

**Approaches for Measuring and
Accounting for Ecosystem Services
Provided by Vegetation in Australia**

Cynthia Maher and Richard Thackway

© Commonwealth of Australia 2007

This work is copyright. Apart from any use as permitted under the Copyright Act 1968, no part may be reproduced by any process without prior written permission from the Commonwealth available from the Department of Communications, Information Technology and the Arts. Requests and inquiries concerning reproduction and rights should be addressed to the Commonwealth Copyright Administration, Intellectual Property Branch, Department of Communications, Information Technology and the Arts, GPO Box 2154, Canberra ACT 2601 or at <http://www.dcita.gov.au/cca>.

The Australian Government acting through the Bureau of Rural Sciences has exercised due care and skill in the preparation and compilation of the information and data set out in this publication. Notwithstanding, the Bureau of Rural Sciences, its employees and advisers disclaim all liability, including liability for negligence, for any loss, damage, injury, expense or cost incurred by any person as a result of accessing, using or relying upon any of the information or data set out in this publication to the maximum extent permitted by law.

Postal address:

Bureau of Rural Sciences
GPO Box 858
Canberra, ACT 2601

Executive Summary

This report summarises the ecosystem service approaches developed for measuring and accounting for ecosystem services provided by vegetation in Australia. The approaches include those developed by national, state and regional bodies.

Two fundamental policy objectives – sustainable agriculture and biodiversity conservation¹ – are critically important for the balanced supply of ecosystem services from the Australian environment. Water, soils and biota are key components of healthy, functioning ecosystems but policies and programmes that address ecosystem services frequently focus on various aspects of vegetation because it is the easiest component to manipulate and it is a good indicator of ecosystem health. Desired changes to vegetation are easy to communicate to land managers, the wider community, industry groups and parliamentary advisers.

Ecosystem Goods are material benefits derived from managed ecosystems. They include genetic resources, foods, fibres, water, pharmaceuticals and building materials. Priced and unpriced ecosystem goods may be traded or exchanged through markets.

Ecosystem Services are a wide range of beneficial outputs derived from ecosystem functions. They have environmental, economic, cultural, aesthetic and spiritual values ranging from ‘regulating’ services benefiting air, water quality and climate to ‘cultural’ services benefiting social and aesthetic experience and recreational amenity to ‘supporting’ services such as nutrient cycling to benefit the production of other ecosystem services.

The concept of ecosystem services provided by vegetation are complex but can be used to underpin sustainable development in production landscapes. It is a challenging area of research that requires multi-disciplinary approaches to develop an understanding of the many factors that contribute to the provision and maintenance of these services. *Production landscapes* are areas where vegetation is managed for the production of ecosystem goods such as horticulture, cropping, grazing and the harvesting of wood products. In the majority of landscapes, there is a mosaic of

¹ these objectives include forestry

landscape elements which may include areas of vegetation managed for biological diversity or amenity values.

The report summarises the different approaches developed and used by Australian governments and research agencies to assess, model and report economic, social and environmental components of ecosystem services. The summary shows that most state and territory government agencies are developing and/or testing tools and approaches to address issues of ecologically sustainable use and vegetation management. These tools aim to minimise the short and long-term risks of significant and irreversible losses of natural capital associated with ecosystem services.

A list of 41 Australian approaches for measuring and accounting for ecosystem services (Table 2) was compiled and a conventional five step-wise ‘decision making cycle’ used to rank the relevance of each approach in each of the five steps. The majority of approaches received scores in two of the five steps, i.e. *Step 1 - Characterise the resource or asset* and *Step 3 - Design and implement the programme*. The Step 1 approach includes frameworks and tools used or being investigated by Australian, state and territory governments, research and R&D corporations for describing and assessing (e.g. ranking and scoring) ecosystem services. The Step 3 approach includes stewardship and incentive-based approaches such as Market Based Instruments (MBI) as well as grants and education activities.

The review shows few approaches received high scores for *Step 4 - Track on-ground progress toward desired policy goals*, but highlighted the absence of high scoring approaches for *Step 2 - Articulate the policy responses using evidence* (set goals, objectives and priorities) and *Step 5 - Complete vegetation resource assessments following action*.

The report identifies a number of issues including the need for national leadership and coordination in the area of multiple ecosystem service outcomes provided by managing vegetation. For example, the review shows that it is necessary to define and operationalise the concept of vegetation condition to better link vegetation management practices with ecosystem function and ecosystem services. The vegetation condition is often difficult to define and requires knowledge about the intact vegetation condition and likely vegetation over time.

For production ecosystems, this is relatively easy because the suitability and market potential of various agronomic or pastoral states is generally well known. For native vegetation, whether intact or disturbed but not cleared (e.g. selective thinning for grazing, timber getting, impacts of wildfire), the trajectories are less predictable for some ecosystem services (e.g. weeds, feral animals, water harvesting), but nevertheless the impacts of land management practices on vegetation and ecosystem services is widely understood.

In order to address these issues, the Bureau of Rural Sciences (BRS) convened an expert technical workshop in November 2005. This involved key representatives from the Australian, state and territory governments, regional bodies, research agencies and subject specialists from research and industry sectors. The aim of the workshop was to:

- (i) seek feedback on whether an earlier version of this workshop was comprehensive of the main activities being undertaken at national, state and regional levels; and
- (ii) (ii) whether there was benefit in developing a national framework for measuring and assessing multiple ecosystem services associated with vegetation management.

List of abbreviations

ABARE	Australian Bureau of Agriculture and Resource Economics
AGO	Australian Greenhouse Office
APSIM	Agricultural Production Systems Simulator
ASSESS	A System for Selecting Suitable Sites
BRS	Bureau of Rural Sciences
CATCON	Catchment Condition module of ASSESS
CSIRO SE	CSIRO Sustainable Ecosystems
CRC	Cooperative Research Centre
DAFF	Department of Agriculture, Fisheries and Forestry
DEM	Digital Elevation Model
DEC	New South Wales Department of Environment and Conservation
DSS	Decision Support System
DWLBC	South Australian Department of Water, Land and Biodiversity Conservation
JVAP	Joint Venture Agro-forestry Programme
LUOS	Land Use Options Simulator
LWA	Land & Water Australia
MBI	Market Based Instruments
MCA	Multiple Criteria Analysis
MDBC	Murray-Darling Basin Commission
MOLA	Multi-Objective Landscape Assessment

MOSAIC	Multiple-Objective Spatial Allocation for Information Choice
NAPSWQ	National Action Plan for Salinity and Water Quality
NHT	Natural Heritage Trust
NRM	Natural Resource Management
NRMSC	Natural Resource Management Standing Committee
RIRDC	Rural Industries Research and Development Corporation
SCARM	Standing Committee on Agriculture and Resource Management
SOE	State of the Environment
SRES	School of Resources, Environment & Society, ANU
VAST	Vegetation Assets States and Transitions

Glossary

Ecosystem Goods	Ecosystem Goods are material benefits that we derive from managed ecosystems. They include genetic resources, foods, fibres, water, pharmaceuticals, building materials etc. Priced and unpriced ecosystem goods may be traded or exchanged through markets.
Ecosystem Services	Ecosystem Services are a wide range of beneficial outputs from ecosystem functions. They have environmental, economic, cultural, aesthetic, and spiritual values and range from ‘regulating’ services benefiting air and water quality and climate, to ‘cultural’ services benefiting social and aesthetic experience and recreational amenity, and to ‘supporting’ services such as nutrient cycling that benefit the production of other ecosystem services.
Production landscapes	Production landscapes are areas where vegetation is managed for the production of ecosystem goods – e.g. horticulture, cropping, grazing and the harvesting of wood products. In the majority of landscapes, there is a mosaic of landscape elements which may include areas of vegetation managed for biological diversity or amenity values.

Introduction	11
Approach taken.....	15
Results	17
The Scenario Planning and Investment Framework (SPIF) tool.....	20
Frameworks and tools for Assessing the Status of Ecosystem Services (Step 1) ...	21
Indices and Metrics.....	22
Decision Support Tools	22
Mechanisms for influencing changes in land use and land management (Step 3)..	22
Discussion.....	24
Conclusions	28
Acknowledgements	29
Bibliography	30
Appendix A. List of current key national ecosystem services projects and activities.	34
NB: refer to bibliography for full details of references provided in table.....	34
The Scenario Planning and Investment Framework (SPIF) tool.....	51
Exchange Incentive Fund	51
Land Innovation Fund	52
Strategic Landscape Investment Model (SLIM)	52
The Gwydir Ecosystem Services Project.....	53
Better Knowledge Better Bush Project.....	54

Preamble

In mid 2004 DAFF NRM approached the Bureau with a request to assist in the development a multiple ecosystem service framework for use by DAFF NRM to inform the allocation of NRM priorities and investments under current and future NRM programmes. The framework should be based on assessing the provision of ecosystem services provide by vegetation and give due consideration to the various national and state ecosystem service projects and activities.

An earlier version of the information presented in this report was circulated to participants of the November 2005 workshop [please refer to *Approaches to Quantifying Ecosystems Services Provided by Vegetation Workshop* (2005) at: <http://adl.brs.gov.au/ecosystem/>].

Introduction

The provision of ecosystem services from vegetation in production landscapes is emerging as a challenging and complex priority for the future of sustainable agriculture. Vegetation provides societies with a broad range of ecosystem ‘goods’. Sustainable vegetation management generally results in a positive outcome of multiple environmental benefits arising from the interactions between different ecosystem services (Shelton *et al.* 2001).

Vegetation management practices can have a profound effect on Australia’s natural resources, the environment and agricultural production (Thackway and Lesslie 2005). Where vegetation management in agriculture aims primarily to produce food and fibre (Chesson and Whitworth 2005), it is increasingly recognised as a way to sustain and secure natural resource benefits, or ecosystem services (Millennium Ecosystem Assessment 2005). For example, the removal of deep-rooted perennial vegetation and replacement with shallow-rooted annual vegetation in some areas has resulted in degradation of soil health, carbon storage, water quality and loss of habitat. In such cases, landholders should evaluate the trade-offs in investing in sustainable farming practices over an immediate fiscal commitment (Nelson *et al.*, 2004; Stoneham *et al.* 2003).

There are many dimensions of ecosystem services in agriculture based on regional priorities and expectations. Ecosystem services can be defined as the natural capital, conditions and processes that sustain and fulfil human life (Daily, 1997; Chee, 2004; Eamus, *et al.* 2005). Williams (2005) expands on this definition to describe the services as recognised and defined by people who are beneficiaries of natural assets which include soil, water, atmosphere and biota (flora and fauna). Sustainable agricultural systems recognise that properly functioning ecosystems contribute to wider benefits such as maintenance of water quality, waste removal, soil structure, water infiltration, erosion control, carbon sequestration, pollination, and refugia for species during droughts and floods.

Table 1 presents a breakdown of ecosystem services in terms of their capacity to provide goods and services (Provisioning), benefits obtained from regulation of ecosystem processes (Regulating), non-material benefits (Cultural) and services necessary for the production of other ecosystem services (Supporting).

Table 1 – Summary of Ecosystem services

Provisioning Services	Regulating services	Cultural Services
Products or goods obtained from ecosystems	Benefits obtained from regulation of ecosystem processes	Non-material benefits obtained from ecosystems
<ul style="list-style-type: none"> • Food • Fresh water • Biomass fuel • Fibre • Biochemicals • Genetic resources 	<ul style="list-style-type: none"> • Climate regulation • Drought and flood mitigation • Water regulation and purification • Pollination • Disease regulation/pest control 	<ul style="list-style-type: none"> • Spiritual and religious • Recreation/ecotourism • Aesthetic • Educational • Cultural heritage • Inspirational
<p>Supporting services</p> <p>Services necessary for the production of other ecosystem services</p>		
<ul style="list-style-type: none"> • Soil formation 	<ul style="list-style-type: none"> • Nutrient cycling 	<ul style="list-style-type: none"> • Primary production

Source: – Davey (2005)

The literature review shows there are more methods available to assess and measure biodiversity alone as an ecosystem service (Faith *et al.* 2003; Parkes *et al.* 2003) than multiple ecosystem services. Given the complex nature of these multiple services, such as water yield and quality, carbon sequestration and food and fibre production, there would be benefit in developing a nationally consistent multi-disciplinary approach to gain a more informed understanding of the importance of ecosystem services and assets in Australia.

A nationally consistent and cohesive method to assess multiple ecosystem services is currently not available. This is a reflection of the complex, uncertain and often socially contentious issues that affect ecosystem management decisions. This is the case where the ‘services’ do not pass through traditional markets or benefit the whole of community (Chee 2004; Proctor *et al.* 2002). It is also a reflection of the different disciplines involved in decision making around ecosystem services and the different temporal and spatial scales that need to be considered.

Generally, the concept of ecosystem services in a policy context is poorly understood. For example, there is a need to demonstrate how the management of vegetation contributes to the

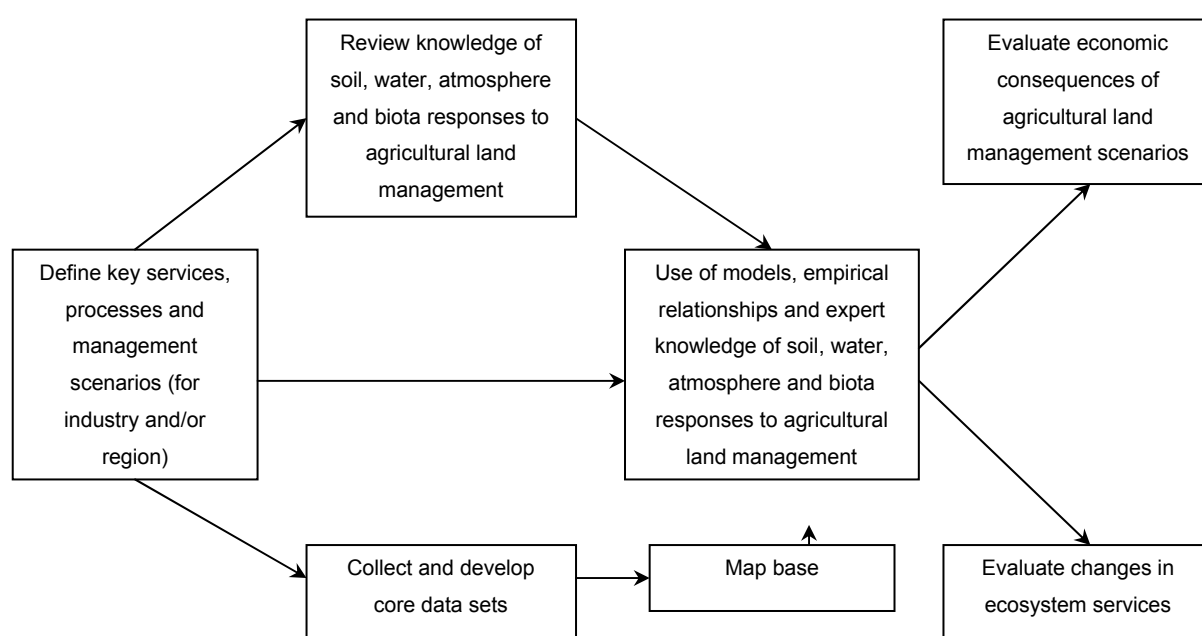
delivery of multiple ecosystem services and how in turn that information can be used to:

- define objectives and options and to evaluate and set priorities for delivering multiple natural resource outcomes; and
- to inform decisions on the role and benefit of using policy and programme instruments to influence on-ground multiple ecosystem services.

Without the development of a nationally consistent ecosystem services framework, it is difficult to effectively monitor the relationships between natural resource condition (i.e. multiple ecosystem services) and the effectiveness of public investments in improving natural resource condition through on-ground actions. Assessments of multiple ecosystem services are needed to inform priorities for investment; i.e. placing a value/s on the different ecosystem services in an area provides a mechanism for implementing on-ground ecosystem services actions.

Figure 1 outlines a generalised framework for evaluating ecosystem services in production landscapes. However, there is a also need to develop frameworks to assess and visualise the comparative values of ecosystem services that are typically associated with managing patches of vegetation across the landscape for multiple outcomes. In the context of long term degradation processes and the impacts beyond farm boundaries, many landholders face the difficulty of comparing the long term benefits of investing in sustainable farming practices against the immediate costs (Nelson *et al.* 2004; Stoneham *et al.* 2003).

Figure 1 - A framework for evaluating ecosystem services for agriculture



Source: generalised from Abel *et al.* (2003)

An analysis of the Australian Government's NRM programme and policy areas show the need for information on the provision of the following core ecosystem services:

1. food and fibre production
2. healthy soil
3. water quality and yield (including salinity mitigation)
4. biodiversity conservation
5. carbon sequestration
6. social values (recreation, employment and aesthetics etc)

While matters for target and indicators have been developed for most of these core ecosystem services under the National Monitoring and Evaluation Framework, there remains a disjunction between information required to inform NRM programme delivery and actual on-ground progress toward sustainable management and improvement to natural resource condition. There is a need to develop a more integrated process to bridge this disjunction.

The development of a national ecosystems services framework provides such a bridge [refer to the Outcomes from the *Approaches to Quantifying Ecosystems Services Provided by Vegetation Workshop* (2005) at:

http://adl.brs.gov.au/ecosystem/papers/Outcomes%20BRS%20ES%20workshop_301105_final.pdf].

Approach taken

The report provides an overview of current approaches being used and tested to assess and evaluate ecosystem services and discusses these approaches in combination with environmental benefits projects (e.g. MBIs) to influence the delivery of ecosystem service outcomes. The report also investigates opportunities for developing a nationally consistent approach for assessing multiple ecosystem services, noting that existing approaches are well understood or widely supported to enable adoption of these approaches across different regions or catchments at different spatial scales.

The Bureau worked closely with the relevant NRM policy and programme areas to identify the information needed to understand the key ecosystem services and how this information can assist in the setting of NRM priorities and investments under current and future NRM programmes. The information has been compiled in Box 1.

Based on the outline of NRM interests in ecosystem services information, outlined in Box 1, we undertook a literature review of national, state and regional projects that explore socio-economic and biophysical issues associated with the provision of ecosystem services from vegetation in production landscapes. The source of the literature review was internet, published case studies, scientific papers and reference material provided by contacting key stakeholders in Australian governments and research agencies. The following attributes were tabulated for each project/activity and a bibliographic database was used to document the references:

<i>Attributes of each approach</i>	<i>Description</i>
○ Organisation/Institution	Australian governments and research agencies
○ Project/activity	Name of the project
○ Current status	Ongoing or proposed
○ Description	Brief description of the uses of the project outputs
○ Further Information	Key contacts, web links and references

One of the outcomes of compiling this information was that the Department of Agriculture, Fisheries and Forestry (DAFF) requested the Bureau to convene a national workshop of key stakeholders in the Australian, state and territory governments, research agencies and industry sectors as well as regional and catchment groups. The Workshop held in late 2005, provided an opportunity to assess whether the Bureau's review was comprehensive of the main activities being undertaken at national, state and regional levels and whether there was benefit in developing a national framework for measuring and assessing ecosystem services.

Box 1 - Outline of NRM interests in ecosystem services information

Topics

- 1.0 Assessments and Case studies** – characterise the condition state/s of vegetation
- 2.0 Assessment Tools, Indices and Metrics**
 - 2.1 Habitat Indices
 - 2.2 Biodiversity Indices
 - 2.3 Environmental Benefits Indices
 - 2.4 Salinity Benefits Indices
- 3.0 Decision Support Tools**
 - 3.1 Carbon Accounting
- 4.0 Mechanisms to assist in procuring ecosystem services and/or influencing changes to land management practices including:**
 - 4.1 Cap and Trade schemes
 - 4.2 Auctions and Tendering processes
 - 4.3 Taxes and subsidies
 - 4.4 Experimental Economics
 - 4.5 Green Offset schemes
 - 4.6 Tradeable Net Recharge contracts
 - 4.7 Conservation Insurance
 - 4.8 Farming Finance schemes
 - 4.9 Education Programmes
 - 4.10 Regulation

Results

Much of the information compiled prior to and after the 2005 Workshop, focused on a single ecosystem service, such as carbon sequestration or biodiversity conservation. The breadth of this information included methods for applying scores and indices, methods and results of models and scenarios and tools for informing trade-offs and investment. Many of the current integrated projects funded under Australian Government initiatives such as the NHT and the NAPSWQ, were not directly referred to as ecosystem services projects. However, the projects did constitute approaches that influenced the delivery of multiple ecosystem service outcomes by promoting changes in land use, vegetation and land management.

Information presented in **Table 2** has been summarised for each tool/approach from the list in Appendix A. Each approach was scored using five steps:

1. *Characterise the resource or asset* (i.e. vegetation-related ecosystem services) that are of interest to policy goals;
2. *Influence priority settings* i.e. priorities for improving, maintaining and/or restoring vegetation-related ecosystem services;
3. *Design and implement a programme* – mechanisms for efficiently targeting investments in changing land management practices, attitudes, behaviours, and resource condition in accordance with goals/objectives
4. *Tracking on-ground progress toward desired goals/objectives* – on-ground surveys to check for changes in social and economic values and uses of vegetation by landholders – has land management practice/s changed;
5. *Complete vegetation resource assessments following action* – regular reports that document vegetation condition states and trends in the use and management of multiple ecosystem services.

These five Steps represent the key information sets required in developing, implementing and evaluating policies and programmes.

Table 2. Scoring of the relevance of the approaches for measuring and accounting for ecosystem services using a five step decision support cycle as outlined above.

		Scores for the five criteria *** = High, ** = Med, * = Low, - = NA				
Organisation/ Institution	Project/Model ²	1	2	3	4	5
ABARE	MOSAIC	***	*	-	-	-
	SALSA	***	-	-	-	-
	TRANSPLANT	***	-	-	-	-
Bureau of Rural Sciences	MCAS prototype model using the VAST vegetation condition states framework	***	**	*	*	*
	ASSESS	***	*	-	-	-
Department of the Environment and Water Resources	The Biodiversity Toolbox	***	*	***	-	-
	The Tasmanian Forest Conservation Fund	*	*	***	-	-
Department of Agriculture Fisheries and Forestry	Native Vegetation Regional Pilot Projects - sustainable native vegetation management on farms	*	*	***	*	-
Department of Agriculture Fisheries and Forestry	National Market Based Instruments Pilot Programme – Round 2	-	-	***	-	-
AGO and the CRC for Greenhouse Accounting	Carbon Accounting Toolbox	***	-	-	-	-
NSW Department of Natural Resources	Property Vegetation Plans (PVP)	***	-	**	**	*
	Enterprise Based Conservation - West 2000 Plus	**	*	***	-	-
Forests NSW	Environmental Services Scheme – Biodiversity Benefits Toolkit	***	*	**	-	-
NT Government / Tropical Savannas CRC	Multiple Use in Savanna regions	***	-	-	-	-
Queensland Environment Protection Agency	Biodiversity Incentives Tender	*	*	***	-	-
Victorian Department of Sustainability and Environment	BushTender	*	*	***	-	-
	BushBroker - a native vegetation credit registration trading scheme	*	*	***	*	*
	Carbon Tender Programme – Round 2	-	*	***	*	-

- ² Projects/tools can address one or multiple ecosystem services (these are denoted in **Appendix A**).
- The table is confined to projects and tools available in Australia up to the end of December 2006.
- The authors welcome feedback and comment on the table.

		Scores for the five criteria *** = High, ** = Med, * = Low, - = NA				
Organisation/ Institution	Project/Model ²	1	2	3	4	5
	Catchment Activity Management System	-	-	*	*	-
	Land Health Index (under consideration)	***	*	*	-	-
Victorian Department of Sustainability and Environment & Department Primary Industries	EcoTender	*	*	***	*	-
CSIRO Sustainable Ecosystems, Land & Water, Entomology, & Forests and Forestry Products, RIRDC, JVAP, LWA, Goulburn-Broken Catchment Authority, Blackwood Basin Group, Coleambally Irrigation Cooperative Ltd, DIPNR.	Markets for Ecosystem Services Project	*	-	***	*	-
Agricultural Production Systems Research Unit; CSIRO – Entomology, Land & Water, and Sustainable Ecosystems; Queensland Government (DIPNR); Uni of Queensland	Agricultural Production Systems Simulator (APSIM)	***	-	-	-	-
Land & Water Australia	Native Vegetation R&D Programme	***	-	-	*	-
	Traprock Information Management System (TIMS) – online toolkit for NR management	***	-	-	*	-
School of Resources, Environment & Society - ANU	Multiple Objective Landscape Analysis (MOLA)	***	-	-	-	-
Australia Museum	Biodiversity Index	***	-	-	-	-
CRC for Spatial Information	Developing a 4-D landscape modelling approach	***	-	-	-	-
UNE/DIPNR/CSIRO/Cotton CRC	The Gwydir Ecosystem Services Project	***	-	-	-	-
Vic DSE/Vic DPI/DAFF/Vic North Central CMA (Vic)	eFARMER – four staged pilot project	***	-	*	-	-
Goulburn Broken CMA (Vic)	The 'Bush Returns' Trial	*	*	***	-	-
Greening Australia/LWA	Exchange Incentive Fund – supported by NHT	*	*	***	-	-
Murray CMA (NSW)	On-Farm Incentive Projects	-	-	***	-	-
Department of Environment and Conservation (NSW)	BioBanking – A Biodiversity Banking Scheme	-	-	***	-	-
Liverpool Plains Catchment Management Committee/WWF Australia (NSW)	Land Management tenders – assessed against the Environmental Benefit Index system	***	*	***	**	*
Greening Australia	Land Innovation Fund	*	*	***	**	-
Southern Rivers CMA (NSW)	Southern Rivers Bush Incentives	**	*	***	*	-

		Scores for the five criteria *** = High, ** = Med, * = Low, - = NA				
Organisation/ Institution	Project/Model ²	1	2	3	4	5
Department of Water Land and Biodiversity Conservation (SA)	South Australian Biodiversity Assessment Tool – assigns a Biodiversity Significance Score	***	-	*	**	*
GreenFleet	Australian Tree Totaller - Carbon Emission offset scheme	***	**	***	*	-
CSIRO/DEC (NSW)/Greening Australia/Charles Sturt University/RMIT University/Southern Rivers CMA	Better Knowledge Better Bush Research Project	***	*	**	***	***
ENSIS	The Scenario Planning and Investment Framework (SPIF) tool	**	**	***	*	***

Table 3 provides a summary of the scores to the 41 approaches in Table 2 in terms of their relevance to a five step decision support cycle. Table 3 shows the majority of the high scores (i.e. ***) coincide with two steps, i.e. *Step 1: Characterise the resource or asset* and *Step 3: Design and implement a programme*. Step 1 approaches include frameworks and tools used or being investigated by the Australian, state and territory governments and research and R&D corporations for describing and assessing (e.g. ranking and scoring) ecosystem services. Step 3 approaches include incentive-based approaches such as Market Based Instruments (MBI). With regard to *Step 4: Tracking on-ground progress toward desired policy goals/objectives* only a few approaches have been allocated high (i.e. ***) and medium (i.e. **) scores. Our review has highlighted the relative absence of high (i.e. ***) and medium (i.e. **) scores for *Step 2: Influence Priority Setting* and *Step 5: Complete vegetation assessments* (assess resource condition following action), respectively.

Table 3. Summary of the scores assigned to the 41 approaches in Table 2 in terms of their relevance to a five step decision support cycle.

Five step decision support cycle	Scores assigned to the tools/approaches in Table 2			
	*** = High	** = Med	* = Low	- = NA
Step 1 Characterise the resource or asset	23	3	10	5
Step 2 Influence priority settings	0	3	19	19
Step 3 Design and implement a programme	20	3	5	13
Step 4 Tracking on-ground progress toward desired goals/ objectives	1	4	12	24
Step 5 Complete vegetation resource assessments following action	2	0	5	34

In compiling information on the approaches presented in Table 2, it was observed that there is confusion on the definition of ecosystem services. Among some stakeholders the term ecosystem services is synonymous with Environmental Management System (EMS) and Market Based Instruments (MBIs).

Frameworks and tools for Assessing the Status of Ecosystem Services (Step 1)

Table 2 and **Appendix A** shows that most state and territory agencies are either exploring and/or implementing approaches for measuring and assessing ecosystem services in production landscapes. This review also highlights multiple ecosystem services as an emerging area of discussion and that there is a clear need for national science-policy coordination and leadership on this issue. While there are various pilot areas and case studies relying on national funding through initiatives such as the National Action Plan for Salinity and Water Quality (NAPSWQ) and the Natural Heritage Trust (NHT), there is a need to develop cohesion between the disparate approaches. There is also a ground-swell of interest in improving the information sharing between these projects and activities, including methods and tools for characterising ecosystem services and modelling future delivery of these services at different scales and time-frames.

There is a range of approaches and frameworks for describing and assessing (e.g. ranking and scoring) ecosystem services but most are generally constrained to provide assessments, models and/or reporting on single ecosystem services for example, biodiversity conservation, carbon sequestration, or the provision of water. Alternate approaches provide the opportunity to integrate a subset of multiple ecosystem services, including the production of food and fibre, conservation of soil health (including salinity mitigation), and provision of aesthetic and cultural attributes, into one model to deliver multiple outcomes.

Indices and Metrics

Indices are a set of attributes and/or attribute combinations that are assigned numerical scores, weights or rankings, for example the Habitat Index (Oliver and Parkes 2003), Biodiversity Index (Faith , and Salinity Benefits Index (Herron et al. 2004). An approach that combines a number several indices into a single index is the Environmental Benefits Index (Grieve 2003).

Decision Support Tools

Toolboxes are used to develop scenario planning capabilities, generally promoting a transparent modelling capacity via web-based, interactive applications, for example, the Carbon Accounting Toolbox (CRC for Greenhouse Accounting) and Biodiversity Toolbox (Department of Environment and Heritage). Indices as described above can be incorporated into these prototype ‘toolkits’ which evolve as new data emerges, and methods and needs change (Oliver and Parkes 2003).

An example of a Spatial Decision Support System is the Multiple Criteria Analysis (MCA) model. MCA provides an interface between Geographical Information Systems (GIS) and simple linear addition and combination of data layers; datasets are ranked from 1 to 5 corresponding to suitable or good to unsuitable or bad. The system allows for the development of output scenarios that may be constructed from different user viewpoints. The ASSESS (A System for Selecting Suitable Sites) tool, is one example which assesses the condition states of hydrological catchments in the intensive land use zone of Australia (Walker and Veitch 2001; Hill et al. 2005).

Mechanisms for influencing changes in land use and land management (Step 3)

As **Box 1** shows, there are numerous mechanisms for influencing the delivery of ecosystem services via legislative or compliance measures, Market Based Instruments (MBI), education programmes and taxes. Our analysis has shown that public benefit ecosystem services can be influenced by MBI. MBIs are mechanisms to value particular ecosystem services and are designed to provide economic or financial incentives to improve environmental practices and

outcomes. Well designed MBIs are targeted to engage private landholders. For example, an auction of conservation contracts can be designed to bring together multiple ecosystem services (terrestrial habitat, groundwater recharge, stream flow, and water quality and carbon sequestration) into one system. Under an MBI framework it is possible to design and create markets that can efficiently allocate resources to the provision of ecosystem services on either public and private land, or a combination of both.

Examples of MBIs are environmental levies and charges, tradeable licences and permits, refund systems, regulatory relief initiatives, cap and trade, offset schemes, auctions and tendering, and taxes and subsidies. Whitten et al. (2004) provide an overview of proceedings of a national symposium dedicated to exploring the appropriateness and effectiveness of MBIs in NRM. Included are examples of the National Market-Based Instruments Pilots Programme that was established to implement on-ground actions that may link to specific policy framework/s. The NAPSWQ funded programme selected 10 pilot projects across the country to examine their effectiveness in creating suitable scenarios for market-based approaches to NRM (<http://www.napswq.gov.au/mbi/index.html>). Recognising that not all MBIs will be useful in all situations, Shelton et al. (2004) describe a rapid assessment technique for identifying the potential for MBI application. A good working example of vegetation management contributing to an ongoing MBI approach is outlined in the Joint Venture Agroforestry Programme (Binning et al. 2002).

A review of Round One of the MBI Pilot Programme (Grafton, 2005), identifies the auction system as cost-effective, offering the lowest risk to landholders, and most readily fitting into existing institutional arrangements and practices. This review also identifies future research needs to test a mix of instruments designed to address a range of environmental problems. Depending on the outcomes that are required, there may be advantages in using a mix of instruments that can be applied either sequentially or offered as a bundle to a defined set of stakeholders.

The Victorian Rural Land Stewardship Programme and New South Wales (Property Vegetation Planner (PVP) have well-developed environmental benefit programmes that systematically identify and value multiple ecosystem service benefits that are provided by native vegetation. The aim of these approaches or activities is to target policy and action through consultation and agreement with private landholders on incentive-based payments for the provision of public non-market benefits, i.e. multiple ecosystem services. These two environmental benefit programmes make explicit the concept of ecosystem services as those public benefits that have previously been overlooked and often compromised for example, clean water, habitat for native species and soil health.

Discussion

The Prime Minister's Science, Engineering and Innovation Council report (Morton *et al.* 2002), identified the urgent need to develop methods to estimate the economic, social and environmental value of the services provided from natural ecosystems. These services are now commonly referred to as ecosystem services and are widely accepted in agricultural literature and reporting mechanisms. However, access to information on multiple ecosystem services provided by vegetation to inform public policy setting and programmes is in its formative stages.

The majority of Australia's land and water resources are used by agricultural industries to produce food and fibre (Chesson and Whitworth 2005). There is an increasing demand for accountability and reporting mechanisms for the contribution of agricultural industries to our total quality of life. While vegetation is managed primarily to produce food and fibre, effective vegetation management is increasingly recognised as critical in responding to major issues such as salinity, water quality and quantity, soil erosion and loss of biodiversity.

The concept of vegetation condition states can be used to operationalise the link between ecosystem function and ecosystem services. The condition state of vegetation is often difficult to define and it requires knowledge about the intact state and likely vegetation over time. For production ecosystems, this is relatively easy because the suitability and market potential of various agronomic or pastoral states is generally well known. For native vegetation, whether intact or disturbed but not cleared (e.g. selective thinning for grazing, timber getting, impacts of wildfire), the trajectories are less predictable for some ecosystem services (e.g. weeds, feral animals, water harvesting).

One practical approach for determining vegetation condition is provided by the Vegetation Assets, States and Transitions (VAST) framework (Thackway and Lesslie 2005). VAST uses a metric approach to classify and map vegetation condition that are the result of land use and/or land management practices. Future NRM programmes could use VAST condition states for assessing current status and for promoting changes in land use and/or land management practices to change the mix of vegetation condition at the catchment scale. The intent of targeting NRM funds would be to

change the mix of vegetation condition across a landscape and, in turn, change the mix of ecosystem services.

Research is currently underway to explore spatially explicit models that are capable of scenario setting to determine the incremental changes and trade-offs associated with the valuation (economic, environmental and social) of benefits provided by vegetation. Coupled with Geographical Information Systems (GIS) and remote sensing capabilities, mapping, assessment, process modelling and decision-making models are evolving and incorporating complex systems approaches. A number of models, prototypes and approaches are currently being developed (**Appendix A**).

A major progression of the ecosystem services concept in production landscapes came from the work of the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Sustainable Ecosystems Division, who developed a multi-partner initiative drawing on theory from ecology, the physical sciences, economics, political, policy and other social sciences (Abel *et al.* 2003). Emerging issues identified in that project included the need for community participation in the learning process and the development of markets for ecosystem services. The emergence of markets for ecosystem services provides another platform to facilitate discussion with the Australian Bureau of Agricultural and Resource Economics (ABARE) to progress understanding in this area.

Land and Water Australia (LWA) has compiled an excellent series of case studies which provide a basis for future studies regarding the maintenance and provision of ecosystem services (LWA 2002). These projects are generally aligned with native vegetation and biodiversity initiatives, with a focus on sustaining vegetated landscapes for conservation and production outcomes. These case studies seek to address integrated ecological, social and economic considerations by managing native vegetation.

An assessment of data requirements and availability to address natural resource condition and trend indicators is summarised in a recent National Land and Water Resources Audit report (NLWRA 2005). The report identified a number of gaps in vegetation datasets in particular, which reflects the complexity of decision-making in this area and the need for sound ecological and/or biophysical data to underpin any valuation of ecosystem services. While modelling and mathematical representations of ecological processes can stimulate understanding of ecosystems and their function

in a rigorous and consistent way, it is the participatory process of collective decision making that that will address issues of uncertainty at regional perspectives (Chee, 2004).

Ecosystem services also provides the opportunity to align with the following government initiatives, including: SCARM National Collaborative Project on Indicators for Sustainable Agriculture (SCARM 1998); National Food Industry Environmental Sustainability Initiative (Allen Consulting Group 2004); National NRM Monitoring Evaluation Framework; *Primary Industries and Energy Research and Development Act 1989*; State of Environment Reporting (SOE); Environmental Management Systems (EMS); and OECD Agri-environmental indicators. These initiatives highlight the participatory process required to gain a greater understanding of the value of ecosystem services in production landscapes.

This review has highlighted the need to develop unambiguous definitions of ecosystem services. This was shown among policy and programme areas that the ecosystem services concept was regarded as synonymous with environmental management systems. An EMS provides a basis for adaptive environmental management. Under an EMS scenario, ecosystem services can be integrated with existing planning and management arrangements at different scales. This can range from an individual management unit to the whole-of-landscape, to provide a holistic management tool for achieving goals of sustainability, as well as improved competitiveness and profitability in the market place. An EMS is a flexible process-based tool for achieving continuous improvement in environmental performance by managing the environmental impacts of an enterprise's activities through a defined set of procedures. These can be summarised as a “plan-do-check-act” continuous improvement cycle.

This review has also raised a number of key issues including:

1. The need to provide clear definitions of ecosystem services.
2. How best to synthesise current knowledge and research into multiple environmental benefits (i.e. ecosystem services) associated with agricultural production?

3. How to identify potential for collaborative partnerships to investigate ecosystem services provided by vegetation – should partnerships be theme based e.g. sectors, region based, or ecosystem service based?
4. How widely understood is the concept of vegetation condition states and the link between vegetation management practices, ecosystem function and ecosystem services?
5. What role does scale play in developing, implementing and evaluating NRM policies and programmes? Is there benefit in developing case studies for use by NRM policy and programmes to demonstrate the approach including integration of stakeholder input/information?
6. What are the gaps in current information and data needed to enhance our understanding ecological function (e.g. eco-physiological modelling)?
7. How best to provide advice to NRM policy and programme areas on the current and proposed developments by Australian governments and research agencies regarding triple bottom line approaches e.g. a discussion paper and a national workshop?
8. How useful is the policy cycle in understanding the connections between the assessments that characterise the multiple benefits provided by vegetation and the NRM programmes that provide funds (e.g. MBIs and other incentives), which are designed to change on-ground land management practices and the condition states of vegetation to deliver desired/targeted environmental outcomes in production landscapes?

Conclusions

There is a growing awareness of the benefits of using integrated information to inform public investment in addressing environmental problems and sustainability of production landscapes. Within this groundswell there is an identified need for the Australian Government to develop a nationally consistent framework for ecosystem services. There is an expectation among state agencies represented in national committees (e.g. NRMSC) that the Australian Government can and should use its influence through NRM programmes such as NHT and the NAPSWQ to improve sustainable production and natural resource condition by adopting and promoting the development of multiple outcomes.

Such a framework for measuring sustainability of production landscapes needs to clearly articulate the separation between:

- (i) concepts of vegetation condition states, vegetation management practices, ecosystem function and ecosystem services;
- (ii) methods for assessing, measuring and reporting on ecosystem services;
- (iii) the objectives and options to evaluate and set priorities for delivering multiple outcomes; and
- (iv) the role and benefit of using incentives and instruments to influence on-ground outcomes. There is a need to consider the advantages and disadvantages of developing a nationally consistent approach to assessing current and modelling potential for future ecosystem services, which can be used to inform policy and programme priorities. Cork and Shelton (2000) however note that a prime consideration when modelling ecosystem services is to reduce the complexity of model interactions without compromising the capacity of the model to be realistic and to deliver clear and understandable predictive capabilities.

Ideally, the development of national a framework for assessing, measuring and reporting on ecosystem services should be progressed as a partnership with the relevant national, state and regional bodies involved in natural resource management policy and programmes in the Australian and state and territory governments. The framework should aim to build on the existing ecosystem services frameworks that

are being used in the States and Territories. The national workshop held in 2005 provided an opportunity for developing such partnerships and moving towards this framework.

Acknowledgements

The Department of Agriculture, Fisheries and Forestry (DAFF) Natural Resource Management (NRM) programme funded the Bureau of Rural Sciences (BRS) to review national and state ecosystem service projects and activities.

The authors wish to acknowledge the support of Philip Pritchard, Rod Carr and Tim Ogden in describing the programme and policy environment which require information on ecosystems and the links with Market Based Instruments.

Mark Parsons and John Davidson from the Forest and Vegetation Sciences Programme in BRS edited earlier versions and provided valuable feedback.

Bibliography

- Abel, N., Cork, S., Goddard, R., Langridge, J., Plant, A., Proctor, W., Ryan, P., Shelton, D., Walker, B., and Yialeloglou, M. (2003) *Natural Values: Exploring Options for Enhancing Ecosystem Services in the Goulburn Broken Catchment*. CSIRO Sustainable Ecosystems, Canberra
- Allen Consulting Group (2004). *National Food Industry Environmental Sustainability Initiative*. Allen Consulting Group, Canberra
- Binning, C., Baker, B., Meharg, S., Cork, S., and Kearns, A. (2002). *Making Farm Forestry Pay – Markets for Ecosystem Services: A Scoping study to set Future Research Directions*. Rural Industries Research and Development Corporation, Canberra
- Chee, Y. E. (2004) An ecological perspective on the valuation of ecosystem services *Biological Conservation* **120**:549-565
- Chesson, J. and Whitworth, B. (2005). *Signposts for Australian Agriculture – Preliminary Framework and Collation of Industry Profile*. Final report stage 1 to the National Land and Water Resources Audit, February 2005.
- Cork, S. J., and Shelton, D. (2000) *The Nature and Value of Australia's Ecosystem Services: A Framework for Sustainable Environmental Solutions*. Proceedings of the 3rd Queensland Environmental Conference, May 2000.
- Daily, G.C. (1997) *Nature's Services: Societal dependence on natural ecosystems*. Island Press, US
- Davey, S. (2005) *Science-Policy and Ecosystem Services*. prepared for the Department of Agriculture Fisheries & Forestry. Bureau of Rural Sciences Seminar, 14 October 2005, Canberra. (Unpublished report)
- Eamus, D., Maccinis-Ng, C.M.O., Hose, G.C., Zeppel, M.J.B., Taylor, D. T., and Murray, B.R. (2005) Ecosystem Services: an ecophysiological examination *Australian Journal of Botany* **53**:1-19

- Faith, D. P., Carter, G., Cassis, G., Ferrier, S., and Wilkie, L. (2003) Complementarity, biodiversity viability analysis, and policy-based algorithms for conservation. *Environmental Science and Policy* **6**:311-328
- Grafton, Q. (2005) *Evaluation of Round One of the Market Based Instrument Pilot Programme* A report to the National MBI Working Group, Department of Agriculture Fisheries & Forestry, Canberra.
<http://www.npswq.gov.au/mbi/round1-evaluation.html>
- Grieve, A. M., (2003). *An Overview of the Individual Environmental Service Indices Developed for Use in the Environmental Services Scheme*. State Forests of NSW, Sydney.
- Herron, N., Peterson, P., and Black, D. (2004) *The Salinity Benefits Index: A Method for Calculating the Impacts of Land Use Change on Stream Salinities*. NSW Department of Infrastructure Planning and Natural Resources, Sydney, Australia
- Hill, M.J., Braaten R., Veitch, S. M., Lees, B.G., Sharma, S. (2005). Multi-criteria decision analysis in spatial decision support: the ASSESS analytic hierarchy process and the role of quantitative methods and spatially explicit analysis. *Environmental Modelling and Software*, **20**:955-976
- LWA (Land and Water Australia) (2002). *What are Ecosystem Services?* RipRap – River and Riparian Lands Management Newsletter, Edition **21**. LWA, Canberra
- Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-being: Biodiversity Synthesis*. World Resources Institute, Washington, DC.
<http://www.millenniumassessment.org/en/products.aspx>
- Morton, S., Bourne, G., Cristofani, P., Cullen, P, Possingham, H., and Young, M. (2002) *Sustaining our Natural Systems and Biodiversity*: an independent report to the Prime Minister’s Science, Engineering and Innovation Council CSIRO and Environment Australia, Canberra
- Nelson, R., Alexander, F., Elliston, L., and Bias, A. (2004) *Natural Resource Management on Australian Farms*. ABARE eReport 04.7

- NLWRA (National Land and Water Resources Audit) (2005). *Status of Natural Resource Information to Underpin the National Natural resource Management Monitoring and Evaluation Framework*. National Land and Water Resources Audit, Canberra
- Oliver, I., and Parkes, D. (2003) *A Prototype Toolkit for Scoring the Biodiversity Benefits of Land Use Change*. Department of Infrastructure, Planning and Natural Resources, Sydney, Australia
- Parkes, D., Newell, G., and Cheal, D. (2003) Assessing the quality of native vegetation: The 'habitat hectares' approach. *Ecological Management & Restoration* 4
- Proctor, W., Cork, S., Langridge, J., Langston, A., Abel, N., Howden, M., Anderies, M., Parry, R., and Shelton, D. (2002) *Assessing Ecosystem Services in Australia*. 7th Biennial Conference of the International Society for Ecological Economics, Sousse, Tunisia, 6-9 March 2002
- Standing Committee on Agriculture and Resource Management (1998) *Sustainable Agriculture: Assessing Australia's Recent Performance*. A report to the Standing Committee on Agriculture and Resource Management by the National Collaborative Project on Indicators for Sustainable Agriculture, SCARM Report Series, Report 70, CSIRO Publishing, Melbourne
- Shelton, D., Cork, S., Binning, C., Parry, R., Hairsine, P., Vertessy, R., and Stauffacher, M. (2001) *Application of an ecosystem services inventory approach to the Goulburn Broken Catchment*. Third Australian Stream Management Conference, August 27-29, 2001. Rutherford, I., Sheldon, F., Brierly, G., and Kenyon, C – Editors. Cooperative Research Centre for Catchment Hydrology, Brisbane, pp 157-162
- Shelton, D., Langston, A., and Whitten, S. (2004) *Market Based Instruments – A rapid assessment technique for identifying the potential for MBI application*. Rural Industries Research and Development Corporation, Canberra, Project No. CSW35A.

- Stoneham, G., Eigenraam, M., Ridley, A., and Barr, N. (2003). The application of sustainability concepts to Australian agriculture: an overview. *Australian Journal of Experimental Agriculture* **43**:195-203
- Thackway, R. and Lesslie, R. (2005) *Vegetation Assets, States and Transitions (VAST): accounting for vegetation condition in the Australian landscape*. BRS Technical Report, Bureau of Rural Sciences, Canberra
- Veitch SM and Bowyer JK (1996). *ASSESS: A GIS-based system for selecting suitable sites*. In: *Raster Imagery in Geographic Information Systems* (Morain S & Lopez Baros S - Editors.). Onword Press, Santa Fe. 182-91.
- Veitch SM (1997). *Land use decisions and site selection: a GIS-based method*. In: *Environmental Software Systems Volume 2* (Denzer R, Swayne DA & Schimak G – Editors) Chapman & Hall, London.
- Walker, J. and Veitch, S.M. (2001) *Assessment of catchment condition in Australia's intensive land use zone: a biophysical assessment at the national scale*. Final Report on Project 7/7 to the National Land and Water Resources Audit, November 2000.
- Whitten, S., Carter, M., and Stoneham, G. (2004) *Market-Based Tools for Environmental Management – Proceedings of the 6th Annual AARES National Symposium 2003*. Rural Industries Research and Development Corporation Canberra
- Williams, J (2005) *Native Vegetation and Regional Management: A guide to research and resources*. Greening Australia, Canberra

Appendix A. List of current key national ecosystem services projects and activities

NB: refer to bibliography for full details of references provided in table

Ecosystem services frameworks and tools				
Australian Government				
Organisation/ Institution	Project/Model	Current Status	Approach	Key Contacts, Web links and References
Australian Bureau of Agriculture and Resource Economics (ABARE)	MOSAIC	Ongoing	MOSAIC is an integrated spatial optimisation framework for exploring future land use and management options at regional and landscape scales. Critical spatial interactions and linkages such as resource use externalities, transport costs and habitat configuration are supported explicitly. MOSAIC provides the capability of identifying the social, environmental and economic trade-offs of changing the way land is managed in particular landscape contexts. The user interface provides GIS functionality and utilises wizards to define scenarios. A prototype application of MOSAIC includes objectives relating to biodiversity, greenhouse emissions, dryland and river salinity, and economic costs and returns.	Kenton Lawson klawson@abare.gov.au http://www.abareconomics.com/publications_html/models/models/models.html
	SALSA	Ongoing	SALSA is an integrated economic-hydrological model of land use and salinity processes in the Murray Darling Basin that explicitly models externalities in resource use. Key capabilities of the	Colin Mues cmues@abare.gov.au http://www.abareconomics.com/publications_html/models/models/models.html

model include that it: Recent uses include: evaluation of salinity control options in the Murray Darling Basin; estimation of the

Ecosystem services frameworks and tools

Australian Government

Organisation/ Institution	Project/Model	Current Status	Approach	Key Contacts, Web links and References
<p>Australian Bureau of Agricultural and Resource Economics (ABARE)</p>			<p>opportunity costs for environmental flows; assessing externalities associated with improved water use efficiency and water trade; impact analysis of climate change on water availability and salinity outcomes</p>	
	<p>TRANSPLANT</p>	<p>Ongoing</p>	<p>TRANSPLANT is a mathematical programming model for key land use activities in Australia. It simulates competition for land and other inputs among competing agricultural activities. It is currently used to provide emissions projections to 2020 for Australian agriculture to the AGO. Currently developing TRANSPLANT to link other land use activities such as timber production, plantations, revegetation and land clearing into the existing framework.</p>	<p>Allan Hansard ahansard@abare.gov.au http://www.abareconomics.com/publications_html/models/models/models.html</p>

Ecosystem services frameworks and tools

Australian Government

Organisation/ Institution	Project/Model	Current Status	Approach	Key Contacts, Web links and References
Bureau of Rural Sciences (BRS)	MCAS-S model (using the VAST vegetation classification system)	Ongoing	The Multi-Criteria Analysis Shell for Spatial Decision Support (MCAS-S) is a software tool developed using the VAST vegetation classification system to analyse trade-offs in ecosystem services scenarios.	MCAS Rob Lesslie Rob.Lesslie@brs.gov.au Steve Dawson Steve.Dawson@brs.gov.au Richard Thackway (VAST) Richard.Thackway@brs.gov.au The Australian Collaborative Land Use Mapping Programme Bureau of Rural Sciences GPO Box 858, Canberra ACT 2601 Phone: (02) 6272 5236 Fax: (02) 6272 5827 Email: land_management@brs.gov.au
	ASSESS	Ongoing	A Decision Support System using Multiple Criteria Analysis as a spatial implementation of the Analytic Hierarchy Process. Analysing natural resources, patterns of use and commodity assets in Australian rangelands and originally developed with MDBC to determine suitable sites for tree planting at catchment scales.	Rob Lesslie Rob.Lesslie@brs.gov.au http://www.affa.gov.au/brs Hill, Braaten, Veitch, Lees, Sharma (2005)

Ecosystem services frameworks and tools

Australian Government

Organisation/ Institution	Project/Model	Current Status	Approach	Key Contacts, Web links and References
Department of the Environment and Water Resources	The Biodiversity Toolbox	Ongoing	Biodiversity assessment designed for Local Government use via regional vegetation management plans and ecosystem service establishment of Property Management Agreements with private landholders. The results are used to inform: conservation covenants; voluntary conservation agreements; model incentive schemes; model levy schemes and environmental grant schemes.	http://www.environment.gov.au/biodiversity/toolbox/index.html
	The Tasmanian Forest Conservation Fund	Ongoing	The FCF will support private landowners to manage their forest for conservation using mechanisms such as: voluntary stewardship arrangements, secured in perpetuity through covenants on the land	Email: fcf@deh.gov.au http://www.environment.gov.au/land/forestpolicy/fcf/index.html http://www.environment.gov.au/land/forestpolicy/fcf/pubs/fcf-brochure.pdf
Australian Greenhouse Office (AGO)	Carbon Accounting	Ongoing	Carbon accounting and land-use change scenario modelling providing a set of tools for tracking greenhouse gas emissions	Gary Richards

Ecosystem services frameworks and tools

Australian Government

Organisation/ Institution	Project/Model	Current Status	Approach	Key Contacts, Web links and References
and the CRC for Greenhouse Accounting	Toolbox		and carbon stock changes from land use and management. It provides access to the Full Carbon Accounting Model (FullCAM), that is derived from Australia's National Carbon Accounting System, and includes all supporting technical documentation. Through the Toolbox, users can access: carbon accounting data for a range of plant species and land management systems; and historic climate records;	Gary.Richards@environment.gov.au http://www.greenhouse.gov.au/ncas/ncat/index.html
Department of Agriculture Fisheries and Forestry (DAFF)	Native Vegetation Regional Pilot Projects – Tasmania and Victoria	Ongoing	The pilot projects, currently underway in Tasmania and Victoria, will assess voluntary mechanisms, such as property management systems (PMS), incentive payments, offsets, extension and information services, to deliver more practical native vegetation management arrangements for landholders.	http://www.daffa.gov.au/__data/assets/word_doc/31702/native_veg_reg_pilot_overview_vic.doc http://www.daffa.gov.au/__data/assets/word_doc/31701/native_veg_reg_pilot_overview_tas.doc
	National Market Based Instruments (MBI) Pilot Programme	Ongoing	Round 1 of the programme commenced in 2003 seeking to increase Australia's capacity to use MBI's in managing natural resource issues, in particular to address the problems of salinity and water quality. Round 2 commenced in 2006 and is ongoing.	http://www.napswq.gov.au/mbi/round1/index.html http://www.napswq.gov.au/mbi/round2/index.html Grafton (2005)

Ecosystem services frameworks and tools

Australian Government

Organisation/ Institution	Project/Model	Current Status	Approach	Key Contacts, Web links and References
<p>Department of Agriculture Fisheries and Forestry (DAFF)</p>	<p>EMS National Pilot Programme & Pathways to Industry EMS Programme</p>	<p>Ongoing - Round 2 proposals for the Pilot Programme are now being sought</p>	<p>The Environmental Management Systems (EMS) approach includes: the EMS Navigator tool; Pathways to Industry EMS Programme; Australia's National Framework for EMS in Agriculture; EMS – Biodiversity Resource Guide; EMS National Implementation Plan; EMS National Pilot Programme; EMS – Pathways to Sustainable Agriculture Programme; and the EMS Incentives Programme. The fundamental objectives of the EMS approach include:</p> <ul style="list-style-type: none"> • improved management of the environmental impacts of farming; • better natural resource outcomes and sustainable agriculture; • potential to respond to market access issues; • improved community perceptions of farming; • adaptive management processes to build on and streamline a range of complementary processes eg Property Management Planning (PMP), Quality Assurance (QA), Best Management Practice (BMP), etc; and • improved business efficiency. 	<p>DAFF EMS Contact Officer: ems@affa.gov.au <u>EMS Navigator</u>, A web-based searchable database, provides access to information on EMS activities being undertaken by industries, government agencies and community groups around Australia and overseas. See http://www.affa.gov.au/emsnavigator or see http://www.affa.gov.au/ems_plan</p>

Ecosystem services frameworks and tools

State and Territory Governments

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
<p>NSW Department Natural Resources (DNR)</p>	<p>Property Vegetation Planners (PVP)</p>	<p>Ongoing</p>	<p>The PVP Developer uses four tools to assess the impact of proposed activities on water quality, soils, salinity and biodiversity (including threatened species). It provides consistent, objective and repeatable results, based on locally-relevant data gathered in each region. The PVP Developer will continue to be refined as scientific knowledge improves. Utilises the Land Use Options Simulator (LUOS).</p>	<p>www.dipnr.nsw.gov.au <u>Biodiversity</u> – Phil Gibbons (CSIRO SE) <u>Threatened Species</u> – Sue Briggs CSIRO SE/NSWNPWS <u>Salinity</u> – Natasha Herron natasha.herron@dipnr.nsw.gov.au Herron <i>et al.</i> (2004)</p>

Ecosystem services frameworks and tools

State and Territory Governments

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
	Enterprise Based Conservation- West 2000 Plus	Ongoing	<p>The programme encourages landholders to develop innovative projects that focus on managing part or all of their property for conservation outcomes rather than for traditional pastoral purposes. Rather than removing domestic stock and 'locking up' the country for five years, the programme is based on achieving positive conservation outcomes through active and adaptive management. The successful completion of agreed conservation-based management activities form the basis of landholders receiving a series of annual payments.</p>	<p>Renee Shepherd renee.shepherd@dipnr.nsw.gov.au</p>
NSW Department of Environment & Conservation (DEC)	BioBanking – A biodiversity scheme	<p>The scheme is currently under development with implementation expected in mid 2007</p>	<p>A Biodiversity Banking and Offsets Scheme (BioBanking) to address the clearing of native vegetation for urban development and the impact it has on biodiversity values, including threatened species. It will allow 'biodiversity credits' to be generated by landowners who commit to enhance and protect biodiversity values on their land. These credits can then be sold. Developers can buy these credits and use them to counterbalance (offset) the impacts on biodiversity values that are likely to occur as a result of development.</p>	<p>biobanking@environment.nsw.gov.au</p>

Ecosystem services frameworks and tools				
State and Territory Governments				
Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
Forests NSW	Environmental Services Scheme	Ongoing	State Environmental Services Scheme using MBIs and incentives eg. carbon, salinity and biodiversity credits using a Biodiversity Benefits Toolkit.	http://www.forest.nsw.gov.au/env_services/ess/default.asp
Liverpool Plains CMAC/WWF Australia (NSW)	Land Management Tenders	Ongoing	Tenders are assessed against an Environmental Benefit Index System.	http://wwf.org.au/publications/LandManagementTenders2005/
Southern Rivers CMA (NSW)	Southern Rivers Bush Incentives	Ongoing	An incentive scheme to encourage Protecting native offering: <ul style="list-style-type: none"> • Free information on the value of your native vegetation and advice on its management • Preparation of a management plan that suits you • Opportunity to apply for funding • Landholder control of the amount of money requested • Protection of native vegetation and wildlife for future generations • Cost-effective expenditure of public funds, based on national, State and regional priorities. 	http://southern.cma.nsw.gov.au/pdf/SRBI-Brochure.PDF

Ecosystem services frameworks and tools

State and Territory Governments

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
Department of Water Land and Biodiversity Conservation	SA Biodiversity Assessment Tool	Ongoing	Using a GIS database and functions to allocate a Biodiversity Significance Score (BSS) to a patch of native vegetation or revegetation.	http://www.dwlbc.sa.gov.au/biodiversity/trading/index.html
NT Government & Tropical Savannas CRC	Multiple Use in Savanna regions	Ongoing	To use ecological and economic modelling to predict and communicate the potential effectiveness of management interventions aimed at modifying woody vegetation structure, using data from regional case studies and multiple projects addressing bio-physical and economic modelling.	http://savanna.ntu.edu.au/
Queensland Environment Protection Agency	Biodiversity Incentives Tender	Ongoing	Incentives offered to landholders particularly targeting high conservation value areas within the Brigalow Belt, Desert Uplands, Einasleigh Uplands and Border Ranges.	http://www.epa.qld.gov.au.nature_conservation/nature_refuges/financial_incentives/
Victorian Department of Sustainability and Environment (DSE)	The Land Stewardship Project – BushTender and BushBroker	Ongoing	Bush Tender (Habitat Hectares) - Biodiversity Benefits Index - a single outcome approach investigating a range of mechanisms, drawing on a number of research papers addressing ecosystem services through land stewardship practices. BushBroker – a native vegetation credit registration trading scheme	http://www.dse.vic.gov.au/dse/nrenlwm.nsf/childdocs/-FA20C94F64F19A5E4A2567D7000B194D-820716FF45CF6AC4CA256D970010D4DC?open

Ecosystem services frameworks and tools

State and Territory Governments

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
Victorian Department of Sustainability and Environment	Carbon Tender Programme – Round 2	Ongoing	Carbon Tender bidders are paid to grow permanent, native vegetation or 'carbon sinks' on their properties. The carbon rights from these voluntary agreements will then be shared by the landholders and the State Govt.	Jack Holden jack.holden@dse.vic.gov.au
	Catchment Activity Management System (CAMS)	Ongoing	CAMS records spatial, non spatial and financial information on catchment activities and on-ground work activities (i.e. tree planting and stream restoration works) It provides a mechanism for managing and tracking on ground work projects for field staff and project managers.	rdn.cams@dse.vic.gov.au http://www.dpi.vic.gov.au/dse/nrenlwm.nsf/FID/ - AD909E2E6267F2514A2569A5000FCD9 C?OpenDocument
	Land Health Index (LHI)	Under consideration	The LHI will provide a measure of land health across landscapes and catchments and assist with monitoring whether management is compatible with the long-term sustainability of the land. Four national indicators - Soil salinity, acidification, erosion (water & wind, and carbon content, along with soil biology/biodiversity, will inform the Index: Land cover, disturbance, use and stability will also be considered. The LHI will become a complementary measure of land condition to Victoria's established Habitat Hectare (vegetation condition) and Index of Stream Condition.	http://www.vnpa.org.au/resources/DSEWhitePaper.htm

Ecosystem services frameworks and tools

State and Territory Governments

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
			<ul style="list-style-type: none"> • The approach will also complement methods for looking at site-specific soil fertility, agricultural productivity and soil naturalness. • The proposed Land Health Index will provide an integrated measure of land health for use in Catchment Condition and State of Environment reporting. • The Land Health Index will provide an ongoing ability to monitor, evaluate and report on land health at the landscape scale and thus be relevant to the protection and enhancement of public and private assets. 	

Ecosystem services frameworks and tools

State and Territory Governments

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
Victorian Department of Sustainability and Environment and Department Primary Industries	EcoTender	Ongoing	Under the auspices of the Australian Government MBI Pilot Programme, EcoTender is a trial combinatory approach using an auction of conservation contracts designed to deliver multiple ecosystem services such as terrestrial habitat, groundwater recharge, stream flow, water quality and carbon sequestration at local and catchment scales. The EcoTender pilot project is being conducted in the Avon-Richardson area of the North Central Catchment Management Authority region and the Cornella area of the Goulburn Broken Catchment Management Authority	David Parkes David.parkes@dse.gov.au http://www.dse.vic.gov.au/DSE/nrence.nsf/LinkView/F18669E8E2A4C02FCA256FDB00031592E2A52365F438A1EFCA256FFF00236D8E
Vic DSE/Vic DPI/DAFF/Vic North Central CMA (Vic)	eFarmer	The pilot to be completed in November 2006 – further development after an evaluation report is submitted late 2006.	The web-based application eFarmer is being trialled in 4 contrasting catchments across Victoria to: <ul style="list-style-type: none"> • improve understanding of the intentions and actions of landholders regarding changes in land management practice • provide a tool to help communicate regional priorities and targets to land managers • contribute to more complete reporting on regional progress towards targets 	http://www.dpi.vic.gov.au/dpi/nrensr.nsf/LinkView/9568C9E45AFE6578CA256FC6001F7EDB61726F7A0F760A89CA256FC6001F02F8

Ecosystem services frameworks and tools

State and Territory Governments

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
Goulburn Broken CMA (Vic)	The 'Bush Returns' Trial	Ongoing – no new rounds but landholders still participating	Bush Returns trials the use of a tender-based approach to achieve large-scale regeneration of native vegetation on private land.	http://www.gbcma.vic.gov.au/default.asp?ID=172 www.gbcma.vic.gov.au .
Murray CMA	On-Farm Incentive Projects	Ongoing	A funding scheme to deliver new and innovative projects that help address the core objectives of the Murray Catchment Action Plan, including: <ul style="list-style-type: none"> • Communities working within the Murray Catchment for greater natural resource management outcomes • Biodiversity enhancement and restoration (plants and animals) • Landscape restoration and healthy soils • Water quality and quantity. 	murray@cma.nsw.gov.au
GreenFleet	Australian TreeTotaler	Ongoing	A Carbon Emissions offset scheme - Its interactive design enables businesses or individuals to calculate the amount of CO ₂ that we produce in our daily lives, taking into account motor vehicle use, as well as air travel and household energy usage. The Tree Totaler then	http://www.greenfleet.com.au/uploads/pdfs/Newsletter%20Winter%202004.pdf

Ecosystem services frameworks and tools

State and Territory Governments

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
			provides an opportunity to offset some or all of our greenhouse emissions, for a tax-deductible payment, through <i>Greenfleet's</i> tree planting programme.	

Ecosystem services frameworks and tools

Research and R&D Corporations

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
<p>CSIRO Sustainable Ecosystems, Land & Water, Entomology, & Forests and Forestry Products, RIRDC, JVAP, LWA, Goulburn-Broken Catchment Authority, Blackwood Basin Group, Coleambally Irrigation Cooperative Ltd, DIPNR.</p>	<p>Markets for Ecosystem Services Project</p>	<p>Ongoing</p>	<p>The project is seeking to identify and build the regional capacities needed to initiate markets for ecosystem services. The approach continues to investigate and develop pilot market opportunities in the three case study catchments (Murrumbidgee - NSW, Goulburn Broken - Vic and Blackwood Basin - WA).</p>	<p>Nick Abel Nick.Abel@csiro.gov.au Stuart Whitten stuart.whitten@csiro.au Dave Shelton david.shelton@csiro.au Abel <i>et al</i> (2003)</p>
<p>Agricultural Production Systems Research Unit; CSIRO – Entomology, Land & Water, and Sustainable Ecosystems; Queensland Government, Uni of Qld</p>	<p>Agricultural Production Systems Simulator (APSIM)</p>	<p>Ongoing</p>	<p>APSIM was developed to simulate biophysical processes in farming systems, particularly as it relates to the economic and ecological outcomes of management practices in the face of climate risk. A recent search for reports of APSIM applications identified 107 items published over the 1996 to 2001 period (see website for details).</p>	<p>www.apsru.gov.au/apsru/Products/publicat1.htm www.apsim.info</p>

Ecosystem services frameworks and tools

Research and R&D Corporations

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
Land & Water Australia (LWA)	Native Vegetation R&D Programme	Ongoing	Generic approach – no model evaluation, however advocates the involvement of community groups, adequate time to implement information into the planning process and collaboration within and between agencies.	Gill Whiting Gill.Whiting@lwa.gov.au
School of Resources, Environment & Society - ANU	Multiple Objective Landscape Analysis (MOLA)	Ongoing	A comparison of combinatory methods within GIS-based methods through applying simulated annealing and genetic algorithms	Brian Lees Brian.Lees@anu.edu.au
Australia Museum	Biodiversity Index	Ongoing	Integrating biodiversity representation and persistence in a trade-offs framework.	Dr Dan Faith danf@austmus.gov.au
CRC for Spatial Information	4-D modelling approach	Under development	Developing a 4-D modelling approach to determine: the implications of land use and landscape change for agricultural production, dryland salinity and water yield.	http://spatialinfocrc.org/

Ecosystem services frameworks and tools

Research and R&D Corporations

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
ENSIS	The Scenario Planning and Investment Framework (SPIF) tool	Ongoing	<p>The SPIF tool incorporates research outputs into a decision support framework that enables planners at catchment and farm scale to understand and predict outcomes associated with establishment of plantations and other forms of revegetation. The tool kit can also be used to identify the different impacts of revegetation projects on salinity, water availability, sedimentation, carbon sequestration and biodiversity.</p>	<p>Ensis Forests and Environment www.ensisjv.com</p>
Greening Australia/LWA	Exchange Incentive Fund	Ongoing	<p>Supported by the NHT, the aim of the fund is to help regional practitioners better manage their natural resources by:</p> <ul style="list-style-type: none"> • Increasing their access to current knowledge and research on native vegetation; and • Generating new knowledge through links to relevant researchers and organisations. <p>The fund contributes around \$5,000 to any given project, although applications for more, or less, than this amount are considered, to a maximum of \$10,000.</p>	<p>http://www.greeningaustralia.org.au/GA/NAT/TipsAndTools/exchange/incentive/</p>

Ecosystem services frameworks and tools

Research and R&D Corporations

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
Greening Australia	Land Innovation Fund	Ongoing	<p>The Land Innovation Fund will invest in projects that:</p> <ul style="list-style-type: none"> • demonstrate the potential to be commercially attractive; • involve significant land use change or new management systems; • demonstrate the potential to provide significant environmental benefits in at least one core environmental issue (water quality, salinity, biodiversity, carbon); and • are from proponents with demonstrated experience and expertise in managing innovative land enterprises 	admin@act.greeningaustralia.org.au
CSIRO Land & Water/Sustainable Ecosystems	Strategic Landscape Investment Model (SLIM)	Ongoing	<p>The strategic landscape investment model (SLIM) can demonstrate the likely returns from a range of environmental activities in different locations across New South Wales. SLIM can inform decision-makers about:</p> <ul style="list-style-type: none"> • changes over time in the conditions of natural resource condition, for example, erosion, sediments, nutrients, salts and water yield, following some type of landscape treatment • likely cost of a desired changes in resource 	<p>Anne Leitch Anne.Leitch@csiro.au</p> <p>http://www.csiro.au/csiro/content/standard/ps1tl.html</p>

Ecosystem services frameworks and tools

Research and R&D Corporations

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
			<p>condition on privately owned freehold or leasehold land</p> <ul style="list-style-type: none"> • level of environmental benefit associated with that change, measured using weighted time-discounted indices and, in some instances, dollars • optimal allocation of programme funds for different landscape treatment options and in different locations across New South Wales. 	
UNE/DPINR/CSIRO/Cotton CRC	The Gwydir Ecosystem Services Project	Ongoing	<p>The ecosystem services project in the Gwydir Valley of NSW will be focusing in four main areas:</p> <ul style="list-style-type: none"> • to estimate the economic value of the ecosystem benefits associated with the community's use of water and soil, as well as the ecosystem services associated with native vegetation and beneficial fauna, and to identify the recipients of these benefits; • to estimate the economic value of the environmental impacts associated with the agro-industries and identify the stakeholders affected by these impacts, both positive and negative; • to determine the policy implications to the wider 	<p>Nick Reid nrei3@metz.une.edu.au</p> <p>http://www.ecosystemservicesproject.org/html/case_studies/gwydir.html</p>

Ecosystem services frameworks and tools				
Research and R&D Corporations				
Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
			<p>community, of the valuation of ecosystem services used or affected by agriculture; and</p> <ul style="list-style-type: none"> to publicise the value of ecosystem services in the Gwydir among farmers, policy and decision makers and the general community. 	
CSIRO/DEC/Greening Australia/CSU/RMIT/Southern Rivers CMA	Better Knowledge Better Bush Project		<p>The Better Knowledge, Better Bush project is providing the science to underpin these landscape restoration initiatives and address gaps in our understanding of native vegetation and its management in agricultural landscapes. The two-year project will develop new techniques, maps and guidelines for managing native vegetation for biodiversity and production outcomes. These tools will directly benefit land management agencies, policy-makers, farmers and other providers such as revegetation contractors, seed collectors and nurseries by improving knowledge and understanding of the function, dynamics and management of native vegetation.</p>	Paul Ryan Paul.Ryan@csiro.au
GreenFleet	Australian TreeTotaler	Ongoing	A Carbon Emissions offset scheme - Its interactive design enables businesses or individuals to calculate the amount	http://www.greenfleet.com.au/uploads/pdfs/Newsletter%20Winter%202004.pdf

Ecosystem services frameworks and tools

Research and R&D Corporations

Organisation/ Institution	Project/Model	Current Status	Approach	Key contacts, Web links and References
			of CO ₂ that we produce in our daily lives, taking into account motor vehicle use, as well as air travel and household energy usage. The Tree Totaller then provides an opportunity to offset some or all of our greenhouse emissions, for a tax-deductible payment, through <i>Greenfleet's</i> tree planting programme.	
ENSIS	Scenario Planning & Investment (SPIF) Tool	Ongoing	The SPIF tool is an output from the ENSIS/CSIRO/DAFF Commercial Environmental Forestry (CEF) Programme. The tool provides the ability to assess the effects of commercial and environmental plantings by predicting growth rates, carbon sequestration potential, salinity reduction, water yield impact, biodiversity and economics. The tool enables practitioners to integrate trees into landscapes to achieve multiple positive outcomes and to help to reduce the risks for various investors and increase certainty that environmental desirable outcomes can be achieved.	Charlie.Hawkins@ensisjv.com