Biodiversity and Pollinators in Soybean Cropping Systems

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Background

Soybean is worldwide the most commonly grown legume

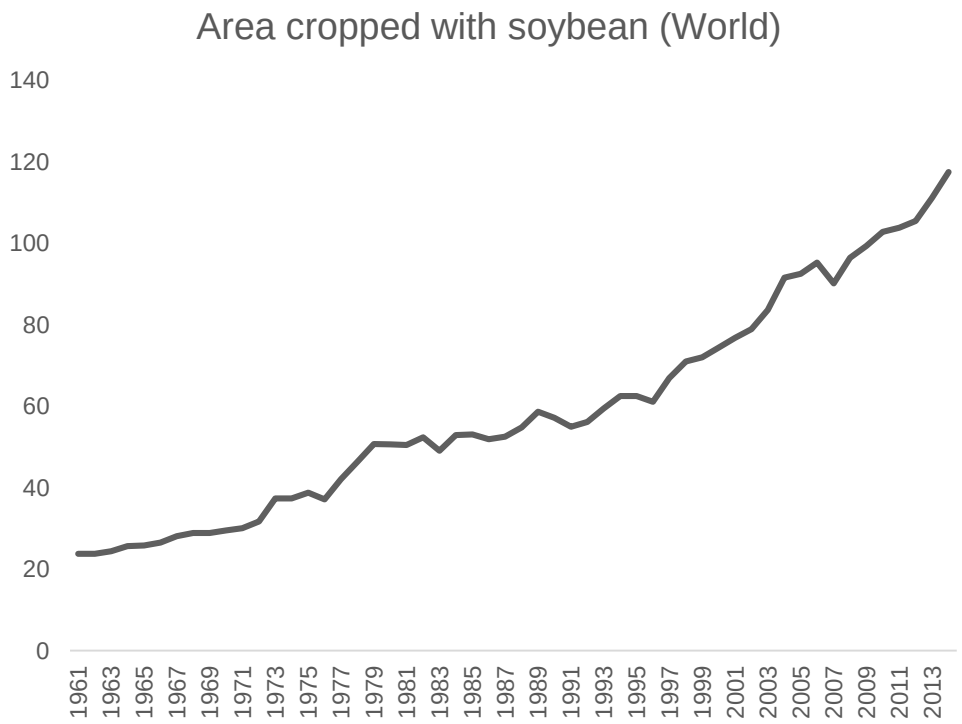
Main producing regions:

USA, South Amerika, China

Cultivated area in Europe is increasing

Main producing countries:

Italy, Serbia, Romania, France



Worldwide area (in Million ha) cropped with soybean from 1961–2014 (Source: FAOSTATS 2017)

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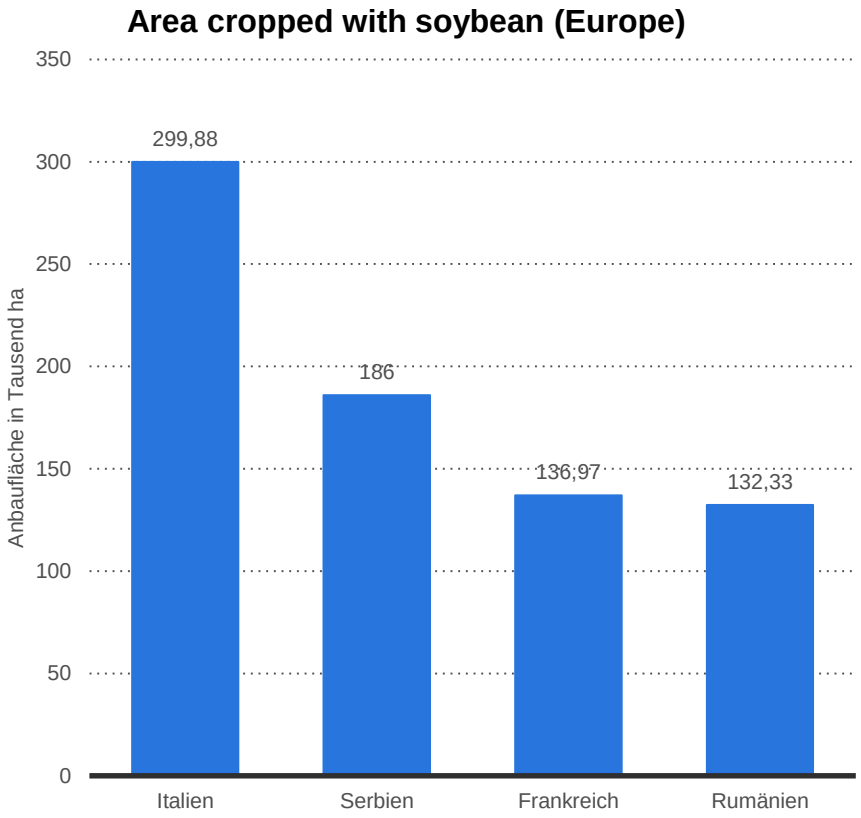


Beneficial Aspects of Soybean Cropping

Soybean Specific Traits

- N-Fixation / N-rich Biomass
- Flowering (nectar and pollen provision)
- Dicotyledonus plant structure

Flowering

- Soybean can profit from pollination
  e.g. higher yields, lower flower loss

- Pollinators and other flower visitors *can* profit from soybean nectar and pollen
  e.g. pest control agents (parasitoids)

Flowering

- Early maturing soybean varieties (000, 0000) are often cleistogamous
  - Benefit for and of pollinators is doubtful
- Crop protection measures can be harmful for flower visitors
- Landscape strongly influences flower visitors
  - Breeding and overwintering
  - Food sources beyond soybean flowering period

Root Structure / Biological Nitrogen Fixation

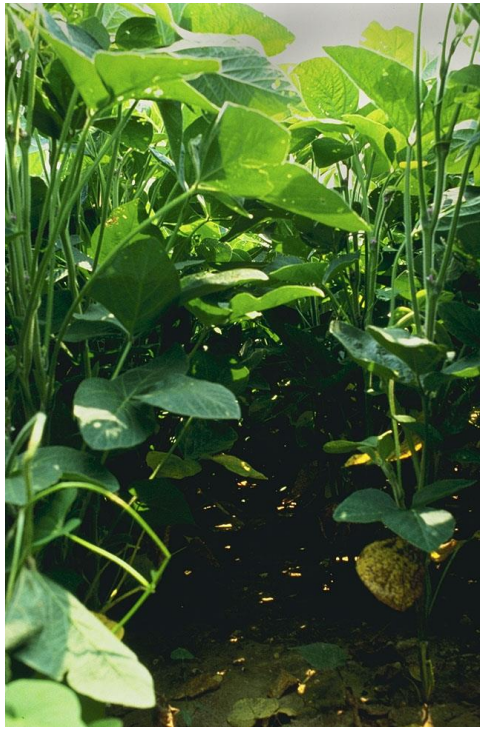
- Reduction of N-fertilizer input even for the following crop
- N-rich biomass remains in soil
- Root structure different to cereals

- High mycorrhization and high abundances of symbiotic and non symbiotic microbes in comparison to cereals

Aboveground Structure

- Different above ground structure allows variation in weed management strategies in cereal rotations

- Annual summer crop in contrast to commonly grown winter cereals
  - allows variation in tillage and crop protection regime



Aboveground Structure / Seed Production

- Slow crop development
  - requires more weed control measures
- Attractive to many pests and diseases
  - requires resistant varieties and/or crop protection measures

Findings of an Extensive Literature Review

Authors	total	Comparison		Organisms			Studied Parameters				Biodiversity drivers		
		Crop vs Crop	System vs System	Plants	Invertebrates	Vertebrates	Community composition	Species richness/ diversity	Abundance / Density/ Biomass	Ecosystem Services	Crop and/or Rotation	Manage ment Effect	Landscape Effect
Number of Studies	**60**	**35**	**49**	**21**	**40**	**6**	**23**	**29**	**51**	**22**	**49**	**46**	**23**

Effect of soybean as a crop on several biodiversity parameters varies strongly

Country	Number of Studies
Argentina	9
Brazil	1
Canada	7
Cameroon	1
Italy	1
Japan	1
Peru	1
Sweden	1
USA	38

Very little information for Europe available

Time	Number of Studies
1980s	5
1990s	11
2000s	18
2010s	26

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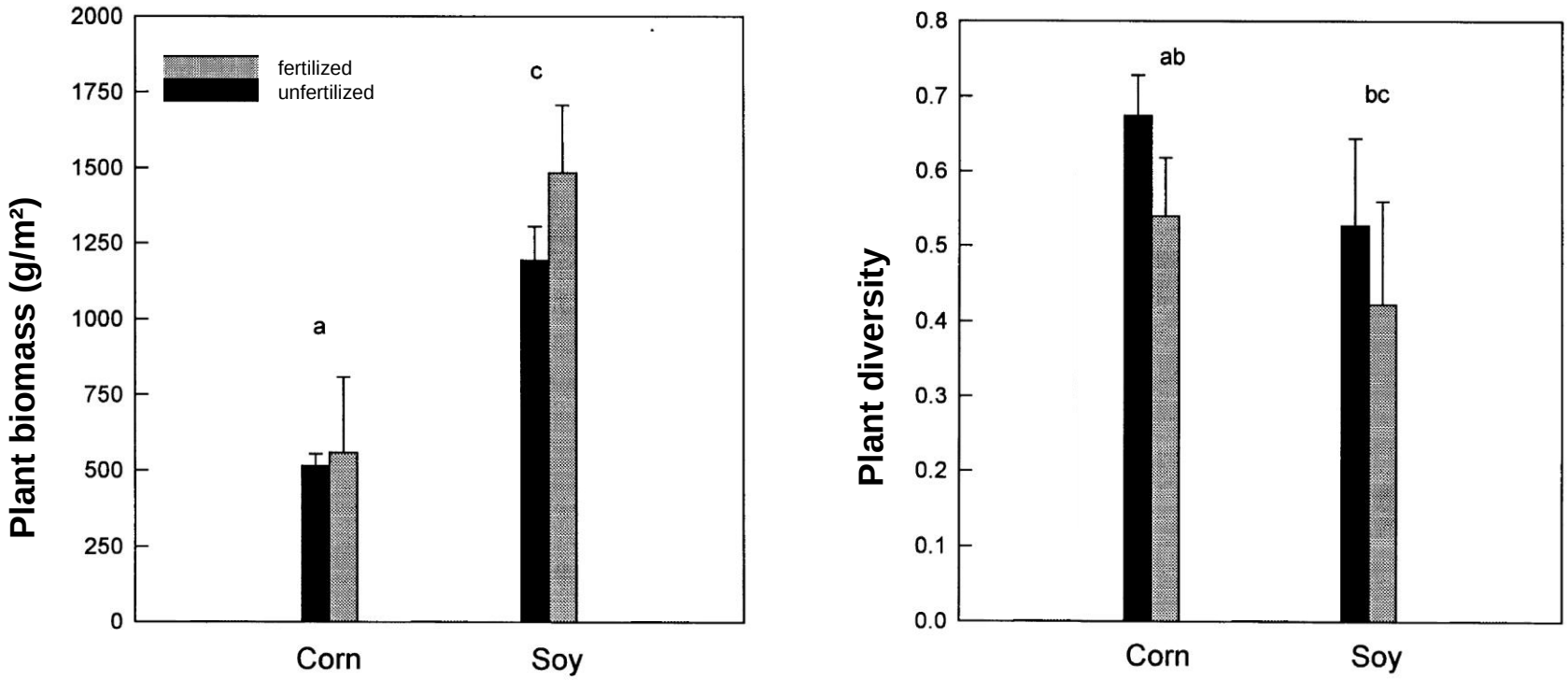
Biodiversity in Soybean



*Left: dry weight (±SEM) and right: Diversity (Shannon diversity, ±SEM) in corn and soybean (N = 4). (**Gomez & Gurevitch 1998**).*

- Higher plant biomass in soybean
- Fertilizer application has a stronger impact on diversity than crop identity

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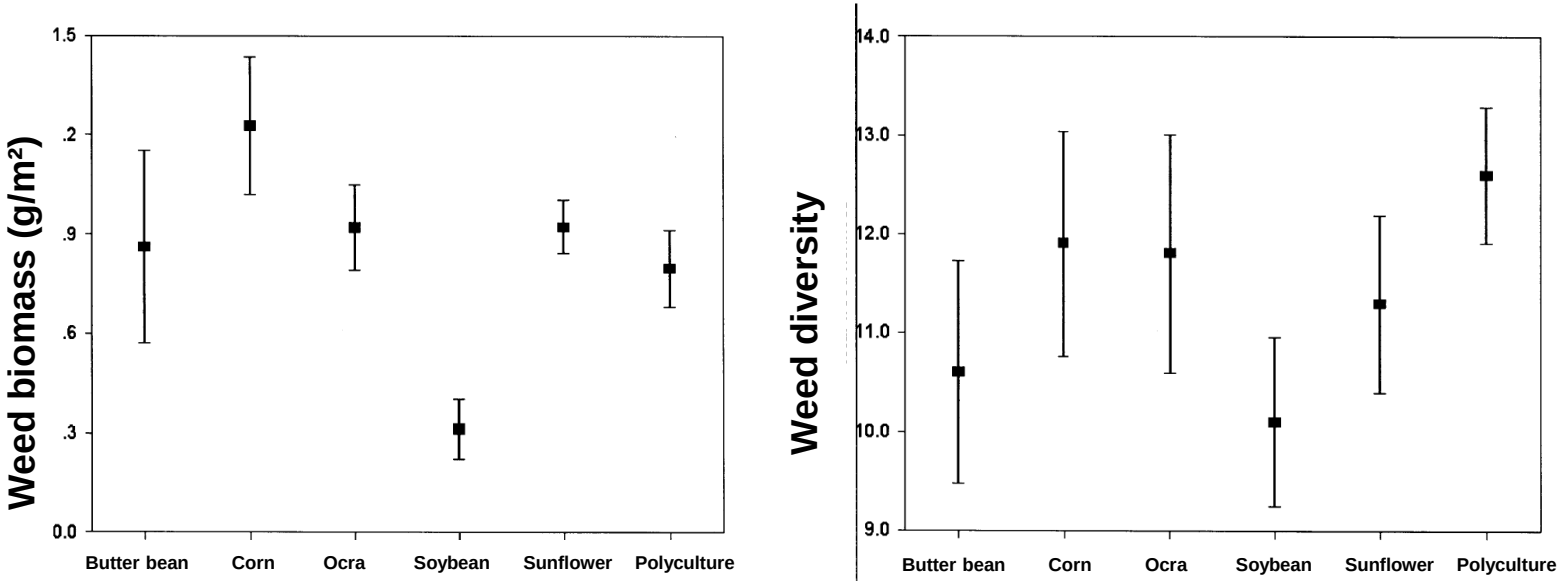
Biodiversity in Soybean



*Links: Biomasse (±95CI) und Rechts: Artenzahl (+95CI) in 5 Kulturarten (N = 10) in Oklahoma, ; (**Palmer & Maurer 1997**).*

Under standardized weed management soybean shows:

- Lower weed biomass
- Lower weed diversity

Biodiversity in Soybean Rotations

	Individuals	Species
Cropping treatment		
Corn, 2-yr	16.79 ± 1.94a	8.13 ± 0.61a
Corn, 4-yr	28.34 ± 2.08ab	9.88 ± 0.91ab
Soybean, 2-yr	37.22 ± 4.47b	8.38 ± 0.68a
Soybean, 4-yr	44.31 ± 8.15b	9.25 ± 0.59ab
Triticale-alfalfa, 4-yr	36.97 ± 7.64ab	13.63 ± 1.72b
Alfalfa, 4-yr	47.69 ± 9.39b	11.63 ± 0.65ab
Crop rotation		
2-Yr	27.01 ± 2.90A	8.25 ± 0.53A
4-Yr	39.33 ± 3.65B	11.09 ± 0.72B

Activity density (abundance) and number of species (±SEM) of carabid beetles in Iowa. ***(O'Rourke et al. 2008)***

- Carabid abundance is higher in longer crop rotations
- Species richness of carabids in soy is similar to other crops
- Rotation length has a stronger impact on biodiversity then crop identity

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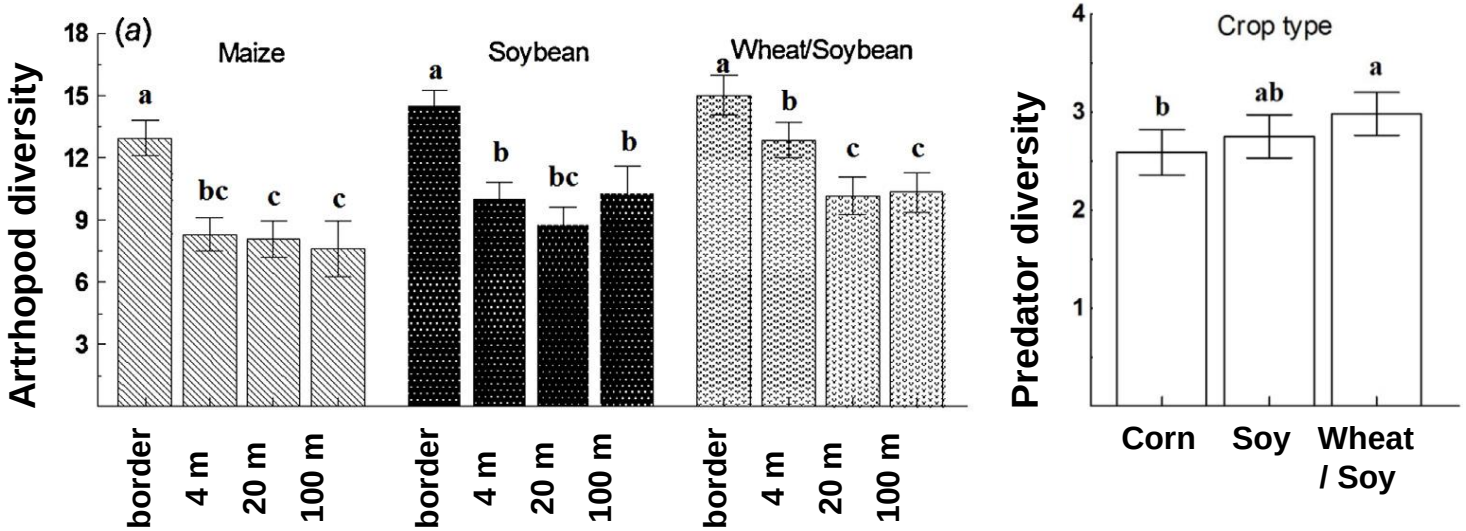
Biodiversity in Landscapes with Soybean



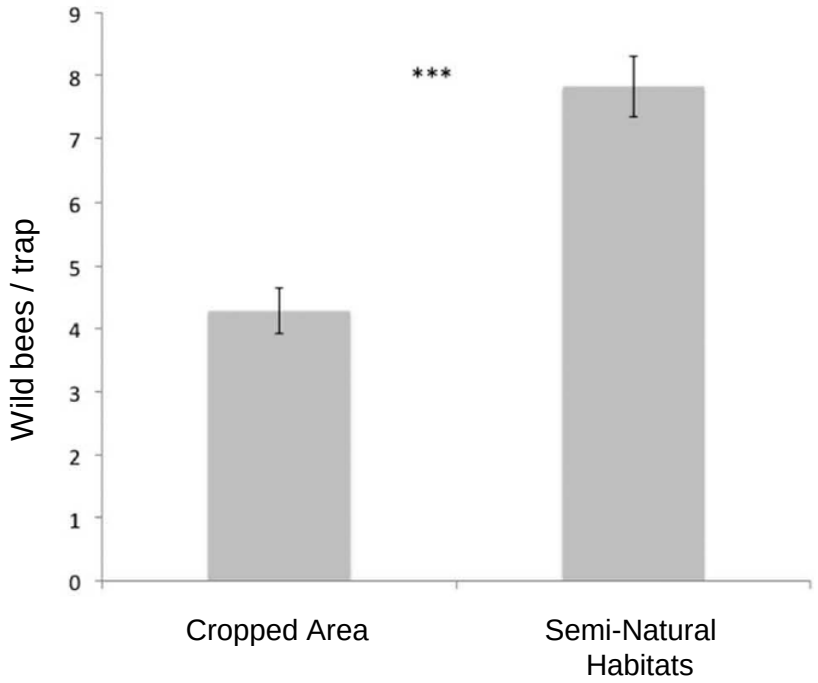
Left: Diversity of Arthropods (±SEM) in different crops and at different positions within the field.
Right: Diversity of natural enemies (±SEM) in different crops / rotations ***(Molina et al. 2014).***

- Landscape parameters have larger effect on arthropods then crop identity
- Diversity of arthropods and natural enemies in soy is slightly higher than in corn, especially, in no-till rotations

Biodiversity in Landscapes with Soybean

- Semi-natural habitats harbour more flower visitors than area cropped with soybean

- Specialized flower visitors, e.g. many wild bees, decrease rapidly



Wild bee diversity in regions with Soybean cropping in comparison to semi-natural habitats ***(Le Feon et al. 2016)***

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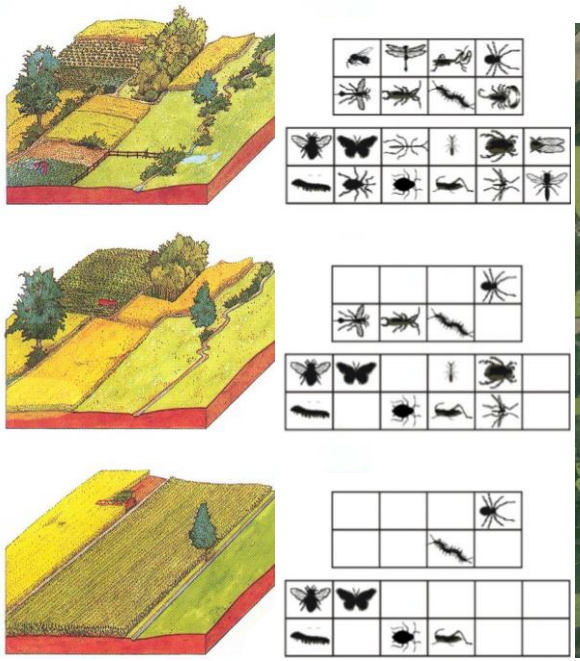
Biodiversity in Landscapes with Soybean

Simple



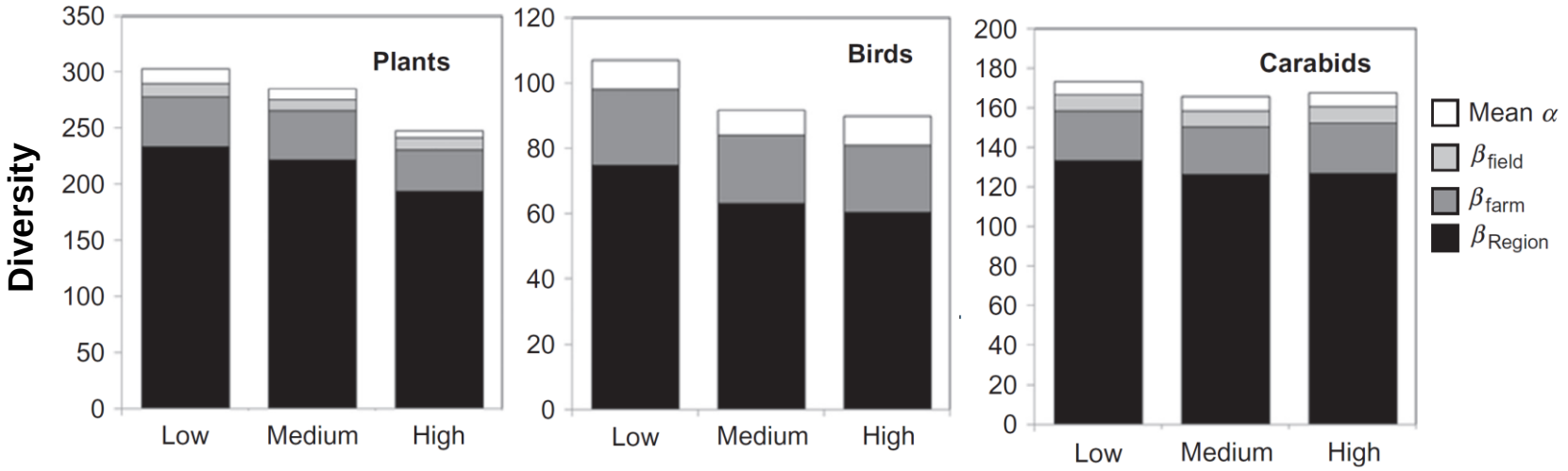
Complex

Semi-natural habitats, such as hedges, fallow land, field borders, flowering strips within the landscape are a refugium for many organisms.

Tscharntke et al. (2005) Ecol. Lett.; Cardinale et al. (2012) Nature

Management Intensity

Fertiliser and pesticide regime, field size, seed density, yield, crop rotation, farm size, amount and connectivity of semi-natural habitats



Effects of management intensity on diversity of plants, carabids and birds in agricultural landscapes.
α = Diversity within the field, β = Diversity between fields, farm and regionens.
(Emmerson et al. 2016, based on Flohre et al 2011a & b)

Conclusion

- Adding soybean to cropping systems in Europe can have positive effects on many biodiversity parameters
  - Increased number of different crops within the landscape
  - Longer crop rotations

- However: Management measures and the surrounding landscape have a much stronger effect than the identity of the crop itself

- → Soybean can promote biodiversity, but only if the management is not not contradicting this effect.

Recommendations for Agricultural Policy

- Support landscape heterogeneity
  - More diverse and longer crop rotation
  - More and interconnected semi-natural habitats
  - Smaller field sizes

- Support reduced management intensity
  - Low input and low tillage strategies
  - Intercropping and trap crops

Literatur

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