

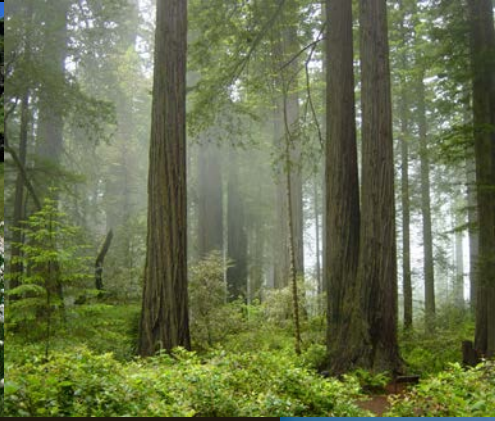
# Common Ground: soil biodiversity for humanity and ecosystems

Diana H. Wall, School of Global Environmental Sustainability, Colorado State University

World Day of Soils 2016  
NRC Washington, DC

The head of the bacterial-feeding soil nematode  
*Acrobeles complexus* (D. Bumbarger)

# ***Biodiversity provides numerous benefits to us***



© Copyright APS Press

# Soil biodiversity sustains the biodiversity we see



# Does soil life matter?

**Soil life does matter.  
A healthy soil is a living soil**



MICHAEL POLE / CORBIS

*R. D. Bardgett, U. Manchester*

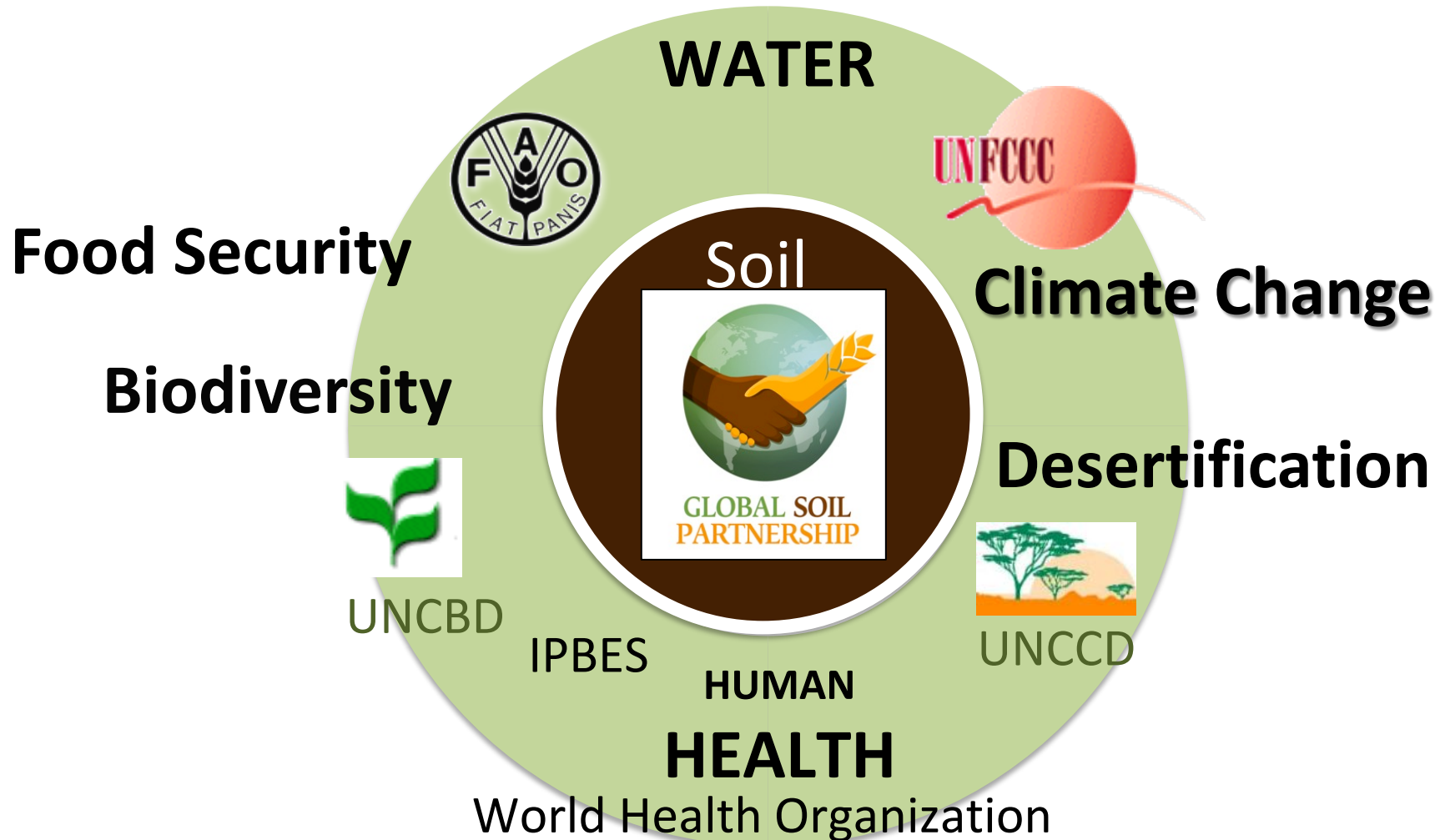
# Does soil life matter?

1. Who is there?
2. What do they do for us?
3. How is it changing?



# Soils are at the center of global agendas

*but the life in soil is often ignored*



# Why a Global Soil Biodiversity Initiative?



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Food Security



**WATER**



**Climate Change**

Biodiversity



UNCBD

IPBES

Soil



GLOBAL SOIL  
PARTNERSHIP

Desertification



UNCCD

HUMAN

**HEALTH**

World Health Organization

# Knowledge on soil biodiversity has accelerated!

## Recognition at policy levels

- 2011 – The Global Soil Biodiversity Initiative (GSBI) will serve as a *primary means of informing the Global Soil Partnership*
- UN CBD Agricultural Biodiversity – soil biodiversity is a cross cutting initiative



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# ***SOILS AT RISK***

**a new report, due fall 2017**

**European Academies of Science Advisory Council**

Report Topics:

- Climate control and consequences of climate change
- Health of humans, animals, *and* plants
- Food quality and security
- Habitat, landscape, cultural, and biodiversity security

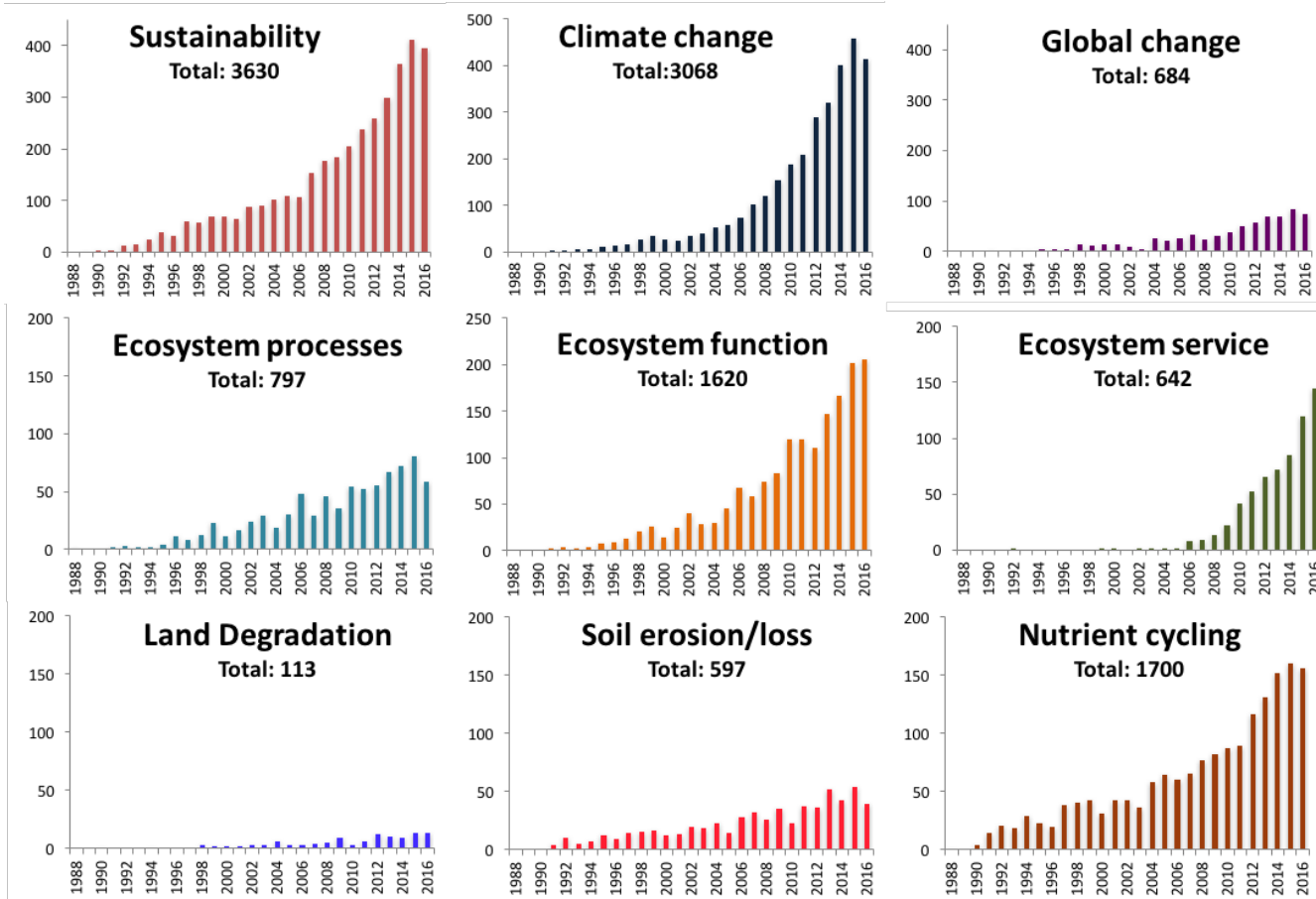
*Contact and Lead:* Wim van der Putten,  
Wageningen

*Co-leads:* R. Bardgett, J. Six  
Specialists from 18 European countries



# Soil Biodiversity and...

Web of Science Publications  
(01 Dec 2016)

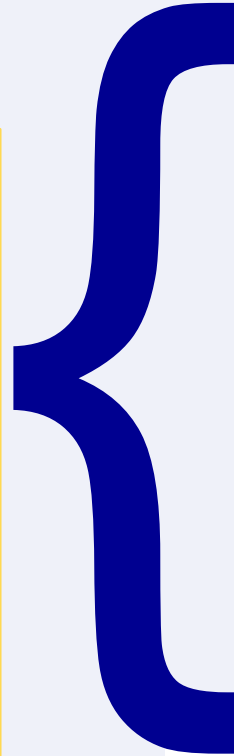
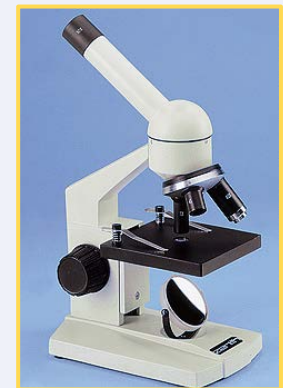


Year



*Soil biodiversity: Who is there?*

**Soil is a dynamic habitat: 10  
– 100 million organisms  
~ 5000 taxa**

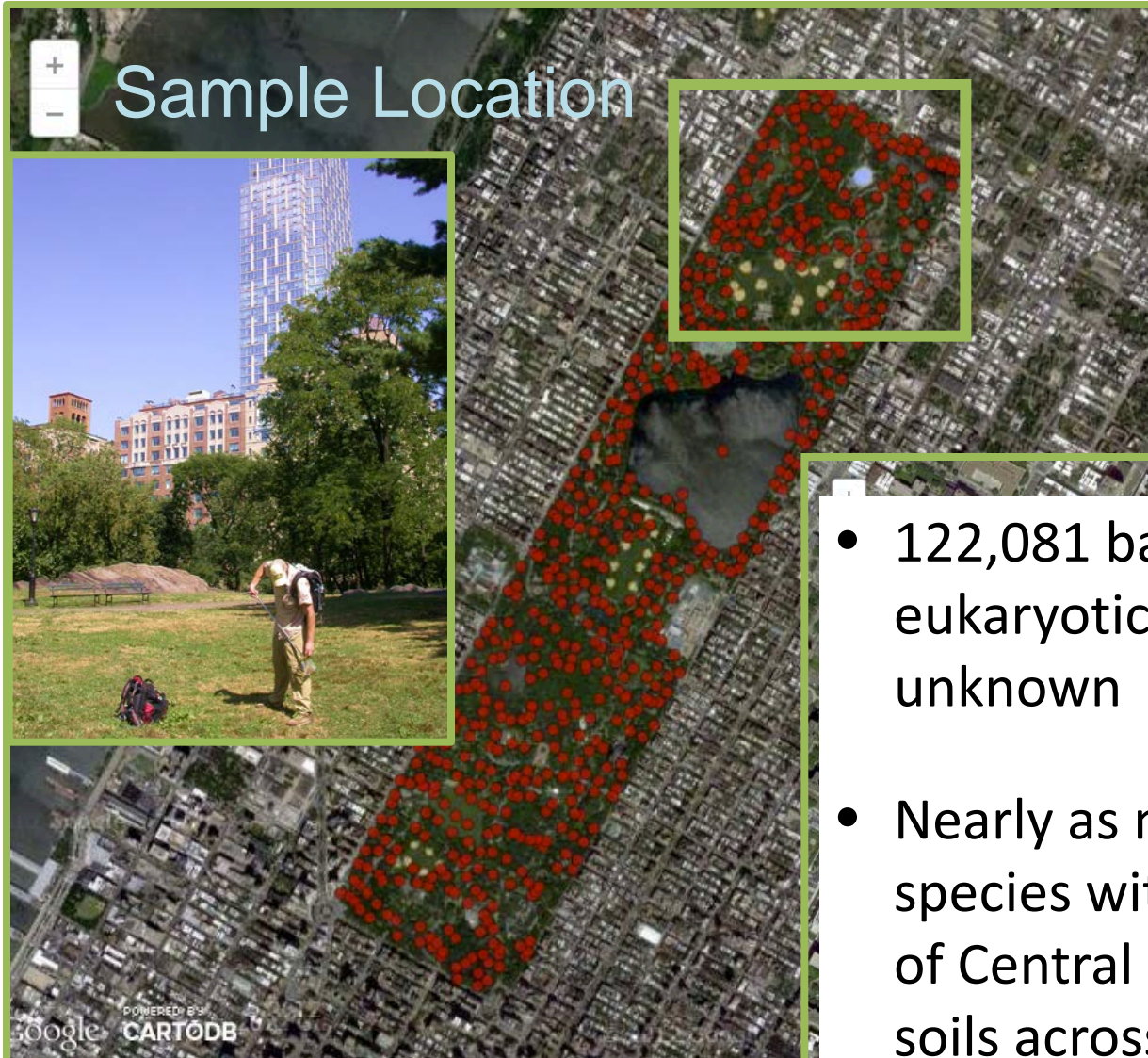


# One quarter living diversity on Earth is belowground



*Bardgett and van der Putten (2014) Nature 515, 505-509*

# Soil biodiversity in Central Park, NY, USA

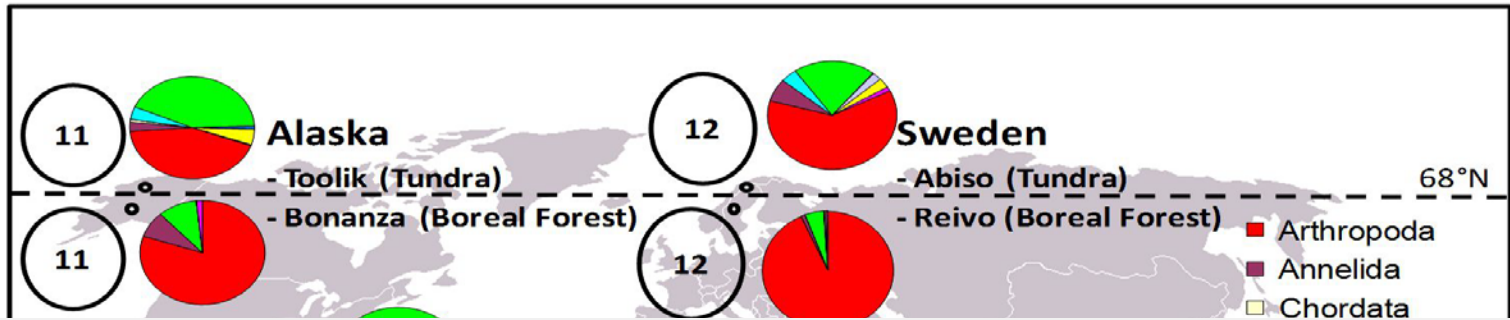


- Standardized
- ~600 samples
- 1 day sampling
- *Bacteria, Archaea*
- *Eukaryotes*

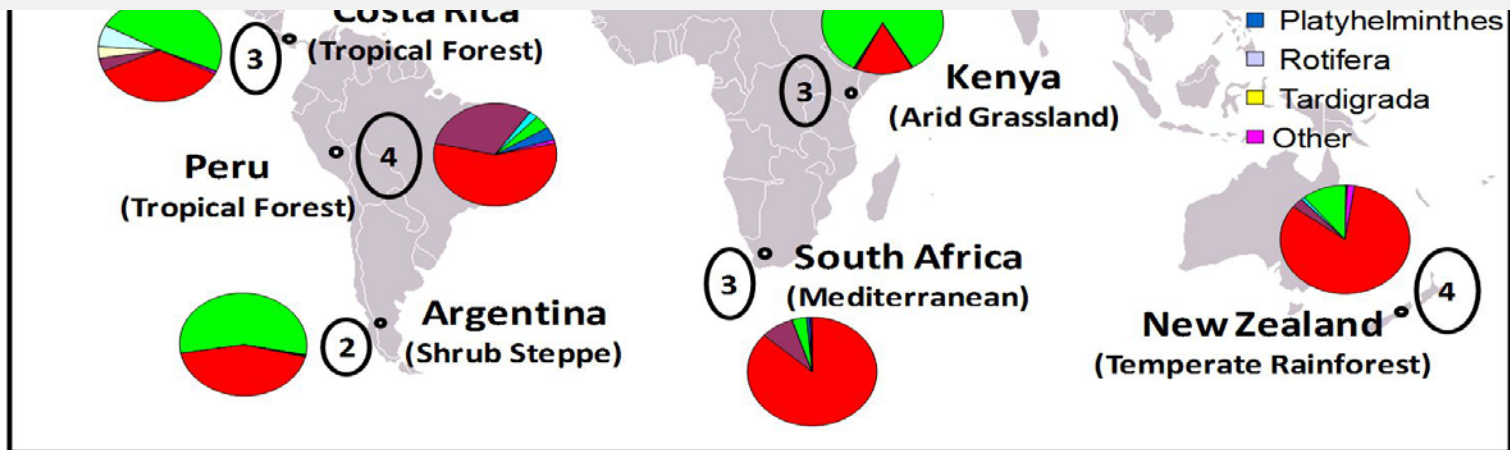
- 122,081 bacterial and 43,429 eukaryotic species, and most unknown
- Nearly as many different soil species within the 3.41 km<sup>2</sup> area of Central Park as find if sampled soils across the world

# Molecular study of the worldwide diversity of soil animals

Large numbers of singletons, high numbers of endemic species, and few cosmopolitan species



All species do not occur everywhere



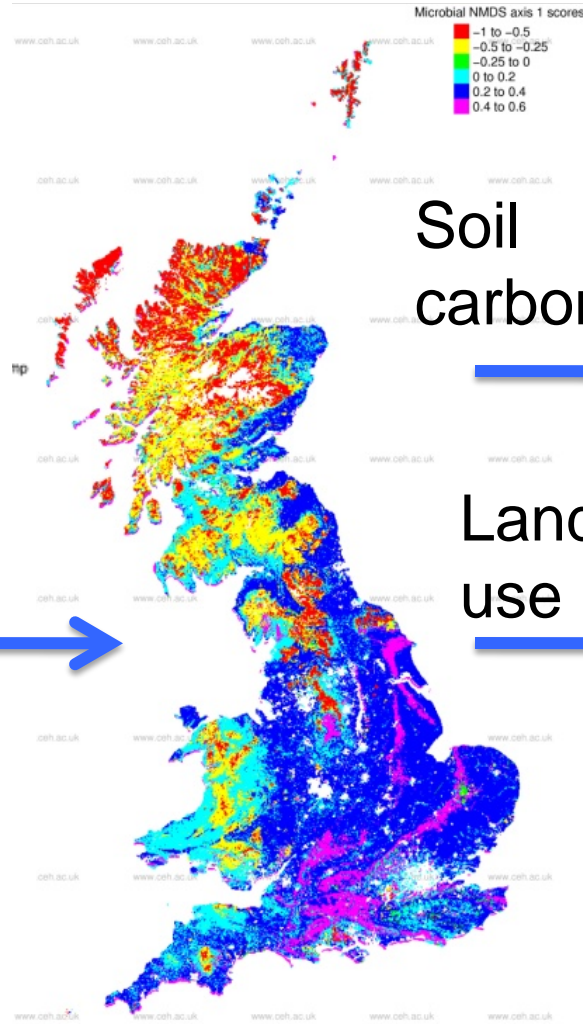
***“Almost all soil animals found at only a single location, suggesting that most soil animals have restricted distributions, or in other words, they are endemic,” Wu, Ayres, Li, Bardgett, Wall & Garey 2011. PNAS 108***

# Soil Biodiversity: Who is there?

## BACTERIA



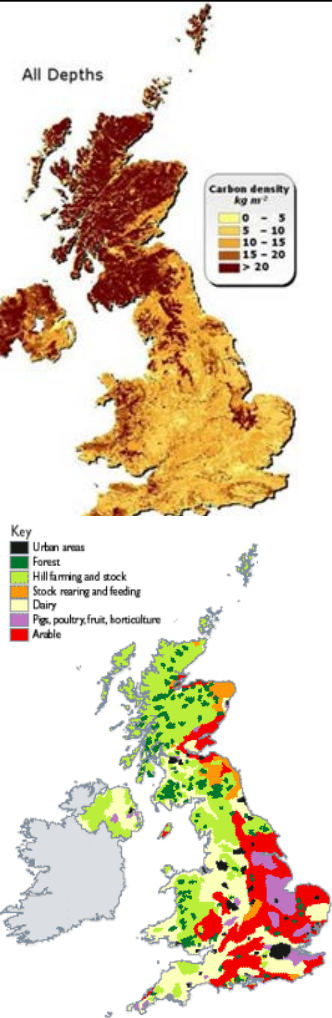
## EUKARYOTES



Soil carbon



Land use



Griffiths et al. (2011) Environmental Microbiology



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# Soil Biodiversity: Who is there? Soil microbiome and plant health



## African Soil Microbiology Project



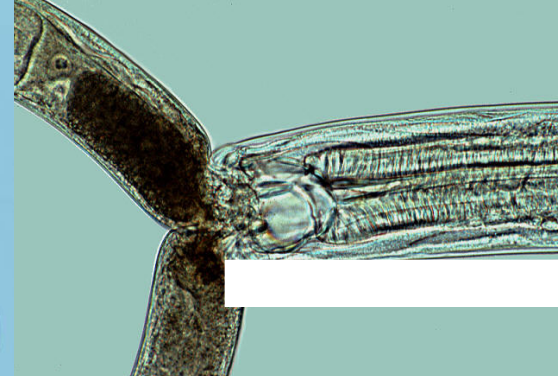
- Scientists from >7 sub-Saharan African countries
- Broad-scale soil sampling across Africa
- Next-generation DNA sequencing
- Funded by USAID



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# SOIL BIODIVERSITY – *what do they do for us?*



*Slide courtesy of Wim Van der Putten*

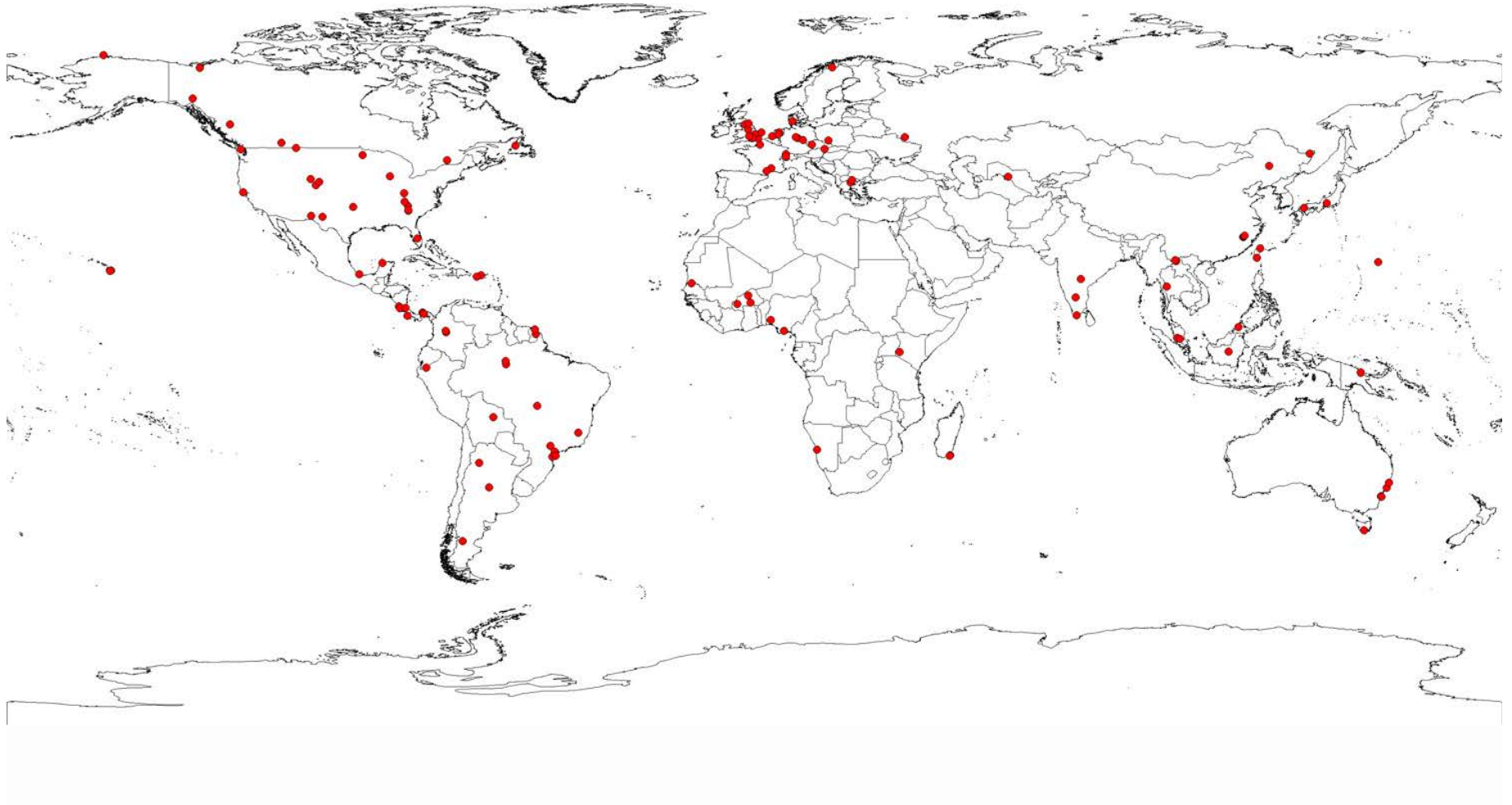
# *SOIL BIODIVERSITY – What do they do for us?*



MICHAEL POLE / CORBIS

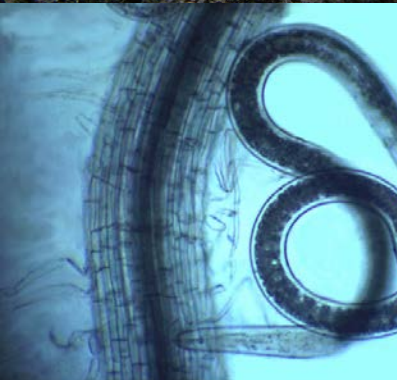
- **Soil biodiversity:**
  - **Food for wildlife**
  - **Suppress pathogens**
  - **Regulates decomposition**
  - **Enhances aboveground biodiversity**
  - **Filters water**
  - **Reservoir of new pharmaceuticals**

# Soil Fauna consistently enhance litter decomposition at global and biome scales (avg ~27%)



# Threats to soil biodiversity

Land-use change  
Climate change  
Desertification  
Invasive species  
Soil sealing  
Pollution  
Soil compaction  
Soil erosion



Land-use change  
Climate change  
Desertification  
Invasive species  
Soil sealing  
Pollution  
Soil compaction  
Soil erosion



Slide courtesy:  
Wim de Boer

# Soil biodiversity: how is it changing?

**2** Global Change Biology

celebrating 20 years

Global Change Biology (2014), doi: 10.1111/gcb.12752

## Intensive agriculture reduces soil biodiversity across Europe

MARIA A. TSIAFOULI<sup>1</sup>, ELISA THÉBAULT<sup>2</sup>, STEFANOS P. SGARDELIS<sup>1</sup>,  
PETER C. DE RUITER<sup>3</sup>, WIM H. VAN DER PUTTEN<sup>4,5</sup>, KLAUS BIRKHOFFER<sup>6</sup>,  
LIA HEMERIK<sup>3</sup>, FRANCISKA T. DE VRIES<sup>7</sup>, RICHARD D. BARDGETT<sup>7</sup>,  
MARK VINCENT BRADY<sup>8</sup>, LISA BJORN LUND<sup>9</sup>, HELENE BRACHT JØRGENSEN<sup>6</sup>,  
SÖREN CHRISTENSEN<sup>9</sup>, TINA D' HERTEFELDT<sup>6</sup>, STEFAN HOTES<sup>10,11</sup>, W.H. GERA HOL<sup>4</sup>,  
JAN FROUZ<sup>12</sup>, MIRA LIIRI<sup>13</sup>, SIMON R. MORTIMER<sup>14</sup>, HEIKKI SETÄLÄ<sup>13</sup>,  
JOSEPH TZANOPOULOS<sup>15</sup>, KAROLINE UTESENY<sup>16</sup>, VÁCLAV PIŽL<sup>12</sup>, JOSEF STARY<sup>12</sup>,  
VOLKMAR WOLTERS<sup>11</sup> and KATARINA HEDLUND<sup>6</sup>



### REVIEW

Received 25 Apr 2015 | Accepted 9 Oct 2015 | Published 23 Nov 2015

DOI: 10.1038/ncomms9862

OPEN

## Extinction risk of soil biota

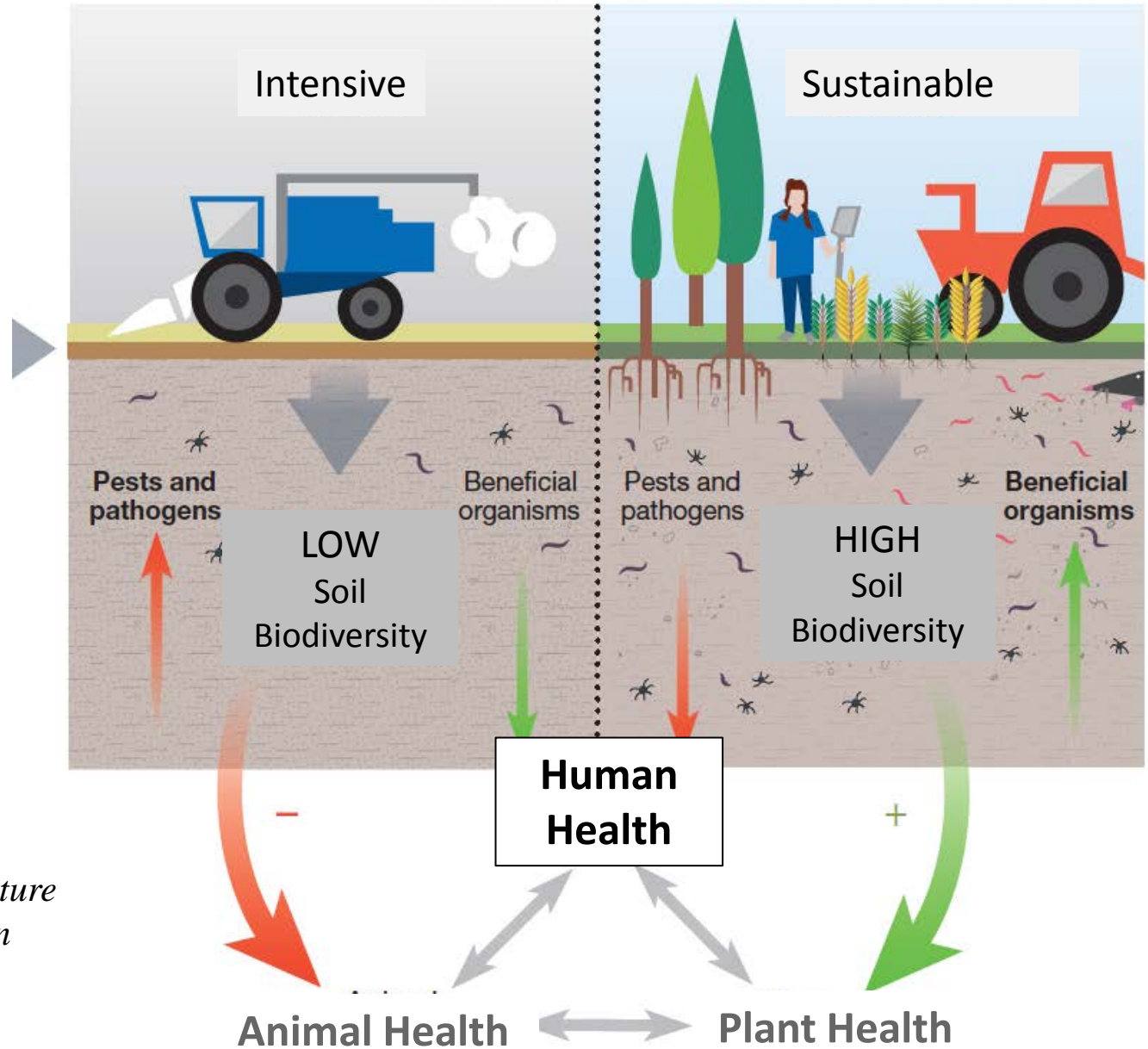
Stavros D. Veresoglou<sup>1,2</sup>, John M. Halley<sup>3</sup> & Matthias C. Rillig<sup>1,2</sup>



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# LAND USE MANAGEMENT

**External Drivers**  
**Climate Change**  
**N deposition**  
**Invasive species**  
**Pollution**

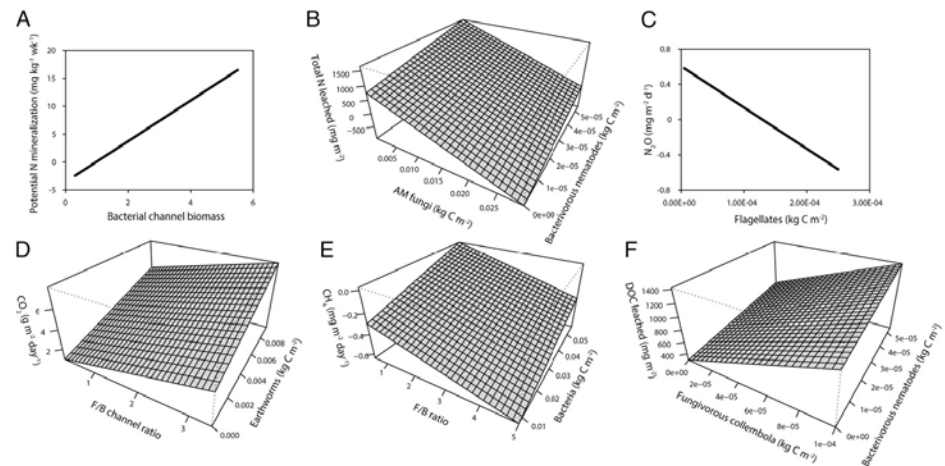


*Wall, Nielsen, Six 2015, Nature  
Soil biodiversity and human  
health*

# Soil food web properties explain ecosystem services across European land use systems 2013

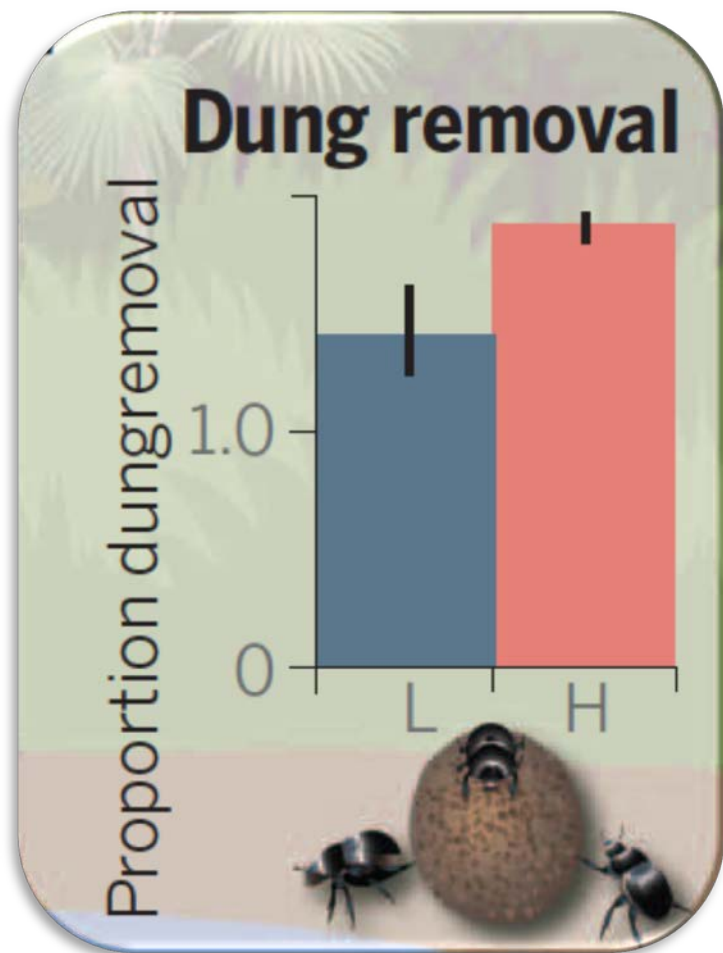
Franciska T. de Vries<sup>a,b,1</sup>, Elisa Thébaud<sup>c,d</sup>, Mira Liiri<sup>e</sup>, Klaus Birkhofer<sup>f</sup>, Maria A. Tsiafouli<sup>g</sup>, Lisa Bjørnlund<sup>h</sup>, Helene Bracht Jørgensen<sup>f</sup>, Mark Vincent Brady<sup>i</sup>, Søren Christensen<sup>h</sup>, Peter C. de Ruiter<sup>c</sup>, Tina d'Hertefeldt<sup>f</sup>, Jan Frouz<sup>j</sup>, Katarina Hedlund<sup>f</sup>, Lia Hemerik<sup>c</sup>, W. H. Gera Hol<sup>k</sup>, Stefan Hotes<sup>l,m</sup>, Simon R. Mortimer<sup>n</sup>, Heikki Setälä<sup>e</sup>, Stefanos P. Sgardelis<sup>g</sup>, Karoline Uteseny<sup>o</sup>, Wim H. van der Putten<sup>k,p</sup>, Volkmar Wolters<sup>l</sup>, and Richard D. Bardgett<sup>a,b</sup>

“Our quantification of the contribution of soil organisms to processes of C and N cycling across land use systems and geographic locations **shows that soil biota need to be included in C and N cycling models and highlights the need to map and conserve soil biodiversity across the world.**“

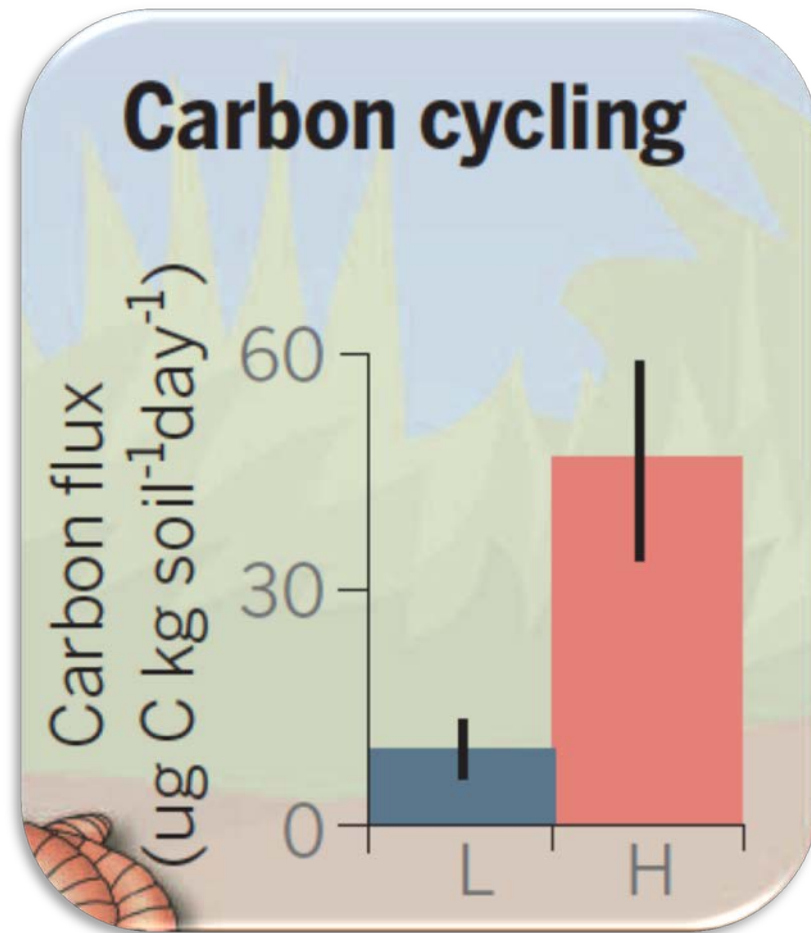


## *Soil biodiversity: how is it changing?*

### **Decline in abundance decreases proportion of dung removed and soil carbon flux**



Dung beetle Slade et al. 2011, Bio. Conserv.

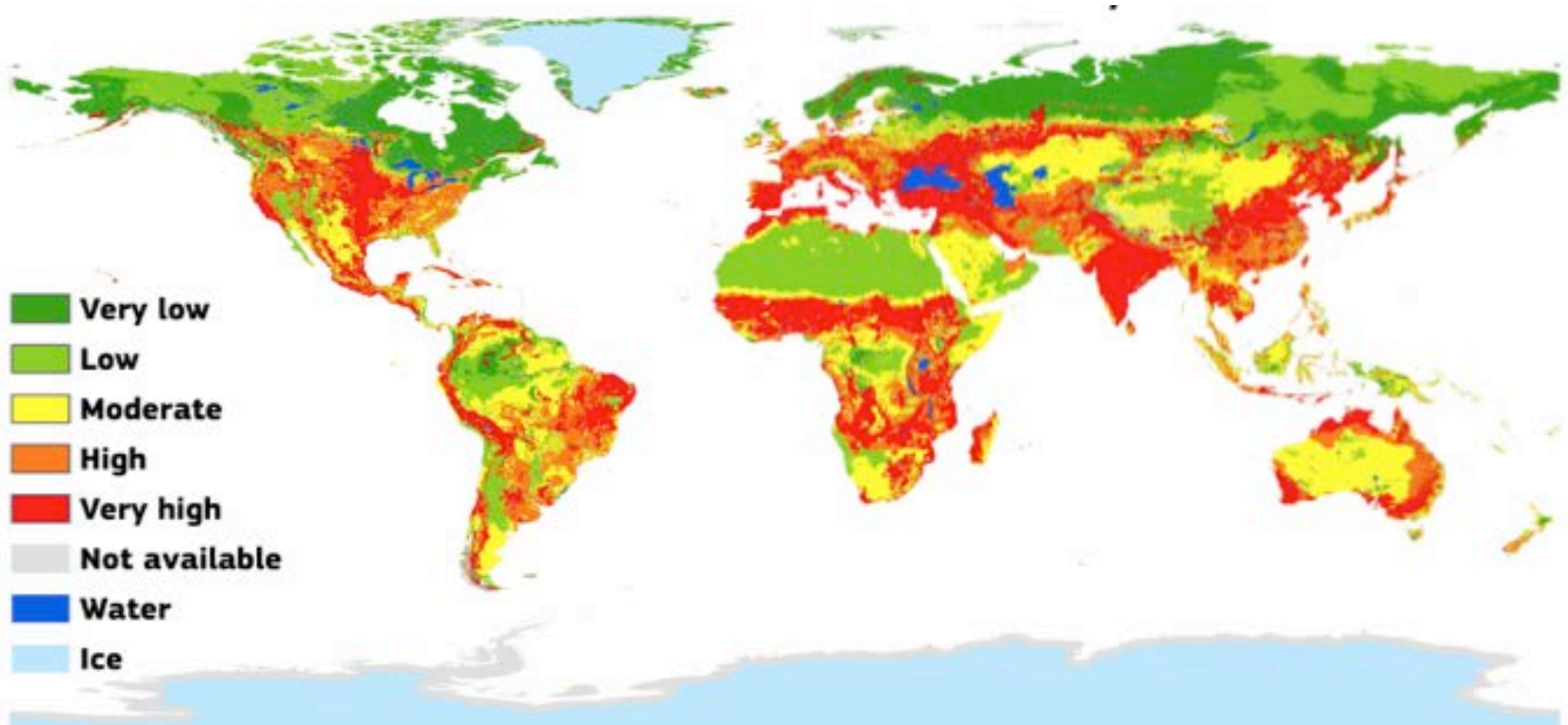


Soil nematodes Barrett et al., 2008

*Dirzo et al. 2014 Science*



# Potential threats to soil biodiversity



*P.134 -135, Global Soil Biodiversity Atlas, 2016; Origazzi et al., 2016*



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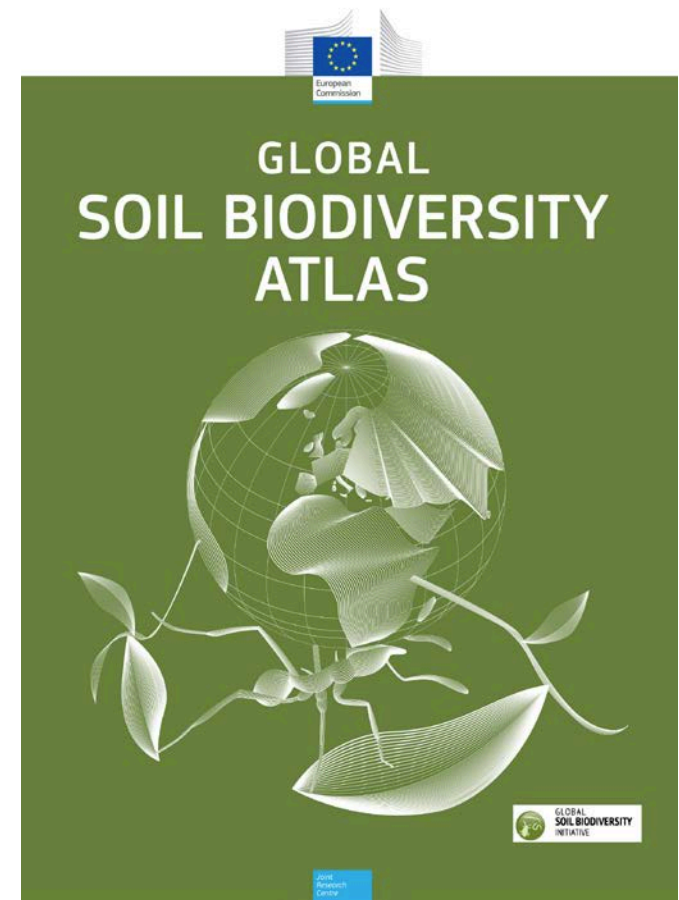
>33K downloads



4.3Million views



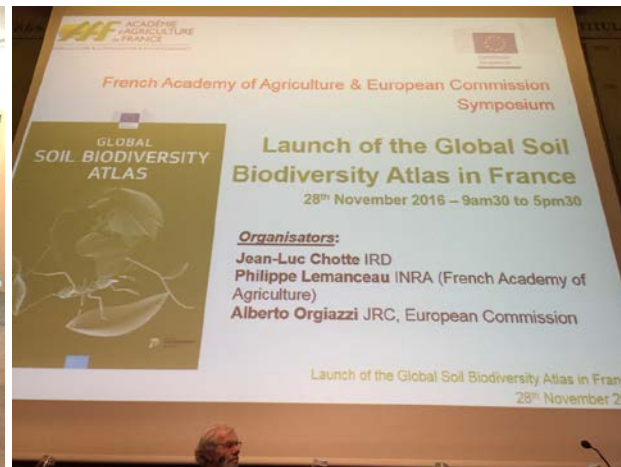
>125M social media views



# Global Soil Biodiversity Atlas launched UNEP, Nairobi, June 2016



**Australian Parliament**



**French Academy of  
Agriculture**



**Brazilian Soil Science  
Society**



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[www.globalsoilbiodiversity.org](http://www.globalsoilbiodiversity.org)



# Atlas Launch Sites:

- 📍 American Association for the Advancemen...
- 📍 BioCrust3
- 📍 Northern Arizona University
- 📍 Soil Science Society of America
- 📍 Brazilian Soil Science Society
- 📍 Brazilian Soil Science Society
- 📍 Royal Society of Edinburgh
- 📍 United Nations Environment Assembly
- 📍 Healthy Soils, Safe Foods, Livelihoods
- 📍 International Colloquium on Soil Zoology
- 📍 Ecological Society of America
- 📍 EuroScience Open Forum
- 📍 Bolivian Society of Entomology
- 📍 Australian Ecological Society
- 📍 French Academy of Agriculture
- 📍 Australian Parliament
- 📍 Latin America Soil Congress
- 📍 Soil Ecosystem Research Group



Global Soil Biodiversity Atlas launch sites

Google maps



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## Toward a global platform for linking soil biodiversity data

Kelly S. Ramirez<sup>1,2\*</sup>, Markus Döring<sup>3</sup>, Nico Eisenhauer<sup>2,4</sup>, Ciro Gardi<sup>5</sup>, Josh Ladau<sup>6</sup>, Jonathan W. Leff<sup>7</sup>, Guillaume Lentendu<sup>8</sup>, Zoë Lindo<sup>9</sup>, Matthias C. Rillig<sup>10,11</sup>, David Russell<sup>12</sup>, Stefan Scheu<sup>13</sup>, Mark G. St. John<sup>14</sup>, Franciska T. de Vries<sup>15</sup>, Testfaye Wubet<sup>2,8</sup>, Wim H. van der Putten<sup>1,16</sup> and Diana H. Wall<sup>17</sup>

nature  
International weekly journal of science

LETTER

30 November 2016

doi:10.1038/nature20150

## Quantifying global soil carbon losses in response to warming

T. W. Crowther<sup>1,2</sup>, K. E. O. Todd-Brown<sup>3</sup>, C. W. Rowe<sup>2</sup>, W. R. Wieder<sup>4,5</sup>, J. C. Carey<sup>6</sup>, M. B. Machmuller<sup>7</sup>, B. L. Snoek<sup>1,8</sup>, S. Fang<sup>9,10</sup>, G. Zhou<sup>9</sup>, S. D. Allison<sup>11,12</sup>, J. M. Blair<sup>13</sup>, S. D. Bridgman<sup>14</sup>, A. J. Burton<sup>15</sup>, Y. Carrillo<sup>16</sup>, P. B. Reich<sup>16,17</sup>, J. S. Clark<sup>18</sup>, A. T. Classen<sup>19,20</sup>, F. A. Dijkstra<sup>21</sup>, B. Elberling<sup>22</sup>, B. A. Emmett<sup>23</sup>, M. Estiarte<sup>24,25</sup>, S. D. Frey<sup>26</sup>, J. Guo<sup>27</sup>, J. Harte<sup>28</sup>, L. Jiang<sup>29</sup>, B. R. Johnson<sup>30</sup>, G. Kröel-Dulay<sup>31</sup>, K. S. Larsen<sup>32</sup>, H. Laudon<sup>33</sup>, J. M. Lavelle<sup>7,34</sup>, Y. Luo<sup>29,35</sup>, M. Lupascu<sup>36</sup>, L. N. Ma<sup>37</sup>, S. Marhan<sup>38</sup>, A. Michelsen<sup>22,39</sup>, J. Mohan<sup>40</sup>, S. Niu<sup>41</sup>, E. Pendall<sup>16</sup>, J. Peñuelas<sup>24,25</sup>, L. Pfeifer-Meister<sup>14</sup>, C. Poll<sup>38</sup>, S. Reinsch<sup>23</sup>, L. L. Reynolds<sup>14</sup>, I. K. Schmidt<sup>32</sup>, S. Sistla<sup>42</sup>, N. W. Sokol<sup>3</sup>, P. H. Templer<sup>43</sup>, K. K. Treseder<sup>12</sup>, J. M. Welker<sup>44</sup> & M. A. Bradford<sup>1,2</sup>

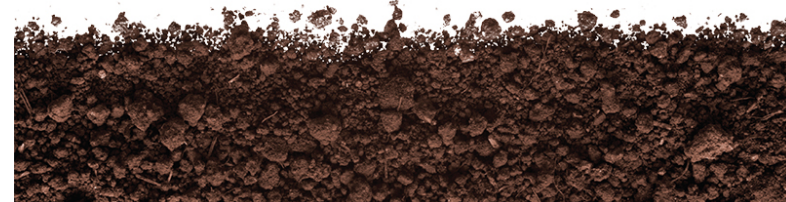
The Synthesis Centre for  
Biodiversity Sciences (sDIV)

  
**SWORM**  
**WORKING**  
**GROUP**

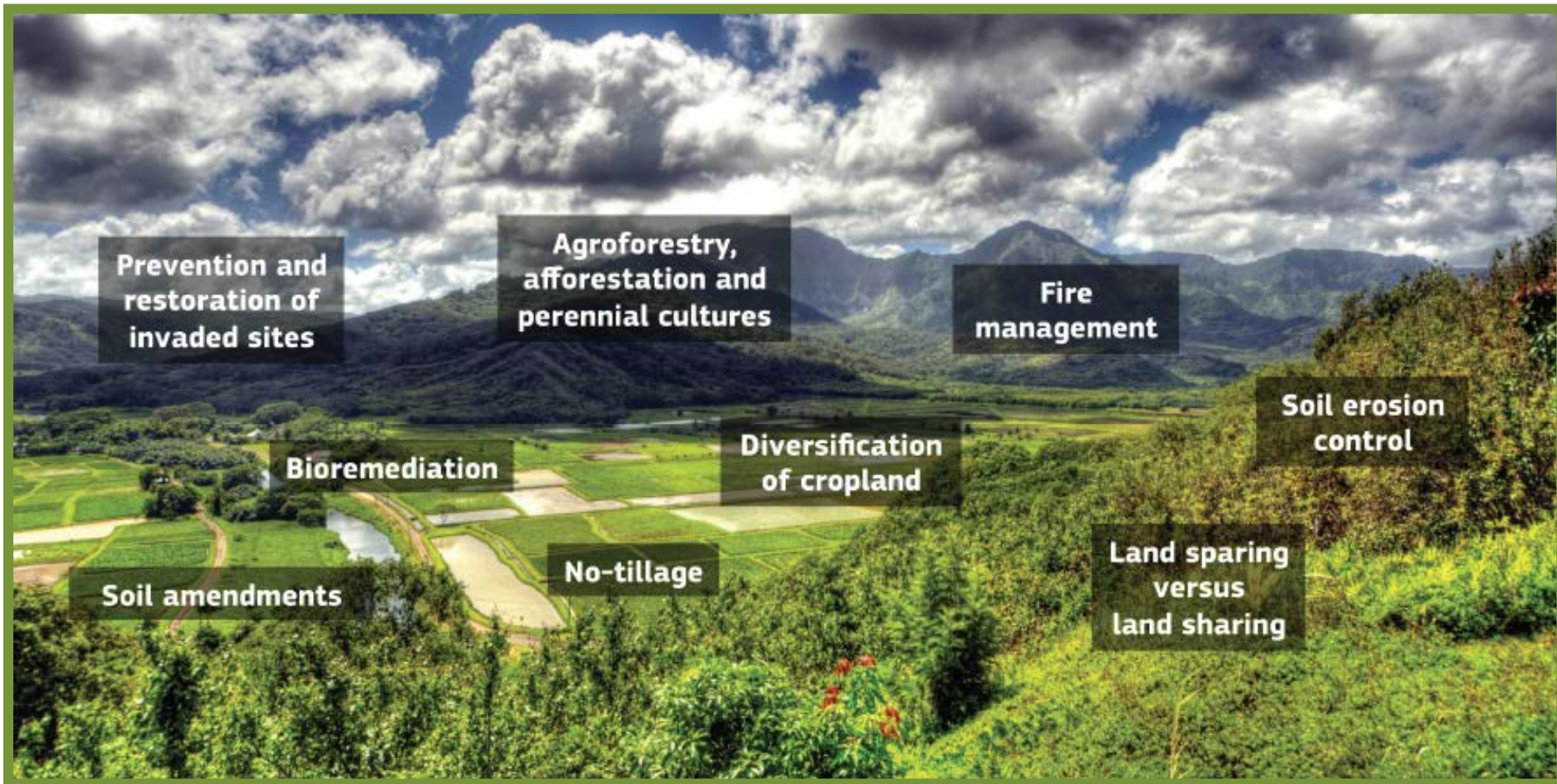
invites you  
to participate in a  
**SURVEY** to assess all global  
soil biodiversity databases



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# How to integrate soil biodiversity?



We can't breathe, eat, drink, or be healthy  
without sustainably managing soils."

*Wall & Six, Science, 2015*



*Global Soil Biodiversity Atlas, 2016*

**Linking life in  
soil to  
sustainability  
[www.globalsoilbiodiversity.org](http://www.globalsoilbiodiversity.org).**



*Global Soil Biodiversity Atlas, 2016*



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