Adoption of cereal–legume intercropping in France: a matter of outlets?

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Benefits of cereal–legume intercropping

CEREAL–LEGUME INTERCROPS CONSIDERED

Cereal(s) + legume(s)
- On the same plot
- At the same time
- All harvested as principal crops

Example of a cereal–legume intercrop: wheat–faba bean intercrop
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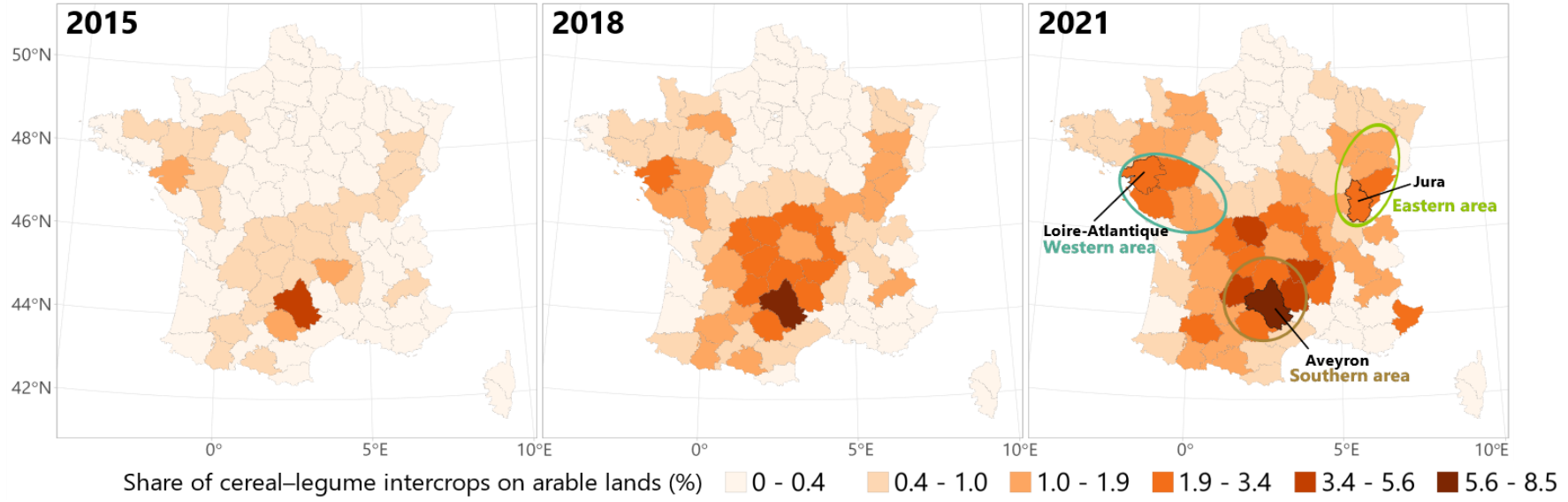
- **Better use of resources** (Brooker et al., 2015)
  - Stability of yields or even higher yields (e.g. Malézieux et al., 2009; Lithourgidis et al., 2011; Bedoussac et al., 2015)
  - Quality of production (e.g. Malézieux et al., 2009; Lithourgidis et al., 2011; Bedoussac et al., 2015; Li et al., 2023)
- **Control of pests and diseases** (e.g. Ratnadass et al., 2012; Beillouin et al., 2021)
- **Competition against weeds** (e.g. Corre-Hellou et al., 2011)

➔ **Reduction of chemical inputs on farms** (Yan et al., 2024)

Low adoption rate but local dynamics

- **Cereal–legume intercrops: <1% French arable lands in 2022** (IGN, 2023)
  - Technical, material, and economic barriers (Himanen et al., 2016; Mamine & Farès, 2020; Timaeus et al., 2022)
- **Increasing dynamic and diffusion from hotspots**
  - Adoption linked to organic farming, animal husbandry? (Verret et al., 2020; Timaeus et al., 2022)
  - Potential roles of local groups? *e.g. machinery cooperatives, exchanges between farmers* (Himanen et al., 2016; Casagrande et al., 2017; Ha et al., 2023)

Hypothesis formulated from case studies



Share of cereal–legume intercrops on total departmental arable lands in 2015, 2018 and 2021, in French departments.
Source of the data: French Land Parcel Identification System (Yan et al., in revision)

AIM OF THE STUDY

Identifying factors favouring the adoption of cereal–legume intercrops

- **National level:** check the hypothesis formulated from the literature and based on case studies
- **Local level:** spot the possible particularities in areas with contrasted agricultural contexts

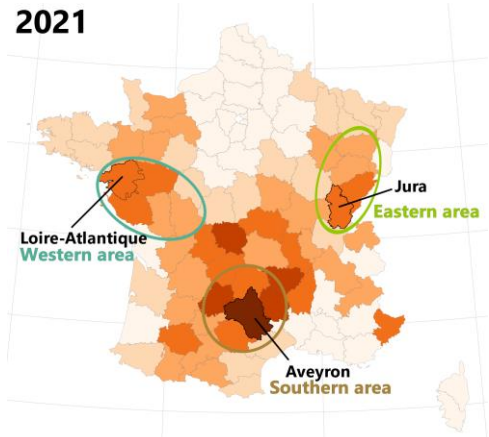
Material & methods
Quantitative study based on exhaustive data

2020 French agricultural census – Exhaustive survey on French farms (once every ten years)
- **43,968 farms**, representative of the French arable crop, livestock and mixed crop–livestock farming systems
- **42 variables** *(literature review)*

1 **42 variables: ranking for selection**
Random forest

2 **Interpretation**
Classification And Regression Tree

1' **42 variables: ranking**
Random forest: 1 per area

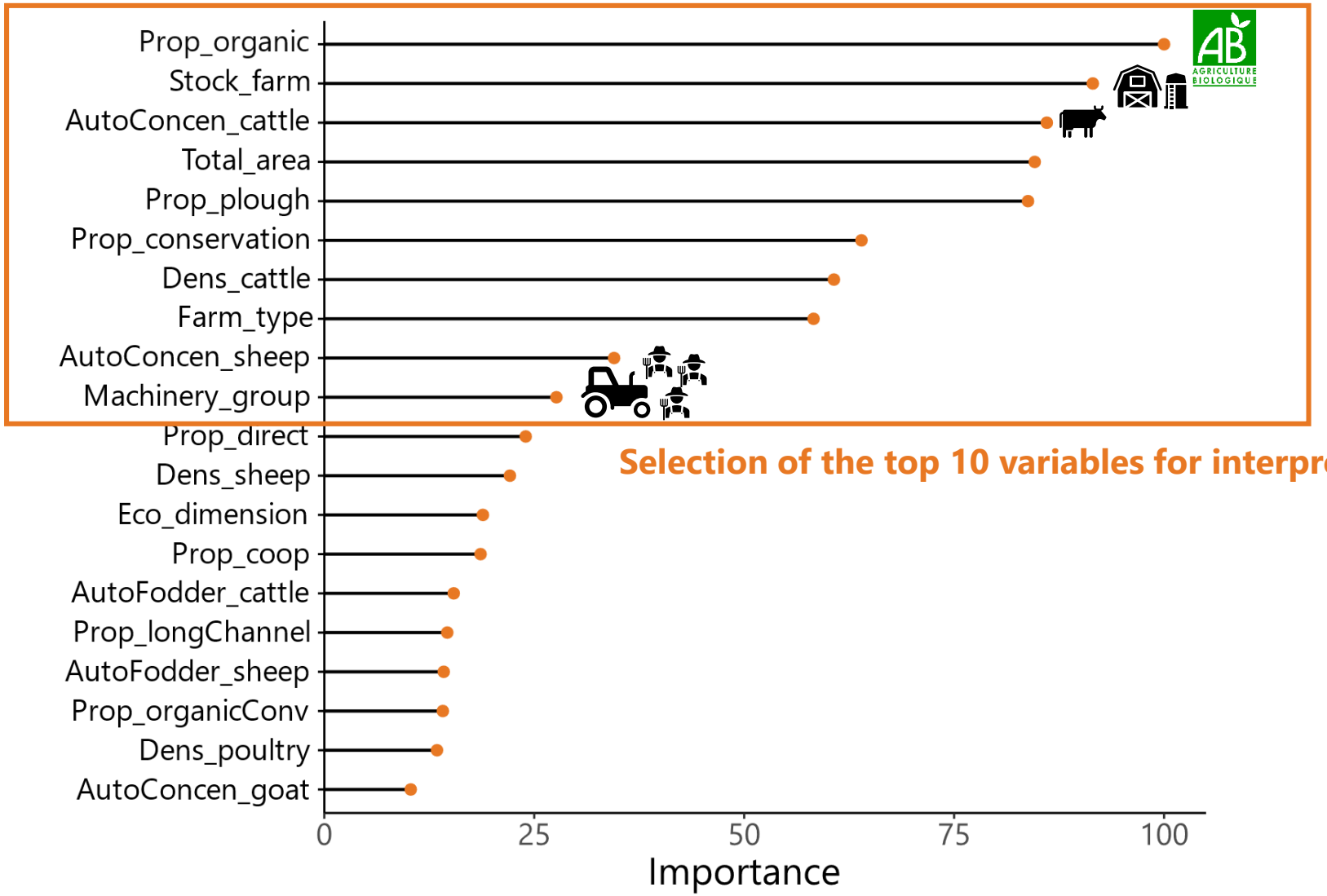


3 **Comparison**

NATIONAL LEVEL ⟷ LOCAL LEVEL

Farms' characteristics at national scale

1 Variable ranking and selection with a random forest

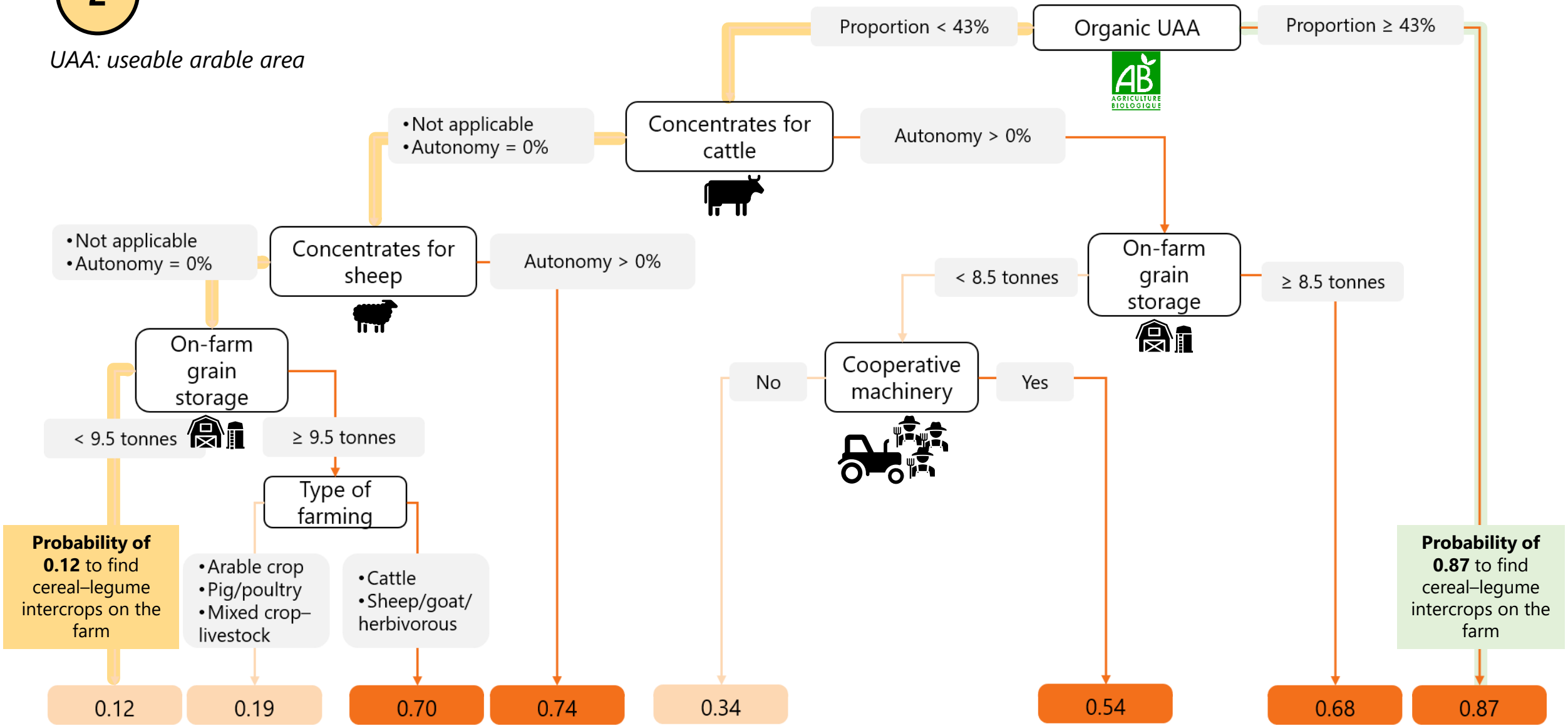


National-level random forest variable importance plot.
Importance is scaled from 0 to 100 relative to the first most important variable (Yan et al., in revision).

Farms' characteristics at national scale

2 Interpretation with a Classification And Regression Tree

UAA: useable arable area



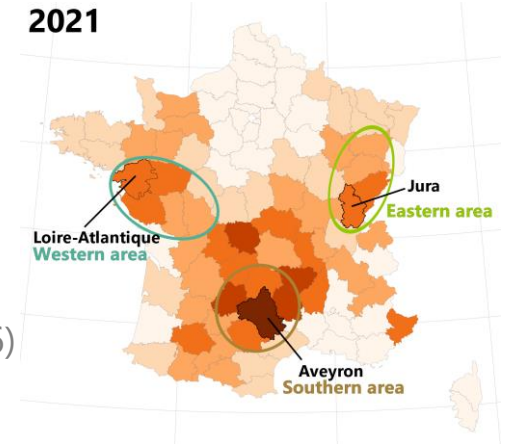
Values: probability of presence of cereal–legume intercrops

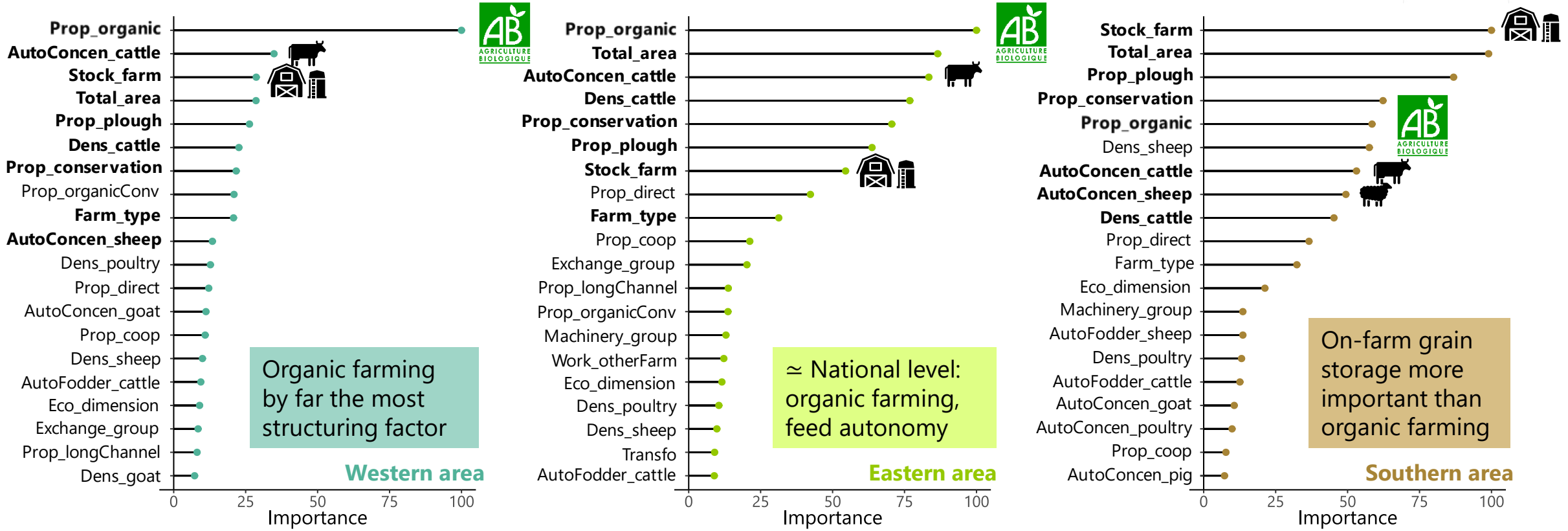
Farms' characteristics: local particularities

1'

3

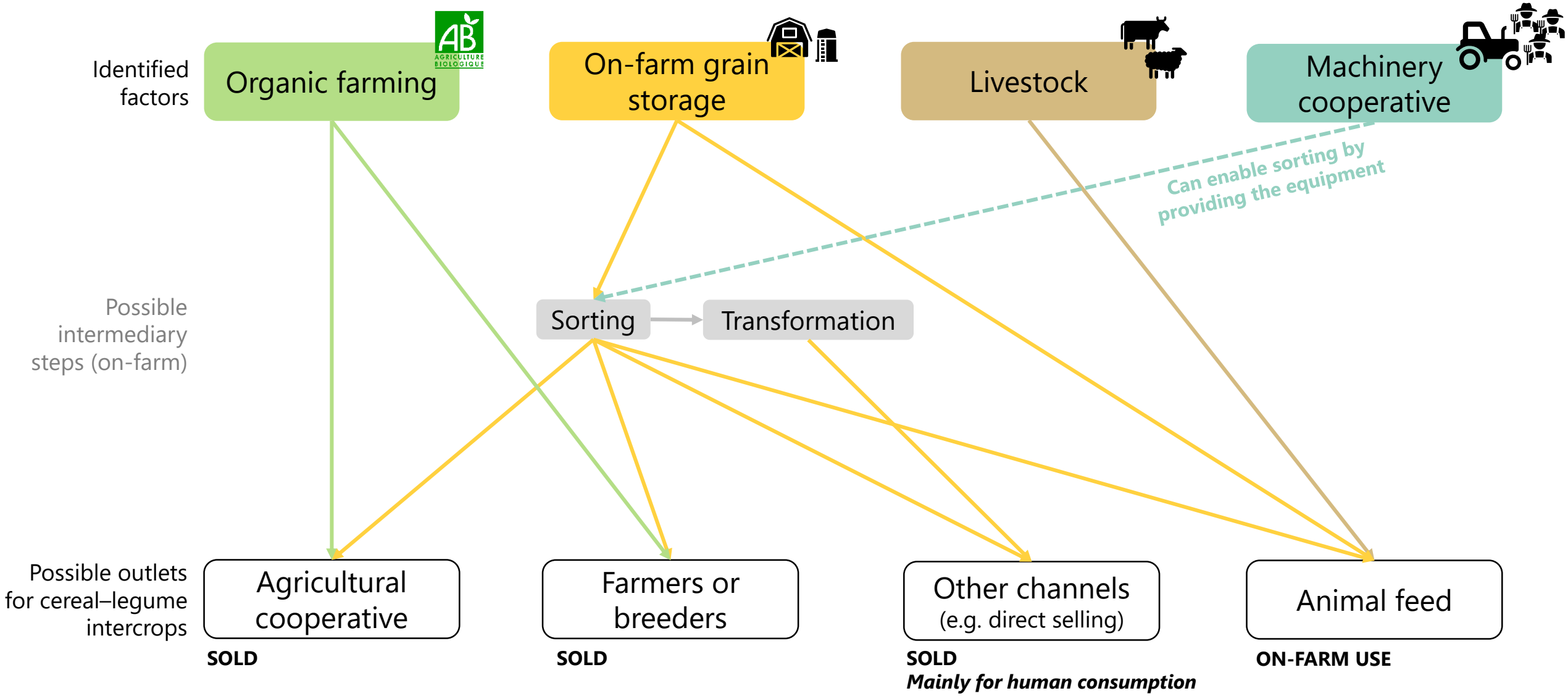
- Globally same characteristics than at national level
- Organic farming: less important in the Southern area
  - Cereal–legume intercropping long-established for livestock feed autonomy (Clouet et al., 1986)
    → On-farm grain storage: indicator for feed storage?





Random forest variable importance plots for the Western, Eastern, and Southern areas.
In each plot, the importance is scaled from 0% to 100% relative to the first most important variable.
Variables in bold are the common variables between the top 10 at the national level and the top 10 at the area level (Yan et al., in revision).

Potential links between the main identified factors and outlets for cereal–legume intercrops



Take-home messages

- **Factors identified in the literature: confirmed at national and local scales**
  - Organic farming, livestock and feed autonomy
  - Farm machinery cooperatives: may provide equipment to overcome material barriers, but also technical and psychological barriers (peer exchanges, learning)
- **How to foster the adoption of cereal–legume intercropping?**
  - Short-term dynamics: local collective actions
  - Long-term dynamics: securing the outlets, developing market opportunities
- **Quantitative study based on farm characteristics: limited understanding of farmers' objectives**
  - Relevance of a mixed approach with on-farm surveys
- **Methodology applicable to other practices**

Spelt – faba bean

Triticale – oat – vetch – pea – faba bean

Triticale –pea

Thank you!

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Access to some confidential data, on which is based this work, has been made possible within a secure environment offered by CASD – Centre d'accès sécurisé aux données (Ref. 10.34724/CASD)

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