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Direct and indirect effects of landscape, mediated by mesoclimate, on carabid communities and weed seed predation in winter cereals

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Introduction

- **Agricultural intensification, landscape simplification and climate change** threaten **biodiversity and ecosystem services**.
- Increasing the quantity of **semi-natural habitats** and **landscape heterogeneity** could help mitigate biodiversity¹ and ecosystem services loss.
- Landscapes could affect biodiversity by providing habitats and resources and by modifying the **mesoclimate**, such as **air temperature**².
- In crop fields, one important service is **the biological regulation of weeds**. Indeed, weeds cause major yield losses and lead to massive use of herbicides.
- **Carabids** are abundant generalist predators contributing to weed seed regulation³. They can be influenced by landscapes and farming practices, and possibly by the mesoclimate⁴.

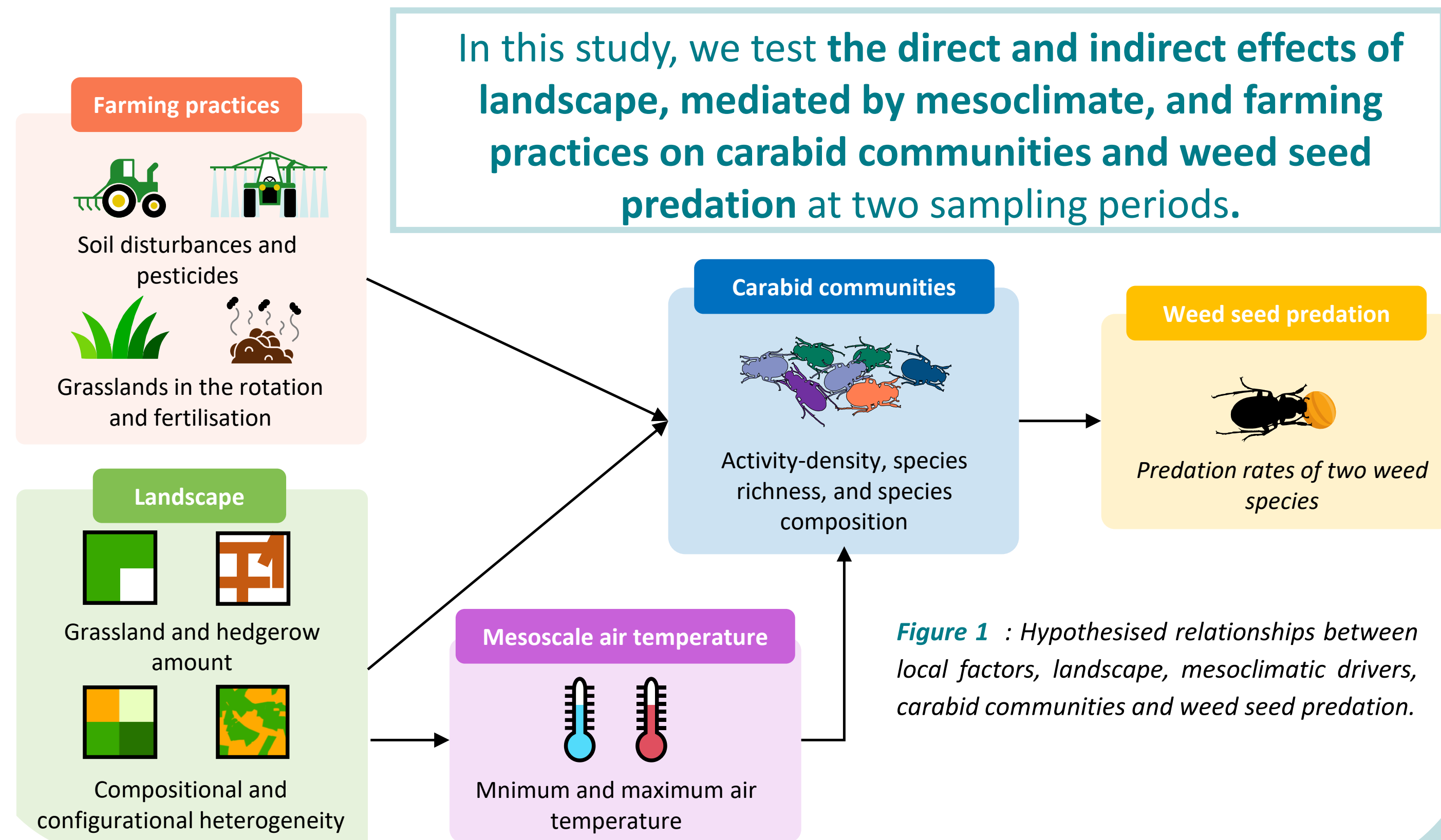


Figure 1 : Hypothesised relationships between local factors, landscape, mesoclimatic drivers, carabid communities and weed seed predation.

Materials and methods

- We selected **20 landscape windows** along uncorrelated gradients of semi-natural habitat amount and landscape heterogeneity. For each window, we also recorded air temperature using automatic sensors.

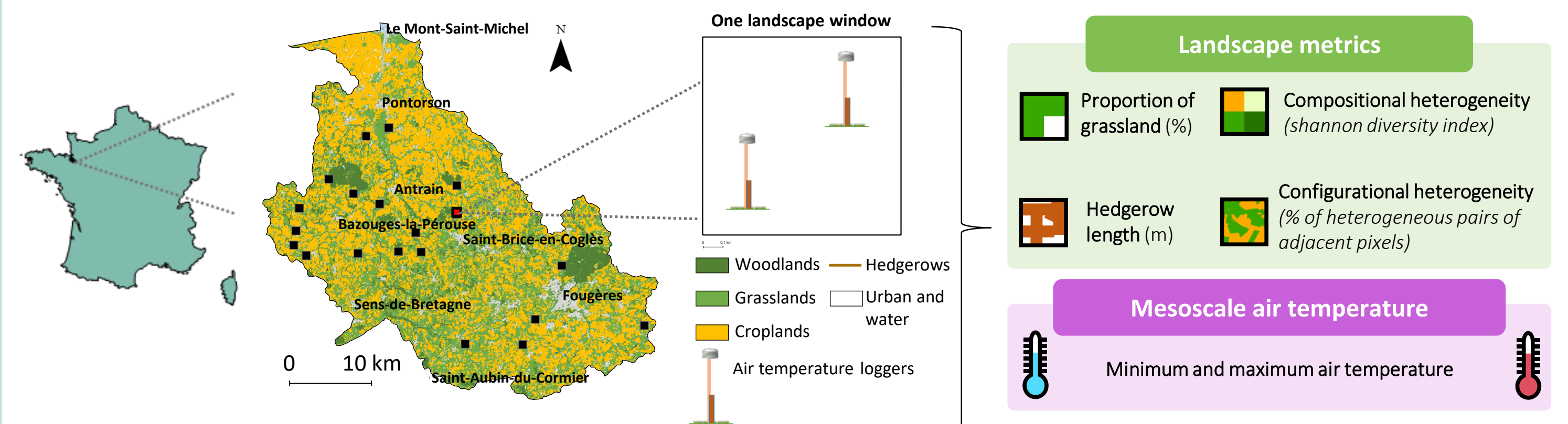


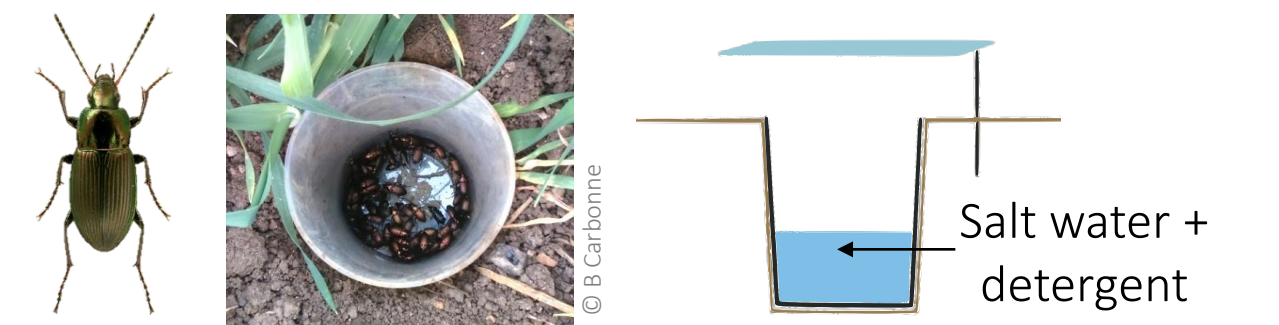
Figure 2: Overview of the twenty 1 km x 1 km landscape windows in the Couesnon watershed (based on Lecoq et al., 2022).

- We sampled **77 fields** (3 to 4 winter cereal fields per window) over two sampling sessions (May/June 2023), during which we surveyed:

• Carabid communities

Activity-density, richness and composition of seed-eating species

Use of pitfall traps to catch carabids (exposed 2 weeks):



• Farming practices

Tillage, fertilization, pesticide, grassland in rotation - summarized with a PCA

Seed card with enclosure cage (exposed 2 weeks)



• Weed seed predation

Predation rates of *Viola arvensis* and *Poa annua*

Structural Equation Models were built to test for the direct and indirect effects of local and landscape factors on carabids and weed seed predation.

Results

- The landscape influenced mesoscale air temperature in June. Specifically, higher grassland amount increased the maximum air temperature. In both sessions, mesoscale air temperature affected carabid species composition.
- Farming practices (numerous tillage operations but without ploughing) and grassland amount positively affected the activity-density of seed-eating carabids, while hedgerow amount affected it negatively. In addition, grassland and hedgerow amounts affected carabid species composition in the second session.
- Carabid activity-density (for both sessions) and richness (only in May) positively affected weed seed predation of *V. arvensis*. In addition, species composition (only in June) was correlated to weed seed predation.
- The landscape has a cascading effect on seed predation through carabid activity-density and composition. This cascade is partly mediated by the mesoclimate.

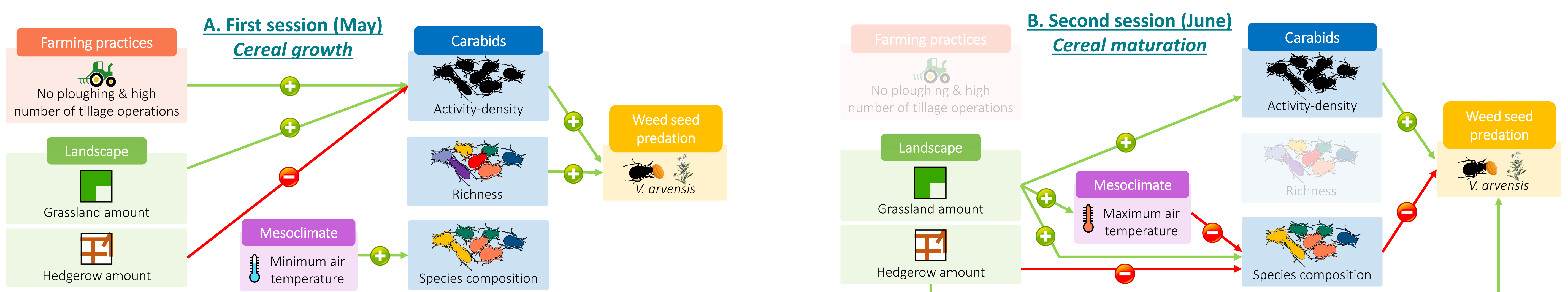


Figure 3 :Structural equation models explaining seed predation by seed-eating carabids during the two sessions: A. May and B. June. For simplicity, *P. annua* seed predation and compositional and configurational heterogeneity are not represented here.

Discussion

- **Local field management and landscape drive carabid activity-density.** The dominant species in our study, *Poecilus cupreus* is known to be disfavoured by ploughing⁵ and hedgerow, and favoured by grassland amount around crop fields¹ - supporting our results.
- **Mesoscale air temperature affected carabid composition** in both sampling sessions:
 - During **cereal growth**, higher **minimum temperature** (positively correlated with those in winter) favoured species less tolerant to low temperature extremes (*Amara plebeja*, *Amara aenea*, and *Anisodactylus binotatus*) while disadvantaging *Pterostichus madidus*, which is able to tolerate low temperatures⁴.
 - During **cereal maturation**, higher grassland amount increased the maximum air temperature likely due to the reduced height of grassland vegetation during this period. In turn, higher **maximum temperature** favoured heat-resistant species at the expense of less tolerant (such as *Amara spp.*).
- Our study confirms the **effects of landscapes and farming practices on carabids**, as well as **their contribution to weed seed predation**. In addition, we show for the first time an **indirect effect of landscape on carabids and seed predation mediated by mesoclimate**.



Figure 4 : *Poecilus cupreus*

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