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Biodiversity and Future Food Supplies

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Washington, May 2011

The sustainability challenge: to produce more food AND minimise impact on ecology

- Biodiversity is valuable but value often hidden
  - Direct values to production
  - Direct values to society
- Sustainability requires protecting biodiversity
- “location is essence” (Pardey, 2011) of how to manage biodiversity for societal gains

Ecology is important: e.g. 15-20% of global food production comes from insect pollinated crops (Klein et al 2008)

Ecosystem Services (ES): biodiversity is important

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- Provisioning
  - Food, fibre, fuel
- Regulating
  - Flood, water purity etc

Cultural

Pollination

Pest control

Soil fertility and C storage

Millennium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Synthesis.* Island Press, Washington, DC.

Point 1: Biodiversity is valuable

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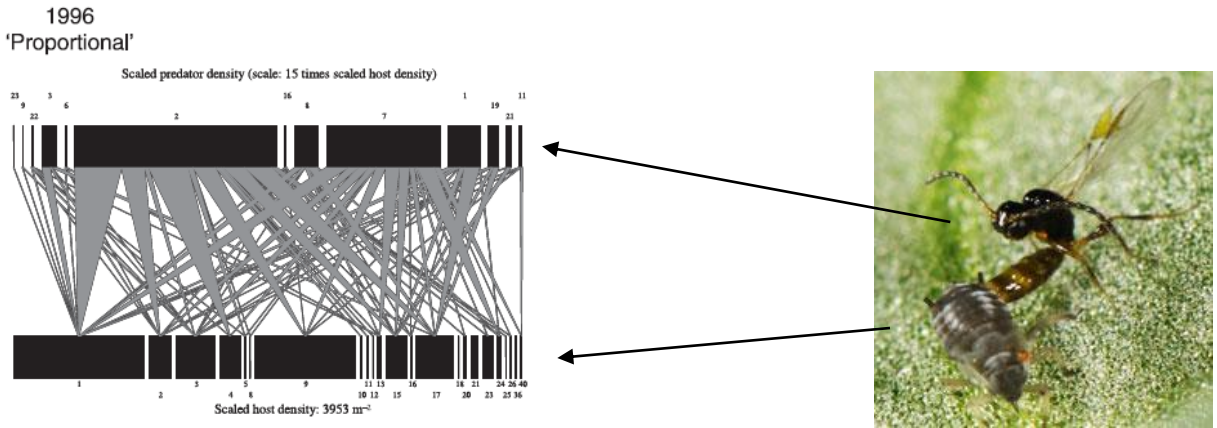
- Functioning of ecosystems *may* require considerable biodiversity
  - we rarely know enough to understand fully the relationship between biodiversity and service delivery in terms of redundancy, resilience and stability



F van Veen et al. J anim Ecol 2008

Coffee's natural enemies work

John Vandermeer & Ivette Perfecto

July/August 2010 / Vol. 60 No. 7 • BioScience 527

Vol 451|24 January 2008|doi:10.1038/nature06477

Plant Pathology (2009) 58, 636–641

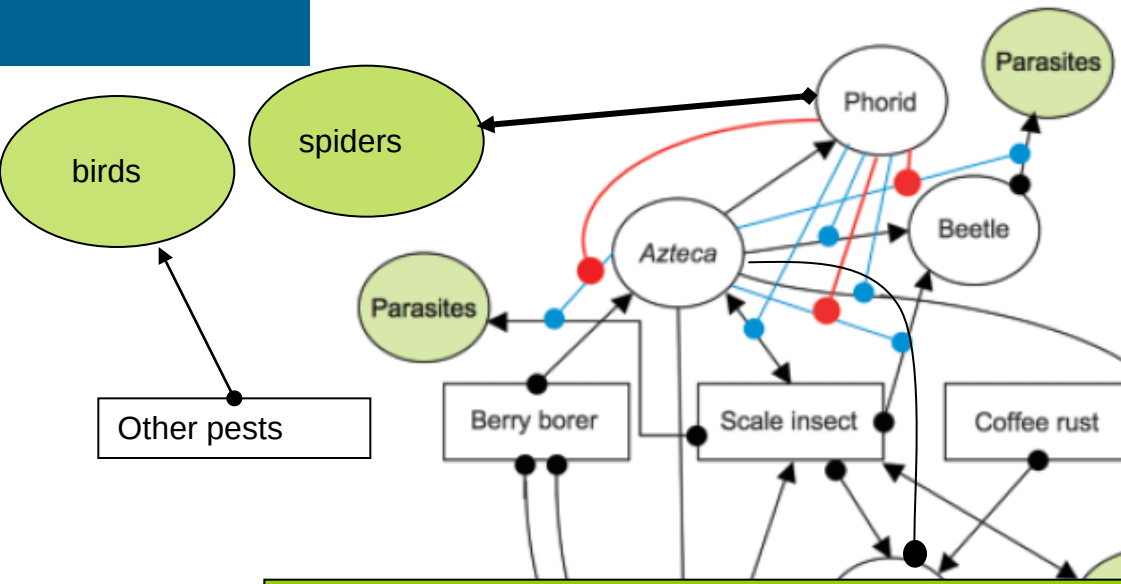
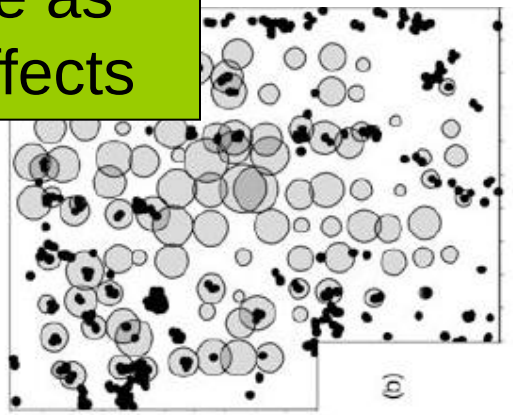


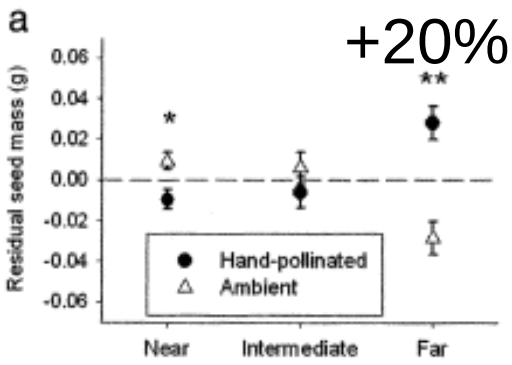
Figure 1 Results of survey of 45-ha coffee plot in (a) dry season and (b) wet season. Size of bubble proportional to incidence of coffee rust, atrix. Solid circles indicate hade trees containing a living nest eca instabilis. Wet season pattern significant, with higher rust sociated with shade trees without

Complex, resilient "almost natural" ecosystem that is largely self-regulating: interventions may be counter-productive as they have indirect, difficult-to-predict, effects

autonomous pest control. The four pests are shown in rectangles and the elements involved in their control in ovals (shaded ovals indicate a species group rather than a single species). Negative effects are shown with a small circle at the end of the connector and positive effects with an arrowhead. Indirect effects are shown as small circles (negative effect) affecting a different connector (an effect on an effect). Indirect effects of order one are indicated in blue. Indirect effects of order two are indicated in red.



Plantation coffee: forest fragments provide valuable pollination services



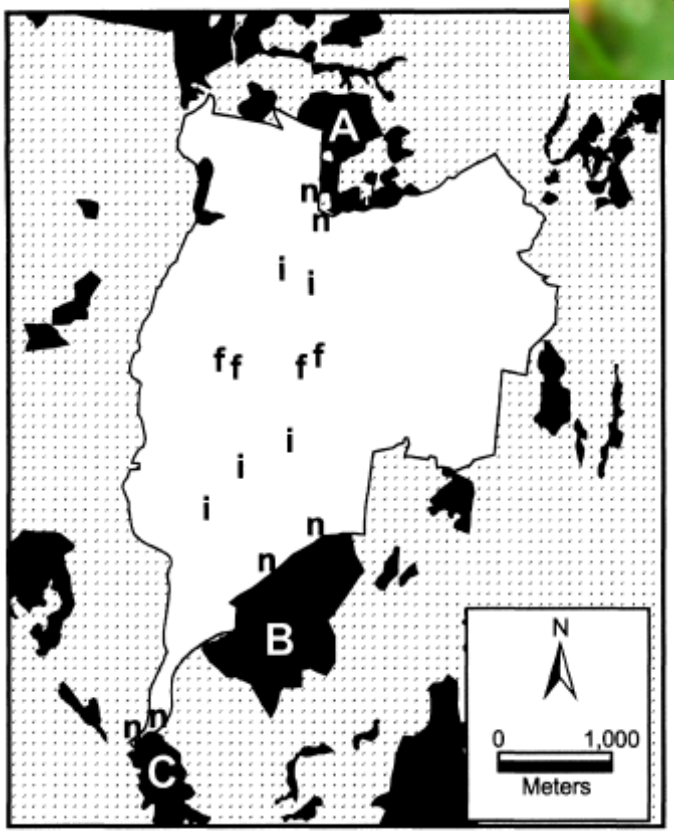


Fig. 1. Map of study area and sites. Finca Santa Fe (1,065 ha) is in white; stippled area is a mix of coffee, pasture, and sugar cane; black areas are forests. The three focal forest patches are labeled A (46 ha), B (111 ha), and C (34 ha). Study sites are labeled n, i, and f for near, intermediate, and far distance classes.

Table 1. Estimates of economic value of forest patches A and B (Fig. 1) to study farm, under seven different assumptions for minimum patch size required to sustain pollination services

Patch size threshold, ha	Area near A and B and far from all other patches above threshold size,* ha	Income resulting from A and B,† $/yr
None	235	30,000
5	270	35,000
10	363	47,000
15	450	58,000
20‡	480	62,000
25	480	62,000
30	480	62,000

*Near area defined as within 1.0 km of forest.
†Results rounded to the nearest $1,000 (see *Methods*).
‡Same as assuming threshold of 18 ha (the size of the riparian strip; see *Methods*), because there are no patches >18 and <20 ha.

Economic value of tropical forest to coffee production

Taylor H. Ricketts*†‡, Gretchen C. Daily†, Paul R. Ehrlich†, and Charles D. Michener§

*Conservation Science Program, World Wildlife Fund, 1250 24th Street NW, Washington, DC 20037-1124; †Department of Biological Sciences, Stanford University, 371 Serra Mall, Stanford, CA 94305-5020; and §Division of Entomology, Natural History Museum, University of Kansas, 1460 Jayhawk Boulevard, Lawrence, KS 66045-7523

Contributed by Charles D. Michener, July 17, 2004

Big challenge

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- Understand, value and commodify ecosystem services
  - Pollination, natural enemies, soil fertility, soil protection, flood protection, water quality, carbon storage etc
  - Direct value to production: values need to be internalised to system
  - Direct value to society and cost to production: need to develop external global market to compensate producers via PES schemes

TEEB (2010) The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB.

Conserving forests avoids greenhouse gas emissions worth US$ 3.7 trillion

Halving deforestation rates by 2030 would reduce global greenhouse gas emissions by 1.5 to 2.7 GT CO_2 per year, thereby avoiding damages from climate change estimated at more than US$ 3.7 trillion in NPV terms. This figure does not include the many co-benefits of forest ecosystems (Eliasch 2008).

Point 2: Location and scales matters

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- What happens in a plot depends on the land around (depending on the group, this may be influenced at very large scales)
  - So solutions will vary from place to place
  - Sustainable agricultural landscapes do not necessarily require sustainable farming

What happens here depends on the land around

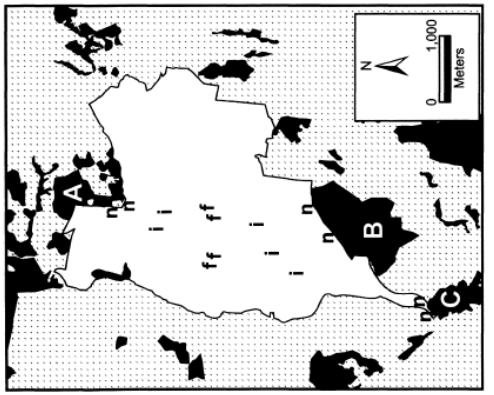

Fig. 1. Map of study area and sites. Finca Santa Fe (1,065 ha) is in white; stippled area is a mix of coffee, pasture, and sugarcane; black areas are forests. The three focal forest patches are labeled A (46 ha), B (111 ha), and C (34 ha). Study sites are labeled n, i, and f for near, intermediate, and far distance classes.

Farming has local and non-local impacts: 1

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- Local actions can have distance impacts
  - E.g. “organic dairy farm” may have low local environmental impact, but export slurry off farm for disposal, and buy in soya feed from S America




Local choices: distant consequences in global market

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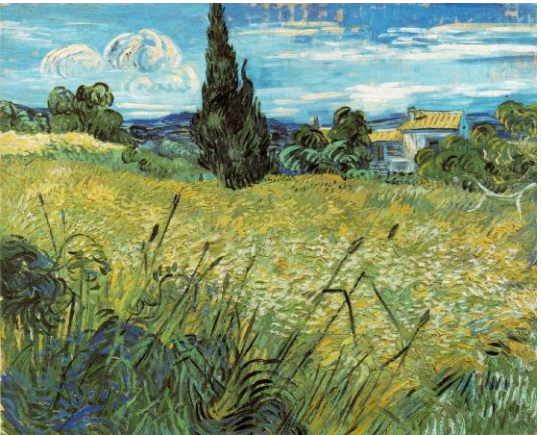
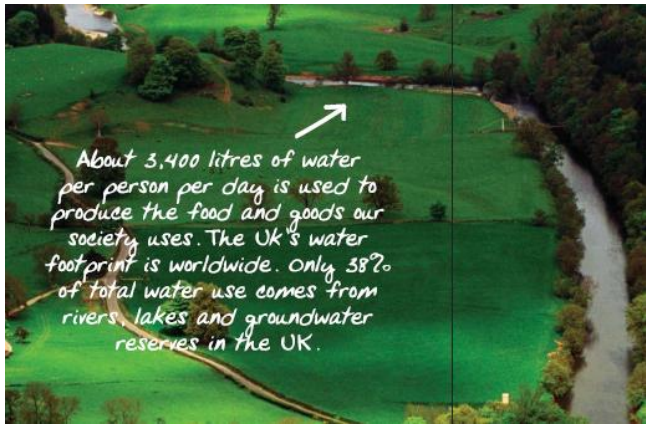
- EU population is falling, but imports of food increasing:
- "virtual land import" is 34.9 million ha
  - Cf 25.3 m ha in 1999/2000
  - Increase in area the size of Portugal
- If organic increase to 20% area in EU would need a further 10.2 m ha
  - Exports and amplifies environmental cost to fragile tropics

Von Witzke & Noleppa 2010



EA report "*Water is precious*" 2009

62% of UK water use "virtually" imported



Big challenge

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- To recognise non local effects and value them appropriately
  - "sustainable farming" in one place may lead to "less sustainable farming" elsewhere
  - North-South trade in biodiversity and conservation of ecosystem services?

Point 3: Sustainable agricultural landscapes do not necessarily require sustainable farming

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"Landscape thinking" leads to the big question:

Is specialising the key to sustainable production?

If an area ("landscape") has to produce both food and "biodiversity", do you get **more of both** if (a) you farm extensively throughout **or** (b) you separate some land to specialise in food and some to specialise in biodiversity?

Sparing vs sharing

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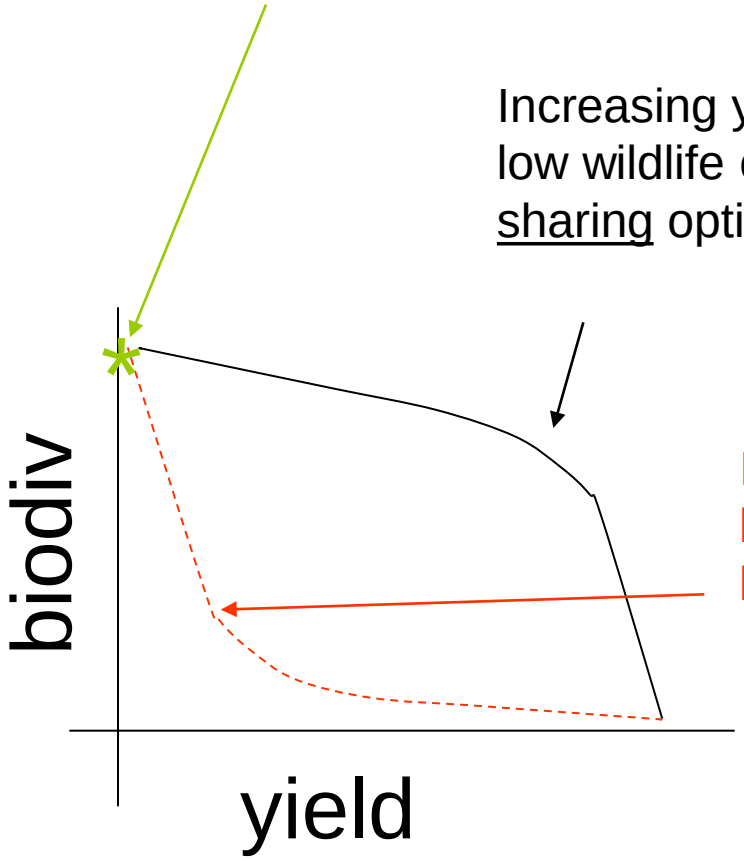
Biodiversity of non-farmed land



Increasing yield has low wildlife cost: land sharing optimal

Increasing yield has big wildlife cost: land sparing optimal

Land sparing:
Intensive + nature reserves

Land sharing:
extensive + no nature reserves

The optimal landscape will vary according to the shape of the trade-offs and decision function

High production landscapes

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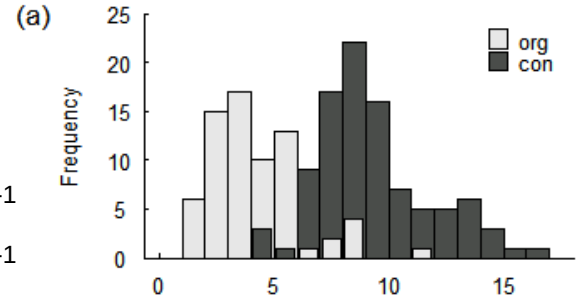
Comparing organic farming and land sparing: maintaining yield and wildlife at a landscape scale.
J A. Hodgson*, W E. Kunin, C D. Thomas, T G. Benton & D Gabriel. (2010) Ecology letters

- Gain in biodiversity converting from intensive to organic ~12%
- Loss of yield 46%
- Land sparing (intensive plus reserves) would produce more food and wildlife

Conventional yield = 9.35 t ha^{-1}

Organic yield = 4.25 t ha^{-1}



Smallholder farming (1) shade coffee

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- Land sharing works: the surrounding areas and extensive farming creates a permeable agricultural matrix which allows the complex, resilient, ecosystem to function
- *Vandermeer & Perfecto mexico field sites*

Smallholder (2): Jatropha in Malawi

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- Large plantations less productive as they act as a magnet for pests and diseases (ecosystem disservices)
- Land sharing better

Dyer, J.C., Stringer, L.C. and Dougill, A.J. (submitted). *Jatropha curcas*: Sowing local seeds of success in Malawi. Submitted to *Journal of Arid Environments*.

Land sparing vs sharing logic

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- The logic of land sparing vs sharing depends on:
  - The relative yields in intensive and extensive systems, and therefore the amount of “extra” land that would be needed to gain the same yield if extensive
  - The relative amount of biodiversity that would be gained on agricultural land by extensive farming
  - The “background” biodiversity
  - Land sharing “optimal” in non-intensive, wildlife-rich landscapes
- Can be applied at single landscape, at regional national or global levels

Point 4: Managing landscapes

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- "Ecological networks" needed to produce connected wildlife-friendly landscapes
  - The scale will depend on the appropriate wildlife (in Europe a field scale network of margins will be needed to maintain pollination and natural enemy services)
  - Networks of spared land or appropriate "permeable" matrix in land sharing situations






Large scale ecological networks in South Africa

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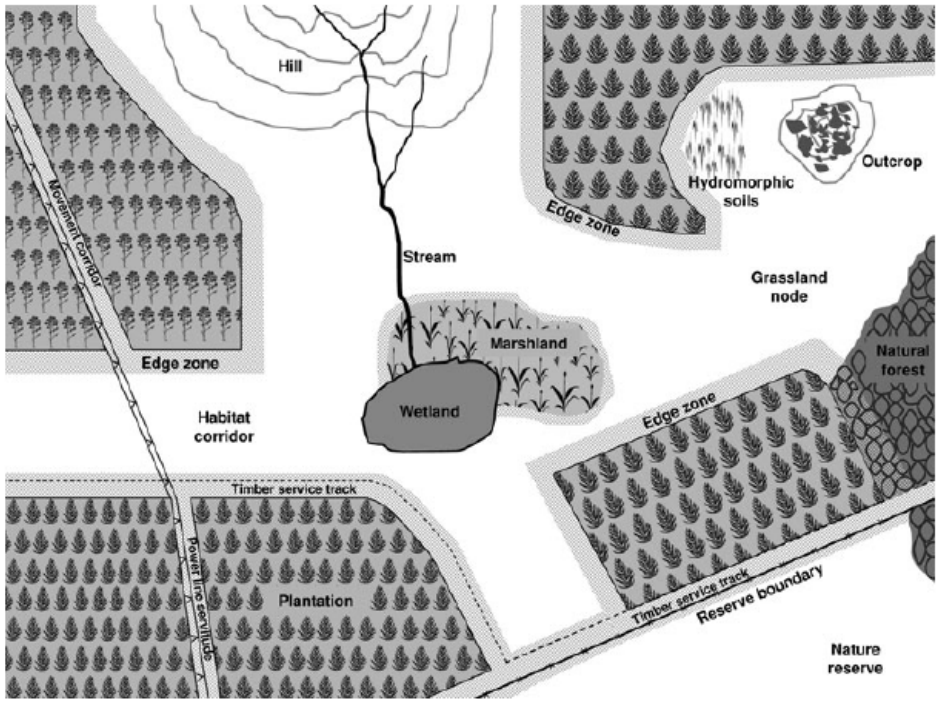


Fig. 2 A conceptual diagram illustrating the emergent properties (over simply corridors) of large-scale ecological networks (ENs) designed to function like the equivalent and adjacent natural reserve area. The EN here is set in the context of afforestation with alien plantation trees. ENs are much more than just a set of corridors. They include nodes which are extensive areas, often at the intersection of large corridors (habitat corridors), special ecosystems (such as wetlands and marshlands), special features (such as outcrops), while enabling natural ecosystem functioning such as water catchment and run off. Small corridors, which may for example be power line servitudes or timber vehicle tracks are a necessary part in the whole design, and yet can also function as movement corridors. The plantation tree patches inevitably have an edge zone which tends to be impoverished in biodiversity compared to the interior of the large, habitat corridors. Hydromorphic soils are not planted to improve overall hydrology. In one of the most advanced of the ENs in South Africa, at iSimangaliso World Heritage Site, the fence between the reserve area and the adjacent EN has been taken down, allowing game animals, even elephant and white rhino, to wander throughout the area

- Implementation driven by FSC compliance

Biodivers Conserv (2010) 19:2949–2962
DOI 10.1007/s10531-009-9715-2

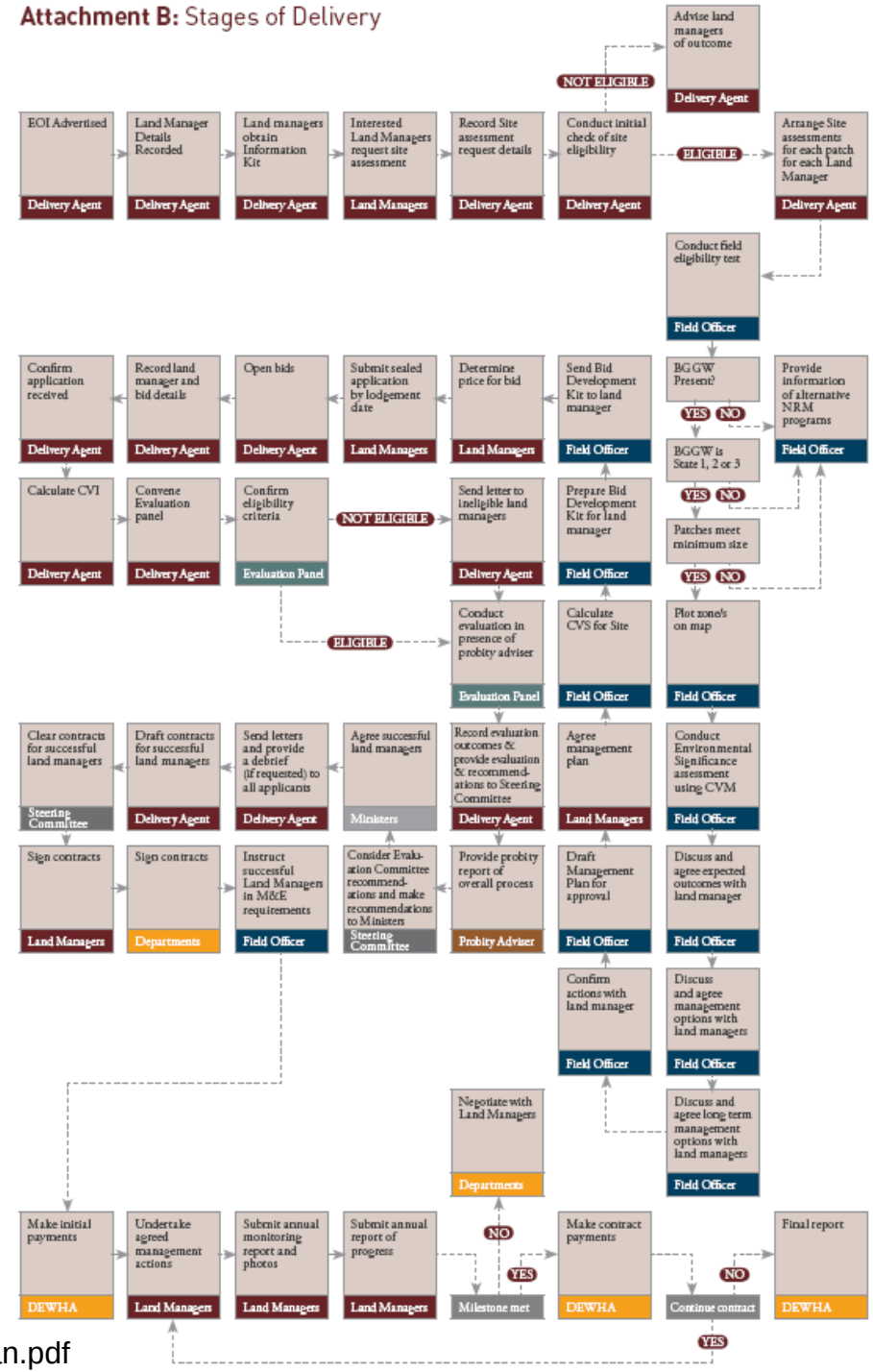
ORIGINAL PAPER

Provision of ecosystem services by large scale corridors and ecological networks

M. J. Samways · C. S. Bazelet · J. S. Pryke

Box Gum Grassy Woodlands in Australia

- Environmental Stewardship Scheme uses a “reverse auction”:
  - site visit uses "Conservation value metric tool" and gives points to location, thus tailoring prescription to locality
  - farmer bids for it balancing likelihood of funding vs feasibility,
  - decision on funding then made



http://www.nrm.gov.au/publications/books/pubs/implementation-plan.pdf

Big Challenge

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- To find economic incentives for managers to conserve biodiversity and policy tools to design global (!), national, regional and local agro-ecological schemes to create sustainable agricultural landscapes

United Nations

General Assembly

Report submitted by the Special Rapporteur on the right to food, Olivier De Schutter

Point 5: "freeze the footprint"

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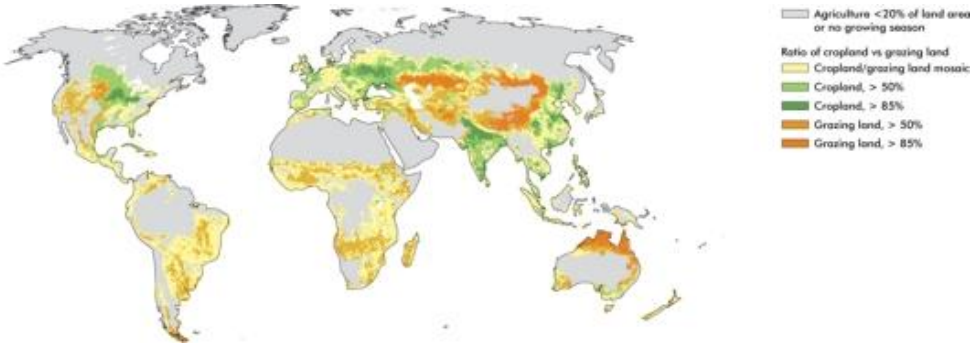
- Do we need more land for more food? No
  - Recent analyses (e.g. Smith et al 2010, PRSB) suggest that we can produce enough food **if** existing high production land *maintains high production* and low production land *increases production*
  - New land increasingly marginal for production, or
  - Comes at very high cost (tropical forests for biodiversity and GHG emission)
- Win-wins
  - Reduce harvest, post-harvest and post production waste
  - Dietary change
  - Increase or maintain yields by sustainable intensification



Conclusions

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- Sustainable landscapes are not necessarily the same as sustainable farming
- Conceptually, biodiversity can be fostered within the agricultural matrix or in non-cropped areas; the optimal balance will vary from place to place
  - High production landscapes may produce more food and ES if land is spared and managed
  - Landscapes less adapted to production may be better farming extensively throughout

Challenges

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- Our understanding of the value of ES and BEF too limited
  - Sustainable farming practice must increasingly rely on this knowledge as ability to resort to chemical management is curtailed by carbon and regulatory costs
- Develop tools for valuing ecosystem services that aid directly aid production in short (or long term)
  - Issues of tenure and governance
  - Extension services
- Develop tools for assessing local vs distant costs and benefits
- Develop tools for designing and managing appropriate “optimal landscape”

Final thought on climate change

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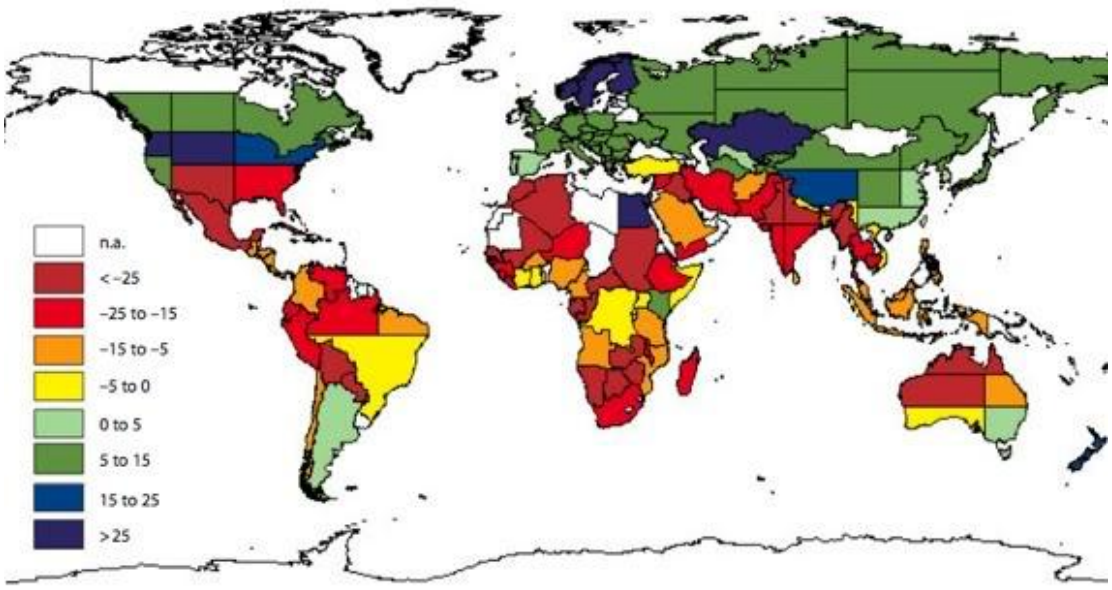
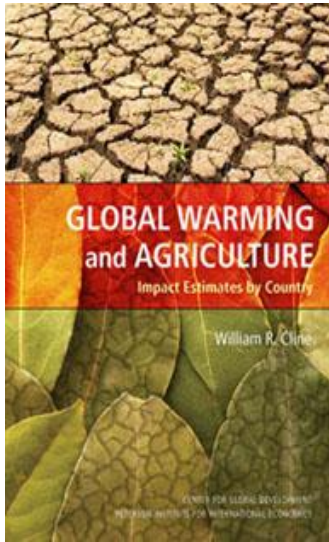
The ability to produce food will be most constrained in areas of high population growth and poverty levels, but also with high biodiversity: what role will the productive and rich north have in mitigating and protecting these countries?



2080 from Bill Cline



Thank you for listening!

Assessing impact of farming practices is difficult because of "landscape effects"

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Organic farms are clumped due to social and environmental factors

Red is high organic, blue is low organic

Organic farms in the UK tend to sit in **relatively unproductive** landscapes and this contributes to their higher biodiversity

Gabriel et al 2009 J appl Ecol