Agroforestry systems (AF) to promote ecosystem services for sustainable cocoa

- The case of Indonesia and Brazil -

Manuel Toledo-Hernández

5th of November 2020

Conference „Towards sustainable cocoa: opportunities and challenges of a complex value chain“

Global Agroforestry Network

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

西湖大學 WESTLAKE UNIVERSITY

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Outline

Part 1

Challenges of small-scale cocoa farmers
– The example of Indonesia -

Part 2

Paradigm shift in food production towards diversified agriculture

Part 3

Agroforestry systems to promote pollinator conservation and pollination

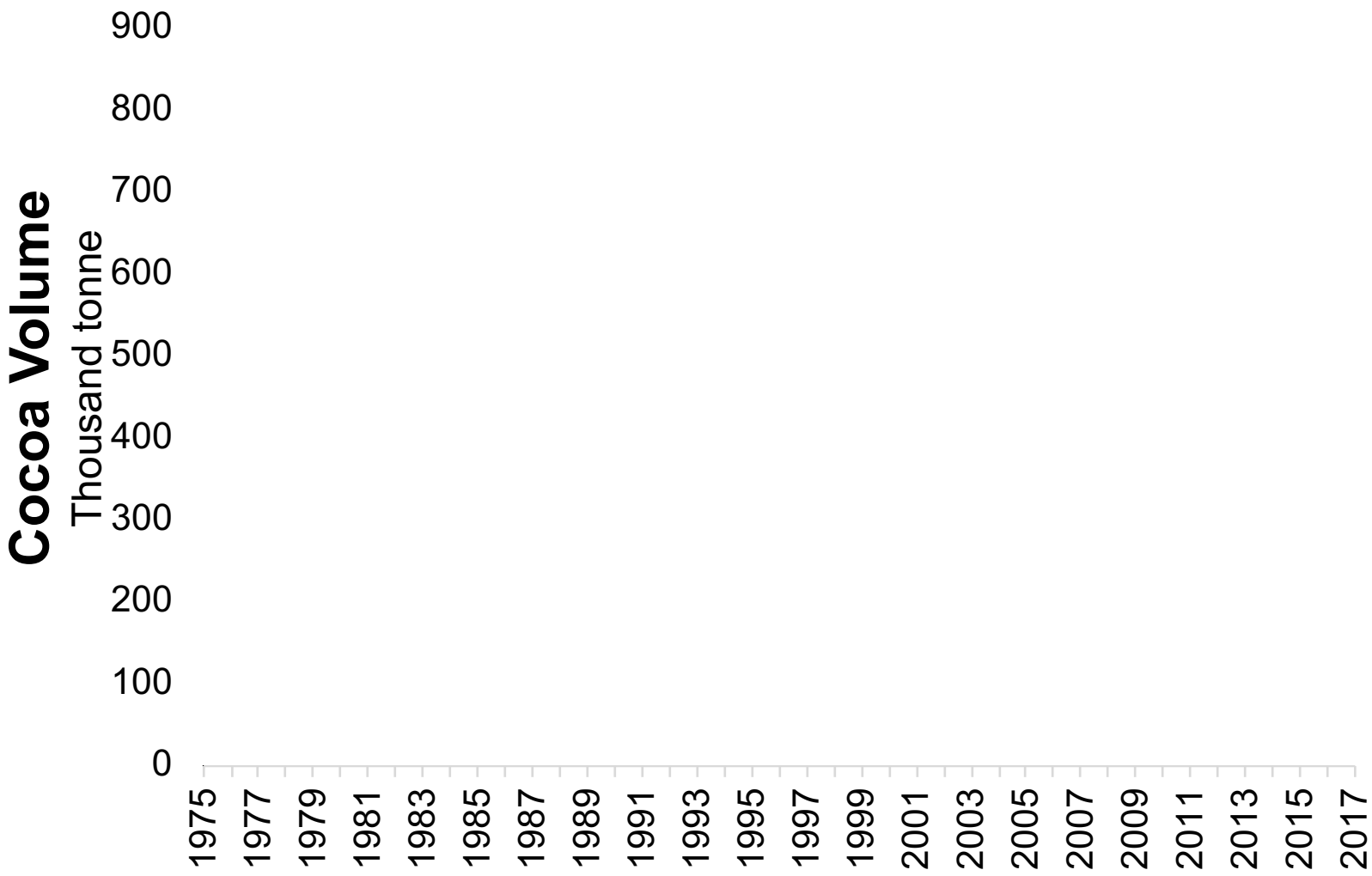
Small-scale cocoa farmers in Indonesia

Napu Valley, Central Sulawesi

Largest cocoa producer in Indonesia (Wijaksono, 2016).

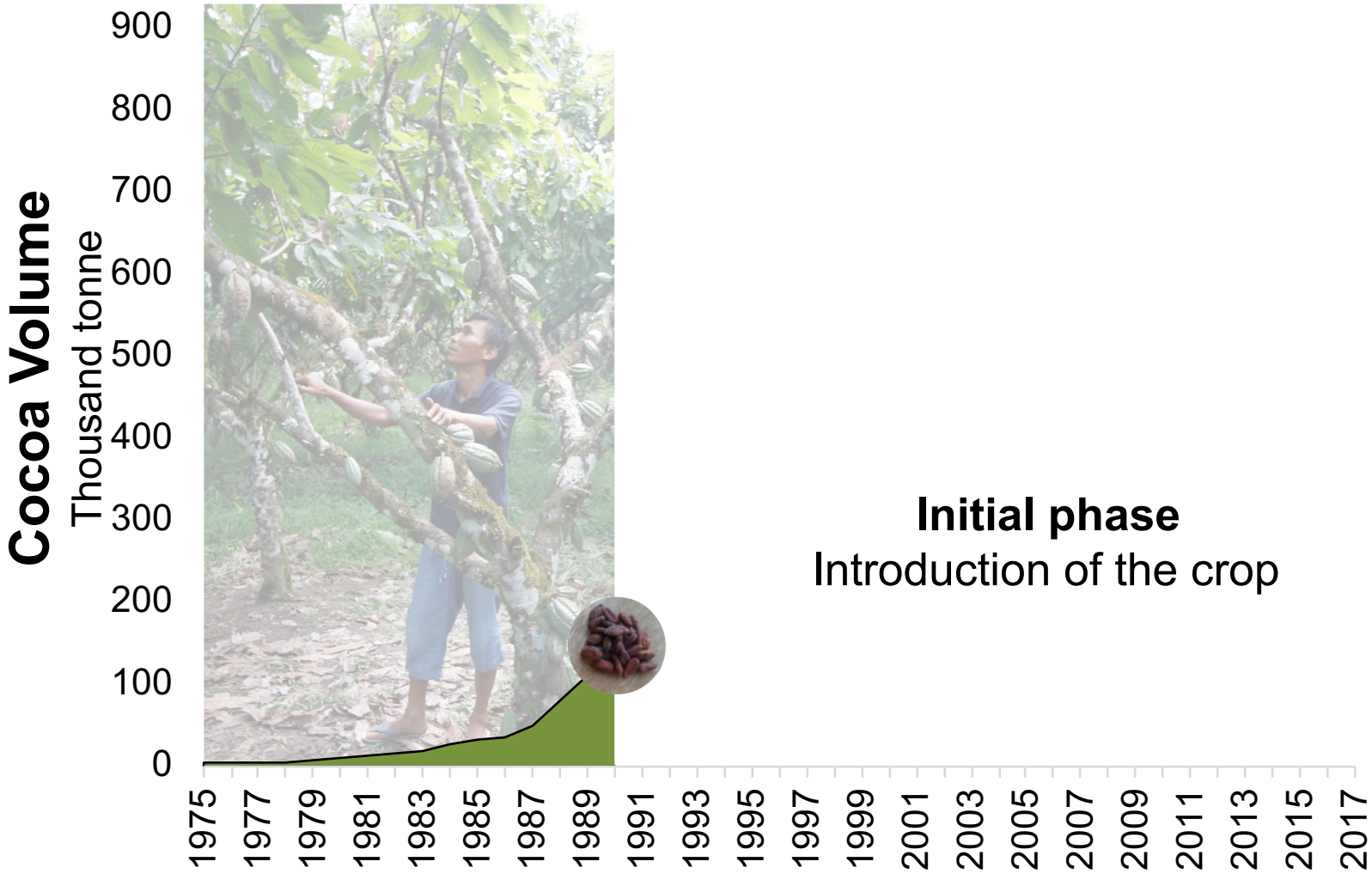
- 70% national production

Boom and bust cycle of cocoa production in Indonesia



(Clough et al., 2009; Tscharntke et al., 2011)

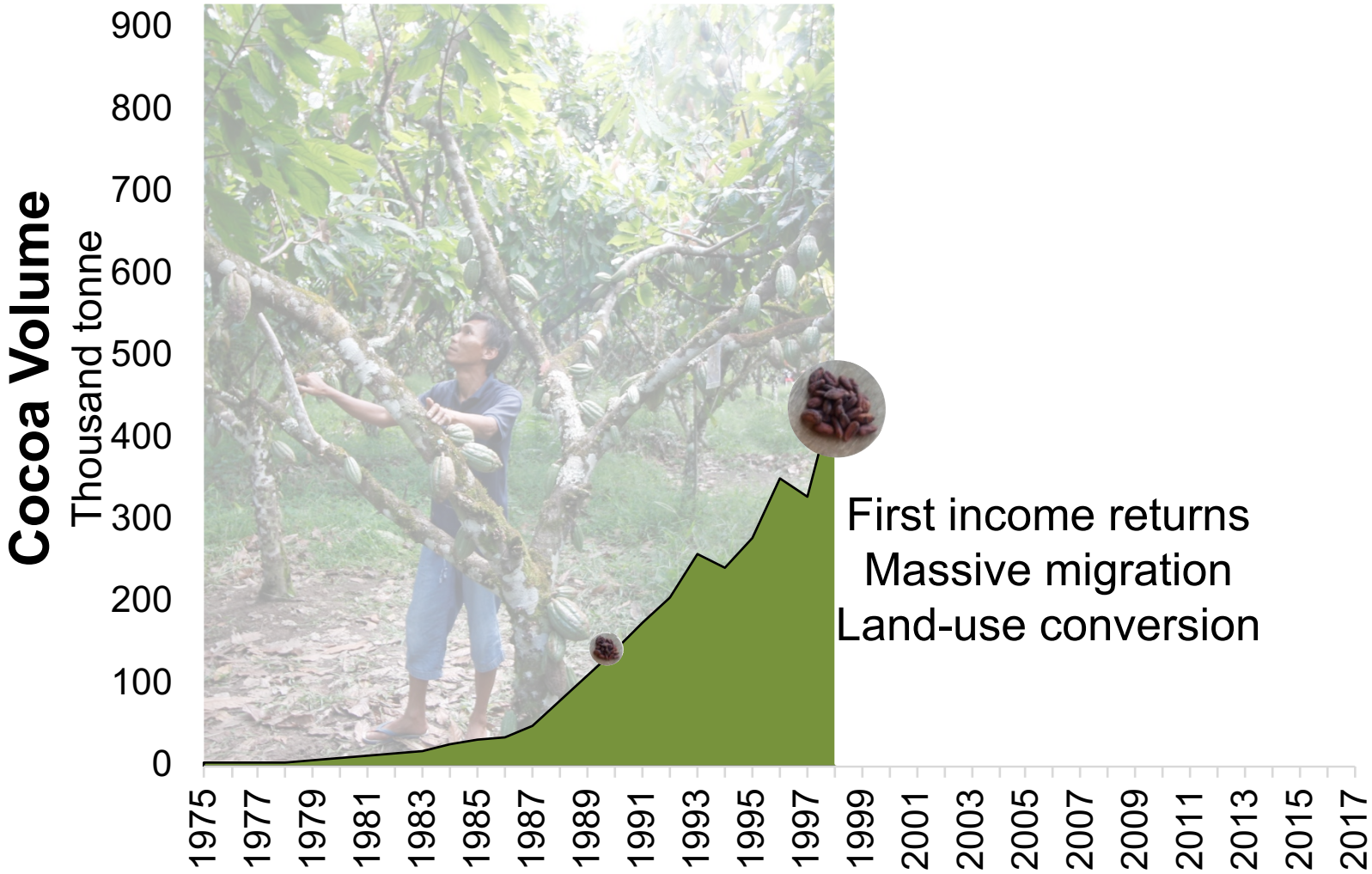
Boom and bust cycle of cocoa production in Indonesia



Initial phase
Introduction of the crop

(Clough et al., 2009; Tscharntke et al., 2011)

Boom and bust cycle of cocoa production in Indonesia



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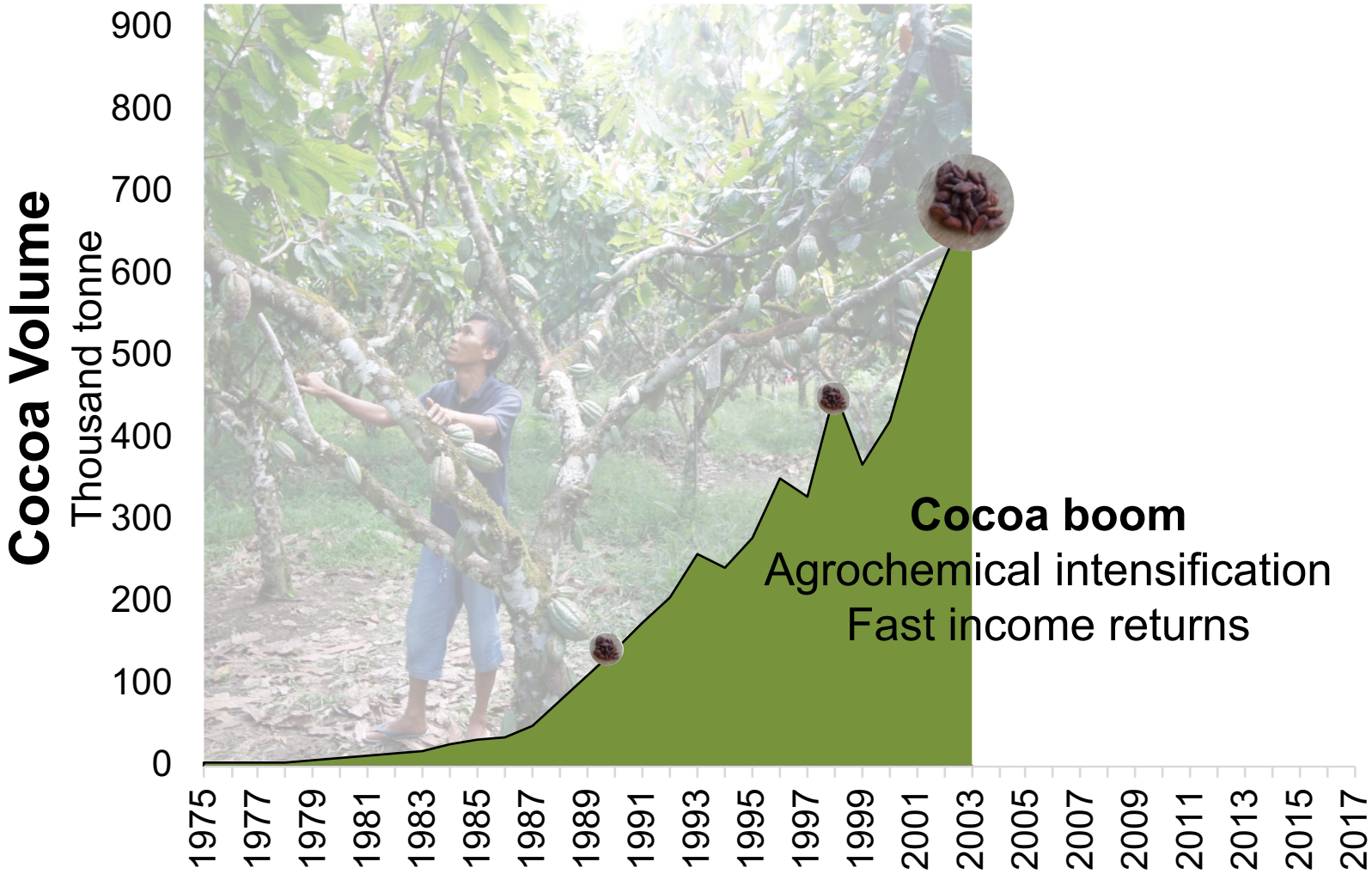

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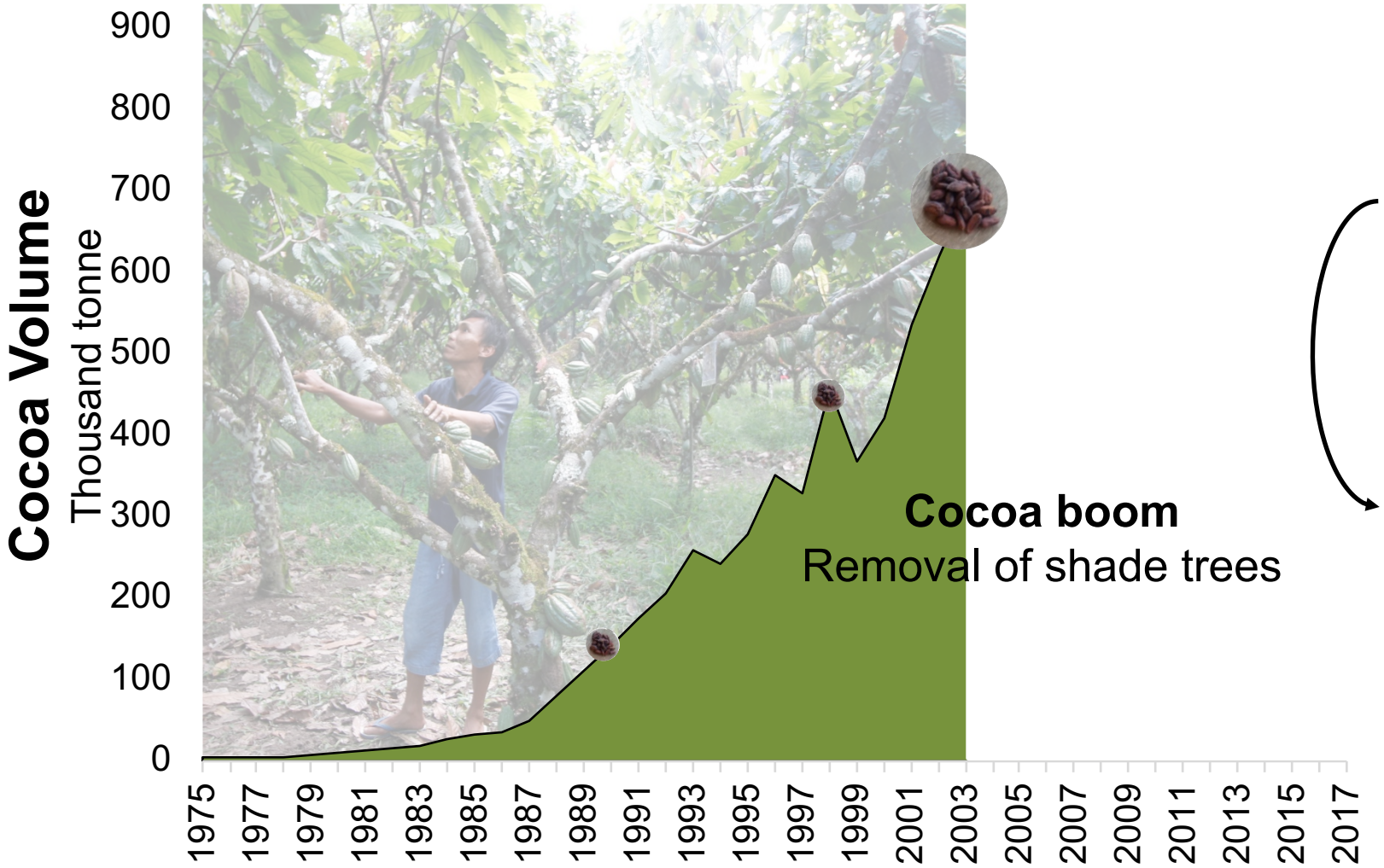
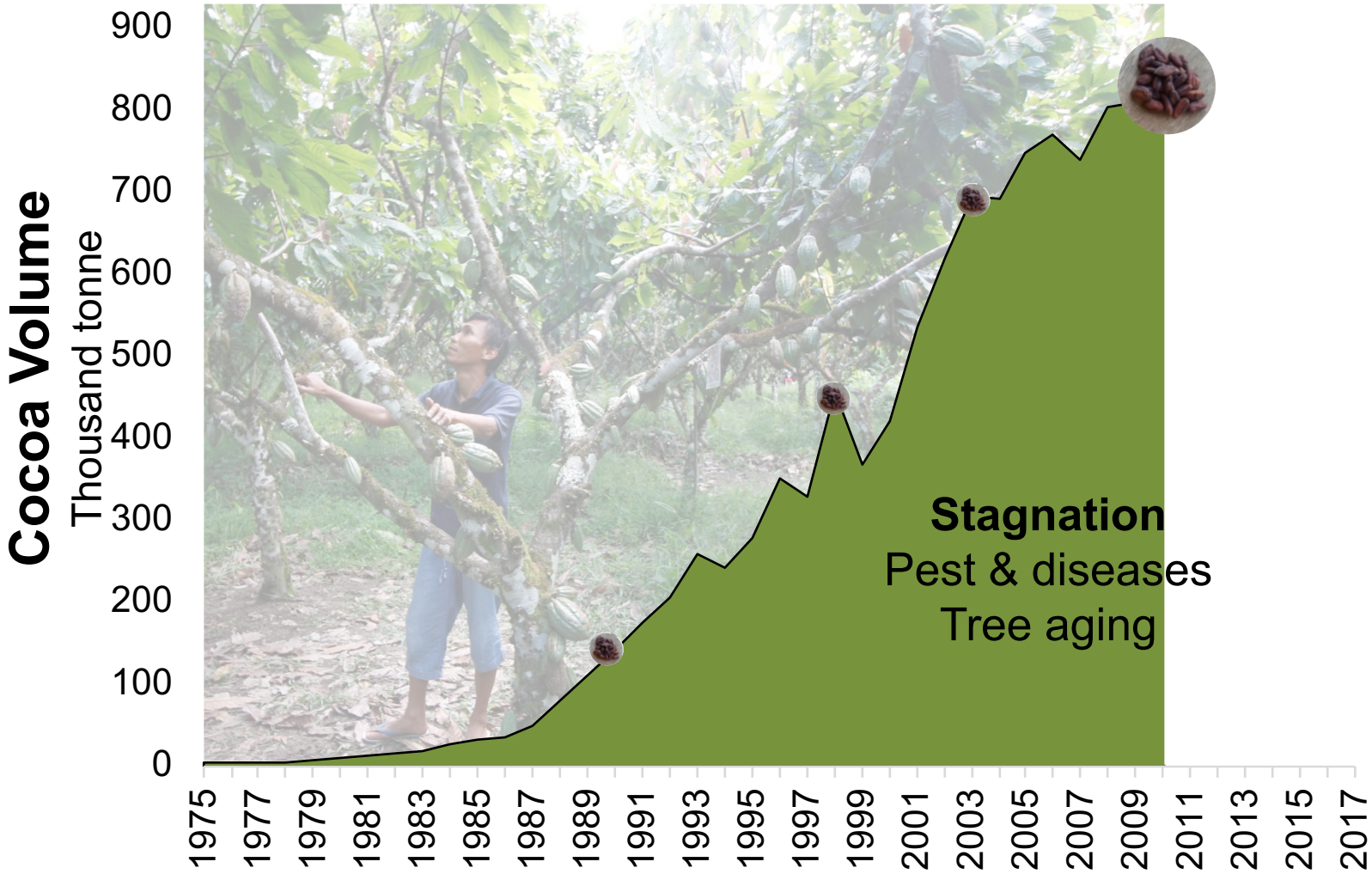


Biodiversity loss

(Clough et al., 2009; Tscharntke et al., 2011)

Boom and bust cycle of cocoa production in Indonesia



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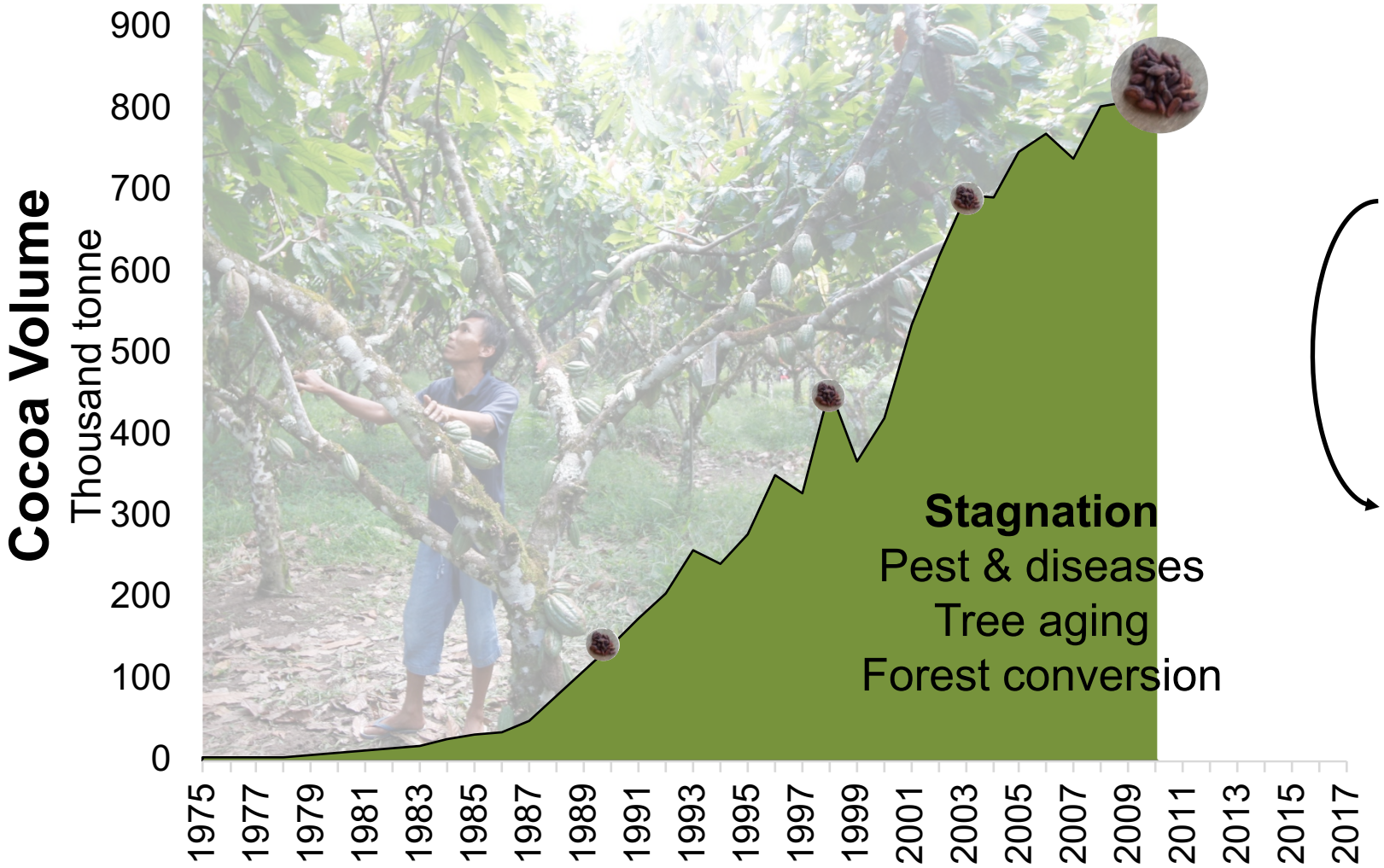
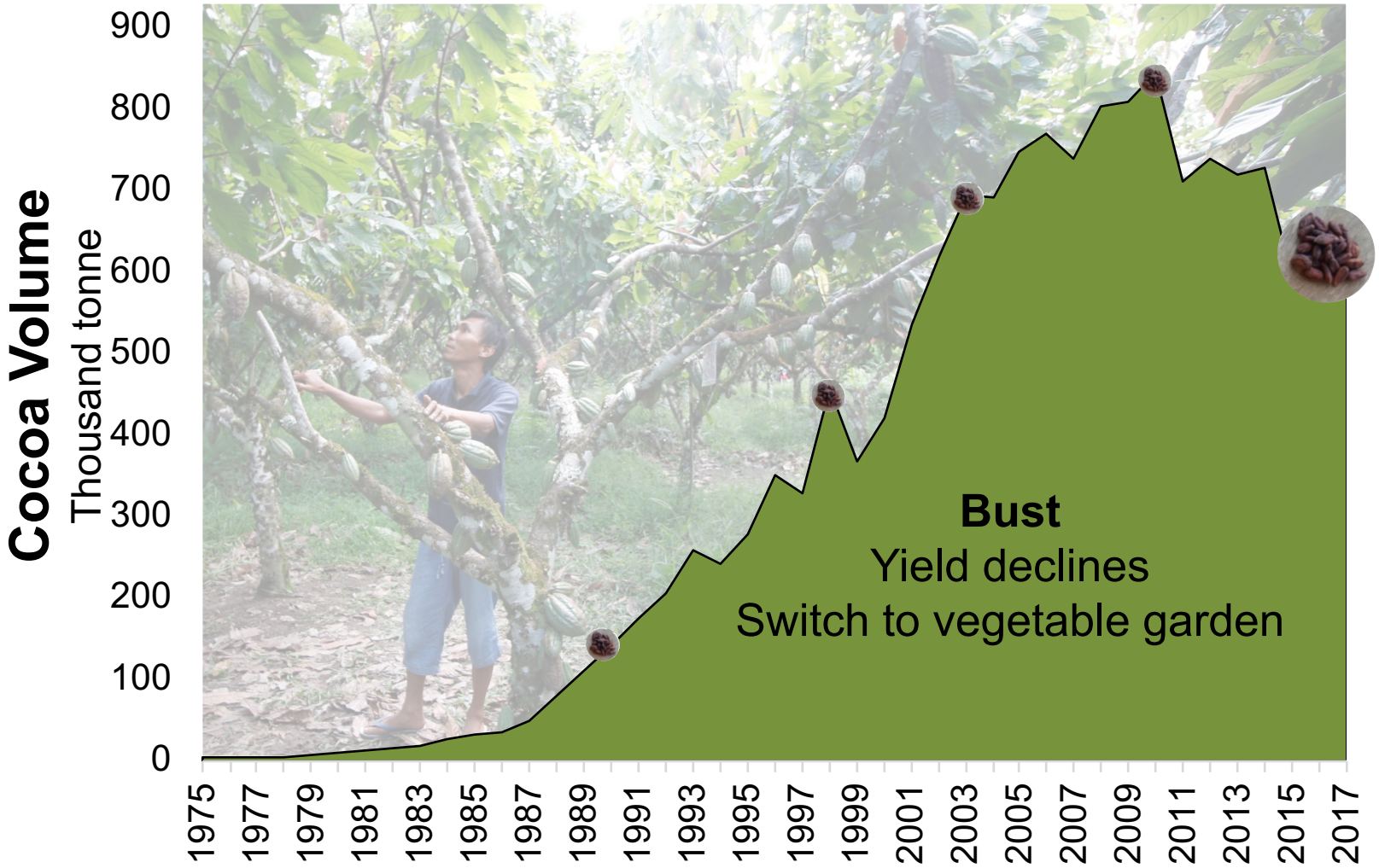


Further biodiversity loss

(Clough et al., 2009; Tscharntke et al., 2011)

Boom and bust cycle of cocoa production in Indonesia

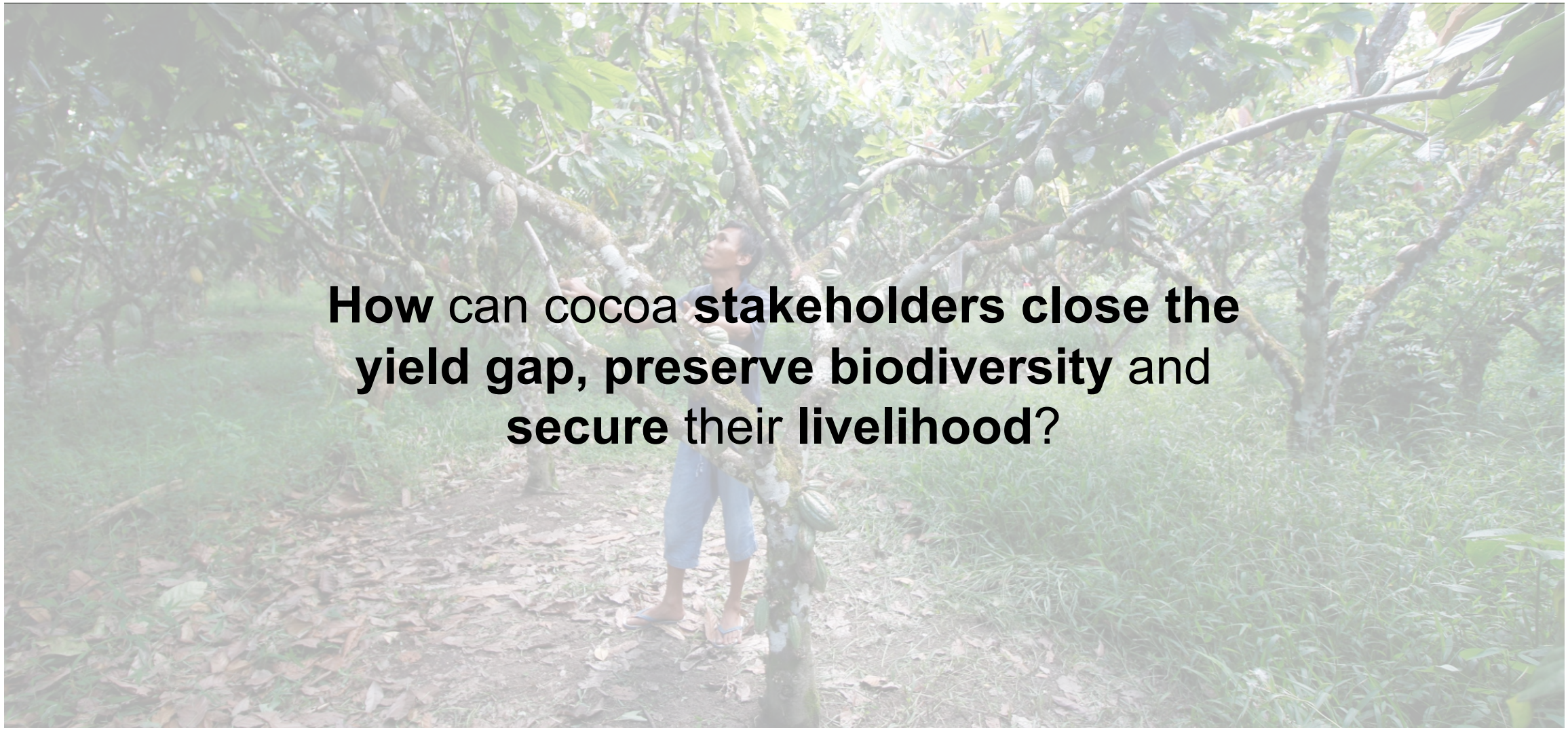


Similar pattern worldwide

1.8% yield decline worldwide since 2013 (ICCO, 2016)

(Clough et al., 2009; Tscharntke et al., 2011)

Boom and bust cycle – The case of Indonesia



How can cocoa **stakeholders close the yield gap, preserve biodiversity** and **secure** their **livelihood**?

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Farm diversification for ecosystem services provision

Paradigm shift in food production **towards diversified** agriculture(Rosa-Schleich et al., 2019; SDG, 2020; Arroyo et al., 2020, Wanger et al., 2020)

Sustainability by 2030

- Biodiversity conservation
- Zero hunger
- No poverty
- Climate change mitigation

Farm diversification for ecosystem services provision

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Farm management
(Agroforestry systems)

Landscape management
(Forest conservation)

Farm diversification for ecosystem services provision

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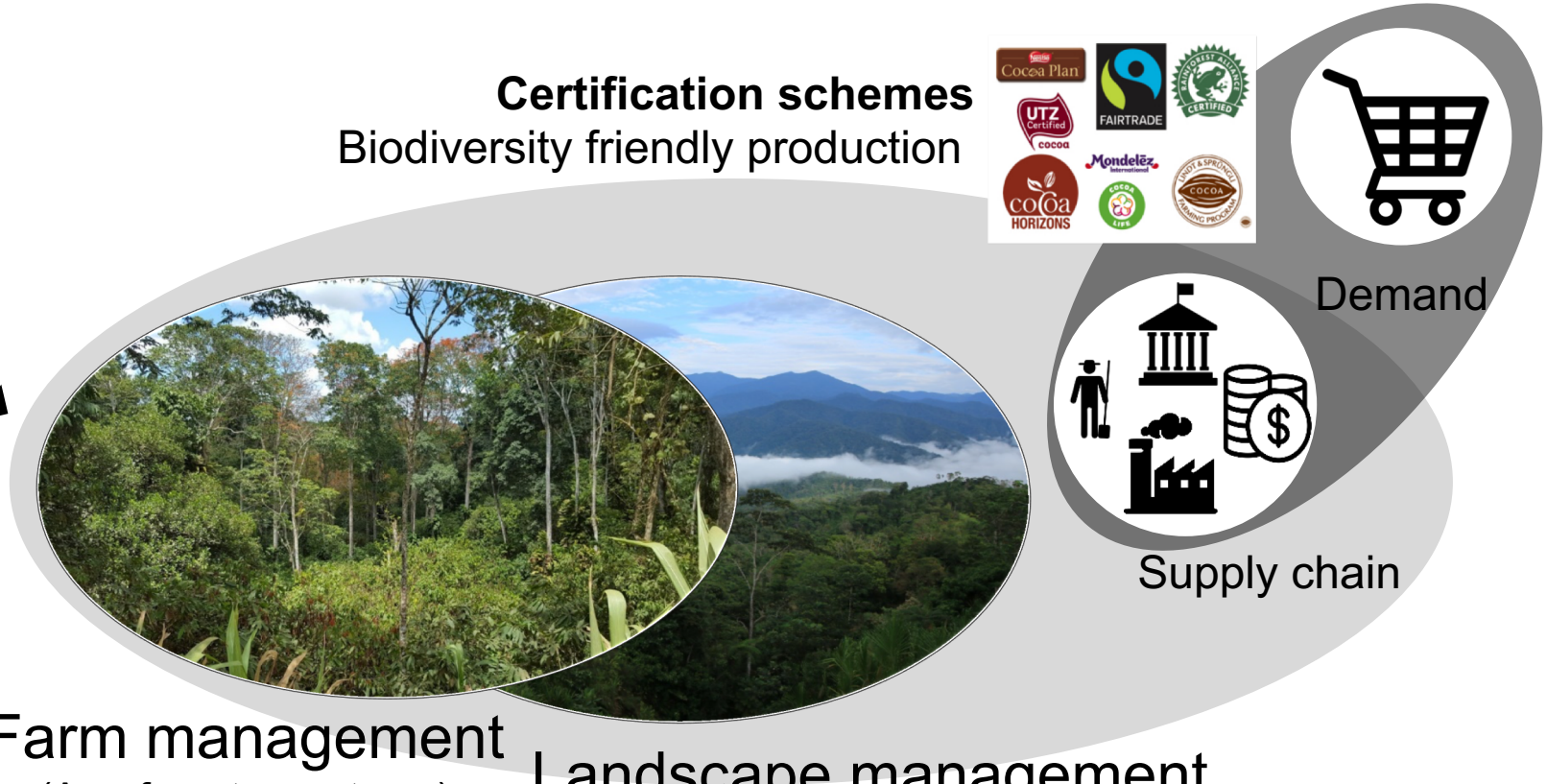
Certification schemes
Biodiversity friendly production



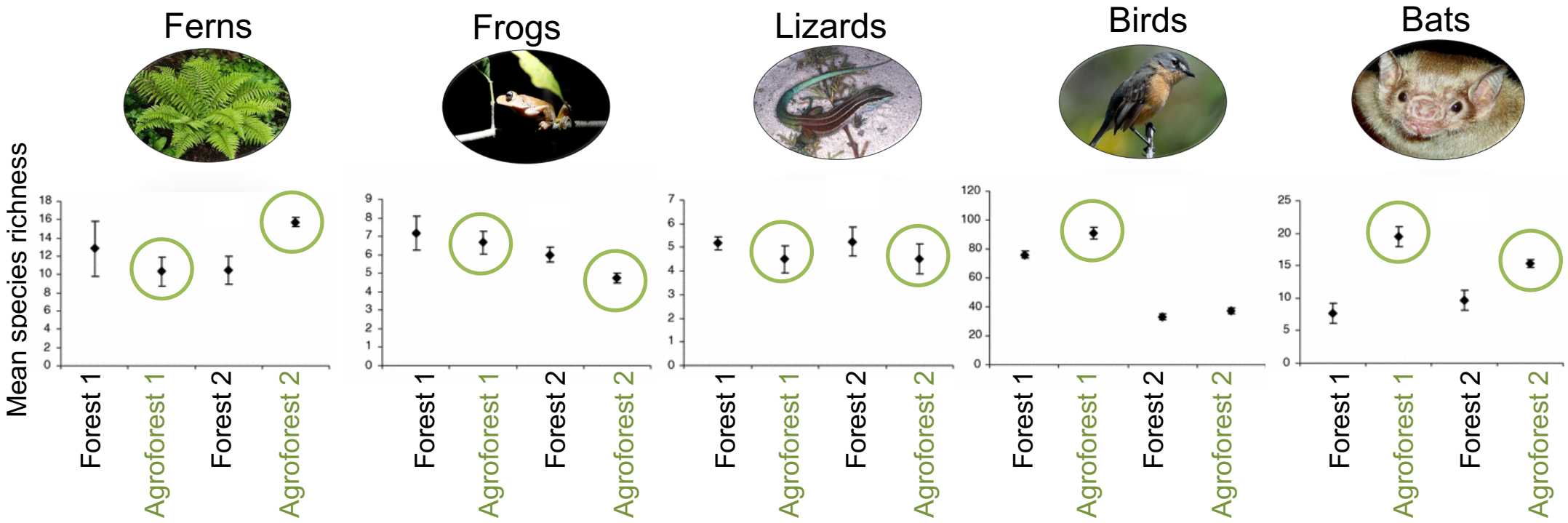
Farm management
(Agroforestry systems)

Landscape management
(Forest conservation)

Agroforestry systems in Bahia, Brazil

Universidade Estadual de Santa Cruz,
Almada Mata Atlântica Project (amap-brazil.org)

Agroforestry systems for biodiversity conservation

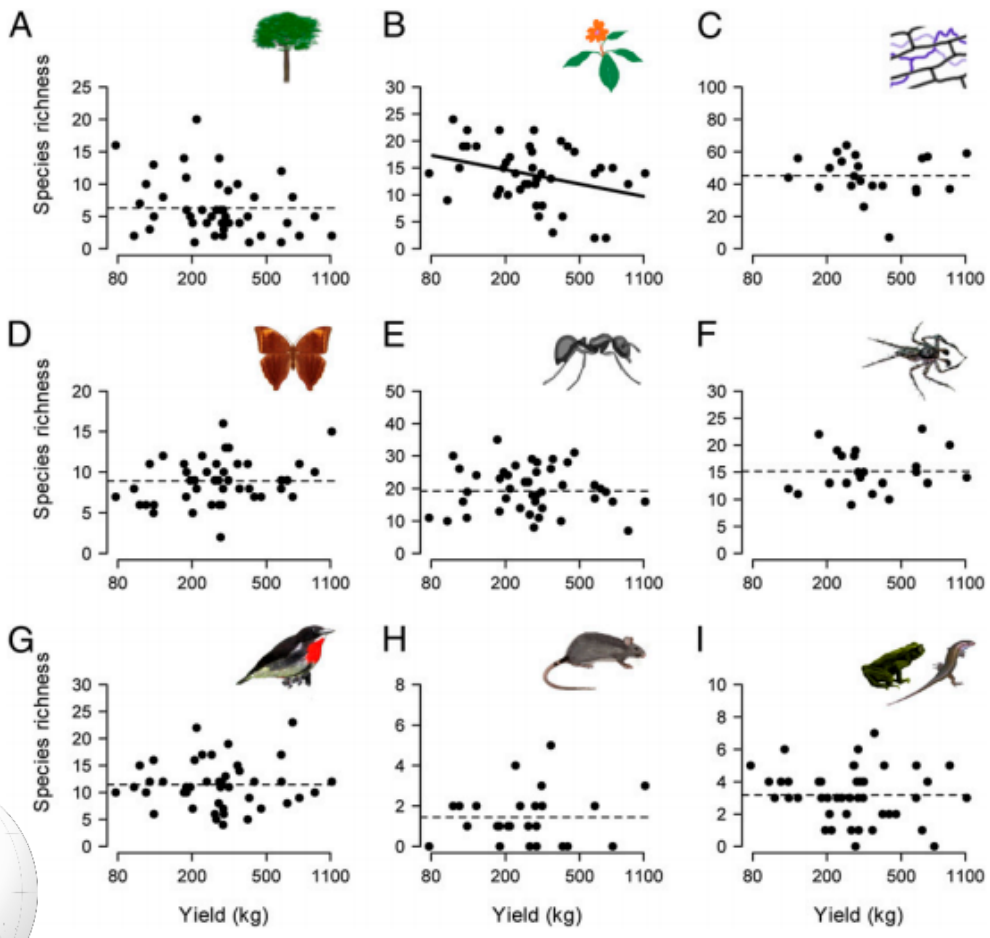


Agroforestry systems in Bahia, Brazil host a **large biodiversity** of plants and animals (Faria et al., 2007)

Agroforestry systems in Central Sulawesi, Indonesia

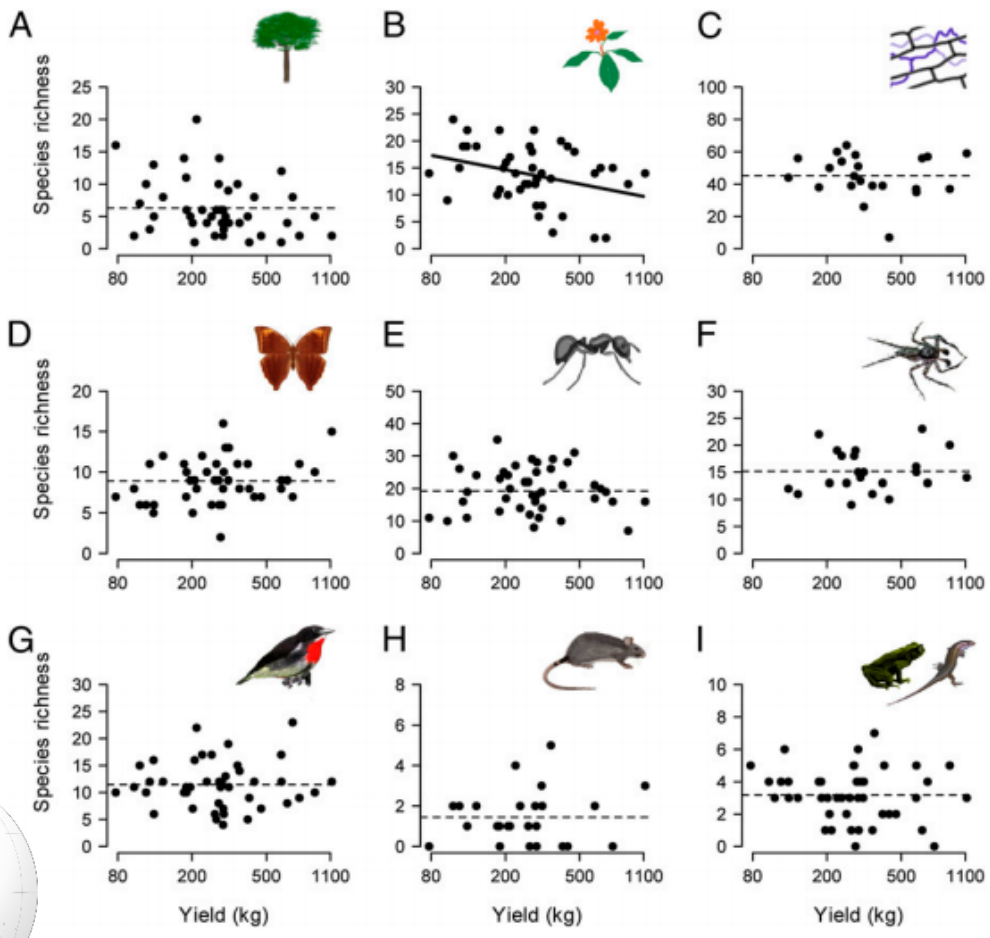
The Stability of Rainforest Margins in Indonesia (STORMA)
University of Goettingen

Agroforestry systems for biodiversity conservation



Biodiversity in cocoa **agroforests** of Central Sulawesi **does not decline with yields** (Clough et al., 2011)

Agroforestry systems for biodiversity conservation



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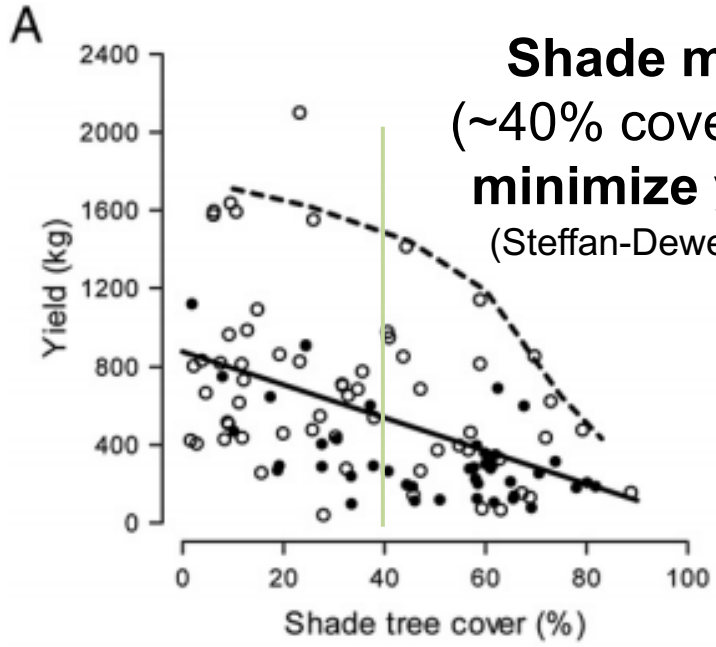

Shade management (~40% cover) required to **minimize yield losses** (Steffan-Dewenter et al., 2007)

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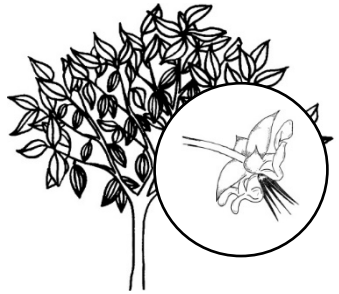

Agroforestry systems to promote pollinator conservation and pollination

What pollinates cocoa flowers?

Toledo-Hernandez et al., 2017

Pollinators are a major **driver** of **pollination success**

- **Cocoa requires** a **pollinator agent** to transport pollen (self incompatibility)

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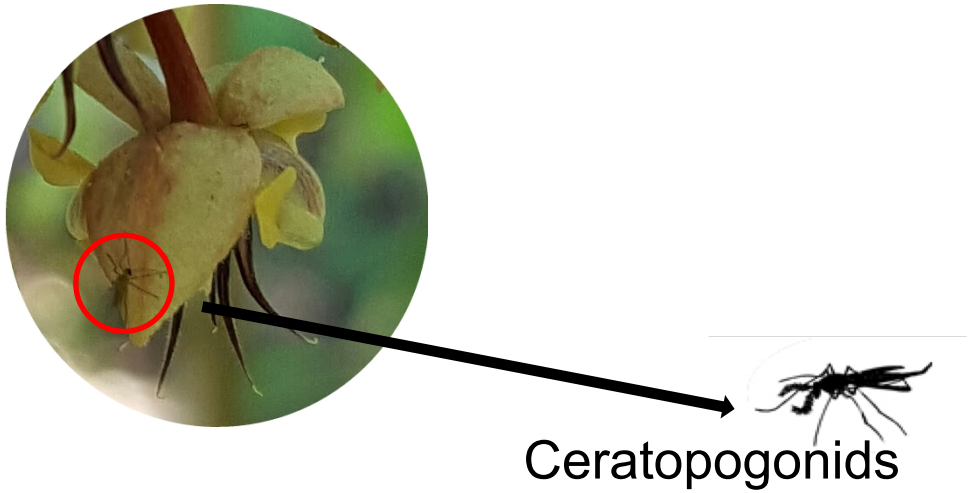

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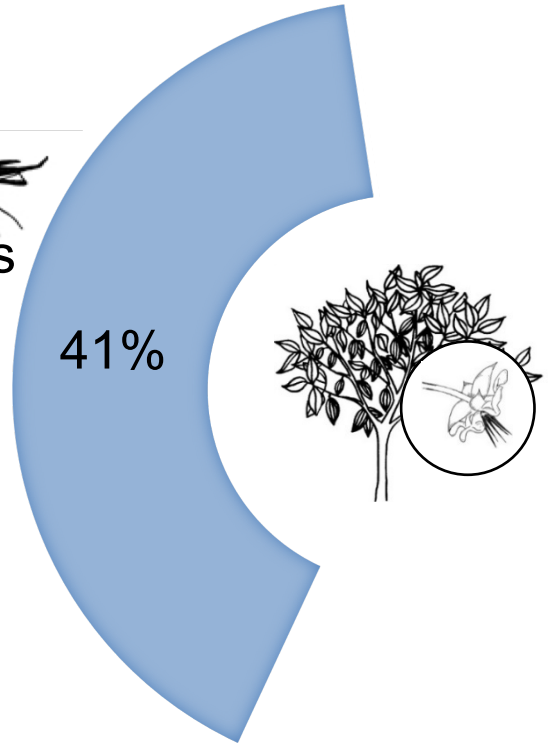
Reported flower visitor spieces in the reviewed studies (123 *spp.* total)

Ceratopogonids

50 *spp.*



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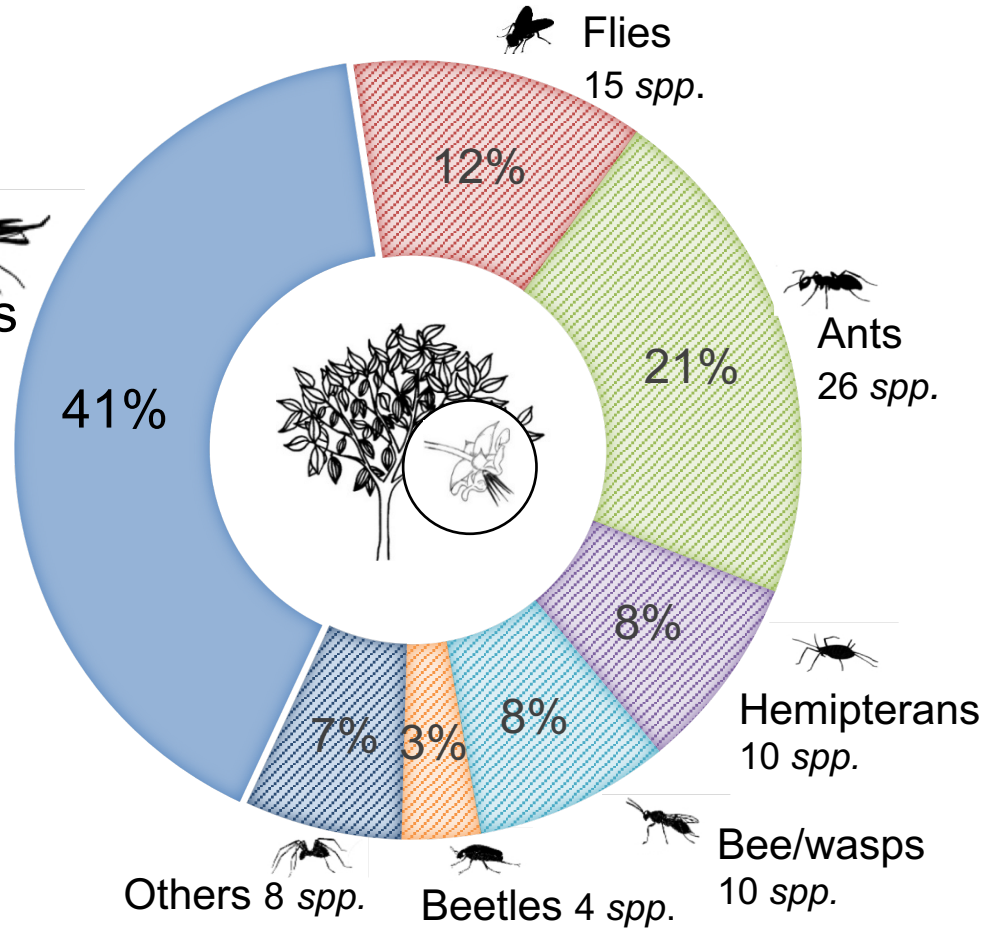


What pollinates cocoa flowers?

Toledo-Hernandez
et al., 2017

Ceratopogonids

50 *spp.*

Habitats

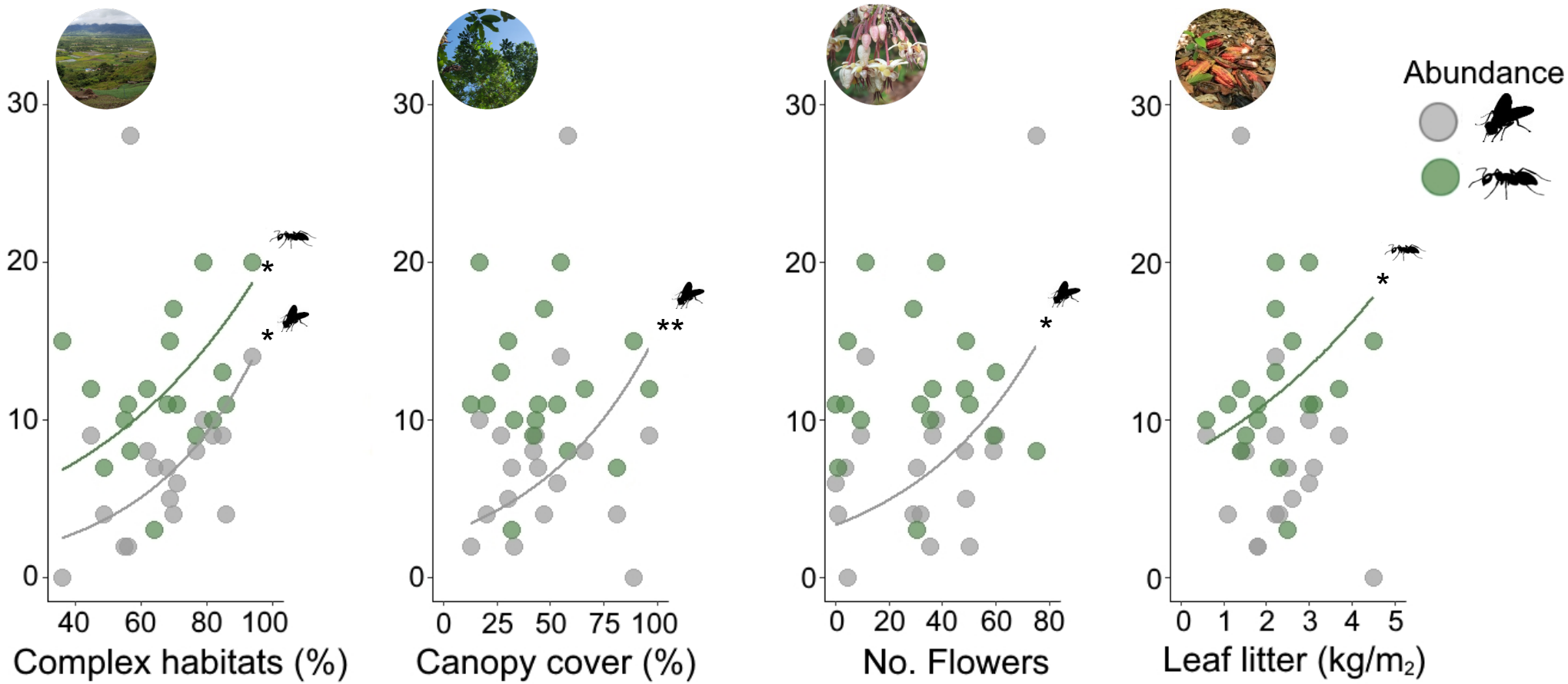
Dark, humid habitats

Organic matter

Forest and agroforest

Drivers of cocoa pollinators in Indonesia

Landscape, **farm** and **tree drivers** of **pollinators** in Central Sulawesi



Toledo-Hernandez et al., *in prep.*

Closing yield gaps in AF with hand pollination (HP)

Artificial pollination to **improve** cocoa **yields** (Toledo-Hernandez et al. 2017)

- Only **<10% flowers** are **naturally pollinated** (Falque et al., 1995)

Hand pollination increased yields

Hand pollination of flowers **below 2m** height

Toledo-Hernandez et al., 2020

Hand pollination increased yields

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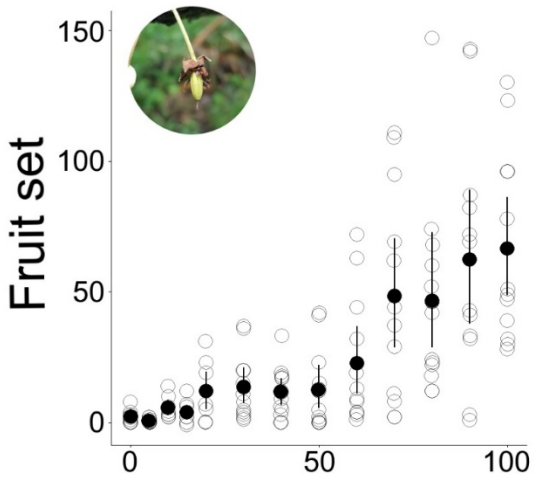
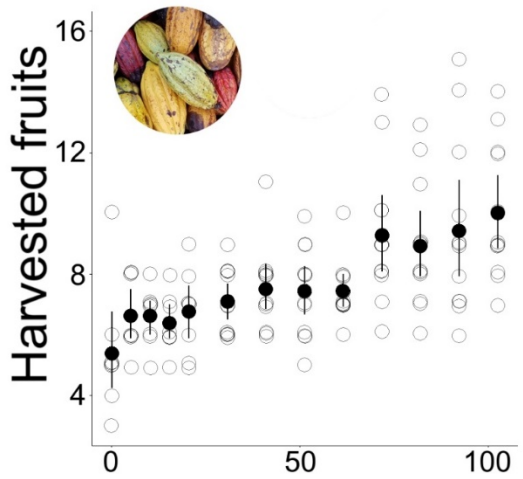
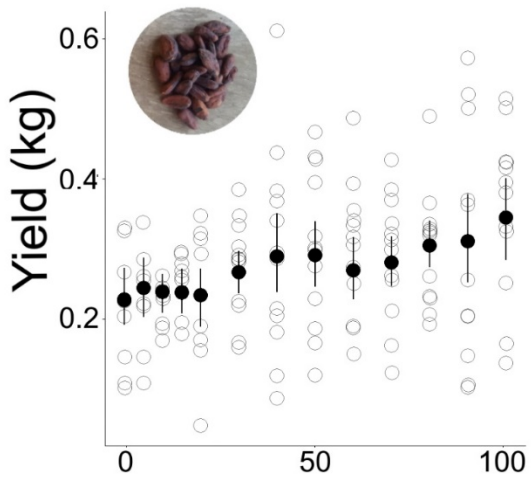






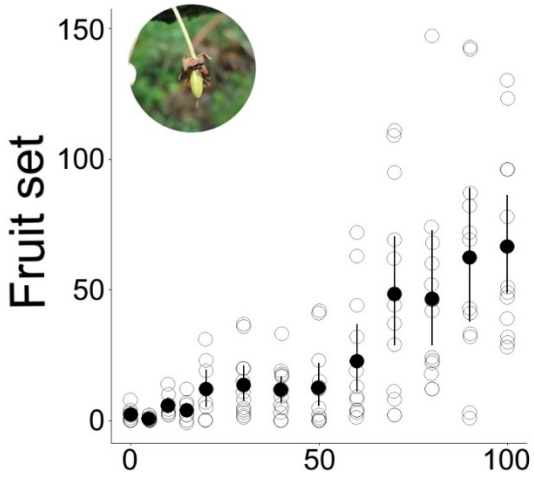
HP rate (%)

Toledo-Hernandez et al., 2020

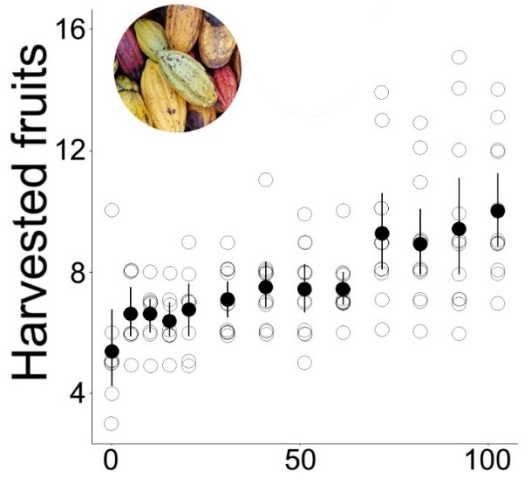
Hand pollination increased yields

Hand pollination of flowers **below 2m** height

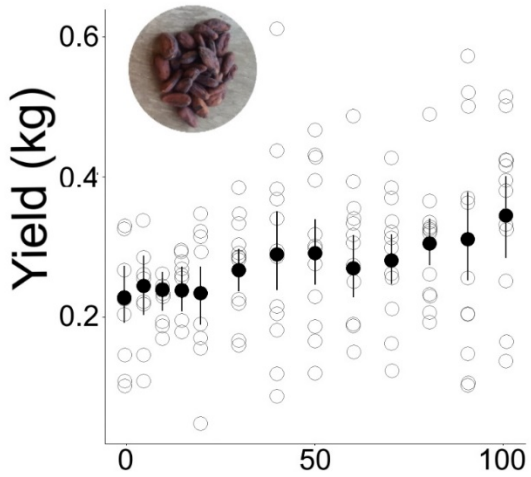
700 %



86 %



51 %

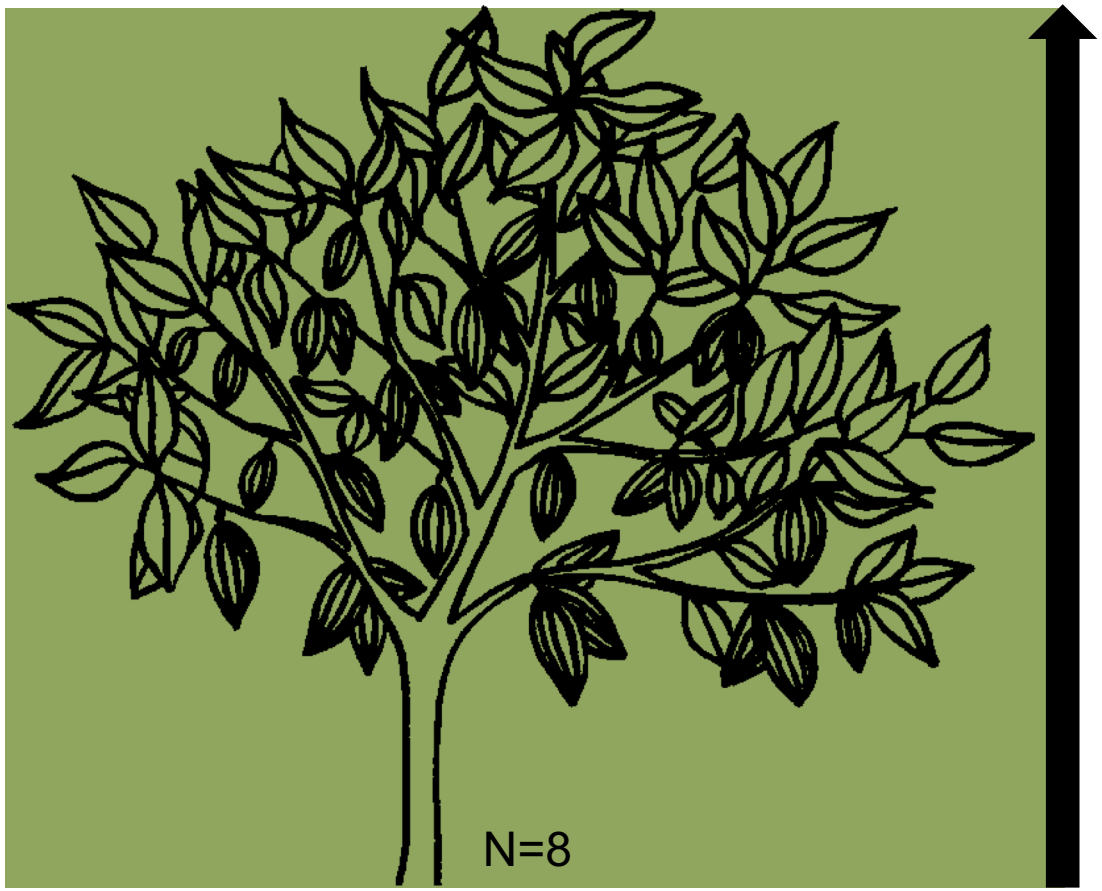


HP rate (%)

Toledo-Hernandez et al., 2020

Results – Contribution to improve farmer income

HP full tree



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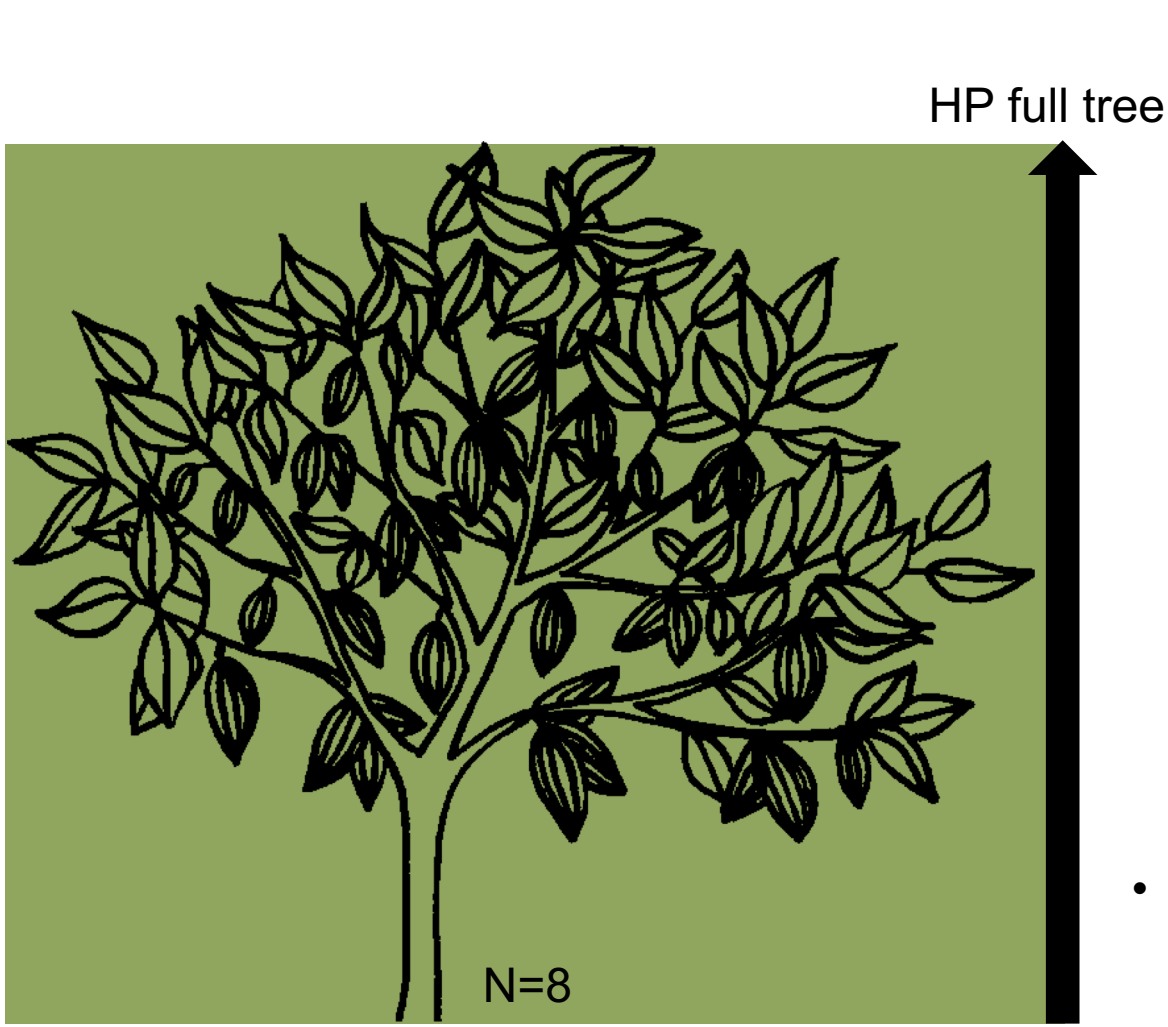

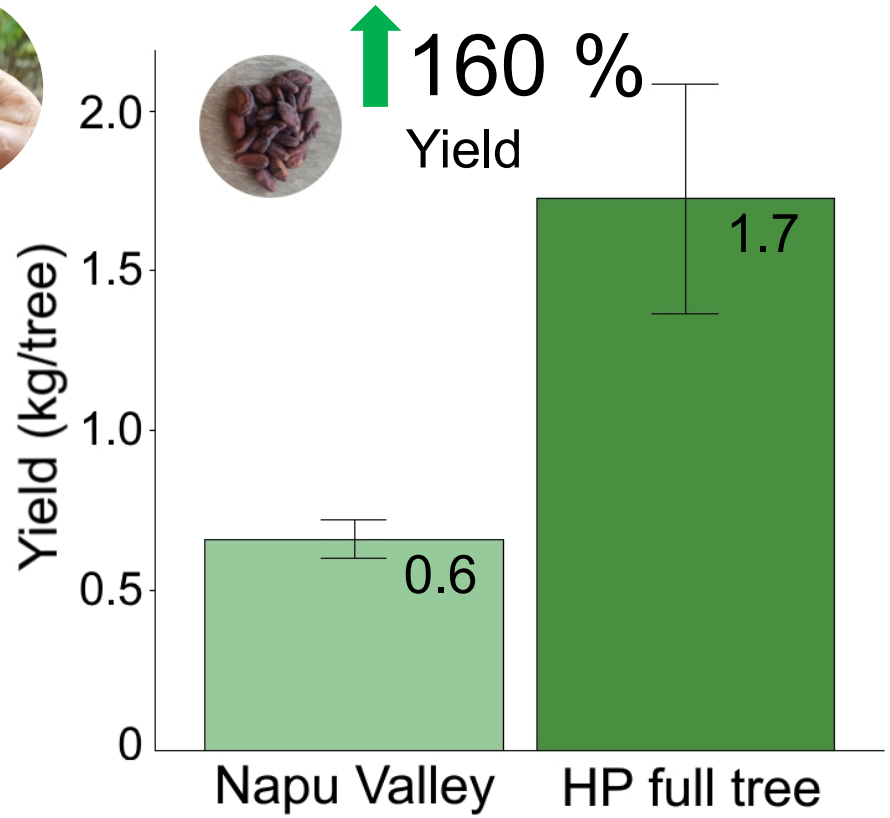

- HP full tree increase yields significantly in contrast to yield recorded in the study area

Toledo-Hernandez et al., 2020

Summary

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Boom and **Bust** cycle → **Low resilience** of conventional systems to **environmental factors**

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Boom and **Bust** cycle → **Low resilience** of conventional systems to **environmental factors**

Part 2

Agroforestry systems can **preserve biodiversity**

~40%

Canopy management to minimize **trade-offs** of **shade** on **yields**

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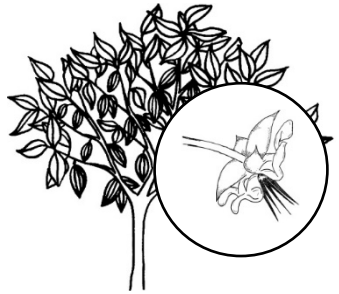

Pollinators

← **Forest** and **agroforest conservation**

Hand pollination

+51% Yield

+160% Yield

The way forward – Understand cocoa agroforestries globally

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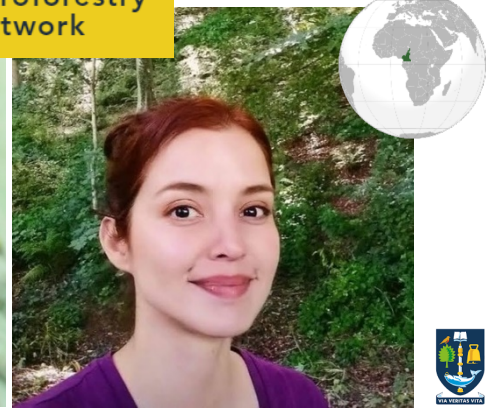
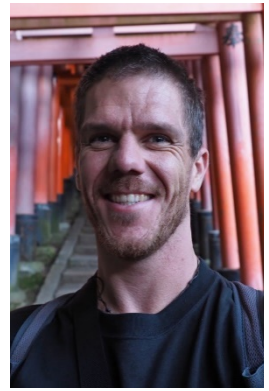


Sustainability, Agriculture & Technology LAB
Thomas C. Wanger
Westlake University



Research ongoing in key producing countries:
Brazil – Manuel Toledo Hernandez *(Postdoc)*
Ghana – Achempong Atta Boateng *(PhD student)*
Cameroon – Alma Lissette Sanchez *(PhD student)*

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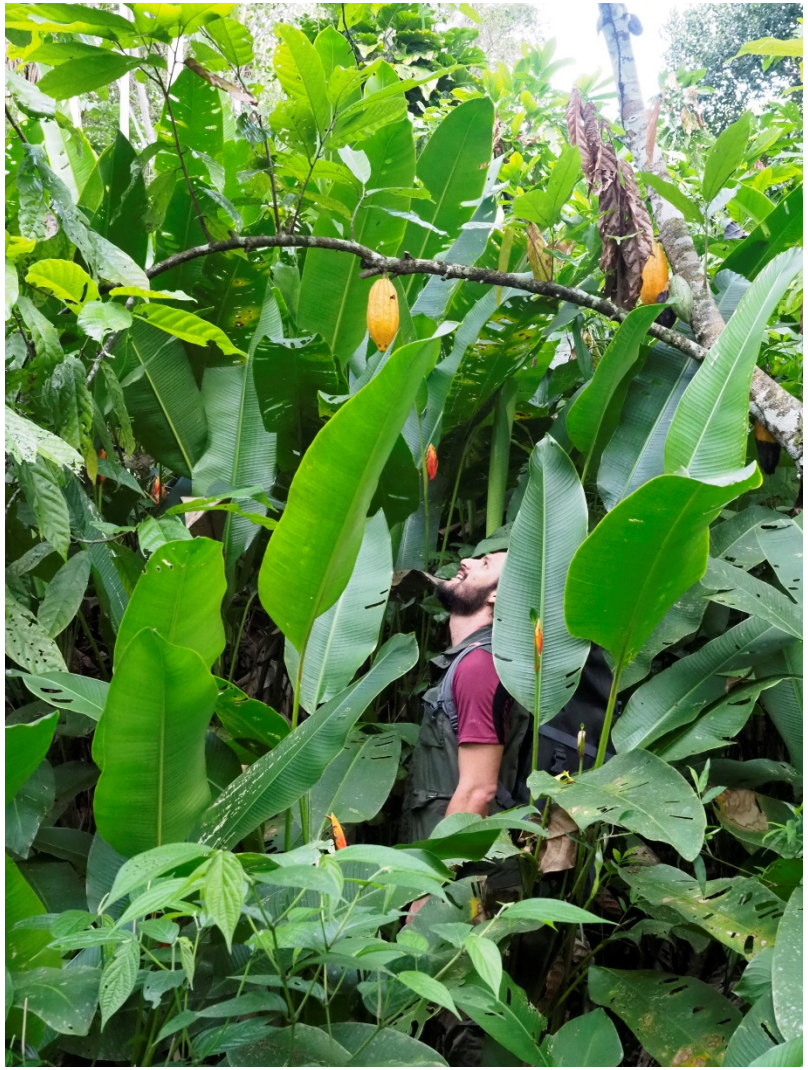
Thank you for your attention



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