

Biodiversity conservation without yield loss



Teja Tscharntke

Agroecology, University of Göttingen

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Food security and biodiversity conservation in
China. Trade-offs or synergies? 04 Sept 2023**



UNITED NATIONS DECADE ON
**ECOSYSTEM
RESTORATION**
2021-2030



Convention on
Biological Diversity



**Halting the dramatic losses in biodiversity
is a major global challenge**

Agricultural expansion & intensification at the cost of
(1) Natural habitats
(2) Biodiversity-friendly land use

Biodiversity-yield trade-offs in agriculture

- I. **Enhancing biodiversity is often at the cost of productivity**, in particular when yield gaps are low, as in EU cereal production.
Geiger et al. 2020, Basic Appl Ecol (EU wheat)
- II. **Optimizing trade-offs**, with high biodiversity gains at low or no costs
Clough et al 2011, PNAS, Wurz et al 2021, Nature Comm (Indonesia, Madagascar)
- III. **Biodiversity can be key drivers of productivity**
based on important ecosystem services or nature-based solutions
Maas et al 2013 Ecol Letters, Ocampo-Ariza et al 2023, Ecol Appl (Indonesia, Peru)

Organic farming

often regard as the win-win alternative to intensified agriculture

Is it really the overarching solution of the biodiversity crisis?

Trends in
Ecology & Evolution

Opinion

Beyond organic farming – harnessing
biodiversity-friendly landscapes

Teja Tschamntke,^{1,*} Ingo Grass,² Thomas C. Wanger,^{3,4,5,*} Catrin Westphal,⁶ and Péter Batáry⁷

Tschamntke et al. 2021
Trends Ecol Evol

EU Green Deal:
25% organic farming
by 2030 (now <10%)



Organic farming - a win-win solution?

Benefits:

- 34% species richness increase per area
- no herbicides on arable land

Limitations:

- 19-25-50% reduced yield
- biodiversity benefits only per area, not per yield
- Pesticide use („natural“ pesticides, e.g. copper)
- **Semi-natural habitat conservation not part of certification**
(hedges, grassy or flower strips, dry grassland, small ponds)
Tscharntke et al. 2014 Conserv Letters; Peter Batary et al. 2010, Biol Conserv
- **Simplified crop rotations, monocultures**
Globally, 4.5 instead of 3.8 years (+15%) (Barbieri et al, 2017, Sci Rep)
- ✓ **Field size (monocultures) can be huge**
- ✓ Organic products from **sterile greenhouse blocks**
- ✓ Organic vegetables from **landscapes under plastic sheets**
(In the mediterranean area, e.g. Andalusia: Almeria)

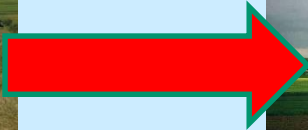


Increasing intensification in organic farming



Organic Farming Practices





Landscape heterogeneity for biodiversity

Key driver of local biodiversity is the landscape-wide species pool

Tscharntke et al. 2005, Ecol Letters, Tscharntke et al 2012 Biol Rev

Affects local species richness on flower strips or fragments of dry grassland

Ingolf Steffan-Dewenter et al. 2002, Ecology; Urs Kormann, Verena Rösch et al. 2015, Div Distr

Increasing heterogeneity & biodiversity

(i) Minimum of 20% semi-natural habitat

Garibaldi et al. 2021 Conserv Letters, Tscharntke et al 2002 Ecol Appl

(ii) Higher crop diversity

Rakotomalala et al 2023 AgrEcosystEnviron,

Tamburini et al 2020 Sci Adv

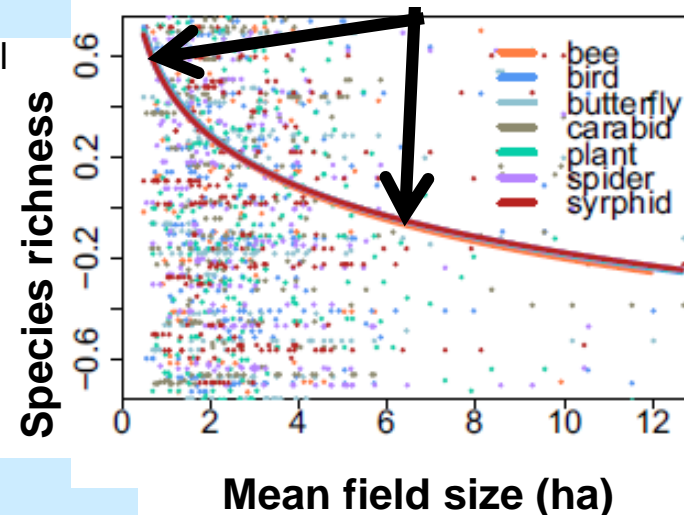
(ii) Smaller fields with longer edges

5-fold increase of bees

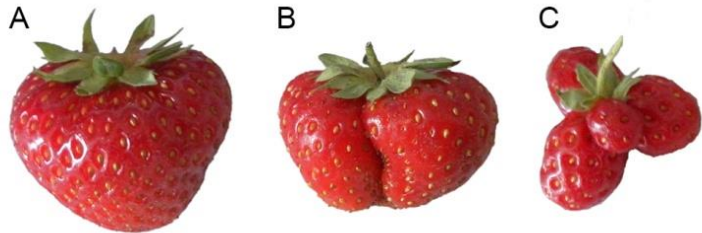
from 100m to 600m edges per km²

Annika Hass et al. 2018 Proc Roy Soc B, Sirami et al. 2019, PNAS

**from 6ha to 1ha:
6x more species**



Pollination and biocontrol may enhance crop yield



Animal pollination Improves production of 75% of the 115 most important crops globally, influencing **35% of global human food supply**

Alexandra Klein et al. (2007) Proc Roy Soc B

Crop quality is also much improved!

Bjoern Klatt et al 2014 Proc Roy Soc B;

Annual monetary value of global pollination services: US\$ 235-577 billion

IPBS 2016

Experimental enclosure of natural enemies:

Tripling densities of cereal aphids

Parasitism of rape pollen beetles

Landscape gradient in % arable land:

3% → 50% noncrop area

89% → 35% **decrease rapeseed damage**

5% → 50% **increase in parasitism**

Carsten Thies & Tscharntke 1999, Science
Tscharntke et al. 2002, Ecol Appl



Ecological intensification of cacao agroforestry

Birds & bats benefit from nearby forest, reduce pests and double cacao yield

In Peru; Carolina Ocampo-Ariza et al 2023 Ecol Appl, & 2022 AgrEcosystEnvir; Vansynghel et al 2022 Proc Roy Soc B; Bea Maas 2013, Ecol Letters; Yann Clough et al. 2011; PNAS; Tscharrntke et al 2011 J Appl Ecol



Exclusion of ants: 27% reduced cocoa yield Introduction of invasive ants: 34% reduced yield

(reducing even, species-rich ant communities in Indonesia)

Arno Wielgoss et al. 2014 Proc Roy Soc London B & 2012 J Appl Ecol



Endemic toads reduce invasive ants, promoting ant diversity

Thomas C. Wanger et al 2011 Proc Roy Soc B; 2009 & J Appl Ecol & 2010, Conserv Biol

Limited cacao pollination confines cacao yield

More flower visitors with higher canopy cover & nearby forests
(in Indonesia) Toledo-Hernandez et al 2021 Biol Conserv



Hand pollination may multiply cacao yield

Indonesia: Hand pollination of 13% flowers/tree Increased yield/tree by 51%.

100% hand pollination increased yield/tree by 161%

Brazil: Hand pollination by 10% of the flowers/tree increased yield by 300%

Manuel Toledo-Hernandez et al 2020 Agr Ecosyst Envir & 2023 Agr Ecosyst Env;

Hand pollination review: Wurz et al 2021 BasicApplEcol

Ecological intensification of tropical agroforests

Oilpalm plantations - restoration with tree islands

Large gains in multidiversity

without compromising oilpalm yield Zemp et al 2023 Nature
(contrasting to monocultures: Grass et al. 2020 Nature Com,
Clough et al 2016 Nature Comm)



Vanilla landscapes (in Madagascar)

Agroforests established on fallows:
38% more endemic species.

Only non-yield related variables largely determined biodiversity,
as yields increased with vanilla vine density

Wurz et al 2022 Nature Comm



Macadamia landscapes (in South Africa)

Exclusion of birds & bats near natural vegetation:
60% yield loss,

but also 26% yield loss by baboon monkeys; Valery Linden et al. 2019 J Appl Ecol



Maintain and restore high biodiversity!



(1) Landscape-wide measures: farmland heterogeneity with small fields & high crop diversity, >20% semi-natural habitat

(2) Certify crops with targeted biodiversity-friendly measures
Organic farming does not solve the food security and biodiversity crisis

(3) Cacao agroforestry management for high biodiversity & high cacao yield

Shade-tree heterogeneity: tree diversity, 40% canopy cover, nearby forest

Bats & birds: 31%-100% more yield

ant diversity: 34% yield increase

Amphibians contribute to yield by reducing invasive ants

(4) Cacao pollination limitation: Low natural pollination (5-10%);

Pollinator identity unknown, small wasps & flies may be involved

Hand pollination can more than double yield

(5) Biodiversity gains without compromising yield: Oilpalm tree islands, vanilla under shade trees, macadamia nearby natural vegetation

