Scenario Development for Bee Risk Assessment and Bee Health Modelling

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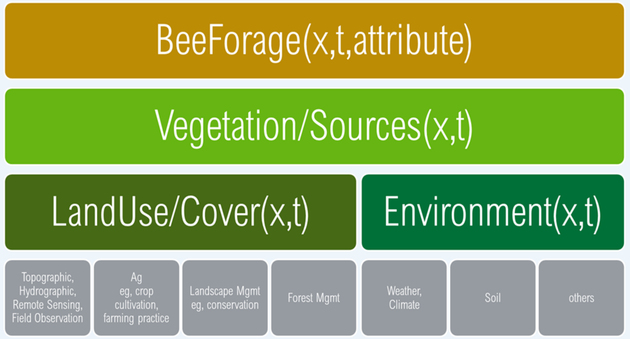
Introduction

- Bee effect modelling has become a core instrument in bee risk assessment (RA) (EFSA 2013, 2018, 2021)
- Scenarios are needed which fulfill regulatory requirements (e.g., representing conservative conditions) and which provide all necessary information to the bee model in appropriate spatial and temporal scales and levels of certainty
- We developed conceptual elements of scenarios in regulatory RA, built a modular bee forage model and demonstrated its applicability for an exemplary use of a PPP in apples in France:
  - **Scenario Site Selection** is driven by vulnerability mapping and beekeepers' management
  - **Scenario Construction** embodies all process steps and entities to build a local BEEHAVE scenario
    - Distinct **bee forage information layers** were defined for a clear and transparent bee forage modelling process
    - A **modular bee forage modelling** approach separated explicit process steps from one information layer to the next (e.g., the BeeForage module models nectar and pollen provision for a given vegetation unit and its phenology)
    - Modules implemented a defined level of complexity to enable a **tiered scenario development scheme**

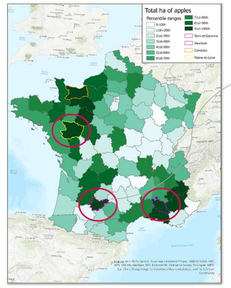


Bee forage modelling information layers

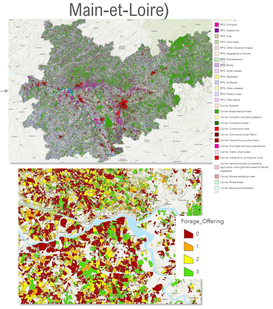
Scenario Site Selection

Country

Country-wide apple density and climatic variability

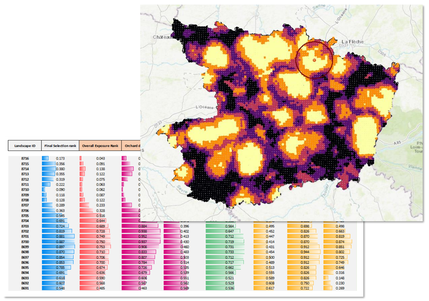


Medium-resolution bee forage mapping (Tarn-et-Garonne, Vaucluse & Main-et-Loire)



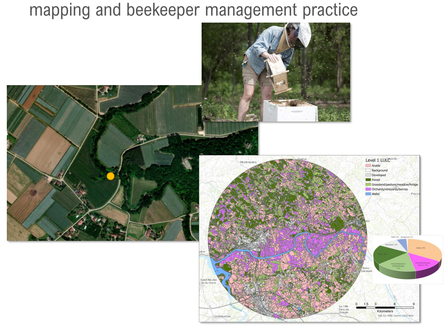
Regional

Vulnerability mapping combining potential exposure and bee forage occurrence

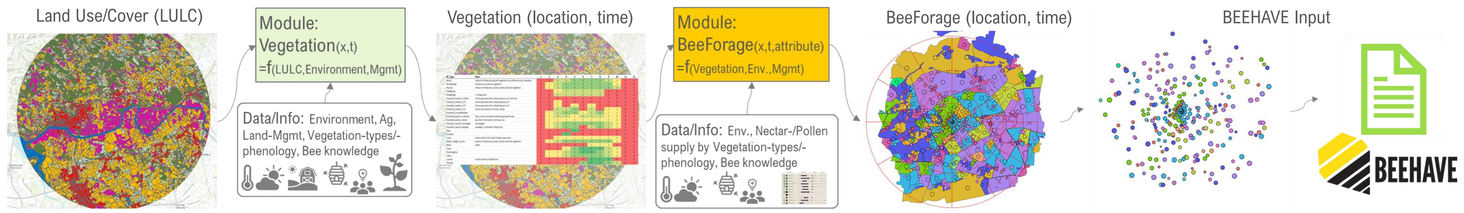


Local

Local selection of apiary location from vulnerability mapping and beekeeper management practice



Scenario Construction (Modular Approach with simple 'Level-1' implementation using Look-up tables)



Layer representing **LULC types that offer bee forage** or which affect bee behaviour

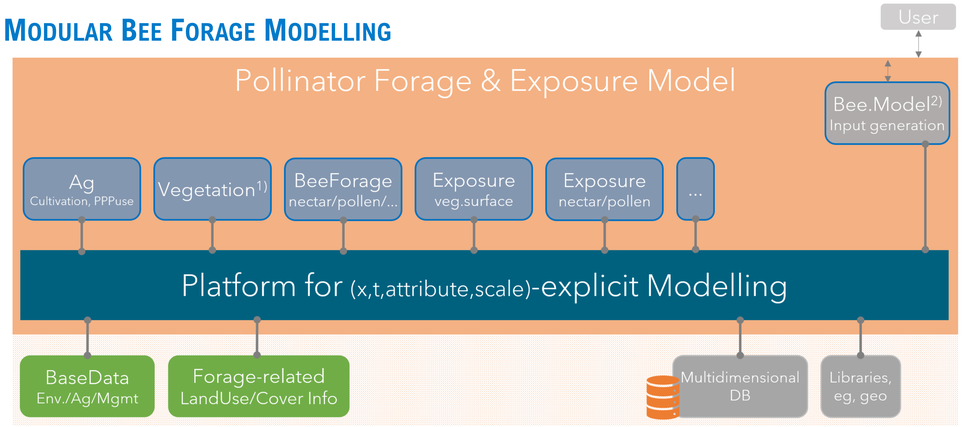
Vegetation units and their phenology related to bee forage supply in space and time (combination of vegetation patches and/or individual plants)

Spatiotemporally explicit representation of bee forage (**nectar** and **pollen**) by given vegetation (location, time) modelled in **five categories (0-4)** with **monthly** resolution and simple quantification of nectar/pollen provision

Consolidation into <500 patches (practical limitation of BEEHAVE)

Ready-to-use BEEHAVE input

Modular Bee Forage Modelling

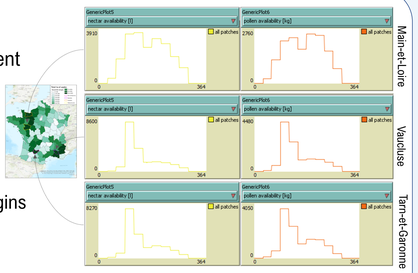


Schematic illustration of a modular platform for spatiotemporally explicit bee forage (as well as bee exposure) modelling

- A generic modular landscape modelling platform was utilized (Schad&Bub in prep., Bub et al 2020, Schad&Schulz 2011)
- Modules on Vegetation(x,t), BeeForage(x,t) and BEEHAVE-input-generation were added
- To get started, the level of complexity of the modules Vegetation(x,t) and BeeForage(x,t) was intentionally simple, by using forage categories and look-up tables
- Simple module realizations can be replaced with more sophisticated ones if/when needed (tiered approach)
- The development of modules can be done by independent experts which facilitates collaboration
- Exposure modules are under development

Results

- An operational conceptual framework for honey bee scenario development has been designed and implemented into a modular BeeForage model
- In an example study, BeeForage scenarios and ready-to-use BEEHAVE input were created which seem realistic according to expert judgement
  - Tarn-et-Garonne and Vaucluse showed similar nectar/pollen dynamics:
    - A prominent spring peak caused by apple cultivation and a summer plateau from grassland and undergrowth vegetation in woods and margins
  - The spring apple flowering peak is less prominent in the Main-et-Loire scenario due to lower apple orchard density
  - All scenarios show an indication of the well-known “June forage gap”
- Scenarios are ready to be evaluated in honey bee RA (adding exposure)



Nectar and pollen availability over BEEHAVE model year

Conclusions

- A conceptual framework with defined entities facilitates complex modelling processes at landscape-scales
- An open, modular and platform-based implementation assures separation of concern, increases transparency and facilitates collaboration
- A tiered realization of module complexity allows immediate scenario provision and stepwise increase of realism, as data and mechanistic processes are available
- The usability of the BeeForage model was successfully demonstrated in a case study

Outlook

- Exposure scenarios for honey bees
- Model publication
- Web-based user interface allowing user to define hive location on a map
- ApisRAM scenario module
- Increase level-of-realism of Vegetation(x,t) and BeeForage(x,t) modules
- Validation
- Extension to wild pollinators

EFSA, 2013. Guidance Document on the risk assessment (RA) of plant protection products (PPP) on bees.
EFSA, 2018. A systems-based approach to the environmental RA of multiple stressors in honey bees.
EFSA, 2021. Outline of the revision of the Guidance on the RA of PPPs on bees.

Schad, T., Schulz, R., 2011. Xplicit, a novel approach in probabilistic spatiotemporally explicit exposure and risk assessment for plant protection products. Integr Environ Assess Manag 7, 612–623. https://doi.org/10.1002/ieam.205
Bub, S., Schad, T., Gao, Z., 2020. XDrift—An R package to simulate spatially explicit pesticide spray-drift exposure of non-target-species habitats at landscape scales. SoftwareX 12, 100610. https://doi.org/10.1016/j.softx.2020.100610

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