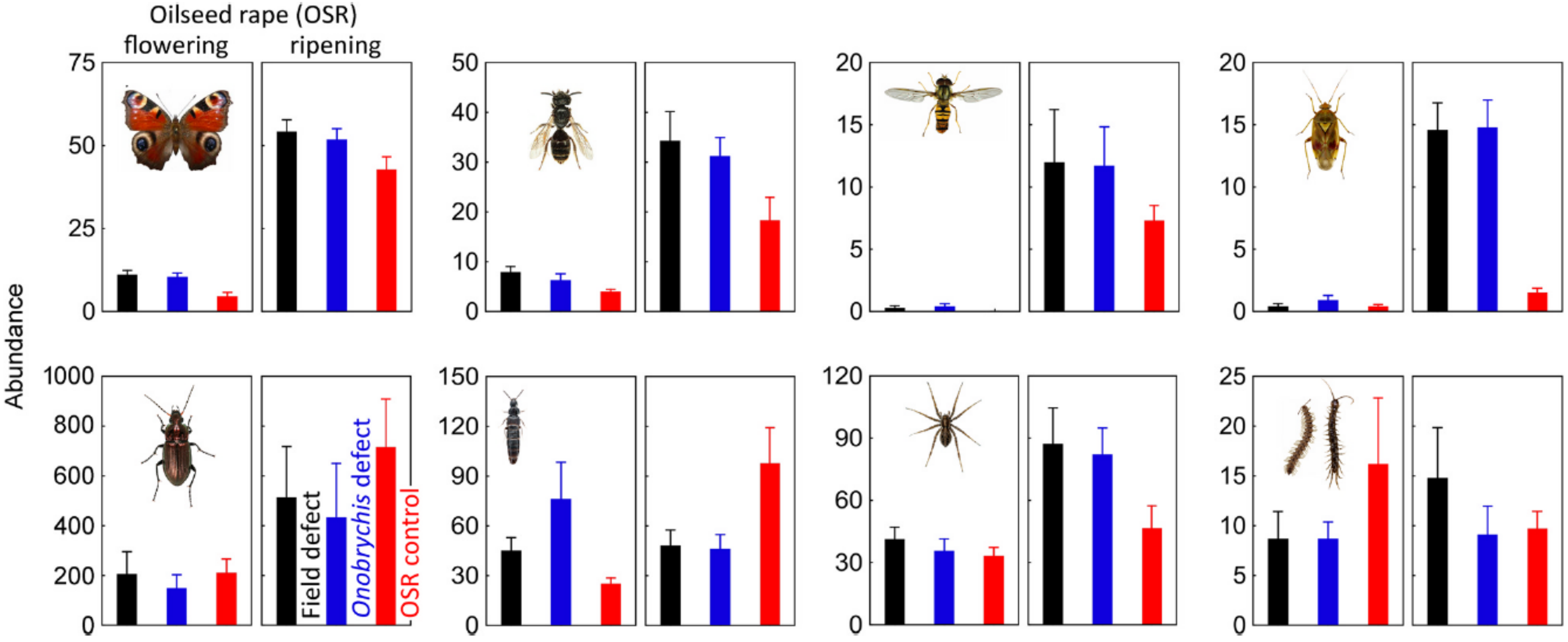


Fig. 2. Effects of habitat type and sampling period on arthropod abundance within oilseed rape (OSR) fields. Habitat types are shown with different colors: OSR controls in red, field defects in black, and *Onobrychis* field defects in blue. Data are shown separately for OSR flowering and ripening periods. Mean values and standard errors are shown separately for butterflies, bees and wasps (combined), hoverflies, true bugs, carabid beetles, rove beetles, spiders and myriapods. (For interpretation of the references to colour in this figure, the reader is referred to the web version of this article.)

Systematic insect monitoring in the Czech Republic

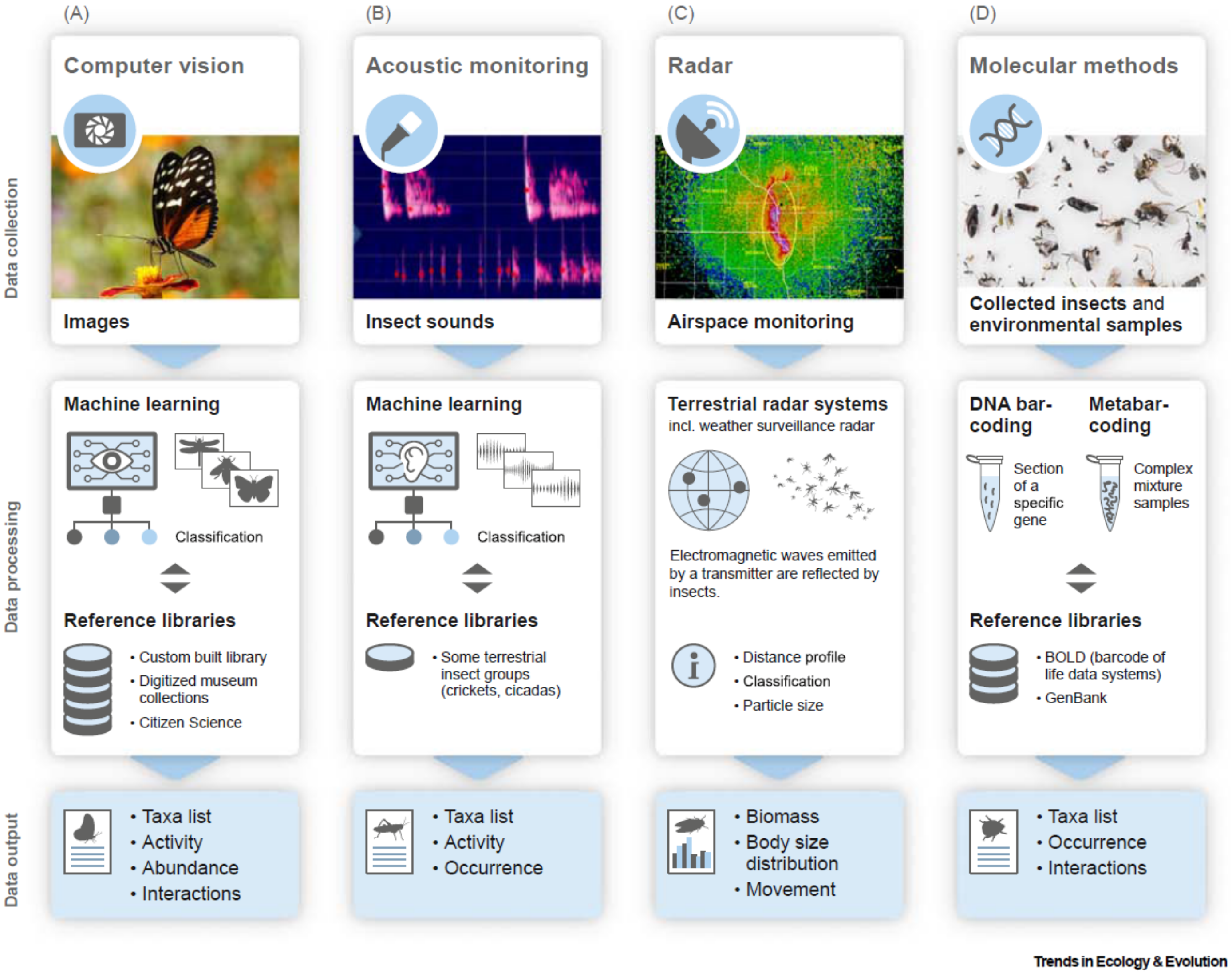
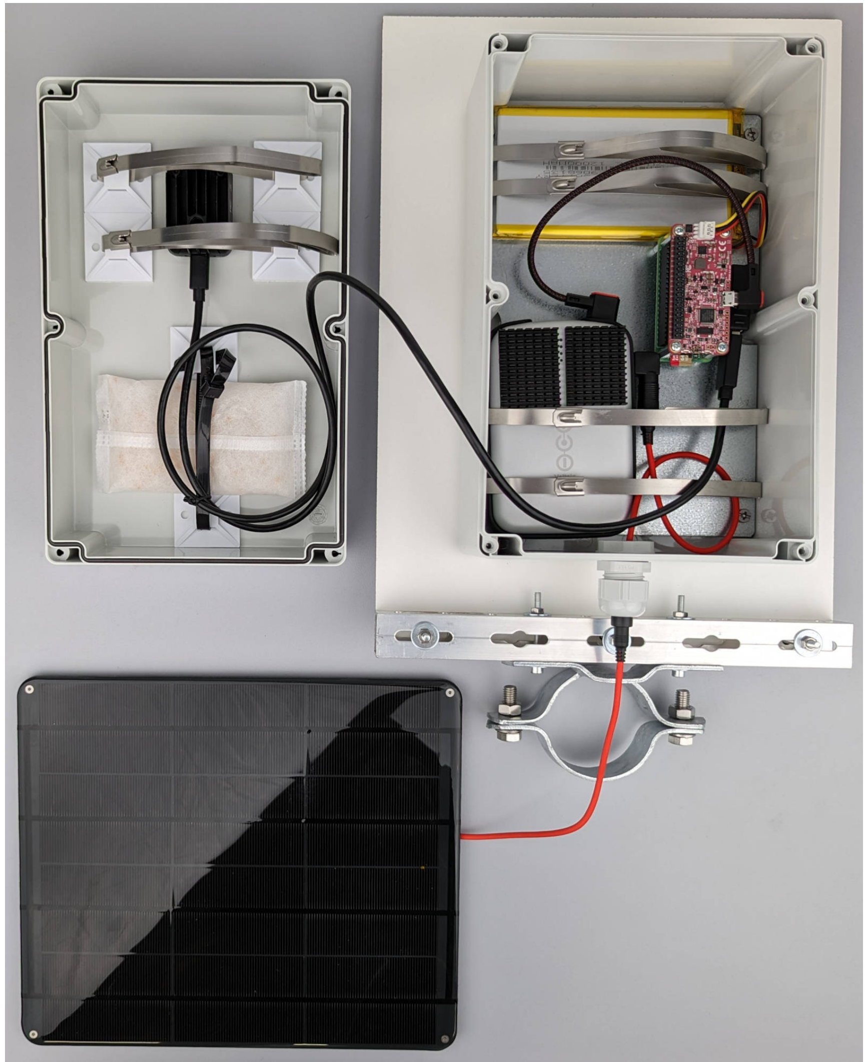
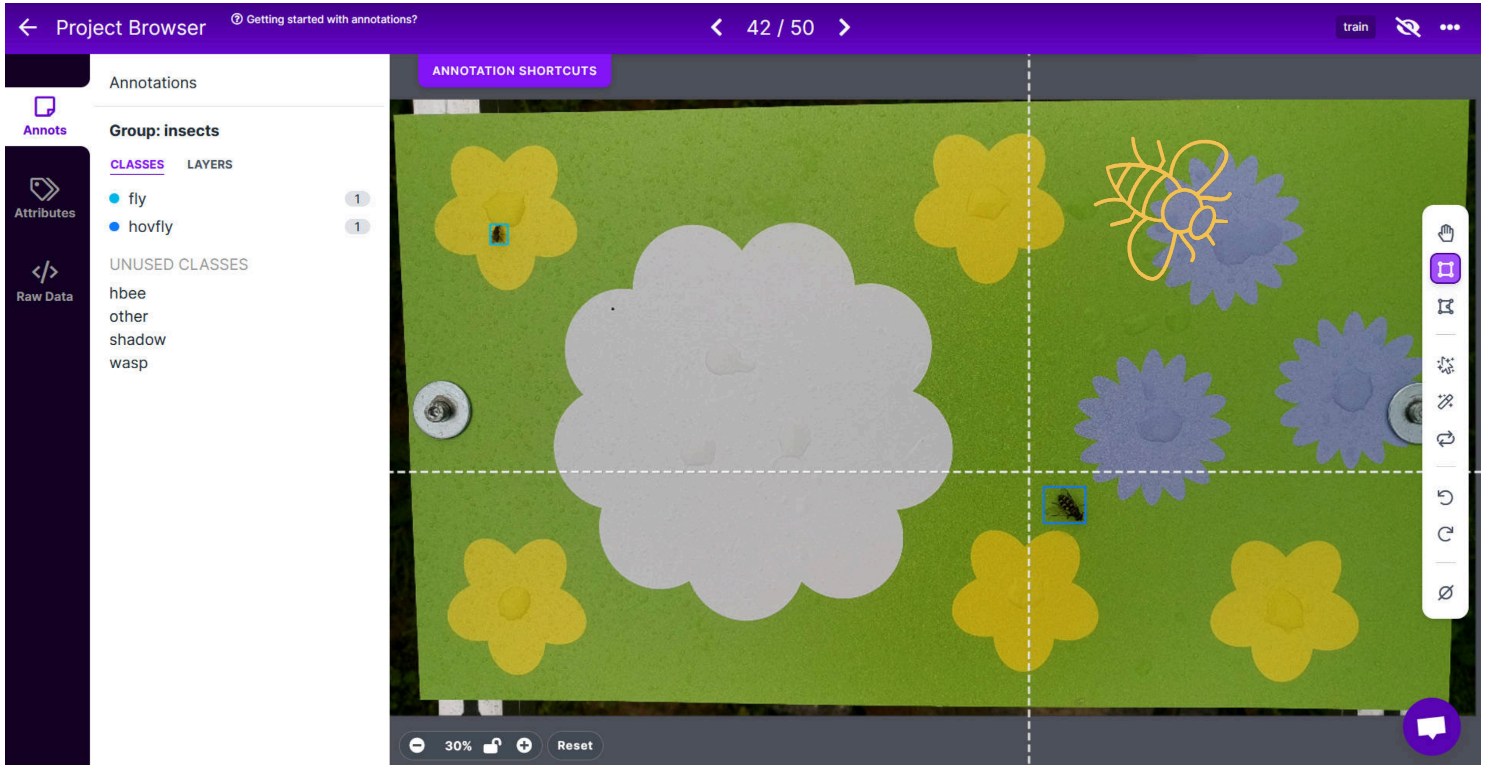


Figure 1. Workflows from data collection to end product of each of the four technologies covered in this review.

Systematic insect monitoring in the Czech Republic





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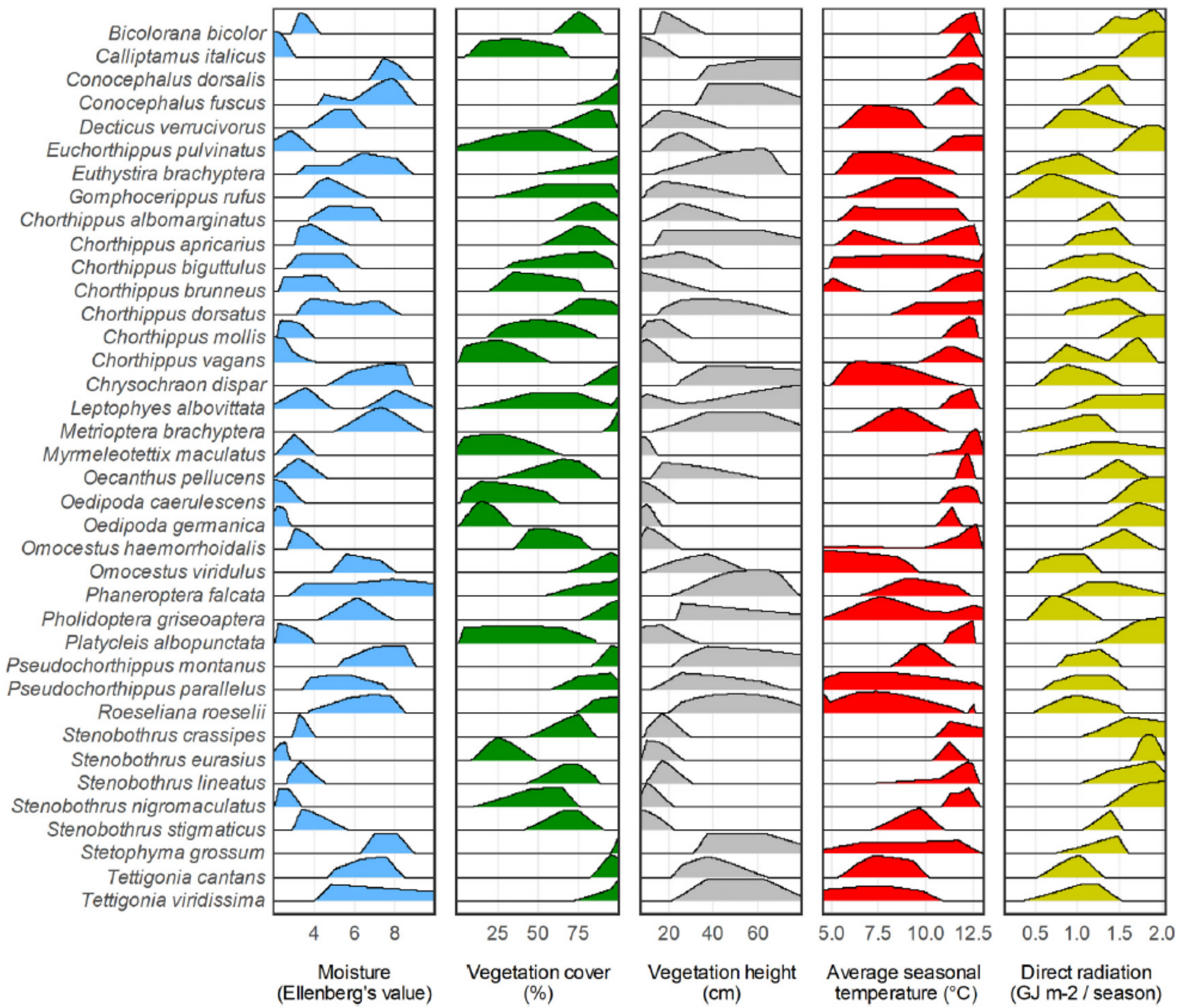
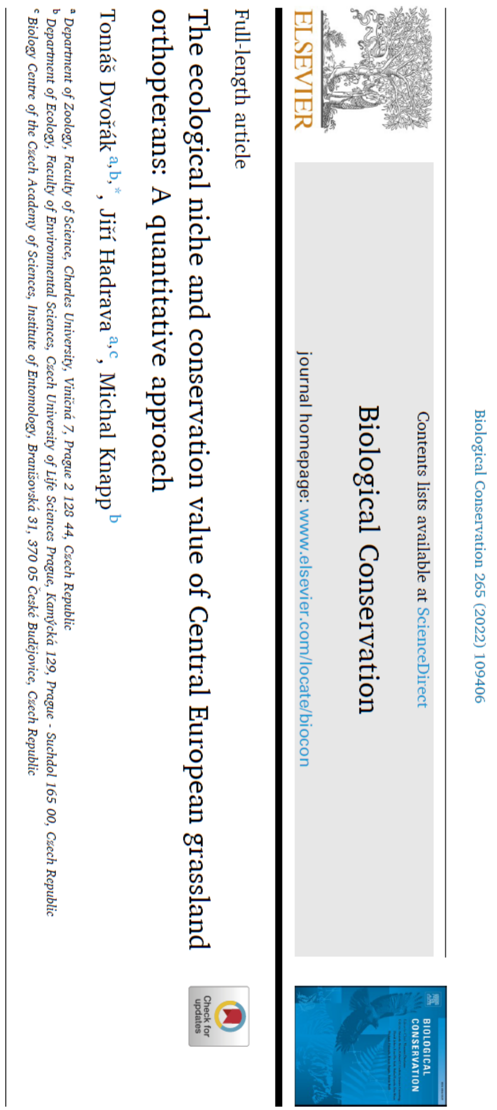


Fig. 3. Presence probability for all analysed species and measured environmental variable combinations. Moisture is shown in blue, vegetation cover in green, average seasonal temperature in red, vegetation height in grey, and direct radiation in yellow. Species are ordered alphabetically. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)



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Full-length article

The ecological niche and conservation value of Central European grassland orthopterans: A quantitative approach

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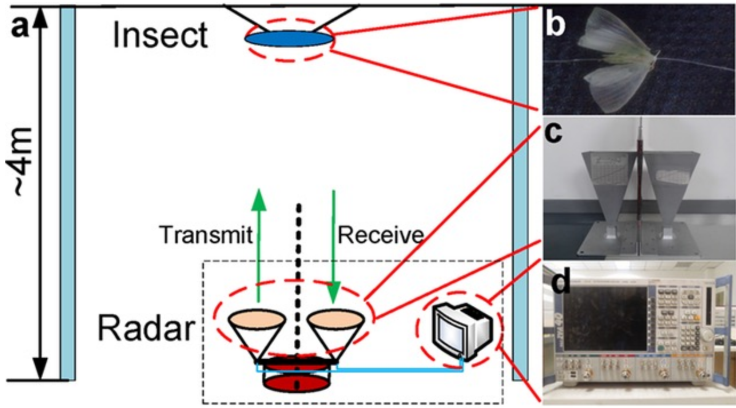
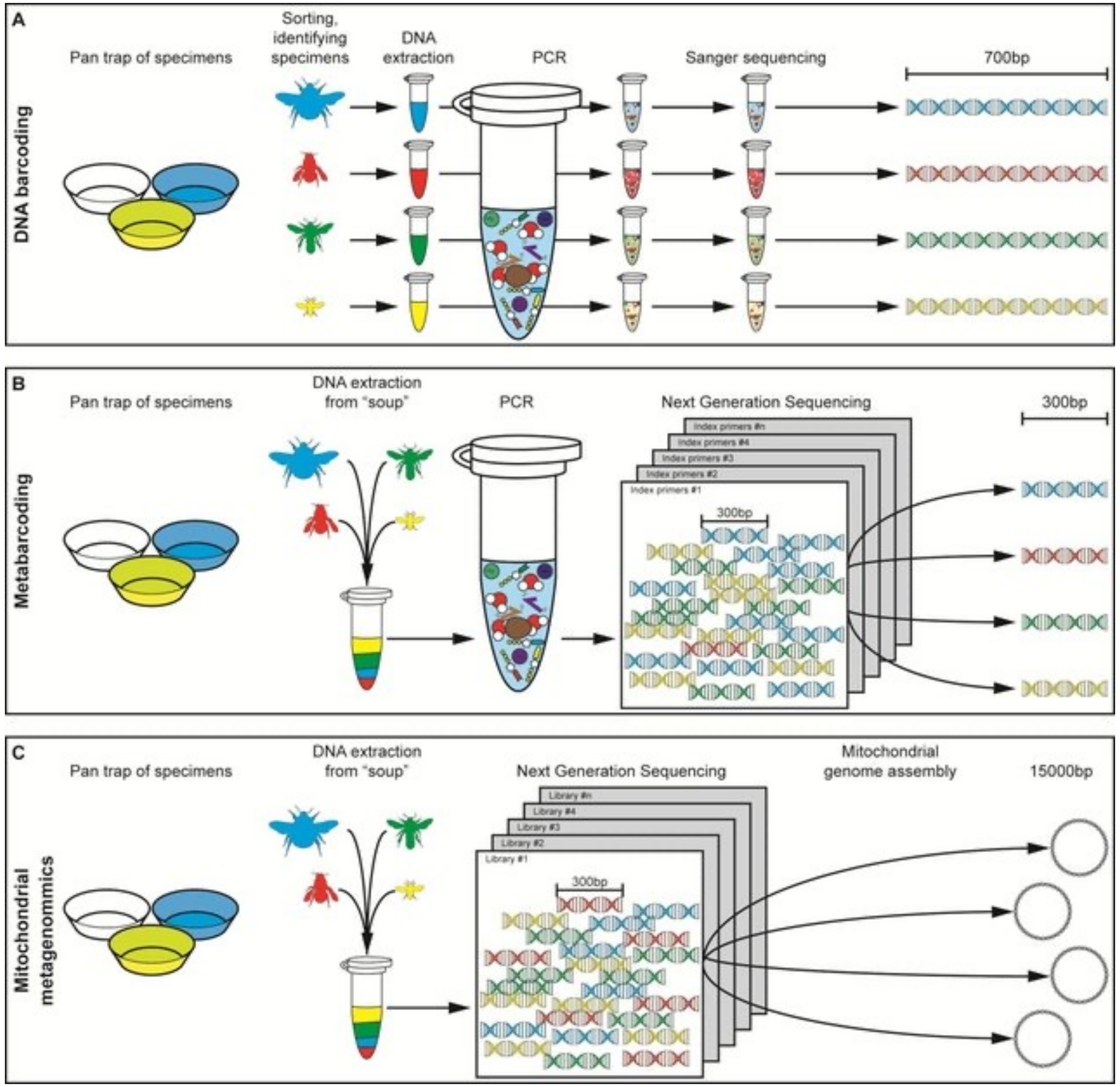
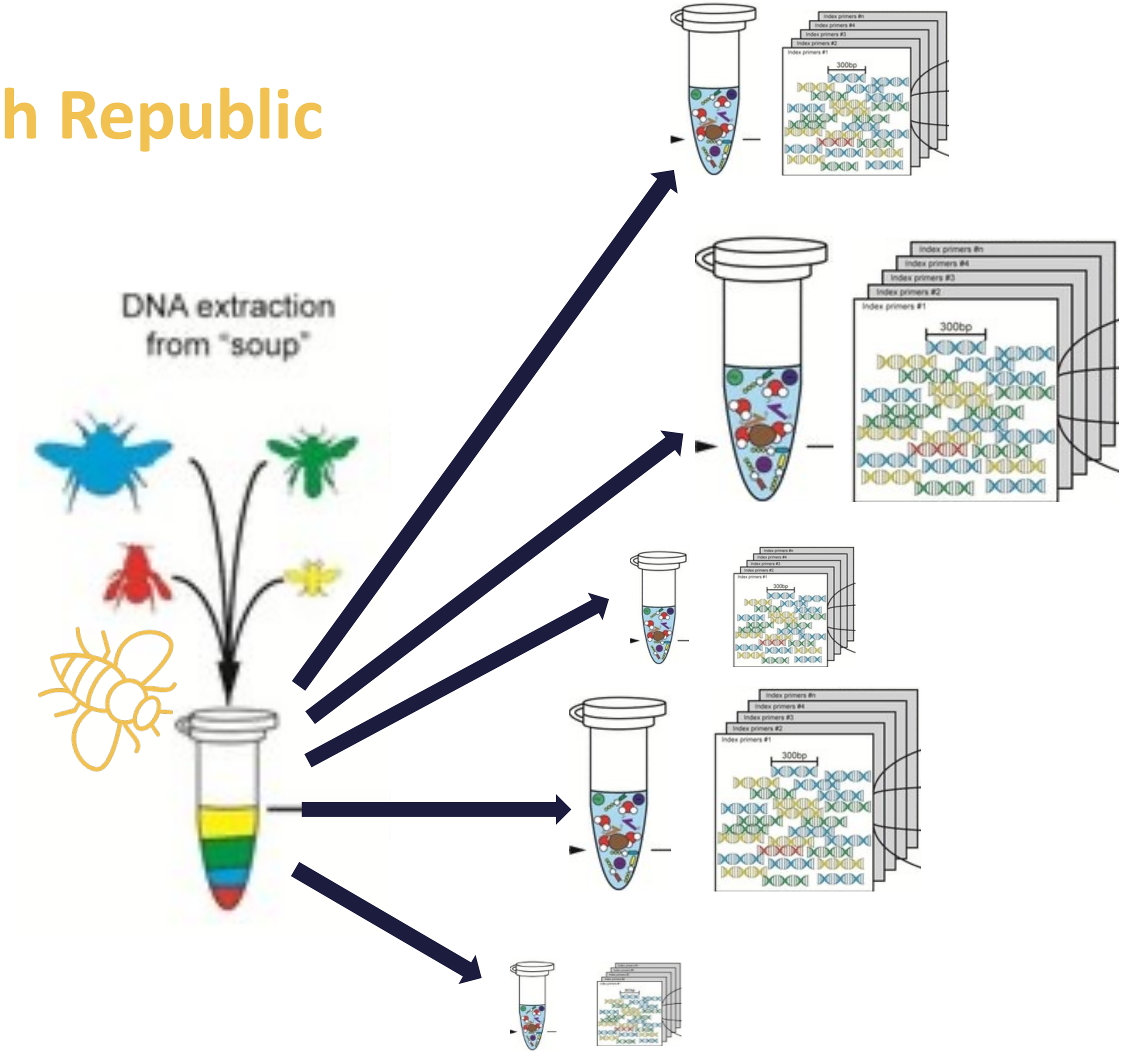
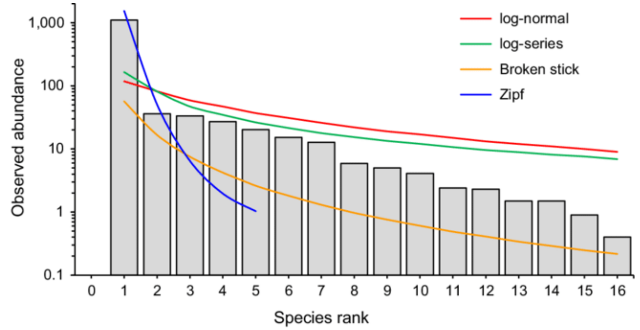
Systematic insect monitoring in the Czech Republic

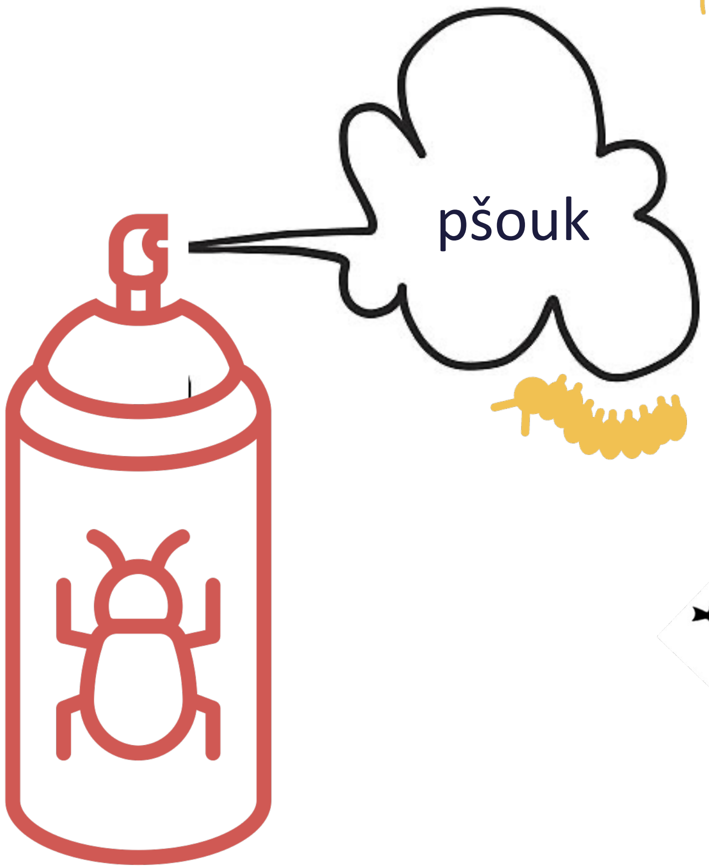


Systematic insect monitoring in the Czech Republic









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Tento projekt je spolufinancován se státní podporou Technologické agentury ČR a Ministerstva životního prostředí v rámci **Programu Prostředí pro život.**

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