Improving Integration of Agriculture and Conservation through Biosphere Reserves
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by Julia Fry

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Foreword

Sustainable agriculture depends on finding ways to integrate the goals of increasing agricultural production with that of conservation of natural resources. The aim of UNESCO’s Man and the Biosphere Program is for biosphere reserves to act as bioregional ‘laboratories’ for communities to find solutions to sustainable development. In Australia there are a number of biosphere reserves with highly valued ecosystems and where agriculture is an important industry. These bioregions provide an opportunity for collaborative research on integrating development and conservation.

Although this report is targeted primarily at biosphere reserves it is also a resource for natural resource management agencies and catchment authorities. It provides a range of strategies for improving integration between agriculture and conservation. The key findings were:

1. That approaches such as strategic adaptive planning and management provide a structure for improving integration between conservation and agriculture.
2. Linking such an approach with participatory modelling and monitoring has the potential to improve collaboration between farmers and conservationists and provide greater understanding of the interactions between agriculture and natural ecosystems.
3. Research specific to local agriculture/ecosystem interactions, such as improving soil management and reducing nutrient loss, is important because of its benefits to both agricultural productivity and conservation.
4. More education and information on biodiversity would also assist to increase understanding of the interactions between agriculture and natural systems.

The research was conducted in collaboration with research partners; the Fitzgerald Biosphere Group, the Ravensthorpe Agricultural Network Initiative, the Department of Agriculture and Food, Western Australia and South Coast Natural Resource Management.

This report was funded from RIRDC core funds provided by the Australian Government. This report is an addition to RIRDC’s diverse range of over 2000 research publications and it forms part of our Dynamic Rural Communities R&D program, which aims to improve the productivity of natural resource use and conservation.

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Dr Julia Fry is an Associate Professor with the University of Western Australia Centre of Excellence in Natural Resource Management. Before joining the University she managed projects in natural resource management and farming systems with the Department of Agriculture in Western Australia including several within the Fitzgerald Biosphere sub-region.

Acknowledgments

I am grateful to RIRDC, the UWA Centre for Excellence in Natural Resource Management, the Department of Agriculture and Food, Western Australia, the Fitzgerald Biosphere Group, the Ravensthorpe Agricultural Initiative Network and South Coast Natural Resource Management for funding this project. I particularly wish to thank Alison Lullfitz for interviewing farmers in the FBR and the Fitzgerald Biosphere Group for providing her with support. Thank you to all the participants for the time and thought they put in to discussions and providing ideas to the project. Thanks to Louise Duxbury for reviewing and to Joanna Ridley for proof reading the final draft.

Abbreviations

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<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>DAFWA</td>
<td>Department of Agriculture and Food, Western Australia</td>
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<tr>
<td>DEC</td>
<td>Department of Environment and Conservation, Western Australia</td>
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<tr>
<td>FBG</td>
<td>Fitzgerald Biosphere Group</td>
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<tr>
<td>FBR</td>
<td>Fitzgerald Biosphere Reserve (notional boundaries)</td>
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<tr>
<td>FRBR</td>
<td>Fitzgerald River Biosphere Reserve (core area)</td>
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<td>FRNP</td>
<td>Fitzgerald River National Park</td>
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<tr>
<td>NRM</td>
<td>Natural Resource Management</td>
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<td>PA</td>
<td>Precision Agriculture</td>
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<td>RAIN</td>
<td>Ravensthorpe Agricultural Initiative Network</td>
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<td>RIRDC</td>
<td>Rural Industries Research and Development Corporation</td>
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<td>UNESCO</td>
<td>United Nations Educational Scientific and Cultural Organisation</td>
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<td>VRT</td>
<td>Variable Rate Technology</td>
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Executive Summary

What the report is about

This report provides a range of strategies to improve integration between agriculture and conservation in a biosphere reserve. The research gathered information from international case studies and evaluated their local relevance in discussions with a range of people with an interest in the Fitzgerald Biosphere Reserve in Western Australia. The participants included farmers, conservationists, agricultural scientists and natural resource managers. The report summarises both the case studies and other ideas from research participants and provides some recommendations for research and demonstration projects. The report provides a pathway for the Fitzgerald Biosphere Reserve, or other Australian biosphere reserves, to further test some of these approaches. The report also highlights the important role UNESCO biosphere reserves can play in logistic support for improving integration between conservation and agricultural productivity.

Who is the report targeted at?

This report is primarily targeted at Australian biosphere reserve communities but is also relevant to other bioregions seeking ways to improve integration between agriculture and conservation.

Where are the relevant industries located in Australia?

While this research was conducted in a broadacre farming area on the south coast of Western Australia it is also relevant other agricultural regions in Australia.

Background

There are challenges in managing natural resources in agricultural landscapes. Conservation objectives are often in conflict with those of increasing agricultural production. It is therefore important to find ways to reconcile the conservation of biodiversity and other ecosystem services, with the needs for food and fibre production, and those of maintaining rural economies. The challenges become even greater with the impact of climate change. UNESCO biosphere reserves are globally recognised bioregions aimed at finding local solutions to sustainable development. They provide the opportunity for natural resource planning and management at a landscape scale.

While many biosphere reserves were originally more focused on protected areas, the Man and the Biosphere program now has a much stronger emphasis on human development (Batisse 1997; Schultz et al. 2011; Nguyen et al., 2011).

One challenge in creating and managing a biosphere reserve is to reconcile in the same space conservation and economic development objectives (UNESCO 2003 p.1).

Increasing agricultural productivity without degrading natural resources is a problem for all farmers. Biosphere reserves provide a landscape scale, spatial area for farmers to work cooperatively to experiment and learn about natural resource management, incorporate conservation objectives into farming systems, and manage agricultural off-site impacts.

The Fitzgerald River Biosphere Reserve is located on the central south coast of Western Australia in the South-West global biodiversity hotspot. The official boundaries are those of the protected area of the Fitzgerald River National Park but the notional boundaries include a larger area around the park. This notional boundary was used to define the Fitzgerald Biosphere sub-region of the South Coast NRM region, used in State and Commonwealth regional NRM processes. The local community is currently going through the process of formally requesting UNESCO designation of buffer and transition zones to comply with the 1996 Man and the Biosphere statutory framework.
A key question for the community at this point is how to use the biosphere reserve concept to achieve better integration between conservation and agriculture. There is also a need for logistic support to increase agricultural productivity and adaptation to climate change.

**Aims/objectives**

The overall objective of this project was to work with a biosphere community to research and develop strategies to integrate agricultural production and conservation of natural resources. The initial part of the project aimed to research some potential approaches to integrating the three functions of a biosphere reserve of development, conservation of natural resources and logistic support such as education and research. The objective of the main part of the project was to use the information from the desktop research together with ideas from a range of participants to develop some strategies to improve the integration of agriculture and conservation.

This objective aligns with the RIRDC objective: integration of resource conservation and agricultural productivity growth for greater economic, environmental and social resilience.

**Methods used**

The methodology of the project included elements of participatory research. Integration of agricultural development and conservation is a complex problem, which needs to recognise different values. By involving different categories of participants in evaluation and discussion there was also an opportunity to assess the case studies in terms of conservation value, likelihood of funding, research needs, practicability and likelihood of adoption by farmers. A literature review was conducted to find case studies, which were then summarised for discussion with research participants. The discussion was based around semi-structured interviews and some small workshops. The participants evaluated the case studies and provided other ideas for integrating conservation and agriculture.

**Results/key findings**

The key findings were:

1. That approaches such as strategic adaptive planning and management provide a structure for improving integration between conservation and agriculture.
2. Linking such an approach with participatory modelling and monitoring has the potential to improve collaboration between farmers and conservationists and provide greater understanding of the interactions between agriculture and natural ecosystems.
3. Research specific to local agriculture/ecosystem interactions, such as improving soil management and reducing nutrient loss, is important because of its benefits to both agricultural productivity and conservation.
4. More education and information on biodiversity would also assist to increase understanding of the interactions between agriculture and natural systems.

The participants found most of the case studies chosen had some relevance to the Fitzgerald Biosphere Reserve but strategic adaptive management received the most consistently positive response. Several participants believed participatory modelling linked to strategic adaptive management would provide a structure for linking agriculture and conservation in the Biosphere Reserve. Many stressed the need for more education about local flora and fauna and greater understanding of agricultural-ecological interactions. Other ideas for improving integration between agriculture and conservation included determining research needs on agriculture/ecosystem interactions, more citizen science and participatory monitoring, research on soil biology and nutrients, and a focus on reducing nutrients going from agricultural land into streams.
Implications for relevant stakeholders

Industry

This report offers some strategies that can be used by Australian biosphere reserves and other bioregional groups to improve integration of agricultural productivity and conservation. The biosphere reserve model, with the right approach and sufficient capacity of community, can provide the basis for developing solutions to the highly complex problem of reconciling the often-conflicting objectives of agricultural productivity and protection of important ecosystems. Biosphere reserves provide an internationally recognised structure for Australian agricultural industries to develop a better understanding of the interactions between agricultural and ecological systems. Partnerships between community, protected area managers and scientists through biosphere reserves provide the opportunity for a coordinated approach to research needs. The benefit of the approach used in this project is that farmers and natural resource managers were able to consider a range of ideas from biosphere reserves and other bioregions elsewhere in the world and discuss the application to their local situation. Locally relevant research and development is going to be essential to address the need to increase productivity, meet the challenges of climate change and reduce the off-site impacts of agriculture.

Community

The biosphere reserve concept provides a mechanism for people to work together with a common goal to integrate social, economic and environmental perspectives. Some of the ideas from this project provide ways to develop a vision for the landscape involving cultural and social perspectives. This includes objectives of maintaining and enhancing community and working with Indigenous people to providing opportunities for reconnection with the land. The project highlighted the community interest in education and citizen science.

Policy makers

The Man and the Biosphere concept differs from regional NRM policy, in that biosphere reserves are viewed as laboratories for reconciling development and conservation and so there is a much stronger emphasis on research, demonstration, capacity building and education. Biosphere reserves can be viewed as places to find solutions that can be applied to other landscapes. They provide a means to integrate research with Commonwealth and State funded regional NRM activities.

One limitation of the biosphere approach is the dependence on volunteers for coordination of biosphere activities. It has been shown that coordination is more effective if there is funding to support such activities.

Setting aside protected areas is not sufficient for conservation of biodiversity, particularly in relation to potential changes in climate. Private land managers are likely to become increasingly important in conservation. The farmers in this project showed that they were interested in participatory conservation but also made it clear that conservation objectives had to come second to their business objectives. In order to devote their time to them, activities had to be provide significant benefit for both sets of objectives.

Recommendations

This project provided some strategies to assist biosphere reserves and other bioregions in Australia to improve integration of agriculture and conservation. The overall recommendations were:

1. Develop an overall plan for the biosphere reserve. Use a system such as strategic adaptive management to develop objectives and thresholds of potential concern. This provides a structure to planning and enables more flexible and adaptive approaches. Strategic adaptive
management recognises that there is uncertainty in complex systems. It provides a mechanism for social and economic values to be considered along with ecological values and can include participatory monitoring. Tools such as participatory modelling of particular areas of conflict or particular NRM problems provide ways to increase understanding of the interactions and share values.

2. Increase the focus on education and citizen science. Many participants in this study suggested educating the community about local flora and fauna is likely to increase their interest in conservation. Involve the community, including schools, in monitoring indicators of the health of ecosystems.

3. Conduct a research needs analysis for the biosphere reserve, particularly those associated with improving the understanding of the interactions between agricultural and natural systems. Increase research activities that specifically provide advantages to both farming and conservation, such as soil management to reduce input costs and off-site impacts.
Introduction

There are challenges in managing natural resources in agricultural landscapes. Conservation objectives are often in conflict with those of increasing agricultural production. It is therefore important to find ways to reconcile the conservation of biodiversity and other ecosystem services, with the needs for food and fibre production, and those of maintaining rural economies. The challenges become even greater with the impact of climate change. UNESCO biosphere reserves are globally recognised bioregions aimed at finding local solutions to sustainable development. They provide the opportunity for natural resource planning and management at a landscape scale.

While many biosphere reserves were originally more focused on protected areas, the Man and the Biosphere program now has a much stronger emphasis on human development (Batisse 1997; Schultz et al. 2011; Nguyen et al. 2011).

One challenge in creating and managing a biosphere reserve is to reconcile in the same space conservation and economic development objectives and foster the convergence of the long-term interests of the stakeholders involved (UNESCO 2003).

Biosphere reserves provide a landscape scale, spatial area for farmers to work cooperatively. This can enable them to experiment and learn about natural resource management, find ways to incorporate conservation objectives into farming systems and manage agricultural off-site impacts. UNESCO views them as laboratories “where new and optimal practices to manage nature and human activities are tested and demonstrated” (UNESCO 2012).

The Fitzgerald River Biosphere Reserve is located on the central south coast of Western Australia in the South-West global biodiversity hotspot. The official boundaries are those of the protected area of the Fitzgerald River National Park but the notional boundaries include a larger area around the park. This notional boundary was used to define the Fitzgerald Biosphere sub-region of the South Coast NRM region, used in State and Commonwealth regional NRM processes. The local community is currently going through the process of formally requesting UNESCO designation of buffer and transition zones to comply with the Man and the Biosphere statutory framework.

The main industry in the area surrounding the national park is broadacre agriculture. There are a number of mines in the Ravensthorpe shire. There are several areas of important natural vegetation outside the national park and patches of remnant vegetation on farms.

A key question for the community at this point is how to use the biosphere reserve concept to achieve better integration between conservation and agriculture. There is also a need to increase logistic support for agricultural productivity and adaptation to climate change.
Objectives

The overall objective of this project was to work with a biosphere community to research and develop strategies to integrate agricultural production and conservation of natural resources. The initial part of the project aimed to research some potential approaches to integrating the three functions of a biosphere reserve of development, conservation of natural resources and logistic support such as education and research. The objective of the main part of the project was to use the information from the desktop research together with ideas from a range of participants to develop some strategies to improve the integration of agriculture and conservation.

This objective aligns with the RIRDC objective: integration of resource conservation and agricultural productivity growth for greater economic, environmental and social resilience.

Plover in paddock, photo Geraldine Janicke
Methodology

The project was based on participatory research methodology and recognises the importance of reflection in participatory research and extension (Percy 2005).

This was the appropriate approach to explore responses from a range of stakeholders living and working in the Fitzgerald Biosphere Reserve. Integration of agricultural development and conservation is a complex problem which needs to recognise different values. Evaluating the appropriateness of technologies is likely to enhance the participants’ ability to use knowledge in their local context (Reed 2008). By involving different categories of participants in evaluation and discussion there was also an opportunity to assess the case studies in terms of conservation value, likelihood of funding, research needs, practicability and likelihood of adoption by farmers.

The UNESCO biosphere model brings research and practice together and supports the participatory approach to research adopted in this project (Stoll-Kleeman & Welp 2008). As Gallopin et al. (2001) argue sustainable development requires both grass roots and expert input. The methodology used in this project recognises the importance of integrating scientific knowledge, technical knowledge about practice of farmers and knowledge about values of different stakeholders (Alroe & Kristensen 2002). The approach recognises the value of case studies and in farmers exploring knowledge from outside their local environment (Percy, 2005), but also that knowledge needs to be adapted to a local context.

The first stage of information gathering was a literature review to develop a number of case studies as a basis for discussion. The literature review included journal articles on biosphere reserves, biosphere reserve websites and journal articles on integration of conservation and agriculture. The initial criterion for the case studies was that they related to the integration of agriculture and conservation in biosphere reserves or bioregions. Six case studies were included for discussion, based on their relevance to broadacre agriculture in a developed economy. A brief document summarising the case studies and a visual presentation were given to participants before the discussions. A combination of individual semi-structured interviews and some small workshops (involving two to four people) were held. This combination of methods was chosen to support the gathering of in depth information exploring responses to the case studies and to determine the range of ideas concerning biosphere reserves and their role in supporting integration of conservation with agricultural production. Individual in depth interviews are important in allowing for contributions without pressure of time, at the convenience of the interviewee and without influence or pressure that can exist in a group situation. As Brooks et al. (2012) suggest:

> some people may be more willing to speak freely during an individual interview than in group situations as they are not as concerned about criticism or potential consequences of expressing a contentious view. 
> Brooks et al. (2012, p29)

The people interviewed included 20 farmers, 6 staff from the Western Australian Department of Agriculture and Food (DAFWA), 4 staff from South Coast NRM, 4 staff from Gondwana Link Ltd. and 2 local conservationists. People were selected for interview on the basis of their knowledge and experience with natural resource management or conservation in the FBR and availability for a one-hour discussion. Interviews were conducted with a range of age groups and both genders of farmers. Discussion included the value of the FBR, suitability of the case studies for adoption by farmers, how they might be modified to suit the FBR and whether the participants had any other ideas for integration of conservation and agricultural production.

The responses from participants of the participatory research are rich in detail and provide the parameters of what is considered relevant and potentially able to be implemented in the context of the FBR.
UNESCO Biosphere Reserves

Biosphere reserves are defined areas containing ecosystems that are internationally recognised within the UNESCO Man and the Biosphere Program.

Biosphere reserves are designed to deal with one of the most important questions the World faces today. How can we reconcile the conservation of biodiversity, the quest for economic and social development and the maintenance of associated cultural values? (UNESCO 1996, p3).

While the fundamental idea of conservation of the resources of the biosphere has not changed, the way biosphere reserves function and how they can contribute to conservation has had several shifts in emphasis from the original concept (Table 1). The Man and the Biosphere program was launched in 1970 following a Biosphere Conference organised by UNESCO in 1968, which examined how to reconcile the conservation and use of natural resources. After several iterations UNESCO has consistently declared since 1984 that Biosphere reserves should have three inter-connected functions:

• Conservation: landscapes, ecosystems, species and genetic variation;
• Development: economic and human and culturally adapted; and
• Logistic support: research, monitoring, environmental education and training

The three functions were specified in a set of criteria as part of a Statutory Framework, known as the Seville Criteria (Table 2). The Statutory Framework set up general criteria for an area to be qualified for designation as a Biosphere Reserve.
Table 1 Key stages in the evolution of the UNESCO Man and the Biosphere Concept
(Source: Fry et al. 2010)

<table>
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<tr>
<th>Year</th>
<th>Key concepts</th>
<th>Significance</th>
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<tr>
<td>1968 UNESCO Biosphere Conference</td>
<td>“Utilization and the conservation of our land and water resources should go hand in hand rather than in opposition, and interdisciplinary approaches should be promoted” (UNESCO 1993 p3-4)</td>
<td>Signalled move from pure conservation to management of resources and integration of humans and ecology (UNESCO 1993). Focus on interdisciplinary research</td>
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<td>1970-1971 Launch of MAB and first meeting of the ICC</td>
<td>Main theme “conservation of natural areas and the genetic material they contain” (Dyer and Holland, 1988). Designation of Biosphere Reserves. Concept of core and buffer zones</td>
<td>Emphasis on conservation and ecological research</td>
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<td>1974 Launch of Biosphere Reserve Network</td>
<td>Increasing emphasis on human interactions with conservation areas</td>
<td>International Biological Program too focused on science (Dyer and Holland 1988)</td>
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<td>1984 Review</td>
<td>People should be considered as part of Biosphere Reserves</td>
<td>More emphasis on human activities in the Biosphere Reserve</td>
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<td>1984 Minsk Action Plan Nine Goals and 35 recommended actions</td>
<td>Concept of outer zone as a transition zone or zone of cooperation added to core and buffer zones. Confirmed the three functions: conservation, development and logistical support.</td>
<td>The zone of cooperation (lacking fixed borders) theoretically strengthened the interaction between human activities and ecological protection and integration at landscape level</td>
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<td>1992 Fourth World Congress on National Parks and Protected Areas</td>
<td>Caracas Declaration and Action Plan : Community involvement, linking conservation and development.</td>
<td>Many of the concepts embodied in MAB program (supported Biosphere Reserves)</td>
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<td>1992 UNCED Earth Summit Convention on Biological Diversity</td>
<td>Sustainable Development as an underpinning concept for biodiversity conservation</td>
<td>Sustainable development aligned well with aims of MAB program</td>
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<td>1995 Statutory Framework of the WNBR</td>
<td>Periodic review process</td>
<td>Biosphere reserves must fulfill all three functions, not just be conservation reserves</td>
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<td>1995 The Seville Strategy Four goals Implementation indicators</td>
<td>Using Biosphere Reserves as models of land management</td>
<td>Aim to use Biosphere reserves to demonstrate how to reconcile conservation and sustainable development (Philips 1995)</td>
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<tr>
<td>Seville +5 Pamplona 2000</td>
<td>Review of Seville and suggested actions following through on Seville</td>
<td>Continued commitment to Seville Strategy</td>
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<td>Madrid Action Plan 2008 31 Targets (see Appendix 1)</td>
<td>Suggested ecosystem services as conceptual framework. Highlighted challenges of urbanization and addressing climate change. Spatial specification of the transition zone</td>
<td>Biosphere Reserves as learning sites. Emphasis on better communication. More integrated approach to the three zones</td>
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Table 2 The Seville Criteria for biosphere reserves

(UNESCO 1996)

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<th>General criteria for an area to be qualified for designation as a biosphere reserve:</th>
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<td>1. It should encompass a mosaic of ecological systems representative of major biogeographic regions, including a gradation of human interventions.</td>
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<td>2. It should be of significance for biological diversity conservation.</td>
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<td>3. It should provide an opportunity to explore and demonstrate approaches to sustainable development on a regional scale.</td>
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<td>4. It should have an appropriate size to serve the three functions of biosphere reserves, as set out in Article 3.</td>
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<td>5. It should include these functions, through appropriate zonation, recognizing:</td>
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<td>(a) a legally constituted core area or areas devoted to long-term protection, according to the conservation objectives of the biosphere reserve, and of sufficient size to meet these objectives;</td>
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<td>(b) a buffer zone or zones clearly identified and surrounding or contiguous to the core area or areas, where only activities compatible with the conservation objectives can take place;</td>
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<tr>
<td>(c) an outer transition area where sustainable resource management practices are promoted and developed.</td>
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<td>6. Organisational arrangements should be provided for the involvement and participation of a suitable range of inter alia public authorities, local communities and private interests in the design and carrying out the functions of a biosphere reserve.</td>
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<td>7. In addition, provisions should be made for:</td>
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<td>(a) mechanisms to manage human use and activities in the buffer zone or zones;</td>
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<td>(b) a management policy or plan for the area as a biosphere reserve;</td>
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<tr>
<td>(c) a designated authority or mechanism to implement this policy or plan;</td>
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<td>(d) programmes for research, monitoring, education and training.</td>
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There has been an increasing emphasis on the human development aspect of UNESCO biosphere reserves and the goals of sustainable development. Biosphere reserves provide the basis for landscape scale approaches, over a range of different land tenures, to the protection and restoration of biodiversity. The biosphere reserve concept is increasingly being applied as a structure for planning at a bioregional scale (Lambert et al. 1995). It provides opportunities to integrate protected area conservation with programs operating in the wider landscape (Bridgewater 2002). Biosphere reserves can bridge and overcome jurisdictional and institutional restrictions (Brunckhorst et al. 1996, 2001). They provide a “strategy for integration” (Kuhn 2000 p897). The status of a UNESCO biosphere reserve can help to build commitment from the community and partnerships with government and others (Brunckhorst 2001).

Biosphere reserves can therefore provide opportunities if considered as a way of bioregional landscape planning, supported by research and education. There are currently 598 sites in 117 countries and UNESCO aims for the world network to share experience, ideas, and promoting best practice through the World Network of Biosphere Reserves (UNESCO nd). In Australia there are currently 14 biosphere reserves (Figure 2), but many of these are protected areas only, without buffer or transition zones, and are therefore not functioning under the Seville criteria. New reserves such as Mornington Peninsular and Western Port designated in 2002, Noosa designated in 2007 and the Great Sandy designated in 2009, conform with the 1996 statutory framework. Stoll-Kleeman et al. (2010) describe these post 1996 biosphere reserves as third generation biosphere reserves. These new biosphere reserves have generated renewed interest in biosphere reserves in Australia (Matysek et al. 2006) with the emphasis now on how they can be used to find ways to reconcile conservation and development.
The World Network of Biosphere Reserves provides an international mechanism to develop and implement sustainable development approaches. Its mission is described by UNESCO as:

To ensure environmental, economic and social (including cultural and spiritual) sustainability through:

- the development and coordination of a worldwide network of places acting as demonstration areas and learning sites with the aim of maintaining and developing ecological and cultural diversity, and securing ecosystem services for human well-being;

- the development and integration of knowledge, including science, to advance our understanding of interactions between people and the rest of nature;

building global capacity for the management of complex socio-ecological systems, particularly through encouraging greater dialogue at the science-policy interface; environmental education; and multi-media outreach to the wider community (UNESCO nd).

The Fitzgerald River Biosphere Reserve in Western Australia, the focus of this project, has had a notional transition zone since the 1980s and has been functioning as a biosphere reserve in all but name. The community are currently applying for re-designation. This process provides an opportunity to examine ways to improve integration between agriculture and conservation at a landscape scale.
The Fitzgerald Biosphere Reserve

The 242,739 ha Fitzgerald River Biosphere Reserve was listed under the UNESCO Man and the Biosphere Program in 1978, after nomination by the WA Government. The boundaries specified were the then boundaries of the Fitzgerald River National Park. The area in the National Park has since increased to 329,000 ha and these areas have been incorporated into the designated reserve. The Biosphere Reserve has very high ecological values that extend beyond the core area. While there was a notional transition zone, known as the Fitzgerald Biosphere sub-region in NRM planning processes (Figure 3), there had been no formal designation of buffer and transition zones with UNESCO. At the time of writing this report, the newly formed Biosphere Implementation Group was going through the process of deciding on boundaries for re-designation with UNESCO with the new name of Fitzgerald Biosphere Reserve (FBR) rather than Fitzgerald River Biosphere Reserve. The spatial area including the notional transition zone will be referred to as the FBR in the rest of this report.
The core area of the Biosphere Reserve (the Fitzgerald River National Park) has very high amenity and ecological values. The Fitzgerald River National Park contains almost 20% of the known flora of the South West Botanical Province. The South West Botanical Province has been listed as one of 25 (Myers et al. 2000) or 34 (Mittermeier et al. 2004) international biodiversity hotspots. The FBR is the only UNESCO Biosphere Reserve within the South West Botanical Province. Hopper and Gioia (2004) argue that the richest flora is in the 300-600mm rainfall zone of the South West hot spot with very high species richness in the FBR. The area has over 2500 described vascular flora species with over 100 species endemic to the FBR.

The notional transition zone is an area where the major industries of mining, agriculture and tourism are important for the sustainability of communities. Most of the river systems in the FBR flow through cleared catchments in the notional transition zone before entering the core area of the reserve. Clearance of native vegetation in the upper catchments has led to loss of biodiversity and changed the hydrological balance of the area. Current threats include feral animals, further habitat fragmentation, inappropriate fire regimes, fungal disease, grazing and weeds. Fragmented habitats are vulnerable to fire, salinity and the fungal pathogen Phytophthora cinnamomi. Rivers and wetlands are affected by increasing salinity and sedimentation. Estuaries and coastlines are impacted by increased nutrients and coastal tourism (Fry 2010).

There is still considerable research to be done on understanding the ecosystems and ecological values of the FBR and the best way to manage the threats to those values. There is also a need to develop a better understanding of the interactions between agriculture and biodiversity in the region.
Agriculture and the Fitzgerald River Biosphere Reserve

The nutrient deficient, highly weathered mosaics of soils, which provide challenges for agriculture productivity, are one of the reasons for the high levels of endemism and biodiversity in the FBR (Hopper & Gioia 2004).

Until the 1950s agriculture was mainly restricted to the more resilient heavy soils but after the second-world-war there was a rapid expansion of agriculture into lighter sandplain soils (Bradby 1989). Land was released under a soldier settlement scheme and later under a conditional purchase scheme. Most agricultural development occurred in the FBR in 1960s. For example, in the period from 1960 to 1973, nearly 300,000 hectares was alienated in the region around what is now the Fitzgerald River National Park (Bradby 1989).

The local economy is now dependent on agriculture. At the 2006 census (ABS 2007) over 30% of the people living in the notional transition zone were engaged in farming (48% in Jerramungup shire and 20% in Ravensthorpe shire).

Agriculture in the region is based on broadacre systems of winter cropping and livestock. The proportion of livestock in the system has declined steadily since the 1980s. Cropping in the notional transition zone of the FBR is mainly wheat and barley in rotation with canola and in some areas lupins. Lupins have proved to be unreliable in many areas of the central south coast. Barley cropping increases with increasing rainfall towards the coast but unseasonal rainfall limits the production of malting barley (Department of Agriculture 2004). Sheep enterprises are mainly self-replacing merino flocks for wool production with some prime lamb production. There is also some beef cattle production in higher rainfall areas near the coast (Fry 2010).
Pastures are mainly annual subterranean clover pastures but there is increasing diversity in the pastures grown, with some aerial seeding annual pastures such as cadiz serradella grown on acidic sandy soils, and perennial pastures, such as kikuyu and lucerne grown on suitable soils. Annual medics are grown in heavier soils. Some field peas are grown on specific soil types. The lack of a suitable grain legume for rotation in much of the FBR has led to relatively rapid adoption of lucerne pastures and annual pasture legumes in the rotation (Department of Agriculture 2004). New tetraploid ryegrasses are also being planted. Summer crops have been trialled in the past with variable success (DAFWA staff pers com cited in Fry 2010) but may become more useful if there is increasing summer rainfall with climate change.

The region has had particular challenges for agriculture due to the nature of the soils, distribution of rainfall, problems with continuous cropping systems and restrictions on investment capital. There have been wide seasonal variations impacting on production and events such as wind erosion, floods, frosts and locust plagues.

Climate change and land degradation are beginning to impact on productivity (Department of Agriculture 2002). The combination of seasonal variability, out of season rainfall and soil constraints has provided particular challenges for the farmers in the region.

Although there has been an increase in perennial pasture, mainly lucerne, in some farming systems in the region, many farmers still have reservations about the establishment and longevity of lucerne, particularly in areas where there is sandy topsoil. Others are unlikely to plant lucerne because of the establishment costs and uncertainty as to the benefits to their system. Soil structure and whether or not there is a livestock enterprise are both important in decisions farmers make about growing perennials (Fry 2010).

Most of the recent innovation in farm management has been a focus on soil amendment with precision agriculture (PA) and variable rate technology (VRT). An important strategy used by the Department of Agriculture and Food (DAFWA) in improving yields is to benchmark best yields against potential yield for rainfall and identifying if the yield gap is due to a soil constraint (Oliver et al. 2009).

There has been very limited diversification in the region into other agricultural activities but there are small enterprises such as yabbies, potatoes, native flora and farm tourism.
Natural resource management in the Fitzgerald Biosphere Reserve

Trialling the effectiveness of different nutrient applications on wheat at Jerramungup, Photo courtesy Jalisa Small, FBG

Natural resource management problems

One of the specific challenges for sustainable farming systems in the FBR region is appropriate management of soil constraints. The off-site impacts of reduced plant growth and water use, include degradation of waterways due to increased run-off, leaching and salinisation (Gazey & Davies 2009).

A significant proportion of the FBR region consists of sandplain soils. The constraints of sandplain soils for production include water repellency, susceptibility to water logging, acidification, low organic matter content and low water and nutrient retention (Hall 2009).

Wind erosion was a major problem on the sandplain soils in the 1980s with some events in the 1990s. Although this has been significantly reduced by minimum or no-tillage practices there can be risks when farmers dry seed or over-graze. Wind erosion not only depletes the top-soil but leads to increased sedimentation and eutrophication of the river systems and estuaries in the FBR.
Acidification of soils is both a productivity and natural resource problem in the FBR (Gazey & Davies 2009). Only 2-3% of sandplain soils are at a pH where they require maintenance liming only (Davies et al. 2009, p.73). Sub-soil acidity is an even greater problem than top-soil acidity and is harder to ameliorate (Davies et al. 2009).

Farmers looking at the effects of sub-soil acidity in the Bremer River catchment, Photo courtesy Anne Sparrow, FBG

Most of the sub-soils in the FBR region are sodic and so highly susceptible to soil structure decline. The most affected are hard setting grey clays and shallow loamy duplex soils. DAFWA suggests that no till farming and the use of lucerne, vetches or green manure to increase organic matter content is the most sustainable solution (Fry 2010). Deep coarse sands with low water holding capacity, low cation exchange capacity, water logged areas, and highly acidic sub soils are considered uneconomic to ameliorate (Lemon 2009, p.97).

Even with increasing levels of inputs, there is evidence that fertility has decreased in some soil types in the FBR since they were first cleared. This is probably due to a combination of factors including increasing soil acidity, past wind erosion events and soil structure decline. It could also be linked to changes in soil that have occurred after clearing of native vegetation, such as decreases in native root channels or changes in organic matter and soil structure (Hall 2009).

Excessive land clearance for agriculture has been the main cause of habitat loss and fragmentation in the region of the FBR. A relatively high number of species across the zone have rare or endangered status (DEC 2012). Grazing of unfenced remnant vegetation and loss of paddock trees in order to develop large scale cropping enterprises further reduces habitat.

Altered hydrology and the subsequent increases in salinity and waterlogging have a major impact on river systems, wetlands and vegetation. Increases in waterlogging interact with salinity to impact on
plant growth. Changes in hydrology have led to infilling of river pools, increased sedimentation of estuaries, altered turbidity and increased flood risk (Gunby et al. 2004). Nutrient run off into rivers and wetlands is another major threatening process. Several of the major river systems and estuaries are eutrophic (Figure 4).

Figure 4 Eutrophic rivers and estuaries in the Fitzgerald Biosphere Reserve.
Source: Modified from map by SCRIPT in Gunby et al. (2004)

More than 80% of the catchments of the Wellstead Estuary, Beaufort and Gordon Inlets have been cleared and these catchments also have high phosphorus levels (Gunby et al. 2004). Increased phosphate loads cause increases in algal growth and loss of seagrass, impacting on marine habitats.
There are therefore major natural resource management risks associated with farming in the region. Farmers, DAFWA and consultants accept that if farming is to remain as an industry, there is likely to be a continuation of the increase in farm size and percentage cropping (Fry 2010). The region has the same problem as many rural regions in Australia; as the population declines in farming areas there is a loss of services. The lack of social amenities in the sub-region is a major dis-incentive for young people. Health services are not of a high standard and it is difficult to attract medical practitioners to small towns. The loss of community as a result of farm amalgamation is impacting on community activities and core volunteer services. This in turn impacts on willingness to volunteer time to protect biodiversity and water quality. Most of the landcare groups argue that they are only able to focus on natural resource management with the assistance of landcare coordinators and government funding (Fry 2010). There are several natural resource management groups working in the region to obtain funds and coordinate activities. Most farmers actively involved in landcare in the region believe they are doing as much as they can to protect natural resources within the constraints of their business and the options available to them.
Natural resource management groups

The regional NRM group, South Coast NRM, has received most of its funding under the Commonwealth NRM programs; The Natural Heritage Trust, The National Action Plan for Salinity and Water Quality, and Caring for Our Country. It also receives some State NRM funding. South Coast NRM, in turn, funds many of the projects within the FBR region including soil health projects, increasing perennial pastures, weed and invasive species control and dieback management (South Coast NRM nd). Commonwealth funded projects through Caring for Our Country have had to align with national rather than regional priorities but they have enabled a continuation of on-ground works.

The two main community landcare groups working in the FBR, the Fitzgerald Biosphere Group (FBG) and the Ravensthorpe Agricultural Initiative Network (RAIN), arose from the original statutory Land Conservation District Committees of the shires of Jerramungup and Ravensthorpe. The Jerramungup group adopted the name, Fitzgerald Biosphere Group, even though the Ravensthorpe based group works in the other half of the Biosphere. This has caused some problems between the two groups. The existence of two separate landcare groups has caused some problems for the overall governance of the FBR.

RAIN also works in parts of the Lake Grace and Esperance shires. The groups are therefore mainly based on social and catchment boundaries and not strict NRM sub-regional boundaries. The FBG and RAIN in turn function as umbrella groups for the smaller catchment groups. Both groups are linked to production groups such as the South East Premium Wheatgrowers Association (SEPWA) and the WA No Till Farmers Association (WANTFA). The project officers of FBG and RAIN work together on re-vegetation and other projects and this ensures there is some coordination across the FBR. For example the FBG and RAIN together formed the Fitzgerald Biosphere Marketing Association (FBMA) to explore marketing opportunities using regional branding based on sustainable agriculture.

The FBG coordinates catchment activities such as Fitzgerald River Catchment Demonstration Initiative and projects protecting the ecological and cultural values of the Bremer River and Wellstead Estuaries. RAIN has also been involved in catchment projects and restoration work on the Culham inlet.

The Friends of the Fitzgerald River National Park (FFRNP) is an independent volunteer community group which assists with conservation activities of the Fitzgerald River National Park. The group currently has a major project rebuilding the Twertup field studies centre, which was damaged by bushfire in 2008. The FFRNP is an active lobby group when there are threats to the biodiversity of the Park. The FFRNP has many members from outside the FBR with a keen interest in the National Park and its biodiversity. The group helps to bridge the Ravensthorpe and Jerramungup communities in the FBR and works with both the FBG and RAIN in projects on protected biodiversity (Fry 2010).

Gondwana Link is a collaboration of private sector groups working to protect and restore ecological functions across the region. The legal entity, Gondwana Link Ltd, provides overall support and coordination for the program. The aim of Gondwana Link is to create “connected and functional landscapes” (Gondwana Link nd). The Gondwana Link member groups, Bush Heritage Australia and Greening Australia, have purchased 10,900 ha in the Fitzgerald-Stirling Ranges link, part of which is in the FBR (Figure 5). The properties purchased have large areas of remaining vegetation and high conservation values. Cleared areas are being restored using best practice restoration methods. Gondwana Link used the Nature Conservancy’s ‘Conservation Action Planning’ method to establish conservation targets.
Whether farmers adopt systems that protect the ecological values of the FBR is dependent on both economics and lifestyle factors and values (Pannell et al. 2006). Restructuring has meant that many farmers are managing much larger enterprises than in previous generations and they have a strong business focus. Systems that prevent the movement of agricultural machinery, constrain the grazing of livestock, harbour more pests and diseases or compete with crop are unlikely to be adopted by farmers (Goldney & Bauer 1998).

The Fitzgerald Biosphere Group regarded catchment initiatives funded under NHT, such as the Fitzgerald Catchment Demonstration Initiative, as an opportunity that arose as a result of being a Biosphere Reserve (Fry 2010). Demonstration projects aim to encourage faster adoption. The Fitzgerald Catchment Demonstration project investigated a number of strategies linking agriculture and conservation, such as intensive soil amelioration and an increase in perennials. Planting of perennials was able to decrease water tables in this catchment (Ferdowsian pers com). This whole of catchment demonstration is good example of UNESCO’s concept of biosphere reserves as sites for demonstrating integration of development and conservation.

The current project aims to suggest new research and demonstration projects for the FBR based on the discussion of the case studies and ideas from the research partners. The following chapter outlines the 6 case studies used in discussions.
Case study 1 Participatory modelling in biosphere reserves

Participatory modelling is an approach that enables a group of people, often with different or conflicting perspectives, to develop a shared understanding of how a complex system operates (Voinov and Bousquet 2010; Sinclair 2012). The advantage of participation in the modelling process is that it captures knowledge from different people, increases the chances of implementation and increases learning (Vennix 1999, van Den Belt 2009). Sinclair (2012, p.45) argues that the most important outcomes are enhanced democracy, greater engagement, improved quality of management solutions and reduced conflict over resources. The limitations of participatory modelling include cost and time (Sinclair 2012) and the need for highly skilled facilitators (Etienne 2006). Other problems that might arise are models that are too complex, have a biased agenda (Leys and Vanclay 2011a) or do not have sufficient expert input or knowledge to be useful for management (Sinclair 2012).

There are different terms used for modelling involving a range of participants including mediated modelling (van den Belt 2009), companion modelling (Etienne, 2006) co-modelling (Levrel et al. 2009) and group model building (Vennix et al. 1992; Richardson et al. 1992). The emphasis varies with some focussed more on the learning and others putting more importance on the model. A range of modelling approaches can be used such as agent-based models, system dynamics or qualitative conceptual models. Models can therefore vary in complexity from graphical representations of mental models through to computational simulation models (Sinclair 2012). Often the value lies as much in the process of developing the model as in the model itself (Voinov and Bousquet 2010). Sinclair (2012, p.26-27) lists the functions of participatory modelling. These include defining the problem, increasing and sharing knowledge of a particular system, enhancing innovation of thinking and solutions, education, increasing participation in decision making and giving it legitimacy, and finding public preferences and values. The participants become aware of the interactions between their actions and the ecological system (Voinov and Bousquet 2010). Modelling can also have a role in assisting communities to work cooperatively (Sinclair 2012, Etienne 2006).

The aim of biosphere reserves is to work cooperatively to reconcile development and protection of biodiversity. Etienne et al. (2011) suggests that the explicit goal of building a model in a biosphere reserve is to assist collective decision-making processes. The aim of constructing a model of a natural resource management problem in a biosphere reserve is to find a way to manage the interactions between the human (economic and social) dynamics of the area and the ecological dynamics (Etienne 2006). The model captures the interactions, viewpoints and objectives in relation to a particular natural resource management problem (Etienne 2006; Etienne et al. 2011; Rouan et al. 2010; Voinov and Bousquet 2010. The pooling of information enables co-production of knowledge about the system (Levrel et al. 2009).

A form of participatory modelling, known as companion modelling or co-modelling, has been used in French and African biosphere reserves (Etienne et al. 2011; Levrel and Bouamrane 2008; Levrel et al. 2009; Rouan et al. 2010; Anselme et al. 2010; Mathevet 2011). The models are used in French biosphere reserves when they are initiated, at periodic review and if there is any natural resource conflict that needs resolving (Etienne 2006). The particular approach used in French biosphere reserves is agent-based modelling also known as a multi-agent system (Etienne et al. 2003; Bousquet and Le Page 2004).

The explicit goal of model building in biosphere reserves is to assist collective decision processes (Etienne et al. 2011). It involves a series of workshops. Interested groups may include land managers such as farmers, NGOs, scientists and local policy makers. The questions the group answer are:
1. What are the principal resources of the territory and what is the key information to guarantee a sustainable use of these resources?

2. Who are the main stakeholders involved?

3. What are the main processes that drive strong changes in resource dynamics? (Etienne 2008, p. 868)

In the model building process, the people, the resources, the dynamics and the interactions are identified and clarified (Etienne et al. 2011). It is critical to have highly skilled facilitators, representation and legitimacy in the participants and clear objectives (Etienne 2006; Levrel et al. 2009). The product is a conceptual model; a graphical representation of a model of a natural resource management problem in the biosphere reserve. This can be translated into a computer model to examine various scenarios (Etienne 2006) and used to develop an adaptive modelling approach (Voinov and Bousquet 2010).

The Man And Biosphere (MAB) UNESCO program and the French Institute of Biodiversity (IFBR) launched a co-modelling process in order to analyze interactions between human activities and ecological dynamics in several biosphere reserves (Anselme et al. 2010). The case studies below are from the Isle of Ouessant in the Mer d’Iroise Biosphere Reserve, Lure mountain in the Lubéron-Lure Biosphere Reserve and the Camargue Biosphere Reserve.

**Mer d’Iroise Biosphere Reserve Reserve – Isle of Ouessant**

From Levrel et al. (2009); Rouan et al. (2010)

The Isle of Ouessant is off the western coast of Brittany and is part of the Mer d’Iroise Biosphere Reserve. Changes in agricultural practices and lower numbers of livestock have led to shrub encroachment by bramble, gorse and willow (Gourmelon et al. 2001; Levrel et al. 2009; Rouan et al. 2010). The modelling enabled the participants to develop mental models of the system and all its interactions (Levrel et al. 2009; Rouan et al. 2010). The aims of the project were to understand the vegetation dynamics, how people view natural resource management practices and the impact of management strategies (Levrel et al. 2009; Rouan et al. 2010). There were a number of workshops in constructing the conceptual model and the facilitator had to construct a clear diagram of the system. Although the diagram was a simplification of the Isle’s agricultural, ecological and tourism interactions, the process of constructing it brought together different viewpoints and the participants felt it was a good representation of the Isle’s overall system (Rouan et al. 2010)

**Lubéron-Lure Biosphere Reserve**

From Anselme et al. (2010)

The study on Lure mountain was a multi-disciplinary research project in the Lubéron-Lure Biosphere Reserve. It centred around a similar problem as that on the Isle of Ouessant, shrub encroachment, but this process had to deal with two conflicting conservation objectives and management practices. The objectives were defined by a multi-disciplinary team of scientists but modified significantly by the land managers within the biosphere (Anselme et al. 2010). The modelling in this case study was of most use to scientists involved in understanding the dynamics of the system and enabled them to explore different scenarios.

A report on the modelling process was prepared for the 2010 periodic review of the Lubéron-Lure Biosphere Reserve. The International Coordinating Council of the Man and the Biosphere Program recommended the report be distributed through the World Network of Biosphere Reserves as an example of best practice. The Council stated:

*It is a dynamic methodology which makes it possible to bring together the actors of a site around a project and, thus, to hold constructive debates on possible problem areas (UNESCO 2011).*
Camargue Biosphere Reserve

A participatory modelling approach was also used by Mathevet et al. (2011) in the Camargue Biosphere Reserve to explore the degree to which different groups of participants had shared mental models of the water management system of the Rhône delta. Those involved found it very useful in understanding the complexities of the water management system and believed it would contribute to better decision-making (Mathevet et al. 2011, p14).

The use of participatory conceptual/mental models has therefore been explored extensively in biosphere reserves and found to provide a mechanism for a shared understanding of the system and its dynamics.

In Australia participatory modelling has been used as a tool for initiating discussions over plantation hardwood forestry expansion in the sub-tropical Upper Clarence catchment of north-eastern NSW (Leys & Vanclay 2010, 2011a, b). The process was found to reduce conflict and increase social learning (Leys & Vanclay 2010, 2011a,b). The Cooperative Research Centre for Forestry has recently published a technical report: *A Guide to Participatory Modelling* (Sinclair 2012).
Case study 2 Ecosystem services at biosphere scale

Landscape multi-functionality is the concept that the landscape is offering multiple social, economic and environmental benefits (de Groot 2006; Carpenter et al. 2009; Daily et al. 2009; Lovell and Johnson 2009; O’Farrell et al. 2010). It also is a way to envisage the threats, conflicts, trade-offs and costs between the different functions (Bennett et al. 2009; Egoh et al. 2010). Ecosystem services or ecological services are defined as the benefits humans derive from natural systems (Daily 1997; Millennium Ecosystem Assessment 2003).

Agricultural multifunctionality is defined as the joint production of commodities and “ecological services” (Jordan et al. 2007, p.1570). Some of the ecosystem services produced by agriculture include soil retention, pest control, pollination, nutrient cycling, rural lifestyles and aesthetic landscapes (Stallman 2011). In a landscape approach, agricultural landscapes are regarded as multi-functional landscapes offering multiple environmental, social and economic benefits. There may be synergies or trade-offs needed in these multiple goals (O’Farrell et al. 2010, p.1232).

The Millennium Ecosystem Assessment (2003, p.57) divided ecosystem services into functional groups: “provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth”.

<table>
<thead>
<tr>
<th>Provisioning services</th>
<th>Ecosystem regulating services</th>
<th>Cultural services</th>
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<tr>
<td>Food</td>
<td>Climate regulation</td>
<td>Recreation and ecotourism</td>
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<td>Freshwater</td>
<td>Disease regulation</td>
<td>Aesthetic</td>
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<tr>
<td>Fibre</td>
<td>Water regulation</td>
<td>Inspirational, Spiritual or Religious</td>
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<tr>
<td>Timber</td>
<td>Water purification</td>
<td>Sense of place</td>
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<tr>
<td>Genetic resources</td>
<td>Pollination</td>
<td>Educational</td>
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<tr>
<td>Biochemicals</td>
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<td>Cultural heritage</td>
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Supporting services

Figure 6 Examples of ecosystem services
(Modified from Millenium Ecosystem Assessment, 2003)
If agricultural landscapes are regarded as multi-functional, in providing a full range of economic, social and environmental services, the activities of farmers in providing these services has a value to the beneficiaries. For many ecosystem services, the beneficiaries are the public and the services require landscape scale cooperation rather than just action by an individual farmer (Goldman et al. 2007). Many ecosystem services are highly suited to cooperative management at catchment or wider scale such as the scale of a UNESCO biosphere reserve. Although there are costs in establishing and maintaining cooperation, working together at a larger scale reduces those costs (Goldman et al. 2007). Using an ecosystem services approach to conservation has also been found to attract more funding from a greater diversity of funders than traditional conservation (Goldman et al. 2007). The biosphere reserve provides a mechanism for cooperative management and funding of ecosystem services. In the US the Environmental Protection Authority has been exploring a system of environmental accounting to put an economic value on ecosystem services (Jordan et al. 2010).

For example, if farmers protect wetlands on their farm they may be providing habitat, a refuge from climate change and reductions in nutrient and soil export. Increasing perennials in the farming system also has been shown to increase ecosystem services such as reducing soil and nutrient losses and greater carbon sequestration (Jordan et al. 2007). In Western Australia perennials have been shown to reduce water tables and salinity in some landscapes (Turner & Ward 2002). Jordan et al. (2007 p.1571) argued that sites for research and demonstration of multifunctional agricultural systems, need to be at a landscape scale, include trade-offs and involve all interest groups. Chan et al. (2006) argued that the flow of ecosystem services is poorly characterized at the local to regional scale. The spatial scale of the biosphere reserves in Australia is highly suited a local or regional scale approach to mapping ecosystem services.

The concept of multifunctional landscapes is closely linked to the ‘integrated landscape’ approach (Harvey et al. 2008). This approach is in contrast to large-scale industrial agriculture where the emphasis is on maximizing efficiency (Harvey et al. 2008). Fischer et al. (2008) contrasted land sparing with wildlife friendly farming. Under land sparing agricultural yields are maximized on farmland while other areas are spared for nature conservation. In the industrial agriculture approach, nature is seen as separate from human activity rather than integrated. The emphasis in land sparing is on efficiency whereas wildlife friendly farming or ecoagriculture (McNeely & Scherr 2003) may provide a more adaptable landscape (Fischer et al. 2008; Walker & Salt, 2006). In the integrated landscape approach the agricultural landscape is more heterogeneous (Harvey et al. 2008), more fine grained (Fischer et al. 2008) and forms a mosaic landscape. In the landscape there are more vegetation patches, more riparian areas, trees for shade canopies, and greater landscape connectivity. This landscape has the potential to be more resilient (Fischer et al. 2006, 2008). Research on ecosystem services can also indicate whether wildlife friendly farming is more cost effective than retirement of “marginal farmland” to increase habitat (Boody et al. 2005; Jordan et al. 2007, p.1571). There are strong arguments for more research to understand the relationships and tradeoffs of ecosystem services and the way management changes these (Bennett et al. 2009; Carpenter et al. 2009).

By documenting the provision of ecosystem services across landscapes, interactions and connections between them can be established (Bennett et al. 2009). Mapping ecosystem services may involve mapping areas where ecosystem services and biodiversity targets correspond or where there may be potential for conflict between production services and others such as water quality or biodiversity. Examining the spatial correspondence between biodiversity and ecosystem services provides a more integrated approach to conservation planning that includes human needs and well-being (Jordan et al. 2007; Egoh et al. 2007).
Gouritz Cluster Biosphere Reserve -Little Karoo South Africa

From O’Farrell (2010); Egoh et al. (2010)

The Karoo is a semi-arid biodiversity hot spot in the newly formed Gouritz Cluster Biosphere Reserve in South Africa. Overgrazing has caused major degradation and there is pressure from mining, irrigated cropping and inappropriate development. Only about 49% of the natural vegetation remains (Egoh et al. 2010). Climate change is also a threat (O’Farrell et al. 2010; Egoh et al. 2010). Surface water, groundwater, grazing and tourism were identified as the key services in the area (O’Farrell et al. 2010). Although the government conservation agency held a planning forum to explore ways to improve sustainability, including land management programs and the investigation of carbon markets, implementation was slow (Egoh et al. 2010).

O’Farrell et al. (2010) searched for synergies at a landscape scale between biodiversity conservation objectives and ecosystem service use and management in the Karoo. They mapped and modelled key ecosystem services looking for overlap between ecosystem services and biodiversity priority areas. A small number of areas have most of the biodiversity and ecosystem services. The case study aimed to identify synergies and trade-offs and highlight important areas for management. Although they found the overlap between biodiversity and other ecosystem services were generally low there were areas where there were synergies and where action could have multiple benefits. The study also showed the importance of assessment at local level as well as a broader regional level.

Egoh et al. (2010) used data from three ecosystem services, carbon storage, water exchange and fodder provision. They found that by selecting areas for both biodiversity and ecosystem services the opportunity costs of conservation could be smaller. They also used scenarios to explore trade-offs between biodiversity and ecosystem services targets.

Central Coast Ecoregion of California

Similarly Chan et al. (2006) mapped ecosystem services in the central coast of California, comparing priority areas for biodiversity with priority areas for ecosystem services. They used 6 ecosystem services: carbon storage, crop pollination, flood control, forage production, outdoor recreation and water provision. Again, the correlations were quite low but there were areas where high values of multiple benefits coincided. Chan et al. (2006) also found that if they used a strategic set of ecosystem services biodiversity, carbon, flood control, recreation, and water provision, the overlaps were much greater. They concluded that the inclusion of ecosystem services in conservation planning has potential to provide opportunities for biodiversity protection. Chan et al (2006) argued that conservation efforts can be more effective if both the trade-offs and benefits for biodiversity and other ecosystem services are documented.
Case study 3 Linking Precision Agriculture and Precision Conservation

Conservation has the potential to be much more effective and economical if specific, critical areas are targeted. Delgado and Berry (2008) used the term ‘precision conservation’ to describe the use of spatial and temporal information on variability (e.g. differences across the farm or catchment and seasonal differences) in the landscape for conservation objectives. Farmers may develop a better understanding of the relationship between management on specific areas of the farm or catchment and conservation of soil or other natural resources by using the same technologies as used in precision agriculture. It is a dynamic area with new technology and software constantly being developed and the precision improved.

A major objective of precision agriculture is to target inputs to production using geospatial tools such as Global Positioning Systems (GPS), remote sensing and Geographic Information Systems (GIS). In other words the objective is to minimize inputs and maximize yields or profitability per hectare (Bingner et al. 2010) whereas in precision conservation the objective is to use the same geospatial tools to understand off-site impacts and increase conservation of natural resources. There are opportunities to link the two objectives with precision management of the farm system. Sometimes profitability and conservation objectives correspond directly. For example controlled traffic farming increases profitability and reduces soil erosion. Variable rate technology, in some cases, may decrease fertiliser use. Both precision agriculture and precision conservation relate to the enormous variation on farms in terms of soil, topography, hydrology, and past management and how these factors relate to seasonal variations.

Linking precision agriculture and precision conservation enables farmers to target areas:

- to reduce nutrient or soil loss from the farm
- for perennial agriculture which might have dual profit and conservation objectives
- for carbon plantings or conservation plantings with minimum sacrifice of profitable land.

Precision conservation enables the farmer to identify areas for specific management, maximizing the conservation impact per hectare, and also reducing loss of valuable inputs. It can be used across scales from mosaics within paddocks, to field scale and catchment scale. Identifying areas with the heaviest contribution to flows off the farm shows which parts of the farm are most susceptible to run-off and loss of sediment and nutrients (Delgado & Berry 2008; Delgado et al. 2011). At the catchment scale, precision conservation can assist in identifying the most important areas for buffers for reducing erosion and protecting wetlands. It can also be used to design precision riparian buffers so they are most effective in reducing sediment, nutrients or providing shade to protect against climate change. Precision conservation has been used in US watersheds (e.g. Galzki et al. 2011; Tomer et al. 2012) to collect site-specific erosion data.

High Resolution Light Detection and Ranging (LiDAR) Long Point Biosphere Reserve, Ontario

New remote sensing tools such as Light Detection and Ranging (LiDAR) have the potential for detailed terrain analysis, improved hydrological modelling, and monitoring restoration projects. LiDAR is an active remote sensing technology that uses light pulses to measure distance and other characteristics (texture, hardness, etc.) of terrain and objects. For example, LiDAR data can be used to construct Digital Elevation Models at a much higher resolution over much larger areas than previously possible (Liu et al. 2005).
Using LiDAR imagery the Long Point biosphere reserve was able to obtain high-resolution digital terrain data (Figures 7 and 8). The data can be used in hydrological modelling and can be used in precision conservation such as identifying important restoration sites. The information is also being used to develop a spatial database of land management as part of Ontario’s Agricultural Resource Inventory. It provides digital information on farmstead, farm field, fencerow, roadway, ditch, and riparian and rough land areas to assist with both agricultural management and environmental stewardship programs and monitoring (Sweeney 2010).

Figure 7 LiDAR coverage of Long Point Biosphere Reserve
Source: Sweeney (2010)

Figure 8 LiDAR derived digital elevation model
Source Sweeney (2010)
LiDAR of Corangamite Catchment

Liu et al. (2005)

LiDAR data for an area of 6900 km2 were collected over the period 19 July 2003 to 10 August 2003. The data enabled much greater accuracy in defining sub-catchment boundaries, which in turn could improve hydrological modelling and management of water flows.

Clay pan soil field in Missouri

Kitchen et al. (2005)

The aim of precision management of the field was to use precision methods to develop multiple management strategies to address both profitability and conservation simultaneously. In the clay pan soil field, long term monitoring showed where topsoil had been lost and where nitrate was leaching. Kitchen et al. (2005) used a profit map to identify three management zones and then developed a precision agricultural system to integrate production and conservation goals.

Kitchen et al (2005) described four steps to creating a precision management system.

1. Assess the spatial and temporal information on crop, water and soil characteristics of the field. For example soil maps, profitability maps. Identify main management zones.
2. Determine priorities to make the system more sustainable
3. Set up the precision agriculture system
4. Implement and compare to previous management of the field (Kitchen et al. 2005, p.426)

Conservation buffers, Mississippi

McConnell and Burger (2011) identified specific conservation buffers on a 1, 200 ha farm in Tallahatchie County, Mississippi. Using geospatial tools to identify conservation opportunities versus economic trade-offs, specific buffers were identified for enrolment for incentives under the US Farm Bill. This enabled farmers to identify and trade-off specific areas of land without loss of profitability.

Cheney Lake Watershed

In the Cheney Lake watershed in the US, precision conservation methods, including digital elevation models and terrain analysis, were used to identify ephemeral gullies, which contributed a major part of the sediment load to the Lake. This will then enable targeted action on those gullies to reduce loss of sediment (Bingner et al. 2010).

Precision Agriculture in Australia linking profit and conservation objectives

Stephen, Shane and Brian Paddick from Wallaroo on the Yorke Peninsular SA used yield maps to permanently retire low-lying areas of high salt and boron from cropping. Yield maps were used to delineate profitable and unprofitable areas of paddocks over a six-year period. The restriction of inputs to profitable areas should increase whole farm profit (SPAA 2008 p.24 ). Robin Schaefer began yield mapping in 2004. He adopted a variable rate phosphate strategy in 2008 after trials indicated that P fertiliser rates could be substantially reduced across the farm (SPAA 2008 p.36).

Zerger et al. (2009), in a RIRDC project, investigated the potential use of precision conservation in Australia with the Birchip cropping group and the Wimmera Catchment Authority. They investigated the potential to map regional scale conservation objectives using vegetation data and opportunities for high resolution yield mapping to trade-off areas of low agricultural productivity for conservation. Recent climate variability made it difficult for the small number of farmers in the study to identify poor performing areas without detailed analysis of the time series data. Zerger et al (2009) suggested the potential to use precision methods to define management zones.
Precision methods therefore have three main applications in linking agriculture and conservation. At catchment scale they can be used to identify priority areas for on-ground work, such as nutrient buffers, with much greater precision than in the past. At farm scale they can be used to identify low yielding areas, for strategic plantings to increase biodiversity on farm or carbon capture. Finally they can be used to reduce nutrient inputs and thereby off-site impacts on aquatic systems.
Strategic adaptive management was first used in managing river systems in South Africa (Biggs and Rogers 2003). It has since been used in the context of a wider range of natural resource management problems (Biggs et al. 2011) and has been advocated as a way of managing freshwater systems in Australia (Kingsford et al. 2011). Adaptive management can be generally defined as “learning by doing” (Walters 1997) but importantly it recognises the need to be flexible in management and acknowledge uncertainty (Kingsford et al. 2011). The process should include research, planning, management and monitoring in repeated cycles (van Wilgen and Biggs 2011, p1179). Strategic adaptive management differs from traditional adaptive management in that it has a greater emphasis on the desired future condition of natural resources with the setting of goals and a hierarchy of objectives (Biggs & Rogers 2003; Kingsford et al. 2011). Realistic goals are developed for the desired future state of a natural resource based on societal values and scientific rigour (Rogers and Biggs 1999). This adaptive planning stage is viewed as the key to translate a consensus vision of what the future state should be into measurable objectives. It is important that the objectives are revisited and revised with new knowledge (van Wilgen & Biggs 2011). van Wilgen and Biggs (2011, p1182) described adaptive planning as “setting up” adaptive management.

In the original conceptualization Thresholds of Potential Concern (TPCs) were effectively statements of the limits of acceptable change in the ecosystem. TPCs provide a warning that there is a need for management intervention. They effectively act as an amber light (Rogers & Biggs 1999, p. 439; Biggs et al. 2011). Monitoring of the TPCs also provides information on whether the objectives and TPCs need to be modified (Biggs & Rogers 2003). TPCs range from fairly readily defined through to ‘best guesses’ and are determined by human values guided by best knowledge on biophysical limits (van Wilgen & Biggs 2011). Thus they are often “first approximations” that need refining as knowledge of the system increases (van Wilgen & Biggs 2011, p.1186).

The Strategic Adaptive Management approach in which TPCs are embedded assumes an often-changing context in which resource management is taking place (Biggs et al. 2011, p. 1).
The use of TPCs over a period of time has allowed reflection on how they might be better used. The important lessons learnt from the use of TPCs in Africa are that they should not be used in isolation but embedded in a systems context and considered in terms of social, economic and biophysical interactions (Biggs & Rogers, 2003; Biggs et al. 2011; Kingsford et al. 2011) (See Figure 9). The TPCs also need to reflect values and objectives of the desired state (Biggs et al. 2011, p.8). The adaptive planning phase of strategic adaptive management is increasingly considered critical to successful implementation (Roux and Foxcroft 2011 p.2). In relation to river management, improvements in strategic adaptive management have included more explicit links between higher-level biodiversity objectives and TPCs, explicit TPCs per river because of differences in river systems, and social objectives and TPCs (McLoughlin et al. 2011).

**Strategic Adaptive Management in the Kruger to Canyons Biosphere Reserve (based around the Kruger National Park)**

The Kruger to Canyons Biosphere Reserve includes the Kruger National Park, the Blyde River Canyon Nature Reserve and other nature reserves. The Kruger National Park (KNP) (nearly 2 million hectares) is situated in the north-eastern corner of South Africa, bordering Mozambique and Zimbabwe. It is semi-arid savanna with fires in the dry season and highly variable rainfall. The mean annual rainfall varies between 350 mm in the north and 750 mm in the south (van Wilgen & Biggs 2011). The KNP was designated a protected area in 1898 and gained national park status in 1926. The Kruger to Canyons Biosphere Reserve was officially designated with UNESCO in 2001 but before that there had been a long history of park managers working with communities outside the KNP. There is a large area of conservation land in the biosphere reserve but also rural communities living on tribal land.
Land uses include mining, tree plantations and horticulture. Kruger National Park managers had to liaise with people outside the protected area because the perennial rivers originated outside the park (Pollard et al. 2011). Strategic adaptive management served as the means of finding a balance between the vision for the KNP and the catchment stakeholders and a unified management approach (Kingsford et al. 2011). The adoption of strategic adaptive management built on collaboration already in place (van Wilgen & Biggs 2011). Thresholds of potential concern are based around major changes to the ecological system rather than “acceptable variation” and act as a catalyst for management intervention. The major themes for the biophysical desired state include river crises, fire, nutrient cycling, pollination, disease and invasive species (South African National Parks 2008).

The use of strategic adaptive management and thresholds of potential concern originated in the KNP Rivers Research Program and although there have been ongoing problems with river governance there have been some improvements. For example the Sabie river was kept flowing in 1992 due to voluntary restrictions by irrigators, there were improvements in Letaba river flows and reduction in sediment spills (van Wilgen & Biggs 2011).

As van Wilgen and Biggs (2011 p.1187) state “Adaptive management is surviving in the KNP because there is indeed some progress, and no known alternative approach to managing this complex system.”
Case study 5 Canadian Biosphere Reserves - Cooperation Plans

Canada has 16 UNESCO biosphere reserves in 8 provinces (CBRA 2012). Canadian Biosphere Reserves have more in common with Australian biosphere reserves than those in many other countries and have the potential to provide models or ideas for Australian biosphere reserves (Schur 2005; Schurpers com). Their communities are facing the challenge of integrating agriculture and conservation in a developed economy. Many of the Canadian biosphere reserves have small populations with communities engaged in broadacre agriculture. Canadian biosphere reserve volunteer committees are responsible for raising funds for biosphere activities (Mendis-Millard & Reed 2007). Some of the challenges they face include broadening commitment within the community, raising awareness and encouraging Indigenous participation (Mendis-Millard & Reed 2007). They did receive some funding in 2009 ($285,000 each over 5 years) from the Canadian Federal Government but it withdrew funding support in mid 2012 due to budget constraints (CBRA 2012).

The Canadian biosphere reserve committees operate within federal and provincial legislation or work in cooperation with government agencies (Mendis-Millard & Reed, 2007; Reed 2007). They all operate differently with different governance structures but, importantly, the community leads the activities not the government (Schur 2005). The most active biosphere reserves in Canada are those that draw on the skill and interests of a wide range of people and where the community were willing to form partnerships outside the reserves boundaries (Pollock et al. 2008; Pollock, 2009).

Some of the projects in Canadian biosphere reserves include:

- establishing Forest Biodiversity Monitoring Plots (The Niagara Escarpment Biosphere Reserve also trains students at these plots in partnership with the University of Waterloo)
- working with the University of Toronto to develop local-scale climate models for climate change adaptation activities
- creating a sustainable development educational program at Lac St-Pierre
- holding sustainable tourism workshops at the Fundy Biosphere Reserve and
- establishing projects that entail watershed assessment and active community outreach for individual farm producers at the Redberry Lake Biosphere Reserve. (Environment Canada, 2009)

After receiving funding from the Federal government, many of the Canadian biosphere reserves prepared cooperation plans. UNESCO encourage cooperation plans for biosphere reserves and they are particularly useful where biosphere reserve committees have no legal authority and depend on cooperation among a number of different land managers (Edge & McCallister 2009) to obtain funding and initiate activities.

Redberry Lake Biosphere Reserve, Cooperation Plan and Revised Governance Structure


Redberry Lake in Saskatchewan was designated a biosphere reserve in 2000. Redberry Lake Biosphere Reserve is mainly private agricultural land with 89% of the area in the transition zone. The core area of Redberry Lake has a buffer of about 6% of the Biosphere Reserve (Reed, 2007). The area is losing services and population (Mendis 2004). Soon after designation the committee was able to raise funds to develop a plan for the Redberry Lake Biosphere reserve (Mendis-Millard & Reed 2007). This planning process became the model for the Canadian Biosphere Association cooperative planning
process (Mendis 2004). The Redberry Lake Cooperation Plan set out the goals for the three functions of a biosphere reserve. The plan identified the main challenges as: difficulty in comprehending the biosphere reserve concept and problems with funding cycles and their timing in relation to farm activities. It also highlighted the need for information packages which examine the impact of the biosphere reserve on the whole range of people with interests in health, agriculture, conservation and education (Redberry Lake Biosphere Reserve 2002).

After initial activity and the development of their cooperation plan, due to a lack of provincial and federal government funding, the interpretive centre closed and committee morale fell (Mendis-Millard & Reed 2007, p.554). After much lobbying and using results from research, Redberry Lake were able to obtain multi-year funding from the provincial government, renovate the interpretive centre and turn it into a research and education centre which put more emphasis on displays and providing logistic resources for research (Mendis-Millard & Reed 2007, p.554). There was funding for local agricultural stewardship projects. The board, which had lost capacity, was restructured to include government and university scientists and stronger links with local government (Mendis-Millard & Reed 2007; Pollock et al. 2008). Redberry Lake recently signed a Memorandum of Understanding with the University of Saskatchewan School of Environment and Sustainability in order to expand research and education, including field trips for students and postgraduate research projects (Redberry Lake Biosphere Reserve nd).
Case study 6 Biosphere Entrepreneurship

While there are different definitions of social entrepreneurship, in general, social entrepreneurship is seen as entrepreneurship that gives a high priority to the social value/mission of the enterprise. The two important elements are that there is a social (or environmental) mission and entrepreneurial innovation and creativity.

In defining biosphere entrepreneurship Bergstrand et al. (2011, p.14) combined the concept of social entrepreneurship with the unique character of a biosphere reserve and its ecosystem services. They suggested that the key characteristics of biosphere entrepreneurship are:

- The core values of the venture aims at improving human well-being at the same time that natural ecosystems are safeguarded
- Utilising unique biosphere reserve resources, such as ecosystem services
- The venture has a high degree of independence from the state
- The venture is intended to be permanent
- The venture has a sustainable supply of resources and the sale of goods and/or services are of significant importance
- Financial profits are to a high degree reinvested in the venture, in similar ventures or in the generation/regeneration of ecosystem services Bergstrand et al. (2011, p.14)

UNESCO initiated a global biosphere innovation project with pilot studies in three biosphere reserves. Some writers on social entrepreneurship put an emphasis on whether an enterprise is for or not for profit but in general the concept of biosphere entrepreneurship should be some benefit for the biosphere reserve.

What makes biosphere entrepreneurship unique is that the utilization of resources that can be found in the biosphere reserve, such as the services provided by the social and ecological systems, is at the core of the business model of the venture. Of fundamental importance is the fact that this utilization must, at the same time, safeguard the social and ecological systems (Bergstrand et al. 2011, p.14).

Lake Vänern Archipelago and Mount Kinnekulle in Sweden.

Rural areas dominate the Lake Vänern Archipelago and Mount Kinnekulle biosphere reserve. It has “a mix of old cultural landscapes, areas with high biological conservation values, and modern communities” (Begstrand et al. 2011 p. 4). Bergstrand et al. (2011) mapped 25 cases of biosphere entrepreneurship in the Lake Vänern Archipelago and Mount Kinnekulle biosphere reserve.

One of the examples was the Local Synergies project, a farm-based biogas production project. The aim is to connect food and energy production, using carbon dioxide from the local biogas to enhance food production and waste food can go back into the biogas production (Bergstrand et al. 2011).

The Nature Centre, Mont Saint Hilaire Biosphere Reserve, Canada

Mont Saint Hilaire Biosphere Reserve includes the 1000 ha Gault Nature Reserve. The Nature Centre in Mont St Hilaire promotes the biosphere concept and acts as a coordinator (Whitelaw et al. 2004). Raufflet et al. (2010) used the term landscape entrepreneurship in relation to the Nature Centre.

landscape entrepreneurship as a set of innovative activities conducted by an actor aimed at sustaining and developing ecological and social processes in a specific region or landscape so as to improve the ecosystem for human wellbeing (Raufflet et al. 2010, p377).
The Nature Centre receives more than 50% of its funds from entry fees and memberships as well as individual project funding from government and corporate funders. Nature Centre staff also provide technical services.

A major advantage of social entrepreneurship is that it provides the opportunity for biosphere reserves to develop independence from grants (Campbell 2011), although grants may be needed to initiate some of the enterprises (Bergstrand et al. 2011).
Results

Case studies and the Fitzgerald Biosphere Reserve

The results of the discussions with the 20 farmers found that all but one believed the UNESCO biosphere reserve designation was worthwhile for the Fitzgerald although several believed it had not been used to its full potential. The one farmer who didn’t see its current value also believed it hadn’t been capitalised on enough to date. One farmer suggested that there is some cynicism about the concept in the broader farming community.

Most of the farmers interviewed believed it had enabled them to attract funds and coordinate landcare work. Most made it clear that they do not want to lose the biosphere concept. They value the idea of living in a special place and believe it provides a way to coordinate activities. One farm family summed up the advantage of thinking at landscape scale and the educational value of a biosphere reserve:

Yes we think it is important to have a biosphere reserve. We need to better understand the processes and the way the different elements link together and that information we can communicate with the broader public so that they understand it as well.

The farmers interviewed suggested the biosphere label has assisted them to obtain funding for planting riparian zones, strategic fencing and re-vegetation and other activities that are directly associated with protecting the ecological values of the biosphere reserve.

Some farmers were concerned that with a more formal integrated system of a biosphere reserve there might be more regulation.

On the main conservation problems in the FBR: several farmers stressed the biggest problem for the FBR was the fact that prevailing north-westerly winds and water flow move soil and nutrients from the agricultural areas to the core area of the National Park. The other conservation problems they highlighted were invasive weeds and dieback. Both an agricultural scientist and a farmer argued for the need to identify and focus on the biggest threats to the FBR.

Several farmers stressed the problems in communication between the Fitzgerald River National Park manager, the WA Department of Environment and Conservation (DEC), and the community of the FBR. They considered that there was a lack of engagement with the local farming community and the perception that farmers could not be involved in solutions for the National Park. One farmer suggested there was a lack of understanding of what the National Park means to the local community. A conservationist/environmental scientist suggested the best way to improve integration of agriculture and conservation in the FBR was to improve communication between farmers and the Department of Environment and Conservation. The discussions showed that the farmers valued the biodiversity in the region and were interested in protecting it within the constraints of their business. Many stressed the need to educate people about the flora and fauna of the area. One farm family stressed that people had not thought enough about the relationship between ecology and farms or between tourism and farmers.

Several farmers suggested that many of the case studies fitted with new carbon farming initiatives. Some suggested that all of the short listed case studies have some relevance to the FBR but others had very specific preferences. The responses to the individual case studies are outlined below.
Strategic adaptive management

The strategic adaptive management case study had the most consistent positive response from the farmers. Most believed this approach could work well in the FBR. They suggested a range of different indicators including iconic species such as malleefowl, Carnaby’s black-cockatoos and brush tail wallabies but also mentioned small marsupials, frogs, possums, snakes, macro-invertebrates, fish and one particular *Banksia* species. Two farmers suggested the health of black bream was a good way to link the health of the river system to catchment management because as one said “all the locals are keen on fishing.” One farmer suggested that strategic adaptive management using fish as an indicator was something that could work for a defined catchment such as the Bremer. Another stressed the need for monitoring to be seasonal and include trends over time, not just a snapshot.

Another discussed using Indigenous elders’ knowledge. One stressed there was a need to make the connection between management and biodiversity but another was concerned that linking management to indicators might lead to blame.

Some interviewees believed that strategic adaptive management was already being practised informally but believed it would be useful to formalize it and develop thresholds of potential concern.

One or two farmers also recognised that the thresholds of potential concern could also work for sustainability of farm businesses using quantity and quality of commodities produced from the FBR or efficiency of production. They expressed this in the context of the retaining community not just in terms of economics.

Conservationists suggested that the number of paddock trees and the distance between feeding and breeding habitats could be related to the endangered Carnaby’s black-cockatoo. Another discussed finding examples of “canaries in the coalmine” for the health of the natural system e.g. snakes as top end predators and certain plant species such as *Banksia media*.

A common response in relation to strategic adaptive management was the need to educate people about the biodiversity.

*Feeding information to people about the biodiversity gets people in tune and aware of their environment* (Farmer interviewee).

Multifunctional Agriculture and Ecosystem services

The ecosystem service case study generally had a positive response. Most farmers interviewed believed it would be useful to document ecosystem services in the FBR and to work out which ones were important. In contrast, two farmers rejected ecosystem services as too subjective and difficult to document. Two of the conservationists stressed the need to be very specific about ecosystem services in terms of biodiversity, without understanding the level of service it is providing.

Several farmers stressed that mapping of ecosystem services could fit well with carbon farming initiatives and carbon storage in soil. Farmers the important ecosystem services in the FBR as:

- controlling flood risk (which had increased with salinization);
- water quality
- biodiversity on farm, such as Carnaby’s black-cockatoo habitat
- pest control
- pollinators
- nutrient cycling
- the rural lifestyle
- the landscape
Two farmers raised the idea of using ecosystem services they provided for promoting the biosphere reserve and for educational purposes. One farmer suggested:

*If you know what services the landscape is providing it can be used for political*

Another suggested the ecosystem services case study from California was particularly relevant to the FBR. One stressed that for farmers to provide ecosystem services, environmental benefits also need to have a production benefit. He stressed the need to factor in benefit versus time.

One of the NRM staff put the strong argument for mapping land capability for agriculture and ecosystem services.

*Decision-making on appropriate and ‘best’ land use relies on good data and mapping being available to planners that incorporates different values important to the community and the biosphere.*

A farmer also argued that there was value in mapping uncleared land versus cleared land and optimising land use.

**Precision agriculture and Precision Conservation**

The “linking precision agriculture and conservation” case study had a mixed response in terms of applying it in the FBR. At catchment level, as in the US case studies, some felt it could lead to regulation, others believed that they were already using the principles, if not the tools, in their farm planning and management. Two farmers were concerned that certain farmers would be targeted according to their location in the catchment.

One farmer suggested that linking precision agriculture with dual profitability and biodiversity benefits such as reducing inputs has the most potential in the FBR and would be worth a focus if funding became available. Another argued that it could work if tied to carbon market opportunities and a good vehicle to get people to farm according to soil needs. Overall, several farmers tended to be enthusiastic about using precision agriculture and variable rate technology at an individual farm level and believed that the trend was likely to occur independently of conservation objectives. One suggested that all farmers will need to move into VRT over the next 10 years to increase productivity.

More than one farmer stressed that the main objective has to be production with conservation as a secondary objective. The trend to nutrient placement and reducing inputs would be driven by input costs and the need to be more efficient and would only continue if it led to greater profitability.

*There is a greater understanding now about nutrient replacement and maintaining nutrient cycles rather than building a nutrient bank* (Farmer interviewee).

One farmer argued that precision agriculture with an economic goal is easy to envisage but it may be more difficult to quantify some of the environmental and production benefits, such as soil health or pollination. He suggested that it would be useful to have a value in $/ha in terms of more pollinators from a particular management practice. Several farmers suggested that PA with variable rate fertilisers for different soil types has already had conservation outcomes. One argued that PA could also lead to an increase in nutrients in waterways if applied more in wetter higher yielding paddocks. A small number of farmers believed the technology for precision agriculture was too expensive.

The case study of trading off less productive land for conservation purposes highlighted that most farmers are reluctant to write off areas as unproductive because in years when grain prices are high they may be able to afford the inputs. In other years they may crop them for feed with lower inputs. One farmer stressed that as research develops new methods to overcome soil constraints many of these areas can be cropped.
For example minimum till has meant that lighter sandplain soils, once recommended for revegetation, can now be productive.

In contrast several farmers believed precision agriculture would be useful if it could show less productive areas, which could then be planted to trees for the carbon market. They suggested that this would enable better carbon farming planning. One farmer mentioned monitoring ecosystem health such as spread of salinity with aerial photography could be useful but was uncertain whether that would change management. He noted that saline areas are increasingly being regarded as an asset for grazing, with appropriate revegetation these can also increase production. A common theme was a reluctance to give up potentially productive land unless there was some return from it.

A conservationist pointed out that although the case studies highlighted the use of precision agriculture to determine lowest yielding land for conservation purposes, high yielding agricultural land may, in some circumstances have higher value for biodiversity planting.

**Participatory modelling/co-modelling**

Participatory modelling was a more difficult concept and two farmers interpreted the French case study too literally suggesting little similarity between French biosphere reserves and the FBR. One suggested modelling was not suited to the complexity of the FBR. One conservationist suggested that the word ‘model’ is sometimes confusing to people and can be misinterpreted. One of the farmers believed the product from the French co-modelling process was a mind-map rather than a model. Nevertheless several farmers suggested the usefulness of participatory modelling for showing interrelationships and “how everyone interacts and getting people on the same page”. Three farmers suggested that the co-modelling approach could be useful as an educational tool showing the connections and one that it would be a good way to get people thinking about what they value most in the biosphere reserve. Another suggested it would also be useful to look at resources external to the biosphere and the overall economic picture such as how jobs are created. Another believed it could work well for different issues such as salinity or dieback and show who is responsible for what. One farmer mentioned the need to include other industries such as tourism and mining in any modelling of the FBR.

*We need to better understand processes and the way the different elements work together and need to communicate this to the broader public.* (Farmer interviewee)

*A model may help get away from the ‘them and us mentality’.* (Farmer interviewee)

*In the ecological world different elements are linked and this would be a good way of portraying it.* (Farmer interviewee)

One of the agricultural scientists mentioned the use of graphic animators as an adjunct to the facilitation process in co-modelling. The advantage of producing a visual picture of the conceptual model is that it can be shared and it can also have voice-overs.

One of the NRM staff commented:

*The strength of participatory modelling is that the ‘picture’ is developed by the different, and sometimes conflicting, stakeholders. This gives it more strength, people have greater sense of ownership and it becomes a shared picture.*

**Canadian biosphere reserves**

A few of the farmers believed the Canadian model, of one overarching body, was useful but the majority believed having an extra overarching body would stretch volunteers and be unsustainable. Some were afraid of controls that a biosphere authority might exercise. One farmer commented that the biosphere reserve needed to be managed by local people, not people from outside as in the
Redberry Lake example. While two farmers suggested that the current biosphere implementation group could evolve into the Redberry Lake governance model of a cooperative multi-agency organisation, nearly all the farmers raised the problem of volunteer capacity to run a biosphere management committee and most also wanted local ownership of the FBR governance. One suggestion for governance was that each landcare group splits into sub-groups each with a specific focus: a grower group, a conservation group and a third group dealing with communities, tourism and planning which coordinates with the shires. One farmer suggested the idea of biosphere community advisory group which meets once or twice a year and is able to take a more strategic view than the smaller groups.

One of the NRM group staff members suggested that the solution to some of the problems of communication with the Department of Environment and Conservation might be:

A ‘governance’ group or ‘steering’ group that is made up of representatives from all the different groups in the region, would provide an easier way for DEC (and other agencies) to be involved, communicate effectively and understand concerns of landholders in the Fitzgerald Biosphere Reserve.

One of the NRM staff pointed out that the important aspect was that “all have ownership of the plan for the biosphere and a shared vision”.

The conservationists and agriculture staff focused more on the idea of the cooperation plan and felt this was a good way to develop capacity and links across the various groups. Some argued that a comprehensive collaborative plan for the biosphere reserve was essential and one suggested that this would be best if organised by the shires to ensure long term planning and continuity.

**Biosphere entrepreneurship**

Many of the farmers connected the case study of biosphere entrepreneurship with their experience in exploring marketing opportunities using the biosphere label. Therefore most farmers suggested that the biosphere entrepreneurship model would not work in relation to agriculture in the Fitzgerald because of the small population and the fact that the farmers produce commodities that are not distinguished in the market place.

It would be very difficult to bring back marketing of agricultural produce or enterprises as in the Swedish example in the Fitzgerald because of lack of interest after disappointment last time, the sparse population, relatively small number of visitors and need for continuity of supply for the idea to work. (Farmer interviewee)

Several highlighted that there is no market premium for environmental stewardship. Others remained optimistic that it could still be used in relation to some products. Two of the young farmers were interested in the idea of value adding and the need to diversify industry, increase population and increase capacity in the FBR. One young farmer argued that the biosphere entrepreneurship model has the most value of all the case studies but would need some seed funding for start up. He argued for the idea of value adding to products and also the idea of power generation from a biosphere run feedlot. He also saw the opportunities for the entrepreneurship model in the carbon market. One of the NRM staff suggested:

…perhaps with the opportunities the Carbon Farming Initiative brings, the whole community’s approach could change – growing biomass to generate their own power and gaining valuable ecosystem services (protecting soil, water, biodiversity) in the process.

Tourism rather than agriculture was seen as the most likely industry to be associated with the entrepreneurship model. One farmer believed the idea was probably only useful for niche products such as quandong jam or wood products. He stressed that the highest produced commodity is grain and this went in bulk, half to Albany port and half to Esperance Port.
Small-scale homemade produce may have a market but would need commitment.

One other idea was the potential to use the old school building at Fitzgerald as an interpretive centre and to house backpackers for the labour market.

Several farmers stressed the importance of ensuring there are benefits to the FBR if people use the biosphere status in their enterprises.

Although the farmers interviewed were cautious about the biosphere entrepreneurship case study several believed that it should remain an option. One of the agricultural scientists argued that it was the most sustainable model for providing funds for biosphere activities.

Other ideas for integrating agriculture and conservation

Promoting the ecological values of the FBR to farmers

Several farmers showed their interest in the flora and fauna of the FBR. This was strongly apparent when they discussed potential indicators of ecosystem health. Two farmers suggested more local promotion of the ecological values of the FBR.

Feeding a bit of information gets people in tune and aware of the environment. A lot of people don’t even know about the common species such as echidnas. (Farmer interviewee)

Another suggested making scientific information such as that which had been collected on invertebrates in rivers, other water measurements, and ant studies that had been conducted in the FBR, much more accessible to the community. Some commented on the difficulty of accessing information that was held by natural resource management agencies and the lack of funding for government agencies that used to be involved in NRM.

Some conservationists questioned whether promoting the ecological values to farmers actually changes farm management. Nevertheless, this emerged as a potential theme which fits with the concept of a biosphere reserve. Linked to this was the idea of more emphasis on education in the FBR. Three farmers argued that the biosphere reserve was not currently maximizing its education benefit to the community.

Three female farmers interviewed particularly stressed involving children in environmental monitoring; as one said:

It encourages kids to do something for their community and develop values around helping others and the environment

Citizen science

Several farmers expressed enthusiasm for involvement in monitoring.

Citizen science programs would work well with the biosphere concept/ aims. (Farmer interviewee)

In relation to monitoring another suggested:

It needs a charismatic person to engage people and make it a fun thing to be involved in.

The idea of involving school children in monitoring was raised several times and one farmer suggested it also provides a social role.

There is a role for the community in feeding information back to scientists or management agencies. (Farmer interviewee)
You need to tap into something that interests a particular farmer such as an unusual plant or the behaviour of ants and termites. (Farmer interviewee)

Children collecting macro-invertebrates to monitor streams. Photos courtesy Alison Lullfitz

A process for determining research priorities

One of the agricultural scientists suggested the importance of locally relevant research and determining research priorities that had multiple benefits for agriculture and conservation. He suggested forming a research reference body of scientists, policy and local practitioners. This group could lead the development of research and development issues and ideas on environmental, social and economic needs with local community, scientists, and policy people that have a skill and interest in the biosphere. From this a core research group could develop a set of research priorities and develop project proposals judged on what they can deliver in terms of multiple benefits. As soon as a groundswell of research and on-ground activities has begun, then the reference group could explore/exploit it for opportunities for the entrepreneurship (similar to the case studies in the entrepreneurship model).

It is essential that the reference group instigate sharing activities such as forums, between the core researchers and the local networks to ensure sharing of knowledge and experience. Bring everyone and everything done together and learn together regularly. (Agricultural Scientist Interviewee)
Soil improvement with conservation and production benefits

Improving soil management and soil health by increasing understanding of soil biology is one idea that was raised by farmers and was also viewed as important by South Coast NRM. Less reliance on fertilizer is an important factor for farmers faced with increasing input costs. Increasing soil carbon for the carbon market with soil fertility benefits was also suggested. The differences in soils and the way they respond to management has highlighted to local farmers the need for research at the local scale, if production and conservation benefits are going to be maximized.

Conservation planning at the scale of the FBR

One farmer proposed the idea of functional landscape planning at the scale of the FBR. Gondwana Link has used this approach in some parts of the FBR as part of the Nature Conservancy’s conservation action planning method. This approach has encouraged more strategic fencing and re-vegetation by farmers. Another farmer stressed the need to identify areas in the FBR that are really important so these can be targeted. This also fits with the theme of conservation planning.

Focus on streams and nutrient movements.

This idea of focussing on streams and nutrient movements emerged from farmers but also from one of the conservationists and several of the agricultural scientists. They stressed the need to better understand nutrient movements from farm to river to estuary. Several farmers were interested in the impacts of reducing nutrients on recreation, fish, and native macro-invertebrates such as koonacs.
Using “the Most Significant Change technique”

This was suggested by one of the NRM practitioners. It is a form of participatory monitoring and evaluation designed to accompany other forms of monitoring (Dart & Davies 2003). The method involves collection of significant change stories, which are then further selected on the basis of project impact. (Davies & Dart 2005). It is a participatory form of monitoring that is suited to complex programs such as NRM. The Most Significant Change Technique has been used in Australia in the Target 10 Dairy Extension Program (Dart 2000) and recently in farm forestry (Moore & Offer 2012) and in landcare in Victoria and Tasmania. The most significant change technique is designed to focus work towards explicitly valued directions and away from less valued directions. Dart and Davies (2003, p. 149) suggested its use in the dairy extension program helped to establish a shared vision, a more unified understanding of outcomes, and it also assisted in planning new activities.

Discussion

The case study on strategic adaptive management had the most positive response from farmers but some highlighted the difficulty of finding appropriate TPCs that link to farm management. The interest and knowledge that farmers in the landcare groups showed in the natural history of the FBR could certainly be used to encourage greater links between agriculture and conservation. Most felt alienated by the national park managers and believed they could have a role in protecting the park. An important strategy for integrating agriculture and conservation is to involve farmers in developing conservation related TPCs. This has already worked with the interest in mallefowl in the region as an iconic species relevant to the health of the ecosystem. This interest by the farmers in community-based conservation is consistent with the goals of biosphere reserves. “Participatory conservation, a major paradigm shift, nowadays strongly guides the concept of biosphere reserves” (Stoll-Kleeman et al. 2010 p.227).

Some elements of conservation action planning used by Gondwana Link are similar to those in strategic adaptive management. Both set a landscape scale framework with clear objectives and targets. Strategic adaptive management explicitly recognises complexity in systems and is particularly suited to river and catchment management (Kingsford et al. 2011). TPCs can also be used in examining sustainability of the farming systems and social systems of the FBR thereby integrating ecological, social and economic values.

Although the literature based on the use of strategic adaptive management in the Kruger National Park argues that there are problems with development of TPCs, the overall consensus is that strategic adaptive management is the best way to manage complex systems. There is good overlap between strategic adaptive management and participatory modelling and co-learning (Kingsford et al. 2011) and several farmers in the current project recognised these as working well together. Both these approaches explicitly recognise complexity and overlapping governance structures (Kingsford et al. 2011).

The precision agriculture/conservation case studies had three components: catchment scale conservation; farm level precision agriculture to reduce nutrients; and farm level precision agriculture to trade off land for conservation. Each of these had different responses from farmers. Some viewed precision conservation as simply an extension of the farm and catchment planning of the 1990s. For others precision conservation was considered to have potential but mainly in relation to more strategic planting of riparian areas and buffers to protect river systems from nutrients.

Some farmers regarded precision conservation as a threat at catchment scale, with the risk that particular farms might be targeted. Farmers’ concerns about precision conservation could be allayed using tools such as spatial multi-criteria analysis (Lesslie et al. 2008 ) which enable participatory processes to be used in determining priorities, capture different values and explore trade-offs (Bureau of Rural Sciences 2009).

A Department of Agriculture and Food interviewee argued for the need for more research and analysis of riparian management in south coast landscapes because the main source of nutrients is sub-soil.
flow. Decreasing sedimentation without decreasing nutrients can lead to more free phosphate in some aquatic systems on the south coast of Western Australia (McKergow et al. 2003). More precision in digital elevation models and hydrological modelling could assist in better design of riparian systems. Vegetation to increase shading in wetlands and rivers is also likely to be an important component of adapting to climate change (Davies et al. 2004).

Some farmers believed that the precision agriculture technology was too expensive and were uncertain of the benefits to production. The GRDC (2008) found that adoption of PA practices is limited by reluctance to invest with uncertain returns; PA equipment that is incompatible with a farmer’s current equipment; and lack of technical support and training. Although variable rate technology (VRT) has the potential to reduce inputs and off site pollution with nutrients it also has limitations where soils with particular constraints are in small, scattered patches (DAFWA, 2009). As in the Zerger et al. (2009) study, the current project found the interaction between seasonal variability and variations in soil type to be constraints to using PA to determine potential trade-offs of agricultural land for conservation. Nevertheless most of the project partners believed VRT could benefit the FBR and it was considered that there is likely to be an increase in adoption of VRT, as input costs rise, particularly among younger farmers. The increase in VRT and potential for decreased loss of nutrients from farms would only occur if there were production benefits.

The Canadian model was regarded as not very appropriate to the FBR because of some resistance to forming one overall governance group for the FBR. Others recognised that there has to be one group that can take an overall strategic view of the FBR and to improve communication between the conservation agency and farmers. There is also a need to have one body as the contact for UNESCO and other biosphere reserves. The Biosphere Implementation Group may evolve into such a group but there is concern about limited capacity of volunteers to serve on several committees. Governance of the FBR was beyond the scope of this project but farmers’ involvement in the governance of the FBR is important if the biosphere concept is to be used to increase integration of agriculture and conservation. Even though they acknowledge a lack of capacity, most wish to maintain local control of governance of the FBR, rather than broaden it beyond the boundaries as in the Redberry Lake model. Nevertheless some could see the benefit of a multi-agency cooperative model, particularly with greater involvement of the shires. There may be opportunities to improve communication between DEC, other conservation bodies and farmers through such a model. The other interesting aspect of the Redberry Lake case study that may also apply in the FBR is the finding that research projects in the biosphere reserve helped to increase community awareness of the goals and operation of the biosphere reserve (Mendis-Millard and Reed 2007).

Biosphere Entrepreneurship was not as well accepted as a strategy by several farmers in the FBR because of recent history with a marketing project. The Fitzgerald Biosphere Marketing Association formed with the aim to use the brand of the Fitzgerald Biosphere to encourage sustainable production systems, and use the ‘green’ image in marketing agricultural products from the region. There was strong interest in the concept and funding from the Federal Regional Solutions program was used to employ a coordinator for 2 years. The initial marketing study identified lamb, yabbies and tourism as the potential flagship products for the regional brand and commissioned consultants to conduct a Lamb and Yabbie Feasibility Study and Marketing Assessment Trial. The main problem for marketing was in attracting sufficient quality supply from the region. The Biosphere brand was also found to be confusing to consumers (FBMA, 2004 cited in Department of Agriculture, 2004). Nevertheless, the project was considered to have increased overall awareness of the biosphere concept in the community (Ebert pers com cited in Fry et al. 2010).

Some of the younger farmers were enthusiastic about the biosphere entrepreneurship model particularly in relation to value adding products. This model would also be highly suited to biosphere reserves with larger populations, such as Mornington Peninsular and Western Port, Noosa or Great Sandy.

A number of other ideas emerged from the discussions. A common theme was the need for increased education about the flora and fauna of the FBR and another was that of engaging the community in
monitoring and citizen science. The interest shown in the idea of involving farmers/school children in monitoring indicators of ecosystem health links well with the interest in the case study of strategic adaptive management and thresholds of potential concern.

Also related to the monitoring theme was ‘the most significant change’ idea as a way to capture environmental change from a community perspective. There have been programs in the past involving children in monitoring such as the highly successful WA Ribbons of Blue Program, but funding has ceased for most of these programs. There is a need for continuity of funding for citizen involvement in monitoring if there are to be long-term benefits. The short-term nature of some of these programs means a lot of effort goes into capacity building and developing community interest and then the program ceases just as the community has become engaged.

The other major theme was improving soil health and increasing agricultural productivity with reducing fertilizer inputs, and this linked to the need for local research. There was a strong interest by several of the farmers in soil biology and soil carbon and the role these might have in increasing soil fertility. This could be an important strategy to increase production and conservation benefits. Research on management practices to reduce nutrient run-off and a better understanding of nutrient flows were was also considered important by agricultural scientists. Farmers in the FBR already use a range of soil amelioration tools which enable them to increase productivity, and also have some conservation benefits. Some of these tools include liming to maintain top and sub-soil pH (Gazey & Davies 2009), incorporating clay to reduce water repellence and wind erosion (Hall 2009), increasing organic matter through stubble retention or green manure, narrow furrow sowing to maximize water retention, controlled traffic to reduce soil compaction, and variable rate technology for precision soil amelioration (Fry 2010). Continued extension of these to farmers in the FBR is important.

The case studies provide stimulus for discussion and enabled the participants to reflect on past landcare activities and consider new ideas for the future of the FBR.

Biosphere Reserves are experimental sites for sustainable development. Those with agricultural enterprises should be experimenting with ways to integrate agriculture and conservation. From the case study discussions and ideas put forward by farmers, conservationists and agricultural scientists the following are suggestions for potential demonstration projects in the FBR or other Australian biosphere reserves with agricultural enterprises such as Riverland, Mornington Peninsular and Western Port, Noosa and Great Sandy.

Potential demonstration projects linking agriculture and conservation in the FBR

From the discussions a number of elements in the case studies plus other ideas emerged and they can provide a resource for potential projects.

UNESCO’s view on projects in biosphere reserves is that:

1. Priority should be given to projects aiming at making biosphere reserves fully functional with effective participation of local communities and different sectors of society
2. Projects on biosphere reserves should give emphasis to UNESCO’s mandate in education, science and culture, and to the MAB approach, promoting the integration of the natural and the social sciences (UNESCO 2002, p.3)

The project showed that there is consensus that there is a need for planning in the FBR. A plan could take the form of a cooperation plan as in those by Canadian biosphere reserves; a participatory land use plan as in Redberry Lake Biosphere Reserve, where they are currently conducting a community planning pilot program; or it could involve adaptive planning methods such as in the Kruger to
Canyons Biosphere Reserve. Tools to assist in adaptive planning include participatory modelling and monitoring.

Strategic Adaptive Planning and Management in a catchment/biosphere reserve

Develop objectives and thresholds of potential concern related to social, economic and environmental aspects in a demonstration catchment which could then be extended to a larger spatial area such as the whole biosphere reserve. The concept would be to develop thresholds of potential concern in relation to biophysical systems such as streams and estuaries as well as social systems such as size of communities, and economic systems such as profitability and productivity.

In the Kruger National Park or Macquarie Marshes Nature Reserve models (Kingsford et al. 2011) there are four types of higher-level objectives:

1. Ecosystem objectives such as to maintain and restore biodiversity within thresholds of natural variability. More specific objectives in the FBR might relate to riparian vegetation condition, sedimentation, number of exotic species, native fish or macro-invertebrates.
2. People objectives such as to protect cultural values and build community support for the aims of the catchment/biosphere reserve. More specific objectives might relate to catchment activities, people supporting the aims of the biosphere reserve, biosphere reserve activities, Indigenous cultural benefits/activities.
3. Balancing objectives such as to agree on a desired set of future conditions that balance the provision of human benefits with the need to conserve ecosystems, with specific objectives related to balanced development and conservation planning, environmentally responsible practices, increasing productivity without increasing off-site impacts.
4. Enabling objectives such as to plan and manage the catchment/biosphere reserve to achieve the ecosystem, people and balancing objectives, with specific objectives related to communication, knowledge of natural resource management, community capacity, governance.

Strategic adaptive management could be linked to participatory modelling of particular problems. Four particular aspects that arose during discussions, and where there are potential conflicts or opportunities in the interaction between agriculture and conservation are:

- nutrients and sediments
- the impacts of kangaroos
- managing fire risk
- improving the habitat for Carnaby’s black-cockatoos.

Loss of nutrients and sediment into the rivers and estuaries of the core area not only causes problems for water quality and aquatic biodiversity but also represents inefficiency in use of soil and inputs. Participatory modelling in partnership with soil scientists and agronomists may assist all participants in a better understanding of the interactions and how management can improve outcomes for both conservation and agriculture. It also has the potential to indicate gaps in knowledge that may require more research or monitoring.

Kangaroo management was one example of a problem for both conservationists and farmers. Overpopulation can potentially threaten both agriculture and biodiversity. Farmers are tending to blame conservationists for increased kangaroo numbers but conservationists in turn claim kangaroos are able to increase their numbers by feeding on agricultural pastures. This is one example where both
modelling and strategic adaptive planning could be used to address the management strategy. Strategic adaptive management of elephant numbers in the Kruger National Park has provided a more flexible way to manage their impact on vegetation (van Wilgen & Biggs, 2011). Modelling the system in the FBR, in terms of factors causing increasing kangaroo numbers, and identifying thresholds of potential concern both for farmers and conservationists could increase understanding of the interactions and determine management actions.

Management of fire risk and appropriate fire control strategies are two other problems shared by conservationists and farmers. Farmers believe increasing carbon offset and conservation plantings is increasing fire risk and are concerned about fuel management. Similarly there are problems between farmers and the conservation agency (DEC), over fire management. In the Kruger National Park a set of thresholds of potential concern were developed and modified as a result of research and monitoring and practicability. High intensity fires were found to have the most impact and management changed because thresholds were exceeded. Landscape scale experiments on ignition patterns and fire areas are also being conducted (van Wilgen & Biggs 2011).

Modelling of the relationship between vegetation and the threatened Carnaby’s black-cockatoo was highlighted as a possible project. It was suggested that thresholds of potential concern in relation to the Carnaby’s black-cockatoo habitat, could relate to distances between nesting and feeding trees that enable the endangered birds to breed and feed successfully.

Modelling, using the French biosphere (ARDI) method, would need to identify those whose practices having a direct impact on the problem; the management entities e.g. carbon plantations, conservation plantings, pasture paddocks and the links between them; goods and products used such as infrastructure, water, minerals, plants and animals; and the key processes such as vegetation dynamics, economic factors, social and cultural factors. It would also need to identify the interactions between users and how they modify processes (Etienne et al. 2011).

**Research and demonstration projects on soil management and more efficient use of nutrients.**

The discussions showed an increasing interest by farmers in improving soil management with a focus on soil biology, soil organic carbon and reducing reliance on imported fertilizers. There is a poor understanding of the biology of sandplain soils, which are common in the FBR (Hall, 2009). Increasing production with less fertilizer inputs has the most potential to provide benefits for both conservation and profitability.

There is evidence that, on some soil types and rainfall zones in other regions, production can be increased by other strategies with less use of nitrogen (Brennan pers com, paper in preparation). Applying fertilizer by a general ‘rule of thumb’ means that much can be wasted. This is particularly pertinent in the FBR where better understanding of the interaction between soils and rainfall could provide opportunities for more strategic fertiliser use. Paddocks with large variations in yield within the paddock are likely to generate the best return from VRT (Lawes et al. 2011). Research on nutrient loss such as the importance of soil surface cover, whether phosphate loss is attached to sediment or labile and how nutrients are applied can also provide ways to improve productivity and reduce degradation of waterways (Anderson et al. 2011). More research and education on PA may also increase adoption (Mandel et al. 2011).

Projects such as the Department of Agriculture and Food’s nutrient mapping in the higher rainfall lower Bremer River also provide the opportunity to reduce nutrient use and nutrient flow into the estuary. Research and demonstration on increasing soil carbon, organic matter, changes in soil biology and structure, and a focus on reducing nutrient inputs have the greatest potential to reduce nutrients and sediment in the river systems flowing into the National Park.

As discussed above farmers are highly aware of the impact of the flow of water and soil from cleared
catchments into the Park. Any strategies that can reduce soil and nutrient flow into the core area of the FBR enable local farmers to not only assist in protecting their individual special recreational places such as the estuaries downstream, but also to feel they are protecting part of the special place that is a UNESCO biosphere reserve. Monitoring of nutrient flows and the impact of improved soil management on water quality and indicators of ecosystem health would also enable farmers to demonstrate the ecosystem services they are providing.

The research in this project provides information that can now be used to conduct more extensive testing of specific elements arising from both the case studies and the input from the participants in the research, for improving integration of agriculture and conservation in the FBR.
Implications

Industry

This report offers some strategies that can be used by Australian biosphere reserves and other bioregional groups to improve integration of agricultural productivity and conservation. The biosphere reserve model, with the right approach and sufficient capacity of community, can provide the basis for developing solutions to the highly complex problem of reconciling two, often conflicting, objectives of agricultural productivity and protection of important ecosystems. Biosphere reserves provide an internationally recognised structure for Australian agricultural industries to develop a better understanding of the interactions between agricultural and ecological systems. Partnerships between community, protected area managers and scientists through biosphere reserves provide the opportunity for a coordinated approach to research needs. The benefit of the approach used in this project is that farmers and natural resource managers were able to consider a range of ideas from biosphere reserves and other bioregions elsewhere in the world and discuss the application to their local situation. Locally relevant research and development is going to be essential to address the need to increase productivity, meet the challenges of climate change and reduce the off-site impacts of agriculture.

Community

The biosphere reserve concept provides a mechanism for people to work together with a common goal to integrate social, economic and environmental perspectives. Some of the ideas from this project provide ways to develop a vision for the landscape involving cultural and social perspectives and to develop objectives that include maintaining and enhancing community. The project highlighted the community interest in education and citizen science.

Policy makers

The Man and the Biosphere concept differs from regional NRM policy, in that biosphere reserves are viewed as laboratories for reconciling development and conservation and so there is a much stronger emphasis on research, demonstration, capacity building and education. Biosphere reserves can be viewed as places to find solutions that can be applied to other landscapes. They provide a means to integrate research with Commonwealth and State funded regional NRM activities.

One limitation of the biosphere approach is the dependence on volunteers for coordination of biosphere activities. It has been shown that coordination is more effective if there is funding to support such activities.

Setting aside protected areas is not sufficient for conservation of biodiversity, particularly in relation to potential changes in climate. Private land managers are likely to become increasingly important in conservation. The farmers in this project showed that they were interested in participatory conservation but also made it clear that conservation objectives had to come second to their business objectives. In order to devote their time to them, activities had to be provide significant benefit for both sets of objectives.
Recommendations

This project provided some strategies to assist biosphere reserves and other bioregions in Australia to improve integration of agriculture and conservation. The overall recommendations were:

1. Develop an overall plan for the biosphere reserve. Use a system such as strategic adaptive management to develop objectives and thresholds of potential concern. This provides a structure to planning and enables more flexible and adaptive approaches. Strategic adaptive management recognises that there is uncertainty in complex systems. It provides a mechanism for social and economic values to be considered along with ecological values and can include participatory monitoring. Tools such as participatory modelling of particular areas of conflict or particular NRM problems provide ways to increase understanding of the interactions and share values.

2. Increase the focus on education and citizen science. Many participants in this study suggested educating the community about local flora and fauna is likely to increase their interest in conservation. Involve the community, including schools, in monitoring indicators of the health of ecosystems.

3. Conduct a research needs analysis for the biosphere reserve, particularly the needs associated with improving the understanding of the interactions between agricultural and natural systems. Increase research activities that specifically provide advantages to both farming and conservation, such as soil management to reduce input costs and off-site impacts.

Specific recommendations for the FBR

1. Develop ways to improve communication between protected area managers and farmers. This could include modelling of systems where there is conflict or discussion on ways farmers can contribute to conservation objectives.

2. Develop a governance structure for the FBR that doesn’t impose extra commitments on volunteers. A compromise governance structure, such as a strategic group, which meets once or twice a year, would also provide a communication hub for other biosphere reserves. Increase the involvement of the shires of Jerramungup and Ravensthorpe in planning for the biosphere.
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Improving Integration of Agriculture and Conservation through Biosphere Reserves

By Julia Fry

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This report provides a range of strategies to improve integration between agriculture and conservation in a biosphere reserve. The research gathered information from international case studies and evaluated their local relevance in discussions with a range of people with an interest in the Fitzgerald Biosphere Reserve in Western Australia. The participants included farmers, conservationists, agricultural scientists and natural resource managers. The report summarises both the case studies and other ideas from research participants and provides some recommendations for research and demonstration projects.

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