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# High plant diversity is needed to maintain ecosystem services

**Forest Isbell, Vincent Calcagno, Andy Hector, John Connolly, W. Stanley Harpole, Peter B. Reich, Michael Scherer-Lorenzen, Bernhard Schmid, David Tilman, Jasper van Ruijven, Alexandra Weigelt, Brian J. Wilsey, Erika S. Zavaleta & Michel Loreau**

[Affiliations](#) [Contributions](#) [Corresponding author](#)

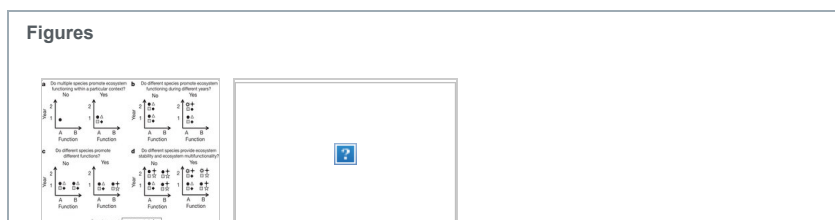
*Nature* **477**, 199–202 (08 September 2011) doi:10.1038/nature10282  
 Received 18 March 2011 Accepted 10 June 2011 Published online 10 August 2011

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Biodiversity is rapidly declining worldwide<sup>1</sup>, and there is consensus that this can decrease ecosystem functioning and services<sup>2, 3, 4, 5, 6, 7</sup>. It remains unclear, though, whether few<sup>8</sup> or many<sup>9</sup> of the species in an ecosystem are needed to sustain the provisioning of ecosystem services. It has been hypothesized that most species would promote ecosystem services if many times, places, functions and environmental changes were considered<sup>9</sup>; however, no previous study has considered all of these factors together. Here we show that 84% of the 147 grassland plant species studied in 17 biodiversity experiments promoted ecosystem functioning at least once. Different species promoted ecosystem functioning during different years, at different places, for different functions and under different environmental change scenarios. Furthermore, the species needed to provide one function during multiple years were not the same as those needed to provide multiple functions within one year. Our results indicate that even more species will be needed to maintain ecosystem functioning and services than previously suggested by studies that have either (1) considered only the number of species needed to promote one function under one set of environmental conditions, or (2) separately considered the importance of biodiversity for providing ecosystem functioning across multiple years<sup>10, 11, 12, 13, 14</sup>, places<sup>15, 16</sup>, functions<sup>14, 17, 18</sup> or environmental change scenarios<sup>12, 19, 20, 21, 22</sup>. Therefore, although species may appear functionally redundant when one function is considered under one set of environmental conditions<sup>7</sup>, many species are needed to maintain multiple functions at multiple times and places in a changing world.

**Subject terms:** [Ecology](#) [Environmental science](#)

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## Author information

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## Affiliations

Department of Biology, McGill University, Montreal, Quebec, H3A 1B1, Canada  
Forest Isbell, Vincent Calcagno & Michel Loreau

Institute of Evolutionary Biology and Environmental Studies, University of Zurich, CH-8057  
Zurich, Switzerland  
Andy Hector & Bernhard Schmid

UCD School of Mathematical Sciences, University College Dublin, Dublin 4, Ireland  
John Connolly

Department of Ecology, Evolution, and Organismal Biology, Iowa State University, Ames, Iowa  
50011, USA  
W. Stanley Harpole & Brian J. Wilsey

Department of Forest Resources, University of Minnesota, St Paul, Minnesota 55108, USA  
Peter B. Reich

Hawkesbury Institute for the Environment, University of Western Sydney, Richmond, New  
South Wales 2753, Australia  
Peter B. Reich

Faculty of Biology, University of Freiburg, Geobotany, D-79104 Freiburg, Germany  
Michael Scherer-Lorenzen

Department of Ecology, Evolution, and Behavior, University of Minnesota, St Paul, Minnesota  
55108, USA  
David Tilman


Nature Conservation and Plant Ecology, Wageningen University, 6700 AA Wageningen, The  
Netherlands  
Jasper van Ruijven

Institute of Biology I, University of Leipzig, 04103 Leipzig, Germany  
Alexandra Weigelt

Environmental Studies Department, University of California, Santa Cruz, California 95064, USA  
Erika S. Zavaleta

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**Contributions**

F.I. conceived the project; J.C., A.H., F.I., P.B.R., M.S.-L., B.S., D.T., J.v.R., A.W. and B.J.W. designed and conducted experiments; F.I. and V.C. analysed the data, with input from A.H. and M.L.; F.I. wrote the paper with input from all authors.

**Competing financial interests**

The authors declare no competing financial interests.

**Corresponding author**

Correspondence to: [Forest Isbell](#)

**Supplementary information**

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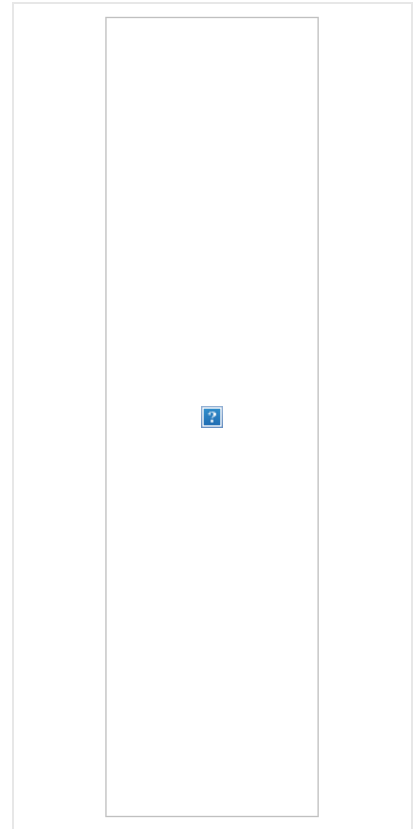
- 1. [Supplementary Information \(281K\)](#)

This file contains Supplementary Figures 1-2 with legends and a table of Supplementary References.

**Excel files**

- 1. [Supplementary Data \(1.1M\)](#)

This file contains details for each context: experiment, year, place, function, environmental change scenario, and whether each species promoted (1), decreased (-1), or had no effect (0) on ecosystem functioning. NA indicates species was not included in context.



**Nature** ISSN 0028-0836 EISSN 1476-4687

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