LETTERS

edited by Jennifer Sills

Conservation: Limits of Land Sparing

ACCORDING TO B. PHALAN *ET AL.* ("RECONCILING FOOD PRODUCTION AND BIODIVERSITY CONservation: Land sharing and land sparing compared," Reports, 2 September, p. 1289), land sparing—protecting some land and farming the rest intensively—saves biodiversity more effectively than land sharing—protecting less land but farming the remainder with wildlife-friendly techniques. The authors qualify their conclusion, saying that it hinges on proper implementation and may not be transferable and that intensification—increasing the harvest yield—could be achieved through higher inputs of knowledge and labor rather than chemicals. These and other considerations severely limit land sparing in practice.

First, many countries lack the means to effectively protect areas but do have a long record of sustainable land sharing (*1*, *2*). Second, situations exist where both yields and biodiversity are high (*3*) or where biodiversity depends on agriculture (*4*). Third, vast regions with shallow soils or low rainfall are only suitable for non-intensive use (*5*). Ironically, where intensification without chemicals is possible, this comes very close to land sharing—namely, knowledge-intensive agroecological systems with multiple crops and a complex structure.

Land sharing. A wildlife-friendly landscape in Romania.

The debate about land sparing versus land sharing is poorly framed as a black-and-white choice that must be made to feed the world's people. In fact, the choice is not between one and the other (*6*, *7*), nor does a higher quantity of food guarantee less hunger. Most famines are caused by a lack of access to food, rather than too little food (*8*).

The simple model by Phalan *et al*. ignores vital social and ecological complexities, including rural livelihoods, the dependence of the world's poor on local ecosystem services, and the lack of reliable governance of many protected areas. It also ignores the fact that, in reality, use of agrochemicals is likely to be the default method to increase yields, which would have negative environmental side effects.

Social and ecological complexities must not be an afterthought in analyses about food and biodiversity, because they fundamentally alter the outcome. Simple models must be balanced with holistic, field-based approaches (*9*, *10*). Otherwise there is a great risk that internally consistent solutions are overinterpreted as externally applicable by policy-makers, the media, and the public.

JOERN FISCHER,[1]* PÉTER BATÁRY,[2] KAMALJIT S. BAWA,[3] LIJBERT BRUSSAARD,[4] M. JAHI CHAPPELL,[5] YANN CLOUGH,[2] GRETCHEN C. DAILY,[6] JOSH DORROUGH,[7] TIBOR HARTEL,[8] LOUISE E. JACKSON,[9] ALEXANDRA M. KLEIN,[1] CLAIRE KREMEN,[10] TOBIAS KUEMMERLE,[11] DAVID B. LINDENMAYER,[12] HAROLD A. MOONEY,[6] IVETTE PERFECTO,[13] STACY M. PHILPOTT,[14] TEJA TSCHARNTKE,[2] JOHN VANDERMEER,[13] THOMAS CHERICO WANGER,[1,6] HENRIK VON WEHRDEN[1,15]

[1]Institute of Ecology, Leuphana University Lueneburg, 21335 Lueneburg, Germany. [2]Department of Agroecology, Georg-August-University Goettingen, 37077 Goettingen, Germany. [3]Department of Biology, University of Massachusetts Boston, Boston, MA 02125, USA. [4]Graduate School for Production Ecology and Resource Conservation, Wageningen University, 6700 AA Wageningen, The Netherlands. [5]School of Earth and Environmental Sciences, Washington State University Vancouver, Vancouver, WA 98686, USA. [6]Department of Biology, Stanford University, Stanford, CA 94305–5020, USA. [7]CSIRO Sustainable Ecosystems, Canberra, ACT 2601, Australia. [8]Mihai Eminescu Trust, Sighisoara 545400, Romania. [9]Department of Land, Air, and Water Resources, University of California, Davis, CA 95616, USA. [10]Department of Environmental Science, Policy and Management, University of California, Berkeley, CA 94720–3114, USA. [11]Department of Geography, Humboldt-Universität zu Berlin, 10247 Berlin, Germany, and Potsdam Institute for Climate Impact Research, 14412 Potsdam, Germany. [12]Fenner School of Environment and Society, The Australian National University, Canberra, ACT 0200, Australia. [13]School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI 48109, USA. [14]Department of Environmental Sciences, University of Toledo, Toledo, OH 43606–3390, USA. [15]Center for Methods, Leuphana University Lueneburg, 21335 Lueneburg, Germany.

*To whom correspondence should be addressed. E-mail: joern.fischer@uni.leuphana.de

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Conservation: Model Management Intensity

B. PHALAN AND COLLEAGUES ("RECONCILING food production and biodiversity conservation: Land sharing and land sparing compared," Reports, 2 September, p. 1289) report that land sparing would do less harm to biodiversity than land sharing and conclude that

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the best strategy for conserving biodiversity would be high-yield farming combined with natural habitat protection. However, the controlling factor in the equation is farm management intensity; changes in intensity affect both harvest yield and biodiversity density. Therefore, a model integrated with management intensity as a decision variable is necessary for reconciling food production and biodiversity conservation. Management practices, rather than land-use types, should be the driving force for the reconciliation.

KIYOTADA HAYASHI

National Agriculture and Food Research Organization, Kannondai 3-1-1, Tsukuba, Ibaraki 305-8666, Japan. E-mail: hayashi@affrc.go.jp

Response

FISCHER *ET AL.* DO NOT DISPUTE OUR FINDING that, in principle, land sparing would be more effective than land sharing for the taxa and areas we studied, but they appear to feel that land sparing is neither achievable nor desirable in practice.

We agree that there are no simple, generic solutions to complex problems such as reconciling agricultural production and conservation. Even in places where land sparing is preferable in principle, achieving its potential benefits will entail addressing intricate social, political, and technical issues (*1*). That said, delivering the intended benefits of land sharing also involves formidable challenges, despite the substantial effort that has been invested. Where land-sharing practices have been identified and incentivized, there is often inadequate monitoring of their quality and effectiveness (*2*). Land sharing can also have the serious unintended consequence of accelerating conversion or degradation of remaining natural habitats (*3*–*5*).

Fischer *et al*. outline several situations where land sharing appears to be a better conservation strategy than land sparing. However, none of the studies they cite provides adequate data to demonstrate greater benefits to biodiversity from land sharing (*6*). The studies rely on simplistic biodiversity metrics such as species richness from which population-level impacts cannot be assessed (*7*–*10*), fail to make comparisons with appropriate baseline habitats (*7*–*9*), do not quantify yields or other benefits to people (*10*, *11*), do not quantify outcomes from land sparing to compare with those from land sharing (*8*–*11*), or do not refer to agriculture at all (*9*). Fischer *et al*. correctly point out that some species now depend on agriculture. However, given that all species have thrived without it for most of their evolutionary history, whether it is essential for their persistence into the future is open to question.

We agree that famine is caused largely by inequitable access to food, but our argument is independent of the need to solve world hunger. Regardless of how much food is produced, society has choices to make about how and where to grow it. Our data suggest that high-yielding, land-sparing approaches—at least in southwest Ghana and northern India—have the greatest potential benefits for biodiversity, because they give explicit attention to the importance of conserving remaining habitats. This pattern holds whether the required production of food is more or less than at present (see Fig. 2 in our Report).

We believe that the best way to develop an understanding of the difficult and complex

TECHNICAL COMMENT ABSTRACTS

Comment on "Atmospheric Pco_2 Perturbations Associated with the Central Atlantic Magmatic Province"

Michael R. Rampino and Ken Caldeira

Schaller *et al*. (Research Article, 18 March 2011, p. 1404) proposed that carbon dioxide (CO_2) released by the Central Atlantic Magmatic Province eruptions over periods of about 20,000 years led to substantial increases of up to 2000 parts per million (ppm) in the concentration of atmospheric carbon dioxide (Pco_2) near the Triassic-Jurassic boundary. Use of an atmosphere-ocean model coupled to a carbon-cycle model predicts Pco_2 increases of less than 400 ppm from magmatic volatiles, with only a small climatic impact.

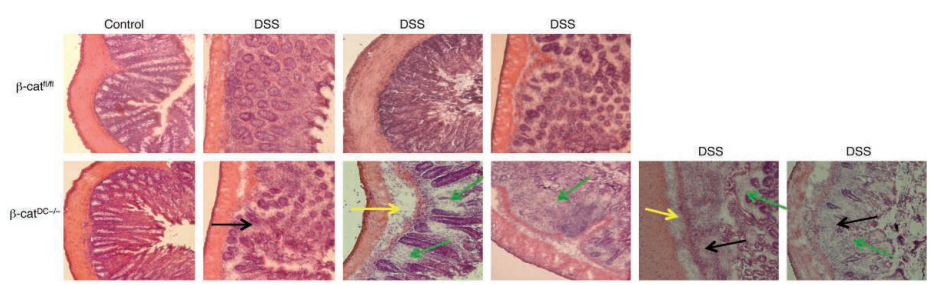
Full text at www.sciencemag.org/cgi/content/full/334/6056/594-b

Response to Comment on "Atmospheric Pco_2 Perturbations Associated with the Central Atlantic Magmatic Province"

Morgan F. Schaller, James D. Wright, Dennis V. Kent

Rampino and Caldeira argue that the first pulse of the Central Atlantic Magmatic Province would increase the concentration of atmospheric carbon dioxide (Pco_2) by only 400 parts per million if erupted over 20,000 years, whereas we observed a doubling within this interval. In the absence of any data to the contrary, we suggest that a more rapid (≤1000-year) eruption is sufficient to explain this observation without relying on thermogenic degassing.

Full text at www.sciencemag.org/cgi/content/full/334/6056/594-c



CORRECTIONS AND CLARIFICATIONS

Books *et al*.: "Picture perfect future past" by G. Riddihough (7 October, p. 41). The first sentence of the third paragraph should have read "But, as *Out of This World* documents, modern science fiction is more than the warmed-over imaginings of earlier generations."

Reports: "Three-dimensional Anderson localization of ultracold matter" by S. S. Kondov *et al*. (7 October, p. 66). Reference 14 [F. Jendrzejewski *et al*., http://arxiv.org/abs/1108.0137 (2011)] should have been accompanied by a note stating that while their paper was in proof, Kondov *et al.* were made aware of related three-dimensional experiments that were released in this preprint.

News Focus: "False positive" by J. Cohen and M. Enserink (23 September, p. 1694). In the last sentence in the first column of p. 1699, the story credits the author of the blog CFS Central with a call for aggressive, ACT UP–style protests and the quote, "I believe we need to act quickly, before the FDA/NIH paper is killed." In fact, it was a patient who wrote this on the blog, not the blog author.

Reports: "African wild ungulates compete with or facilitate cattle depending on season" by W. O. Odadi *et al*. (23 September, p. 1753). An incorrect e-mail address was given for the first corresponding author. The correct address is woodadi@yahoo.com. The online HTML version has been corrected. In Table 2, the heading for the fourth column should be "Dead stems (hits/100 pins)." The reference callouts at the end of the last sentence beginning on page 1754, which begins "We posit that...," should include reference (*22*), to read "...in the Serengeti ecosystem (*18*, *20*–*22*). The reference callout (*22*) in the final paragraph on page 1755 should be (*23*).

Reports: "Activation of -catenin in dendritic cells regulates immunity versus tolerance in the intestine" by S. Manicassamy *et al.* (13 August 2010, p. 849). Some of the arrows in Fig. 4C were incorrect, and the original images did not fully demonstrate the line in the text that referred to "increases in inflammatory cell infiltration, edema, epithelial cell hyperplasia, and loss of goblet cells in the colon of -cat$^{DC-/-}$ mice as compared with -cat$^{fl/fl}$ mice." In the revised figure shown here, the arrows have been corrected and new panels have been added. The corrected caption is: "Histopathological changes in colon tissue from -cat$^{fl/fl}$ or -cat$^{DC-/-}$ mice treated with or without 2% DSS treatment for 7 days. Areas of interest are infiltration of inflammatory cells (black arrows), edema (yellow arrows), and loss of crypts (green arrows) and goblet cells." The changes described here do not affect the Report's conclusions.

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choices involved in land-use decisions is to use theoretical models to guide collection of the critical empirical data and evaluate potential solutions based on measurable outcomes. Extending our approach to incorporate other objectives such as cultural values and ecosystem services, and to develop strategies with strong social safeguards, should be a priority. We contend that it would be premature to dismiss the potential benefits of land sparing as undeliverable in practice when so little effort has been made so far to develop the right tools to implement it.

Hayashi proposes extending our analytical approach to better understand how management intensity affects agricultural yields and species' populations. We agree that such information could be useful for informing decisions by farmers and foresters and that it might be used to improve outcomes from land sharing, land sparing, or intermediate strategies. Our approach focused on decision-making at larger scales, for which understanding the consequences of land-use allocation is more relevant.

"Management intensity" is shorthand for a diverse range of practices, from fertilizer use to tree husbandry to management of hunting, and it is often not clearly defined. High-yield farming need not necessarily involve intensive management in the sense of having high agrochemical inputs. "Sustainable intensification" using resource-efficient practices seems more likely to increase yields with minimal resource degradation and pollution (*12*). Research on the impacts of different management practices will produce useful insights if it can move beyond simplistic biodiversity metrics, quantify pollution and other costs, and integrate fine-scale management concerns with the need to address large-scale land-use change.

BEN PHALAN,[1]* MALVIKA ONIAL,[1] ANDREW BALMFORD,[1] RHYS E. GREEN[1,2]

[1]Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK. [2]Royal Society for the Protection of Birds, The Lodge, Sandy SG19 2DL, UK.

*To whom correspondence should be addressed. E-mail: btp22@cam.ac.uk

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Letters to the Editor

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