Assessing impacts of farming systems on biodiversity using predictive indicators: a gradient of complexity

Christian Bockstaller, Emma Soulé, Bastien Dallaporta, Clélia Sirami

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Christian Bockstaller[1], Emma Soulé[2], Bastien Dallaporta[3], Clélia Sirami[4]

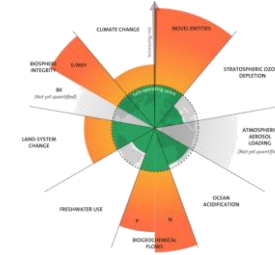[1]INRAE, Université Lorraine, LAE, 68000 Colmar, France

[2]INRAE, Institut Agro, SAS, 35000 Rennes, France

[3]ITAB, l'Institut de l'agriculture et de l'alimentation biologiques, 75012 Paris

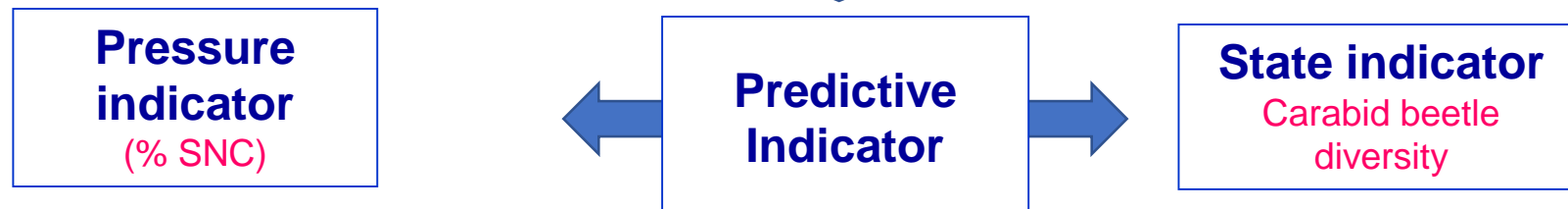[4]INRAE, ENSAT, EI Purpan, 31326 Castanet Tolosan, France

Impacts of agriculture on biodiversity, a major issue (Campbell et al. 2017)

Need of assessment tool

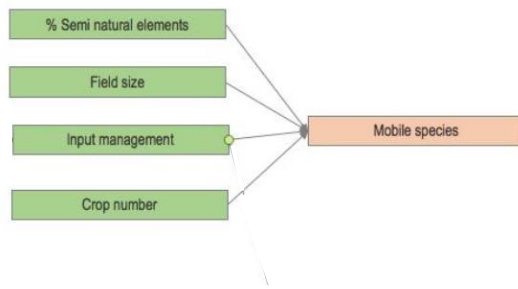| Pressure indicator (% SNC)	Predictive Indicator	State indicator Carabid beetle diversity

$$f(x) = \quad x + c$$

Overview of 3 predictive indicators developed in our team

Overview of the indicator models

NIVA Biodiversity
(Bockstaller et al. 2021)

BioSyScan (Dallaporta et al. 2023)

I-BIO (Soulé et al. 2023)

Model:

Figure 4 : Structure de l'arbre de décision de l'indicateur Grandes cultures

	NIVA Biodiversity	BioSyScan	I-BIO
Output:	Aggregated variable (7 taxa)	2 taxa: soil and mobile organisms	5 taxa: microbes, plants, soil & flying invertebrates, vertebrates ⚠ Direct & indirect effects (trophic)
Inputs	SNC, field size, crop number & diversity	SNC, field size, crop diversity, pesticide, fertilizer, tillage	SNC composition & configuration field size, crop diversity, pesticide (type, TFI), fertilizer, tillage, etc.
Spatial scale	Landscape, farm?	Cropping system, field, product (in landscape)	Cropping system, field (in landscape)

INRA℮

Design of the indicator models

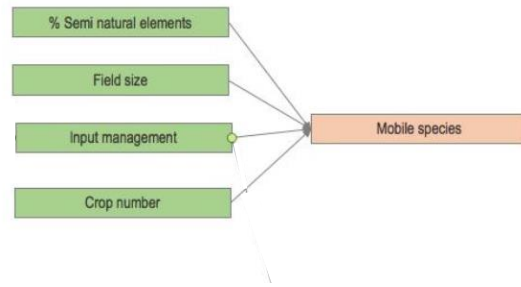| NIVA Biodiversity	BioSyScan	I-BIO
(Bockstaller et al. 2021)	(Dallaporta et al. 2023)	(Soulé et al. 2023)

Model:

Figure 4 : Structure de l'arbre de décision de l'indicateur Grandes cultures

Source

Dataset « FarmLand »	Literature +expertise	Literature +expertise

Treatment

Linear mixed model

Aggregation method

ConTra®
Construction Transparente d'arbre de décision

ConTra®
Construction Transparente d'arbre de décision

DEXi

Bockstaller et al. (2017)

Bohanec et al. (2008)

Aggregation: CONTRA method vs. DEXi

CONTRA®

Construction Transparente d'arbre de décision

😊
- Published
- Transparency
- No threshold effect
- Number of rules =< 32
- User-friendly (soon)

☹️
- Explaining fuzzy logic
- Interpretation of results

INRA℮   Bockstaller et al. (2017)

DEXi

😊
- Published
- Easy to understand
- User-friendly

☹️
- Low transparency
- Threshold effect
- Combinatorial explosion
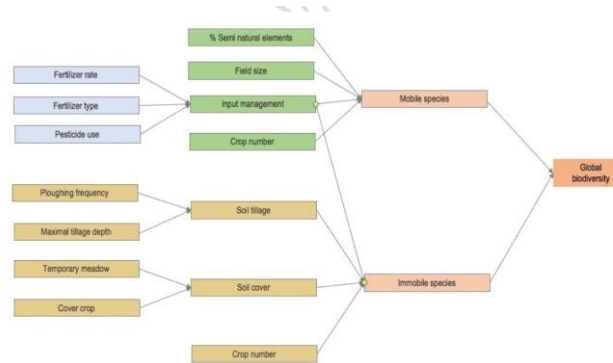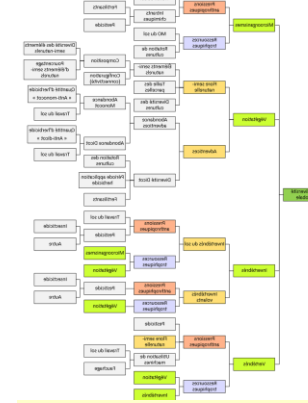
Bohanec et al. (2008)

Evaluation of predictive quality (Bockstaller et al., 2008)

NIVA Biodiversity
(Bockstaller et al. 2021)

> Linear mixed model for the design

🙂 Linear mixed model with $R^2 =< 0.10$

BioSyScan
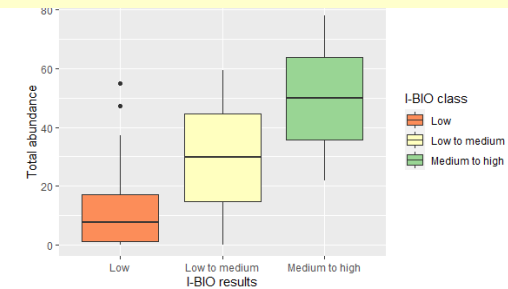(Dallaporta et al. 2023)

> Comparison with 3 Life Cycle Analysis (LCA) methods

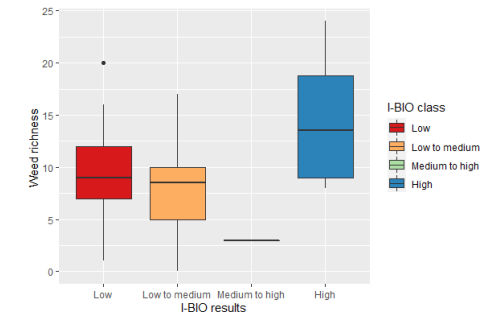🙂 Sensitivity to management

🙁 Integration in LCA Framework
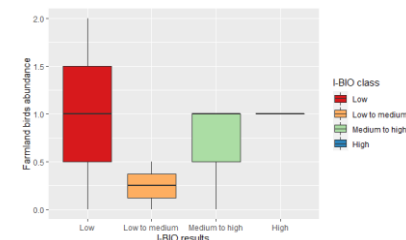
I-BIO
(Soulé et al. 2023)

> Comparison with measurements

🙂 Earthworms & microbes
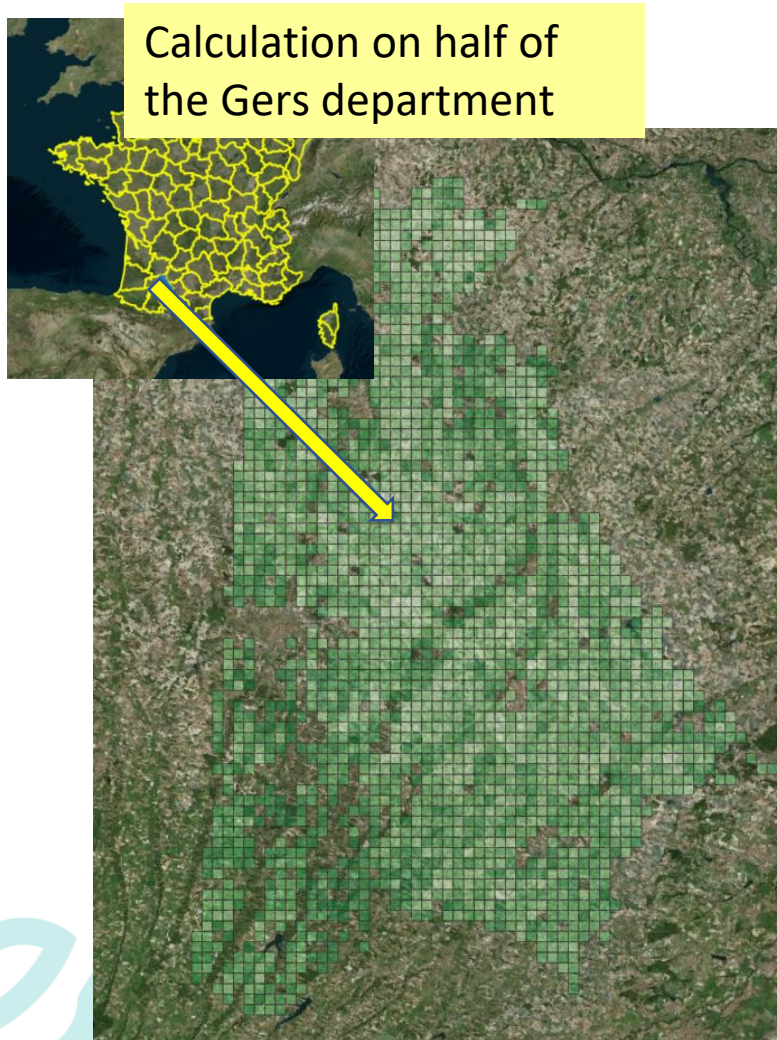
😐 Plants & carabids

🙁 Birds, pollinators, & butterflies

Example of results

NIVA Biodiversity
(Bockstaller et al. 2021)

Calculation on half of the Gers department

BioSyScan
(Dallaporta et al. 2023)

Comparison of different agricultural models (conventional, organic, conservation, etc.)

NAME	Global		Immobile		Mobile		Field size	Semi natural el.	Crop number	Input
Biodynamic label	57		46		62		0.10	1.00	1.00	0.92
Organic farming	53		46		56		0.10	1.00	1.00	0.69
Conservation agriculture	38		80		11		0.00	0.00	0.80	0.06
HVE option A	30		11		22		0.00	0.10	0.40	0.38
Private company label	23		26		12		0.00	0.03	0.60	0.06
HVE oprion B	21		11		14		0.00	0.10	0.40	0.06

I-BIO
(Soulé et al. 2023)

Calculation on a French national network (n=500 fields) and 57 Scottisch farms

Energy diagram agroecosyste
https://univlorraine.sharepoir
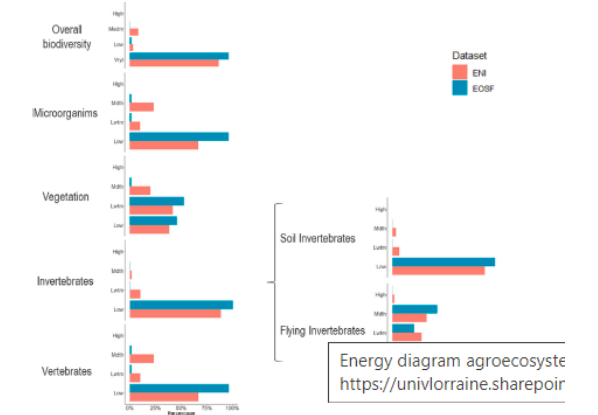
Discussion-conclusion

NIVA Biodversity
(Bockstaller et al. 2021)

BioSyScan
(Dallaporta et al. 2023)

I-BIO
(Soulé et al. 2023a)

→ Integration of processes

Gradient of complexity

Users: | Policy makers | Stakeholders' technical stuff, agronomists | Agronomists

Usage: | Public policiy evaluation | Monitoring, design of innovative system, advice | Design of innovative system, advice
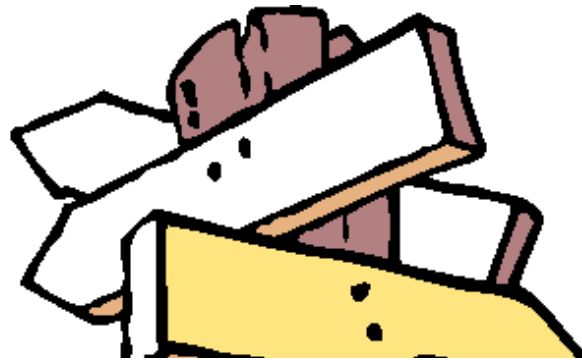
Research gap

- Datasets on relationship between management X landscape and biodiversity
- Role of functional heterogeneity (INRAE Prodige project)
- Utilisability of such indicators (INRAE Prodige project)
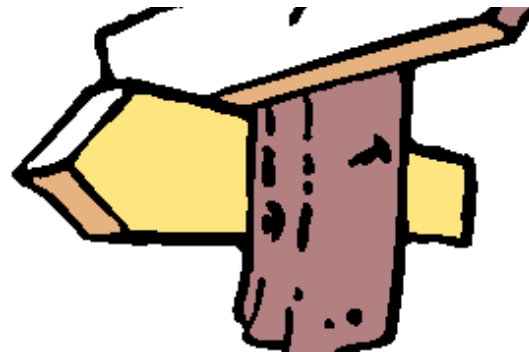- Calculation at large scale (remote sensing, LIPS)

Thank you for your attention