Regenwormen en de broeikasgasbalans van de bodem

- Bodems zijn belangrijk voor de uitstoot van broeikasgassen
- Regenwormen zijn belangrijk voor de bodem
- Wat is de invloed van regenwormen op broeikasgasemissies?

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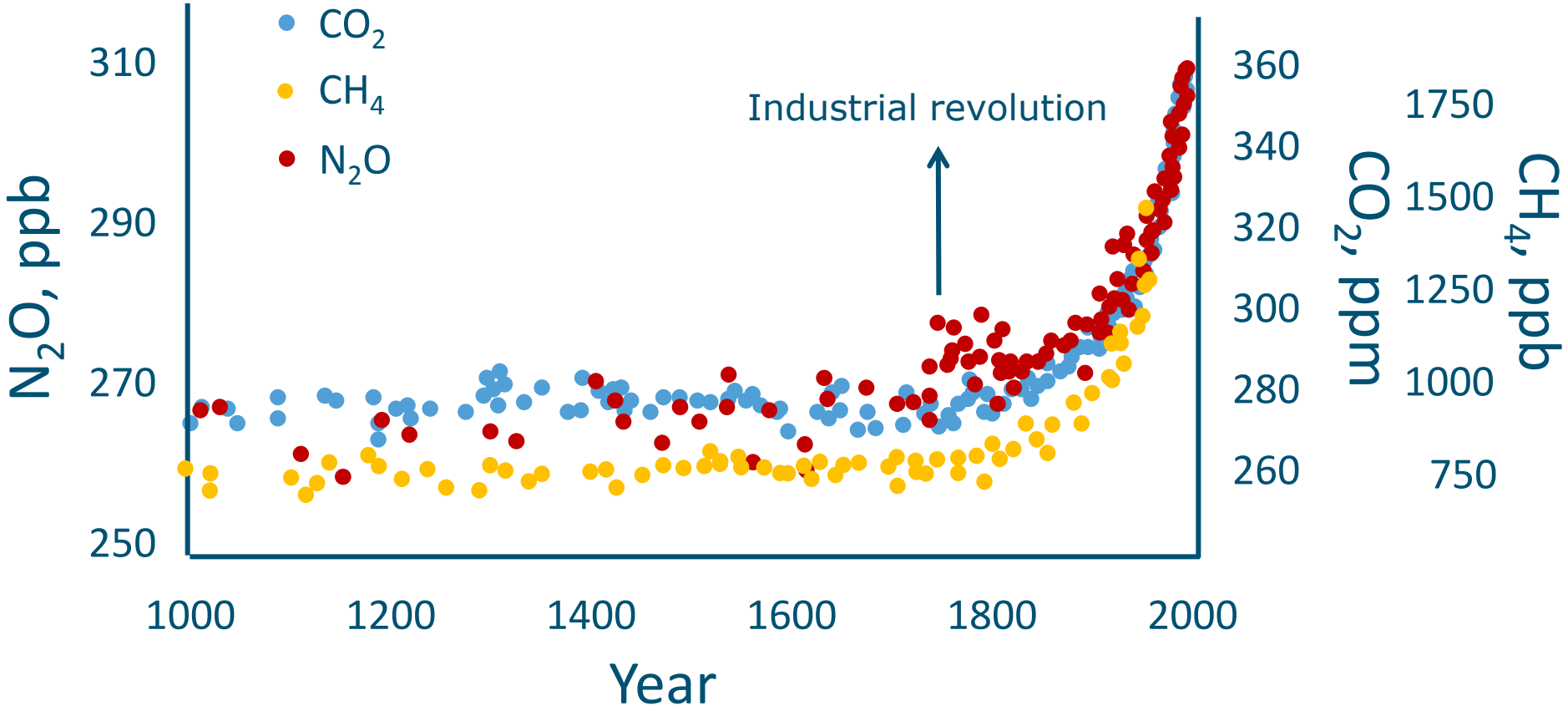
Overview

- Greenhouse gas emissions
- On earthworms
- Main research question
- Thesis contents
- Meta-analyses I and II
- Conclusions / recommendations

Hockey sticks....



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[IPCC, 2005]

Hockey sticks....

Approx. 20% of global CO_2 emissions originate from soils

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[IPCC, 2005]

Hockey sticks....

CH_4 emissions originate from soils unlikely to harbour many earthworms

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[IPCC, 2005]

Hockey sticks....

Roughly two thirds of N_2O emissions originate from soils

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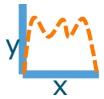
[IPCC, 2005]

Controlling factors for N_2O emission

- Nitrogen  ← e.g. Fertilization
- Carbon  ← e.g. Residue management
- Moisture content  ← e.g. Irrigation
- pH  ← e.g. Liming
- Temperature 

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[Granli and Bockman, 1994]

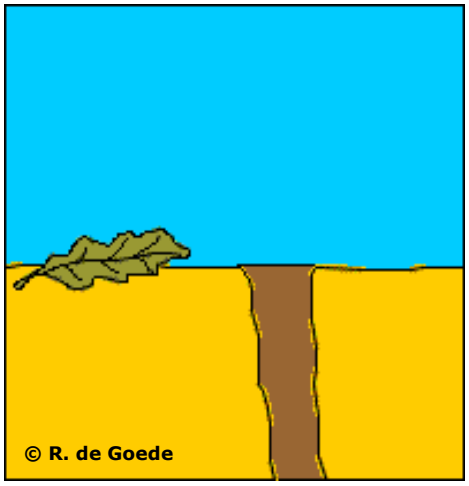
Controlling factors for N_2O emission

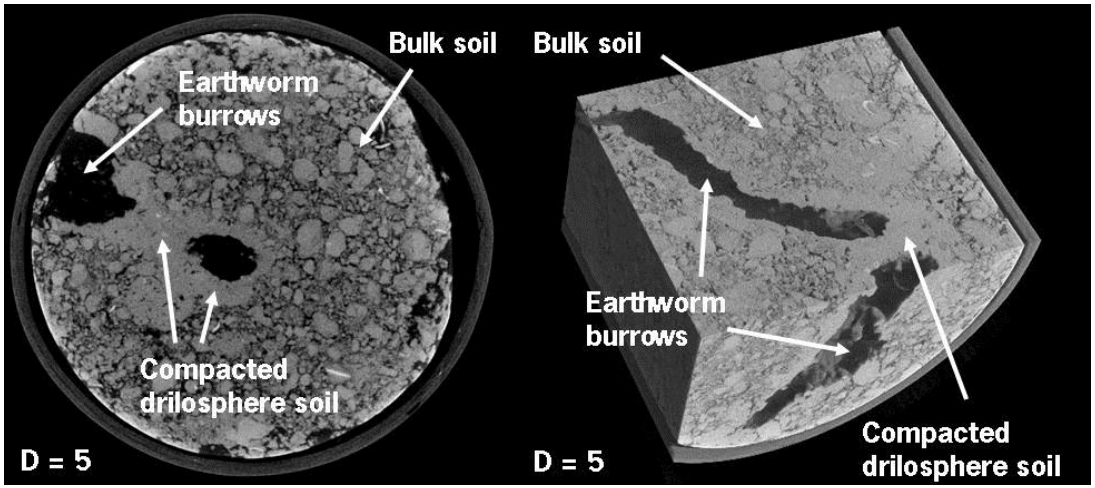
- Nitrogen
- Carbon
- Moisture content
- pH
- Temperature

Strongly elevated in casts

On earthworms

- Earthworms can:
  - increase mineral N and available C by mixing crop residues into the soil
  - change the anaerobicity through their burrowing activity
  - stimulate microbial activity by their intestinal mucus





On earthworms: increased C sequestration?

nature COMMUNICATIONS

ARTICLE

Received 28 Apr 2013 | Accepted 9 Sep 2013 | Published 15 Oct 2013

DOI: 10.1038/ncomms3576

Earthworms facilitate carbon sequestration through unequal amplification of carbon stabilization compared with mineralization

Weixin Zhang[1], Paul F. Hendrix[2], Lauren E. Dame[2], Roger A. Burke[3], Jianping Wu[4], Deborah A. Neher[5], Jianxiong Li[6], Yuanhu Shao[1] & Shenglei Fu[1]

European Journal of Soil Science, August 2005, **56**, 453–467 doi: 10.1111/j.1365-2389.2004.00696.x

Soil organic matter distribution and microaggregate characteristics as affected by agricultural management and earthworm activity

M. M. Pulleman[a,b], J. Six[b,c], N. van Breemen[a] & A. G. Jongmans[a]

[a]*Laboratory of Soil Science and Geology, Wageningen University, PO Box 37, 6700 AA Wageningen, The Netherlands,* [b]*Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523, USA, and* [c]*University of California Davis, Department of Agronomy and Range Science, One Shields Avenue, Davis, CA 95616, USA*

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European Journal of Soil Science, June 2004, **55**, 393–399 doi: 10.1111/j.1365-2389.2004.00603.x

Rapid incorporation of carbon from fresh residues into newly formed stable microaggregates within earthworm casts

H. Bossuyt[a], J. Six[b] & P. F. Hendrix[a,c]

[a]*Institute of Ecology, University of Georgia, Athens, GA 30602,* [b]*Department of Agronomy and Range Science, University of California, Davis, CA 95616, and* [c]*Department of Crop and Soil Sciences, University of Georgia, Athens, GA 30602, USA*

ELSEVIER

Soil Biology & Biochemistry 37 (2005) 251–258

Soil Biology & Biochemistry

www.elsevier.com/locate/soilbio

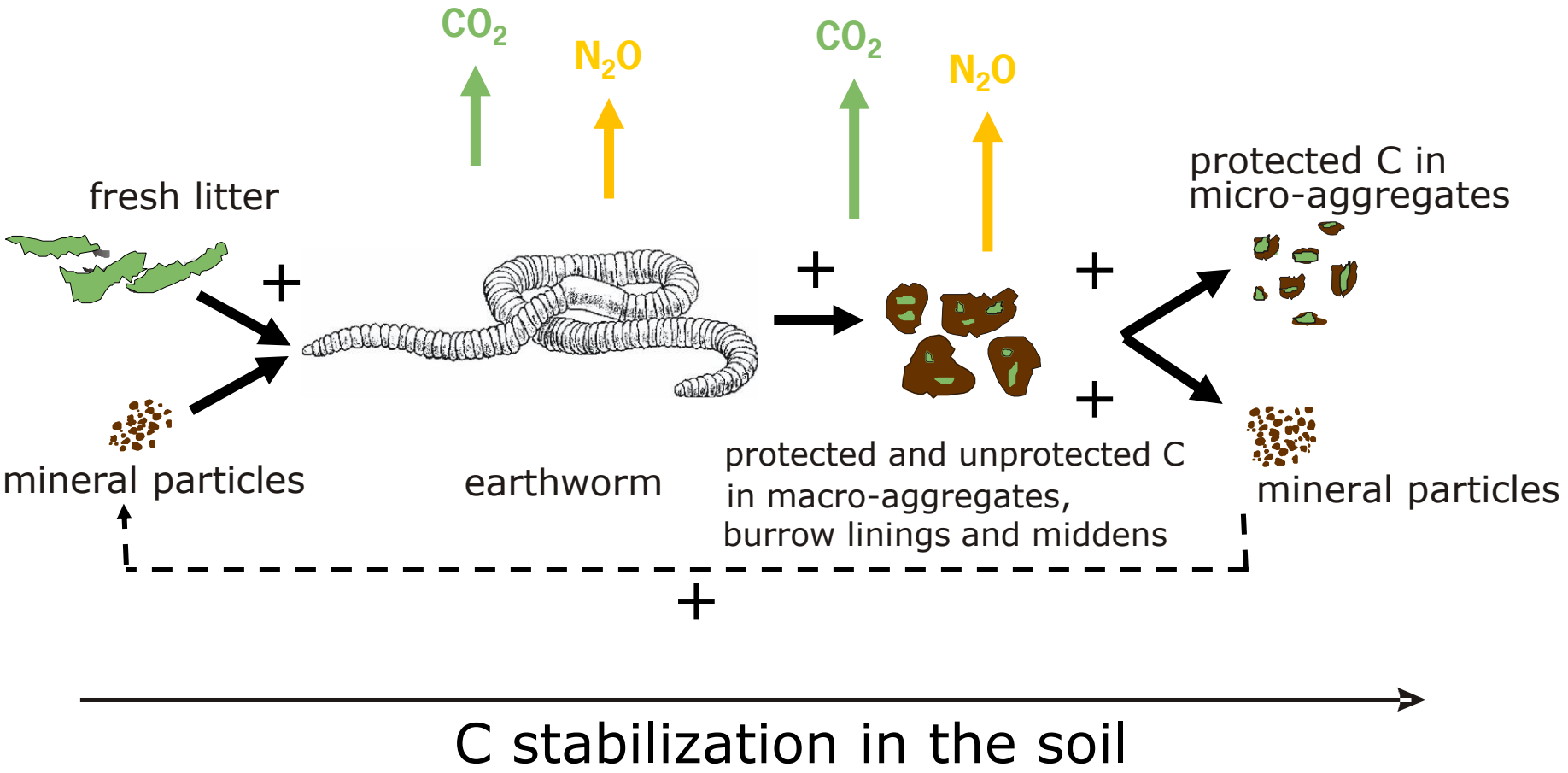
Protection of soil carbon by microaggregates within earthworm casts

Heleen Bossuyt[a,*], Johan Six[b], Paul F. Hendrix[a,c]

[a]*Institute of Ecology, University of Georgia, Athens, GA 30602, USA*
[b]*Department of Agronomy and Range Science, University of California, Davis, CA 95616, USA*
[c]*Department of Crop and Soil Sciences, University of Georgia, Athens, GA 30602, USA*

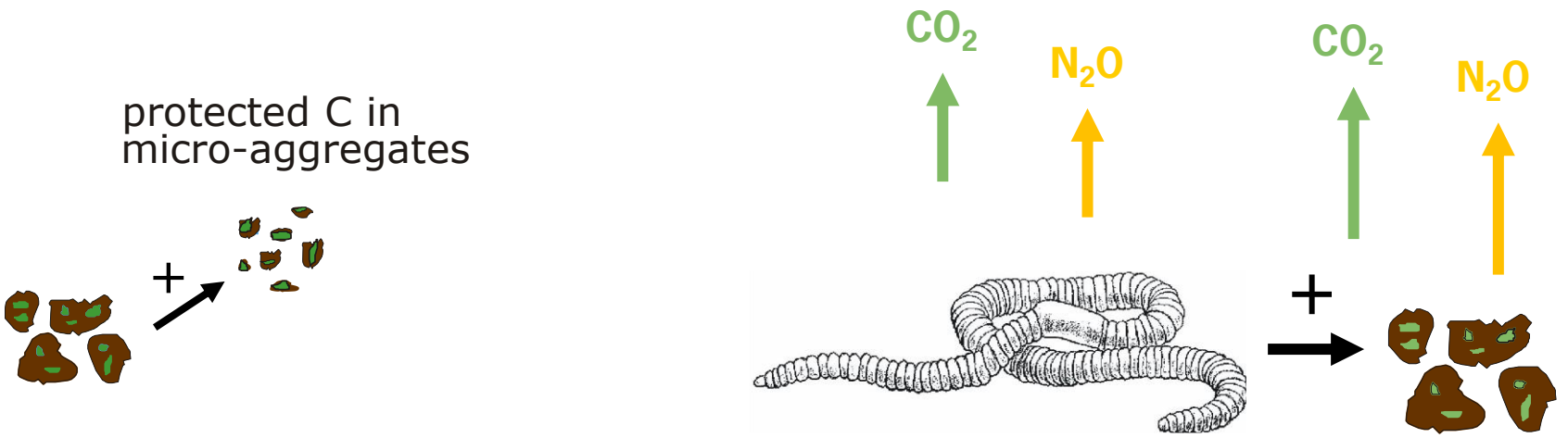
Received 2 January 2003; received in revised form 18 February 2004; accepted 10 July 2004

On earthworms: increased C sequestration?



Main research question

To what extent is C stabilization as affected by earthworms offset by earthworm-induced GHG emissions?



Thesis contents

1. Greenhouse-gas emissions from soils increased by earthworms *(Nature Climate Change, 2013)*
2. A simple and effective method to keep earthworms confined to open-top mesocosms *(Applied Soil Ecology, 2013)*
3. Earthworm-induced N mineralization in fertilized grassland increases both N_2O emission and crop uptake *(European Journal of Soil Science, 2011)*
4. Earthworms can increase nitrous oxide emissions from grassland: a field study *(Agriculture, Ecosystem and Environment, 2013)*
5. Residue incorporation depth is a controlling factor of earthworm-induced nitrous oxide emissions *(Global Change Biology, 2012)*
6. Earthworms reduce the greenhouse gas mitigation potential of no-tillage soils *(under review with Nature Communications)*
7. Enhanced decomposition and stabilization of residue carbon by earthworms *(to be submitted in December 2014)*
8. Earthworms: Nature's free fertilizer? (*Scientific Reports, 2014)*

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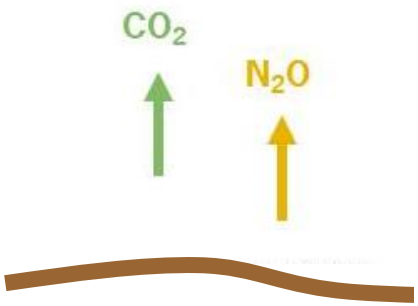
   (*Scientific Reports, 2014)*

Earthworms: good *and* bad

Meta-analysis I:

"Earthworms are bad for global warming!"



Meta-analysis II:

"Earthworms are great for crop production!"

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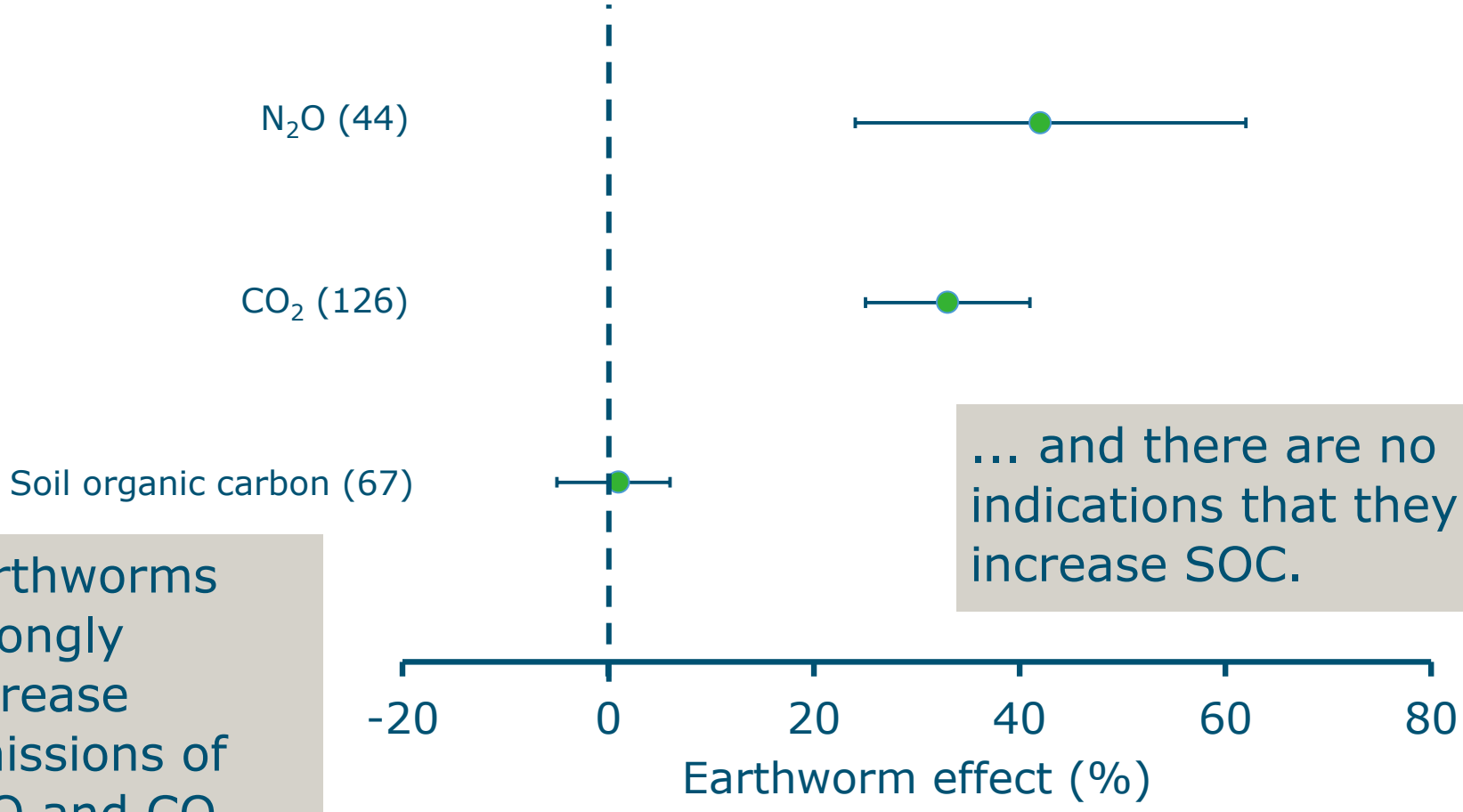
Meta-analysis I: overall effects on GHGs

- 57 peer reviewed studies
- 1990 - 2011
- Cumulative emissions (CO_2 & N_2O) from bulk soil
- With and without earthworms
- Clearly defined experimental period
- Effect of earthworms on:
  - CO_2
  - N_2O
  - Soil organic carbon

Meta-analysis I: overall effects on GHGs



Earthworms strongly increase emissions of N_2O and CO_2....

... and there are no indications that they increase SOC.

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[Lubbers *et al.*, 2013]

The soil greenhouse balance

- The meta-analysis included very few studies with growing plants
- Wouldn't increased primary production compensate for increased CO_2 emissions?
- How do increased CO_2 emissions (33%) compare to plant growth?
    - .... %

Meta-analysis II: effects on plant growth

- Agricultural fields
- 60 studies, 467 observations, all continents (- Antarctica)
- All major grain crops, grasslands, etc....
- 1910 - 2013
- Effect of earthworms on:
    - Aboveground biomass
    - Yield
    - Shoot / root ratio
    - N concentration

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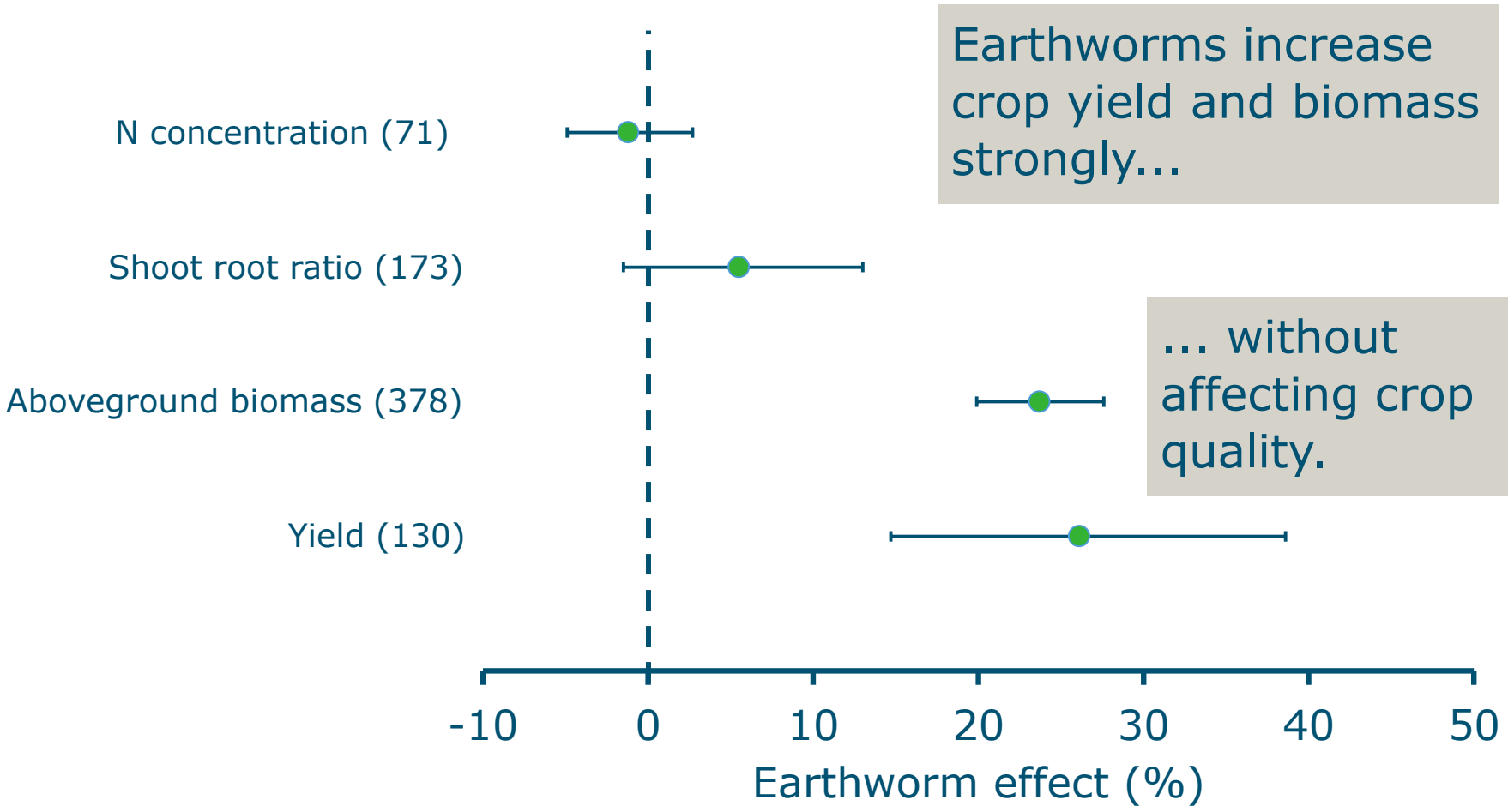
[Van Groenigen *et al.*, 2014]

Meta-analysis II: effects on plant growth



Earthworms increase crop yield and biomass strongly...

... without affecting crop quality.

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[Van Groenigen *et al.*, 2014]

But how do they do this?

- Gilbert White (1777): *"... by boring, perforating, and loosening the soil, and rendering it pervious to rains and the fibres of plants, by drawing straws and stalks of leaves and twigs into it; most of all, by throwing up such infinite numbers of lumps of earth called worm casts which, being their excrement, is a fine manure for grain and grass ..."*

1. Soil structure
2. Fertilization
3. Biocontrol of pests and diseases
4. Stimulation of symbionts
5. Production of plant-growth regulating substances

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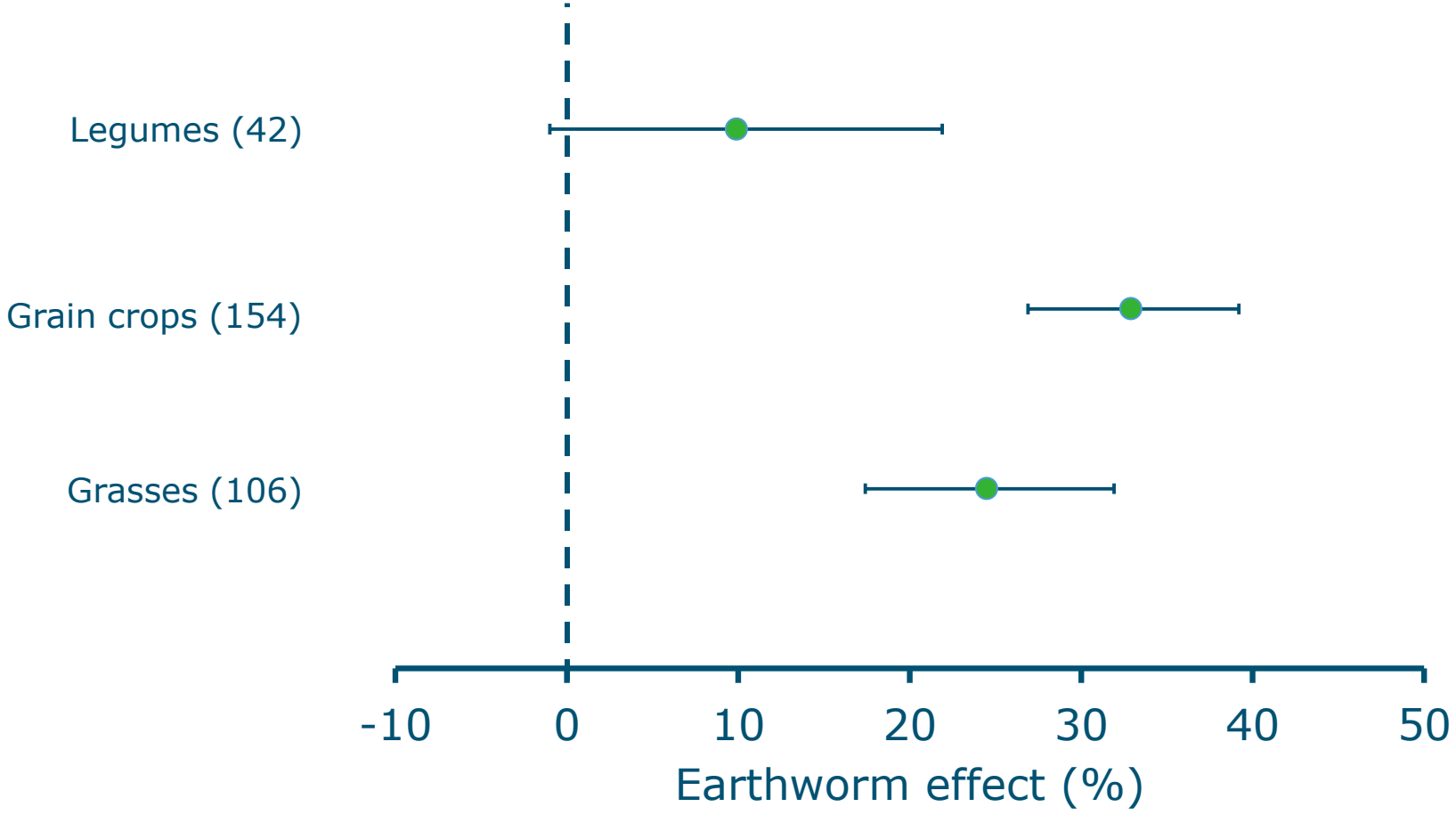
[Brown *et al.*, 2004]

Meta-analysis II: plant groups



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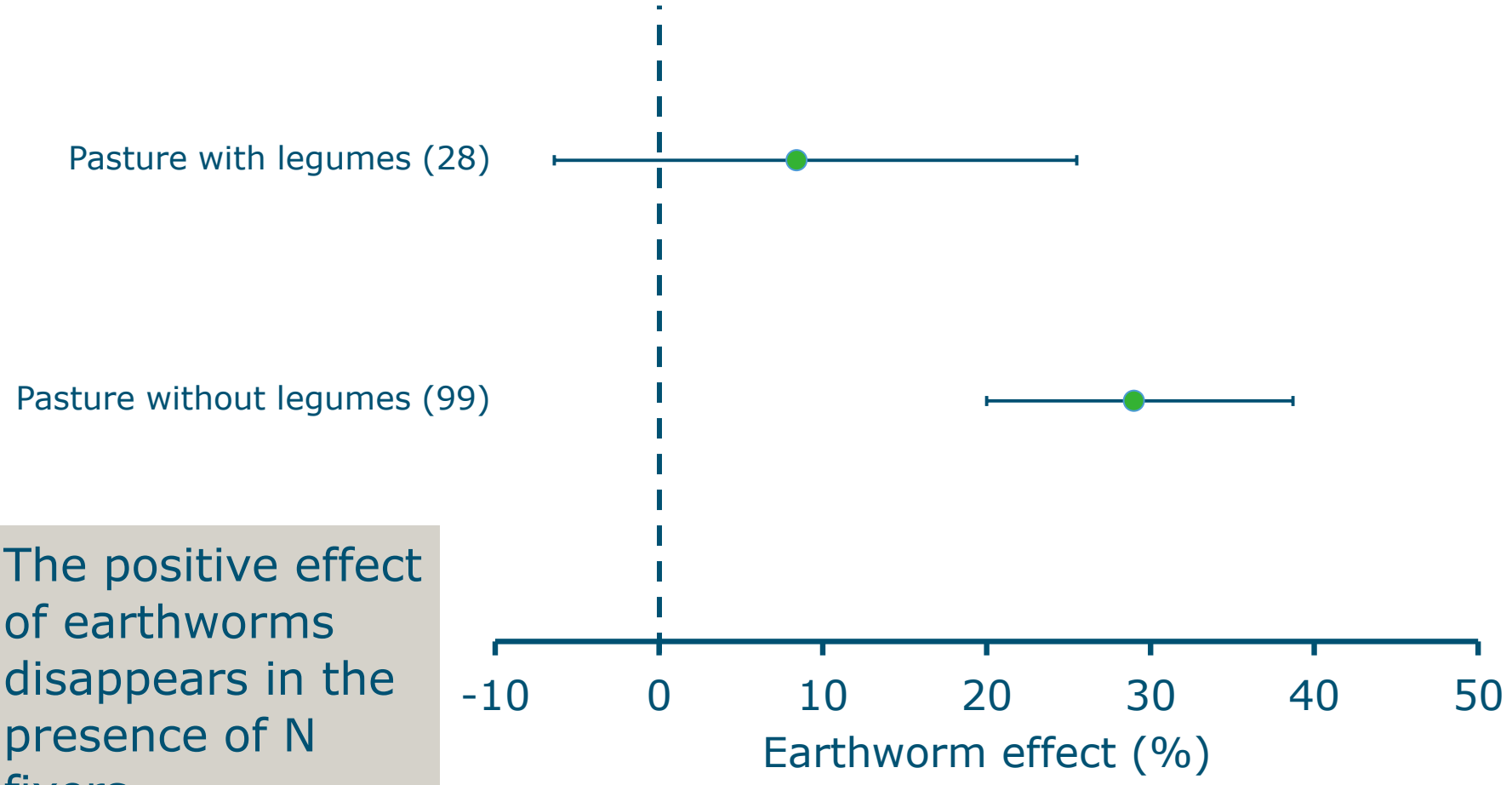
[Van Groenigen *et al.*, 2014]

Meta-analysis II: pasture types



The positive effect of earthworms disappears in the presence of N fixers ...

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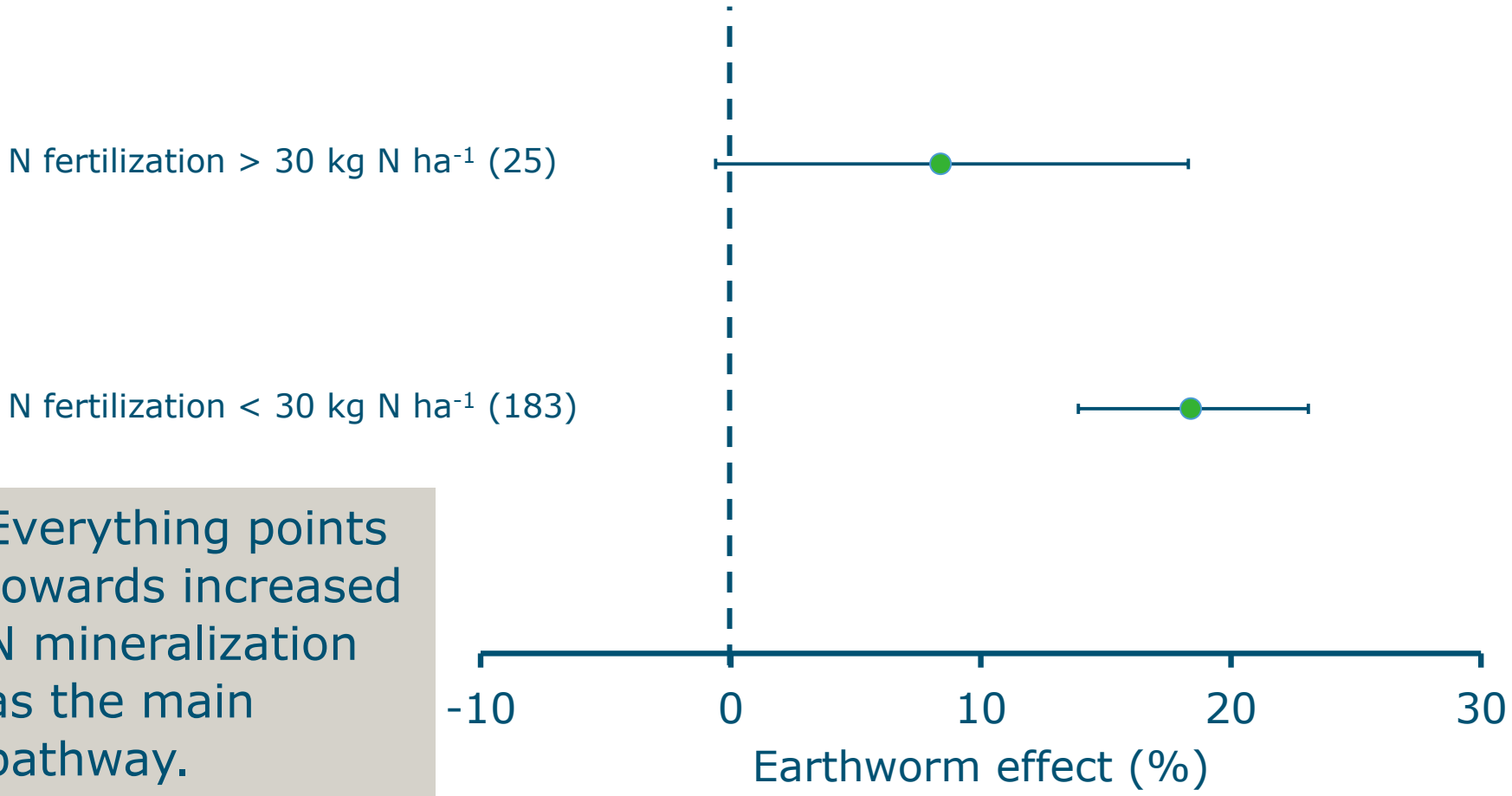
[Van Groenigen *et al.*, 2014]

Meta-analysis II: N fertilization



Everything points towards increased N mineralization as the main pathway.

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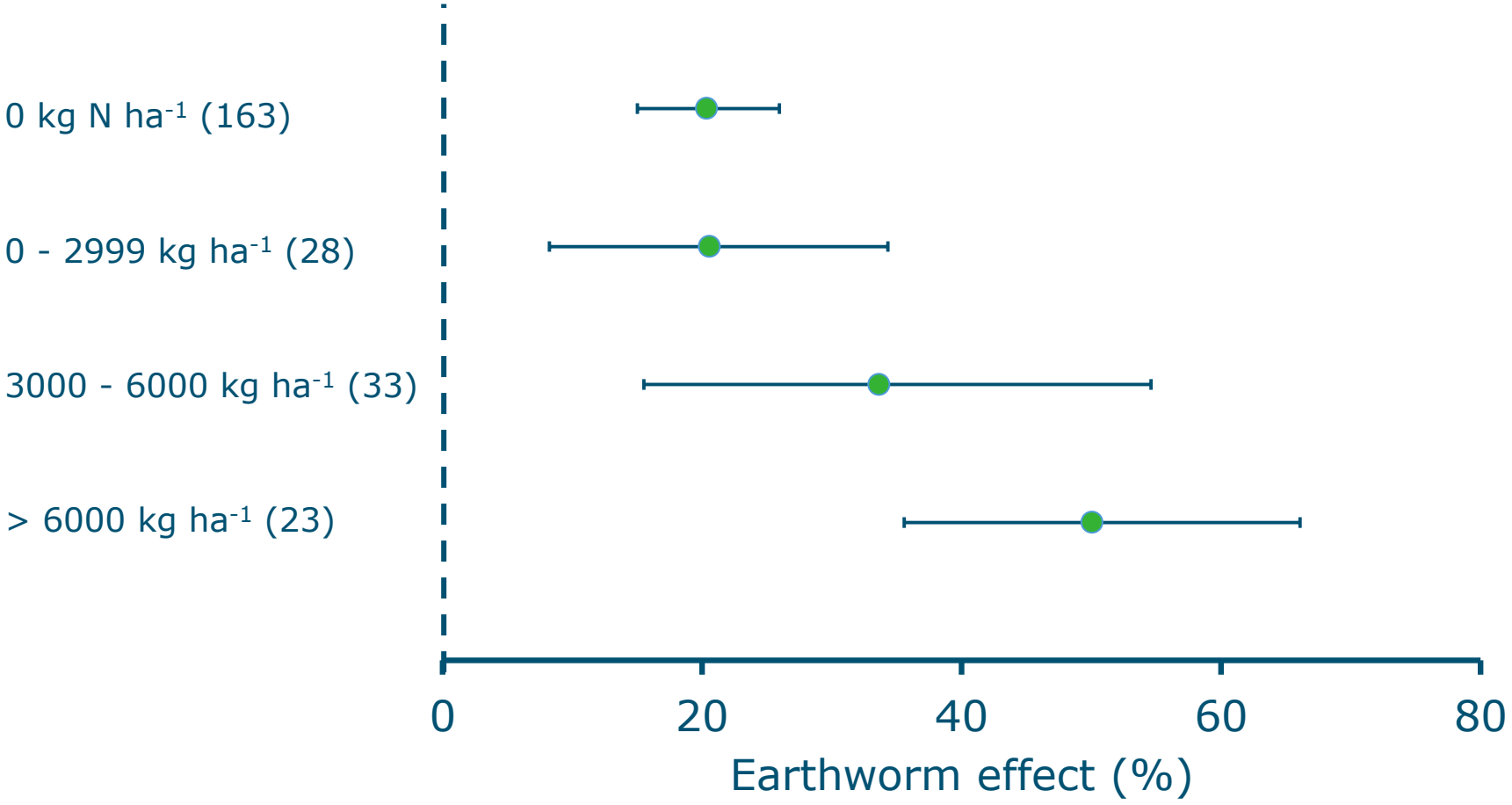
[Van Groenigen *et al.*, 2014]

Meta-analysis II: Residue application



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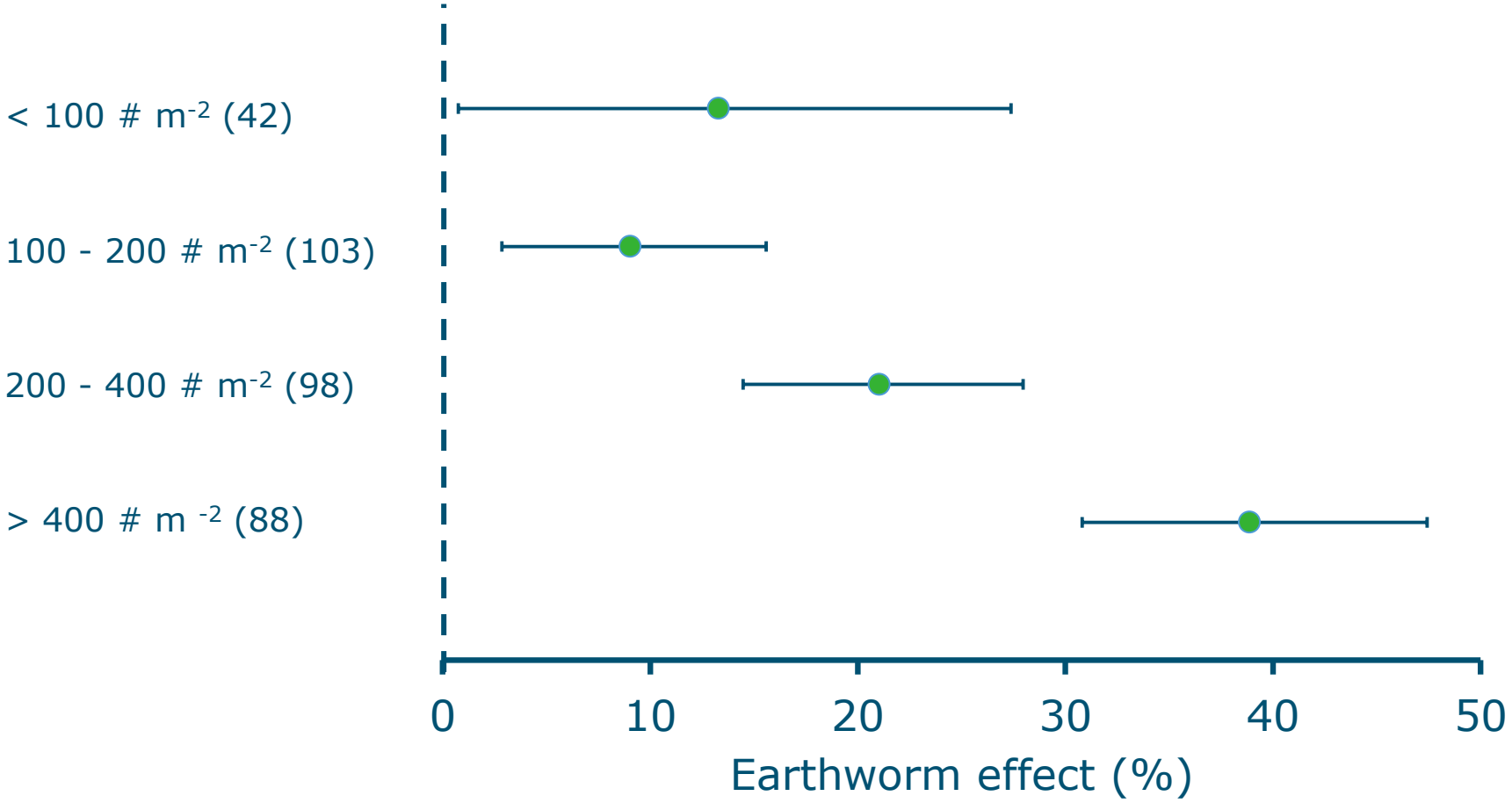
[Van Groenigen *et al.*, 2014]

Meta-analysis II: Earthworm density



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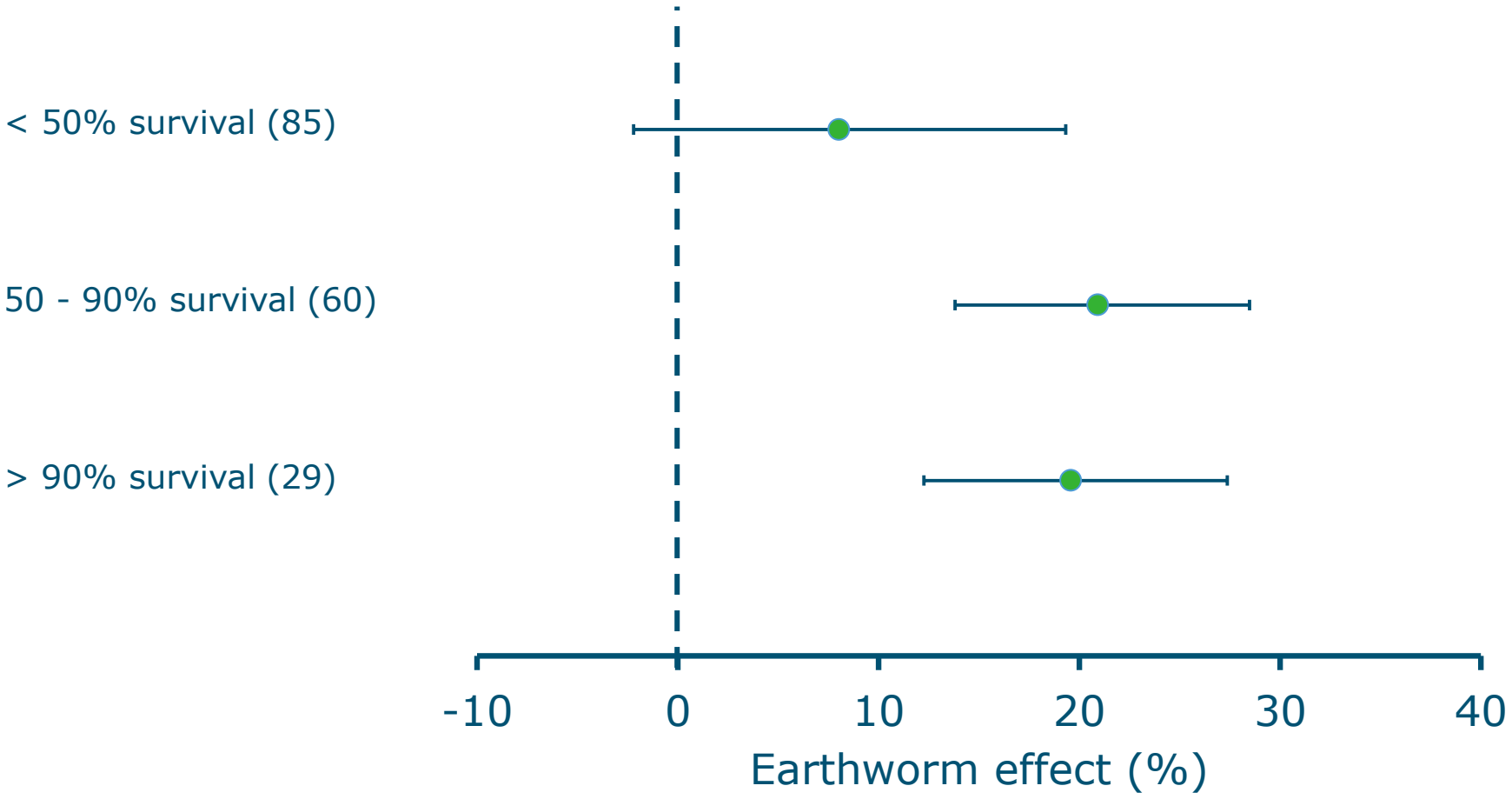
[Van Groenigen *et al.*, 2014]

Meta-analysis II: Earthworm survival



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[Van Groenigen *et al.*, 2014]

Conclusions / Recommendations

Meta-analysis I:

"Earthworms are bad for global warming!"

- **CO_2 emissions +33%**
- N_2O emissions +42%
- No indication for effect on SOC stock

"... at least if mankind applies too much nitrogen and doesn't manage residue well..."

ΔC = -9

Meta-analysis II:

"Earthworms are great for crop production!"

- Crop yield +26%
- **Plant biomass +24%**

Greatest results when:

- No N fertilization is applied
- Residue application is high

"... especially when mankind cannot apply enough nitrogen and manages crop residue well..."

Thank you!

Jan Willem van Groenigen
Lijbert Brussaard
Kees Jan van Groenigen
Birthe Paul
Estefania González
Mirjam Pulleman
Wilfred Otten
Johan Six
Steven Fonte
Eduard Hummelink

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