PRODUCTIVITY COMMISSION

Creating Markets for Ecosystem Services

Staff Research Paper

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The views expressed in this paper are those of the staff involved and do not necessarily reflect those of the Productivity Commission. Appropriate citation is indicated overleaf.

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Contents

BOXES

TABLES

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Abbreviations

ABARE	Australian Bureau of Agricultural and Resource Economics
AGO	Australian Greenhouse Office
CoA	Commonwealth of Australia
CO_2	Carbon dioxide
CO_{2}-e	Carbon dioxide equivalent
CRP	US Conservation Reserve Program
DEH	SA Department of Environment and Heritage
DLWC	NSW Department of Land and Water Conservation
DNRE	Victorian Department of Natural Resources and Environment
EBI	Environmental Benefits Index
IC	Industry Commission
MRFF	Macquarie River Food and Fibre
NCEE	US National Center for Environmental Economics
NLWRA	National Land and Water Resources Audit
NO_x	Nitrogen oxides
NSW EPA	NSW Environment Protection Authority
RECLAIM	Regional Clean Air Incentives Market
SCAQMD	South Coast Air Quality Management District
SEAC	State of the Environment Advisory Council
SO_2	Sulphur dioxide
TEPCO	Tokyo Electric Power Company
USDA	US Department of Agriculture
US EPA	US Environmental Protection Agency
WWF	World Wide Fund for Nature

OVERVIEW

Key messages

- Ecosystem services are the functions performed by ecosystems that lead to desirable environmental outcomes, such as air and water purification, drought and flood mitigation, and climate stabilisation.
- Markets rarely exist for ecosystem services. Typically, those who supply ecosystem services are not rewarded for all the benefits they provide to others, and those who reduce ecosystem services do not bear all the costs they impose on others.
- Without markets, allowing parties to act in their own private interest can result in fewer ecosystem services than is optimal for society as a whole.
- In theory, governments can create a market for an ecosystem service by defining a new property right that is both linked to the ecosystem service and can be exchanged for reward. Two Australian examples are:
  - the introduction of tradeable emission permits to limit saline discharges into the Hunter River; and
  - state legislation separating title over the carbon sequestered in forest plantations from ownership of the timber.
- This approach to creating markets is more likely to be successful if the relevant property right has a number of characteristics, including:
  - ownership can be defined and enforced at reasonable cost; and
  - trades are not significantly hindered by high uncertainty; a lack of buyers and sellers; or a major imbalance in the information held by buyers and sellers.
- It appears that climate change is the environmental problem that is most suitable for market creation. The greatest difficulties are likely to arise in creating a single market for all aspects of biodiversity.
- A review of market creation schemes in Australia and the United States indicated that creating markets can, under the right conditions and with appropriate market design, be an efficient way to achieve certain environmental goals.
- However, policy makers need to pay particular attention to the issues of scientific uncertainty, market liquidity, and the role of supporting regulation.

Overview

This paper investigates how well environmental problems related to salinity, biodiversity and climate change can be addressed by creating markets for *ecosystem services*.

Ecosystem services are the functions performed by ecosystems that lead to desirable environmental outcomes. They include air and water purification, drought and flood mitigation, and the stabilisation of climate. Examples of potential markets for ecosystem services include tradeable permits for carbon sequestration, and auctions for biodiversity conservation grants.

Why create markets?

Ecosystem services affect the wellbeing of individuals and the performance of firms. Yet this is rarely reflected in the financial incentives that parties face. Typically, those who supply ecosystem services are not rewarded for all the benefits they provide to others, and those who reduce ecosystem services do not bear all the costs they impose on others. This is because markets rarely exist for ecosystem services (in broad terms, a market is any context in which the sale and purchase of an item takes place). As a result, allowing parties to act in their own private interest can result in fewer ecosystem services than is optimal for society as a whole.

In general, markets may not exist because of one or more of the following:

- large transaction costs;
- high uncertainty about the attributes of a good or service;
- asymmetric information (sellers are much better informed than buyers, or vice-versa);
- few buyers and sellers; or
- ownership cannot be defined and enforced, or it is very costly to do so.

Arguably, the most prominent reasons why markets for ecosystem services rarely exist are uncertainty about ecosystem processes and an inability to define and enforce ownership. Defining and enforcing ownership can be difficult because ecosystem services are often *nonexcludable* in consumption. This means that it is hard to prevent parties who do not pay for an ecosystem service from benefiting from it. For example, it is impractical to exclude people from enjoying a stable climate.

Remedies for the absence of markets

In theory, the problems arising from an absence of markets can be remedied by government intervention. Such intervention can take the form of regulation and/or market-based approaches (taxes, subsidies and market creation).

Environmental taxes and subsidies are generally seen as being more efficient than regulation because they can provide an incentive to minimise the cost of providing an ecosystem service. At a given point in time, parties will find it preferable to provide an ecosystem service if the cost of doing so is below the tax that would otherwise be incurred or subsidy that would be received. Thus, low cost opportunities to provide an ecosystem service (those below the tax or subsidy) would be undertaken in preference to higher cost options. Over time, parties would also be rewarded for adopting new less costly technologies because this would increase the financial benefit of avoiding the tax or receiving the subsidy. This is in contrast to regulations that prescribe what technology should be used and so limit the scope to reduce costs over time.

However, the case for environmental taxes and subsidies assumes that governments have sufficient information to set them at a level that raises society's welfare. These informational difficulties are compounded when regional differences in ecosystem services (such as salinity mitigated by planting a given number of trees) require governments to apply a different tax or subsidy at every site. Similar problems can arise with regulation, since governments may need considerable information to design appropriate rules. Regulation has the additional handicap that it can hinder innovation if it prescribes what technology should be used to address an environmental problem. In contrast, creating markets can, under certain conditions, lead to an improved outcome for society even though no party has complete information.

Markets for ecosystem services can be created in many different ways. In some cases, a market for an ecosystem service would form of its own accord if regulatory impediments were removed. For example, the supply of certain aspects of biodiversity conservation appears to be hindered by rules for land tenure, competitive neutrality, and taxation (Productivity Commission 2001). This paper does not examine such cases. Rather, the focus is on ecosystem services that, regardless of regulatory barriers, would not be traded in a market because their ownership cannot be defined and enforced.

The term *market creation* is used in this paper to refer to government intervention to form markets for ecosystem services that are nonexcludable in consumption. Such intervention involves the definition of a new *property right* that is both linked to an ecosystem service and can be exchanged for reward. A property right is an entitlement to use a particular good or service in a certain way. For example, a property right could be established over the carbon sequestered in forest plantations. Use of this right is not an ecosystem service per se. However, it could be a proxy for climate stabilisation services, since the process of sequestering carbon may mitigate the greenhouse effect.

Table 1 **Different types of market creation**

	No offsets[a]	*Offsets*[a]
Non-tradeable[b]	Parties sell their property right to undertake a certain activity, such as emitting pollutants. The relevant property right is transferred between parties only once. Example: Farmers compete in an auction to receive biodiversity conservation grants for maintaining native vegetation on their land. Grants are awarded to those offering the most ecosystem services per dollar granted.	A party can undertake an activity that reduces an ecosystem service if it also undertakes (or purchases from another) a separate activity which increases the ecosystem service by at least the same amount. Where the offsetting activity is purchased, the property right for that activity can only be exchanged once. Example: A firm can increase emissions from one factory if it reduces them by at least the same amount at another factory.
Tradeable[b]	An upper limit is set on a certain activity, such as emitting pollutants. Parties who hold the (limited) right to undertake the activity may sell that right to another party. Example: Tradeable permits to emit carbon dioxide.	A party can undertake an activity that reduces an ecosystem service if it also pays another party for a separate activity that increases the ecosystem service by at least the same amount. The property right for the offsetting activity may be exchanged via an intermediary before being used as an offset. Example: A firm can increase its carbon emissions if it pays another party (via a broker) to sequester at least as much carbon in a forest plantation.

[a] Under an offset arrangement, a party can undertake an action that reduces ecosystem services if they also undertake (or purchase from another) a separate action that increases ecosystem services by at least the same amount. [b] A tradeable market creation scheme involves a property right that can be transferred between parties more than once prior to being used. In other words, there is a secondary market for the property right.

Market creation schemes can be divided into four categories, based on whether the relevant property right is tradeable and if it involves an offset arrangement. These categories are detailed in table 1.

Governments play an important role in market creation by specifying the property right associated with an ecosystem service, the process for registering its exchange, and the procedures used to enforce it. Where a cap or limit is set on a certain activity (as in a market for tradeable emission permits), this is established by regulation rather than being determined in a market. In some cases, governments may also participate in the market by buying or selling the property right.

Conditions under which market creation is more likely to be effective

In essence, market creation addresses one of the potential reasons why a market may not exist — an inability to define and enforce ownership — by constructing a new property right. However, clarifying property rights will not necessarily create a market if one of the other potential barriers to market formation also exists. Therefore, market creation is best suited to situations where a number of criteria are met. Most of these criteria can be specified in relation to the newly defined property right (table 2).

Table 2 **Desirable property right characteristics for creating markets**

Property right characteristic	*Description*
1. Clearly defined	Nature and extent of the property right is unambiguous.
2. Verifiable	Use of the property right can be measured at reasonable cost.
3. Enforceable	Ownership of the property right can be enforced at reasonable cost.
4. Valuable	There are parties who are willing to purchase the property right.
5. Transferable	Ownership of the property right can be transferred to another party at reasonable cost.
6. Low scientific uncertainty[a]	Use of the property right has a clear relationship with ecosystem services.
7. Low sovereign risk[a]	Future government decisions are unlikely to significantly reduce the property right's value.

[a] Low in the sense that it does not prevent a market from forming. Moderate levels of risk and uncertainty are not necessarily insurmountable barriers to the operation of a market.

In creating a market, consideration also needs to be given to whether asymmetric information and/or a lack of buyers and sellers is a problem. Where information asymmetry leads to the absence of a market, it may be possible to address this through creative market design. For example, the Victorian Government is trialing an auction process that encourages landholders to reveal what financial reward they are willing to accept in return for undertaking conservation activities.

A lack of buyers or sellers is a concern for tradeable schemes because one party (or a group acting in collusion) may be able to manipulate the price of the new property right. Competition for the new property right could then lead to a suboptimal outcome in the sense that there is an alternative outcome that makes one party better off without making others worse off.

Salinity, biodiversity and climate change

Table 3 indicates how well biodiversity, dryland salinity and climate change meet the conditions under which market creation is more likely to be effective. It seems that climate change is the environmental problem that is most suitable for market creation. The greatest difficulties are likely to arise in creating a single market for all aspects of biodiversity.

In the case of climate change, it is relatively clear what a proposed market is designed to achieve — a reduction in climate change by reducing net greenhouse gas emissions. Further, a homogeneous unit of trade can be defined and measured, enhancing the security of the unit being traded. However, there is some debate about the measurement and verification of carbon sequestration for a tradeable scheme including offsets.

In contrast, there is no consensus on how biodiversity as a whole should be measured (although it may be possible to measure separately some components, such as certain species). Even if a property right were defined, the impacts of exercising that right would likely differ according to location. This problem does not arise in the case of greenhouse gas emissions, which have a uniform impact on global warming regardless of their source.

Site-specific effects may also cause difficulties in designing markets for dryland salinity, since the impacts of a given activity will vary according to factors such as soil type, slope, rainfall and location. Further, the nonpoint source nature of dryland salinity makes it impractical to measure the effects of individual polluting actions.

Table 3 **Biodiversity, salinity, climate change and the desirable conditions for market creation**

Property right characteristic	*Biodiversity conservation*	*Salinity mitigation*	*Climate stabilisation*
Definition	May be able to define particular aspects of biodiversity. Difficult for transboundary issues and biodiversity as a whole.	Mitigation actions can be defined in many cases.	Can be defined using the proposed measure of tonnes of CO_2 equivalent, based on global warming potentials of different gases.
Verifiable	Possible for particular aspects of biodiversity. No consensus on a comprehensive measure of biodiversity.	Partly (for example, area planted with trees).	Likely. Measurement protocols already exist or are under development.
Enforceable	Only in certain cases.	Yes, for point source problems. Difficult for nonpoint sources.	Yes.
Valuable	Likely to be few buyers other than governments and philanthropic groups.	Yes, salinity affects the production of primary commodities. But property right would be worthless in cases where salinity is irreversible.	Likely. Emissions an unavoidable byproduct of activities that are valued.
Transferable	In some cases.	In some cases.	Probably, given established unit of exchange (tonnes of CO_2 equivalent).
Scientific uncertainty	High. Particularly a problem for offsets. Impacts likely to differ by location. Irreversibility could be a problem.	High. Relationship between mitigation activities and salinity often unclear. Impacts likely to differ by location. Long time lag between mitigation and outcomes. Some problems are irreversible.	Relatively low, since majority of scientific opinion supports a link between emissions and climate change. Carbon sequestration is more contentious.
Sovereign risk	Probably high, given scientific uncertainty.	Probably high, given scientific uncertainty.	High, unless there is a comprehensive global agreement on climate change.
Sufficient buyers and sellers for a tradeable scheme	Unlikely unless reductions in biodiversity must be offset against increases.	May be unlikely, given problems often highly localised.	Yes, given common unit of exchange that is associated with many economic activities.

Site-specific effects could be particularly problematic for tradeable market creation schemes because they lead to a tradeoff between market liquidity and scientific certainty. For example, defining tradeable property rights narrowly to reflect site-specific effects could result in few buyers and sellers, compromising market efficiency. Alternatively, defining tradeable property rights broadly to ensure a large number of market participants could mean that the property right is not clearly related to the environmental outcome being sought. It may be possible to address this problem by using 'exchange rates' that account for how the impacts of exercising a property right vary between different locations.

The high scientific uncertainty associated with biodiversity conservation and salinity mitigation could mean that market creation schemes for these ecosystem services are subject to considerable sovereign risk. In particular, there may be a high probability that the property right associated with a market creation scheme would need to be changed in the future because of new scientific discoveries. This uncertainty could diminish the value of the property right and hence the likelihood that market creation would be effective.

In the case of climate stabilisation, sovereign risk could be high because a global agreement on how to create markets — such as for tradeable emission permits and carbon sequestration credits — does not exist. The absence of a global agreement is a problem because unilateral action by a country to reduce its greenhouse gas emissions could impose sizeable costs on that country while a large proportion of any benefits accrue to foreigners. This raises the prospect of future changes in any property rights established to encourage climate stabilisation.

Existing and proposed markets

There is extensive experience with market creation schemes in the United States. Examples include tradeable permits for the emission of airborne pollutants (such as the Regional Clean Air Incentives Market — RECLAIM); wetland banking; and auctions for biodiversity conservation grants (Conservation Reserve Program).

The use of market creation is still at an early stage in Australia, with a number of pilot schemes in operation and proposals being developed. Examples include tradeable permits for saline water discharges (Hunter River Salinity Trading Scheme); offset arrangements for clearing native vegetation (NSW Government proposal); auctions for biodiversity conservation grants (Victorian BushTender pilot); and 'bubble' arrangements that allow a single organisation to offset its emissions from one plant against reductions from another (South Creek Bubble Licence Scheme).

Table 4 summarises how well the schemes analysed in this paper meet the desirable conditions for market creation. The results are mixed, with some schemes appearing to meet their goals efficiently while others have not. Overall, it is possible to make the following points:

Table 4 **Property right characteristics of existing and proposed schemes**

Property right characteristic	*RECLAIM*[a]	*Hunter River Salinity Scheme*	*US wetland banking*	*Native vegetation offsets proposal*
Definition	Emissions of SO_2 and NO_x.	Discharge of saline water from point sources into Hunter River.	Destroy, improve or create wetland.	Destroy or improve native vegetation on private land.
Verification	Site inspections and continuous end-of-pipe emissions monitoring systems with computer link to overseeing agency.	Salinity monitoring stations in river.	Site inspections.	Accreditation and registration.
Enforcement	Reduced future permit allocation, financial penalties and/or loss of operating licence.	Forfeiture of permits and/or removal from scheme.	Low. Not often specified. Civil penalties and/or financial penalties.	Proposals include contracts and monetary bonds.
Valuable	Yes. Emissions cap in place. SO_2 and NO_x are byproducts of production.	Yes. Cap on saline emissions. Mines have saline byproducts of production and limited holding capacity.	Yes. Required by legislation. Property development and agriculture sometimes requires wetland reclamation.	Yes. Proposal to introduce legislation requiring offsets. Production and development require land.
Transferable	Yes. Could be improved by establishing central clearing house.	Yes. 24 hour on-line trading.	Yes.	Yes. But costly if need case-by-case approval.
Scientific uncertainty	Low. Regional limits to prevent concentration of pollutants in particular locations.	Low.	High.	High. Difficult to replace like with like. Exacerbated by time lags.
Sovereign risk	Moderate. Legislation in place but property rights not given property right status.	Low. Piloted. Regulation proposed establishing 10 year permit longevity.	Low. Regulation in place.	Unknown. Lower if has legislative/ regulatory basis.
Sufficient buyers and sellers for a tradeable scheme	Yes.	Probably (22 participants).	Yes. Envisage more buyers than sellers.	Depends on rules of scheme, such as location of offsets and scope for clearing.

(Continued on next page)

Table 4 (continued)

Property right characteristic	*Carbon sequestration credits*	*Conservation Reserve Program*	*BushTender trial*	*South Creek Bubble Licence Scheme*
Definition	Sequestration of CO_2.	Undertake environmentally beneficial activities on private land.	Undertake environmentally beneficial activities on private land.	Emission of phosphorous and nitrogen into Hawkesbury-Nepean River.
Verification	Scientific calculations closely related to quantity and age of trees.	Environmental Benefits Index. Random audit by overseeing agency.	Biodiversity Benefits Index. Annual report by participants. Random audit by overseeing agency.	In-stream monitoring.
Enforcement	Legal title to sequestered CO_2.	Penalties, removal from program.	Cessation of annual payments, removal from program.	Review. Penalties.
Valuable	Yes. Provided that emissions are restricted.	Yes. Government cannot provide all conservation on public land.	Yes. Government cannot provide all conservation on public land.	Yes. Nutrients produced as byproduct of sewage treatment and there is limited holding capacity.
Transferable	Yes.	Yes, between government and landholder.	Yes, between government and landholder.	Yes, between management units within Sydney Water, but no external transferability.
Scientific uncertainty	Moderate.	Low.	Low.	Low.
Sovereign risk	Possibly high, given no international consensus.	Low. 10 year renewable contracts.	Low. 3 year contract.	Low.
Sufficient buyers and sellers for a tradeable scheme	Probably. Much higher if an international trading regime for credits is adopted.	Not a tradeable scheme.	Not a tradeable scheme.	Not a tradeable scheme.

[a] Regional Clean Air Incentives Market used to improve air quality in the South Coast Basin (Los Angeles region).

- a tradeable scheme may be inefficient if there is no centralised clearing house for parties to exchange property rights (RECLAIM);
- offset schemes can lead to a net reduction in ecosystem services when scientific uncertainty is high (wetland banking);
- verification can be costly when there is a high level of scientific uncertainty, since each transaction may have to be assessed on a case-by-case basis (wetland banking and possibly native vegetation offsets);
- schemes need to be designed so that they do not allow the concentration of an undesirable activity in a particular area or time period (RECLAIM and Hunter River Salinity Trading Scheme);
- where permits have long life spans, market entry may be facilitated by reallocating permits by auction at regular intervals;
- point source problems are more amenable to market creation schemes than nonpoint source problems (Hunter River Salinity Trading Scheme);
- auctions can be used to overcome the problems of asymmetric information and a limited number of buyers and sellers (Conservation Reserve Program and BushTender); and
- market creation is unlikely to have any notable effect if the relevant property right is not valuable (carbon sequestration credits without restrictions on carbon emissions).

Concluding comments

The analysis in this paper suggests that creating markets for ecosystem services can, under the right conditions and with appropriate market design, be an efficient way to achieve certain environmental goals. Nevertheless, policy makers need to pay particular attention to the issues of scientific uncertainty, market liquidity, and the role of regulation.

Policy makers should be particularly cautious in implementing offset arrangements when scientific uncertainty is very high. This is because it is difficult to be sure that the tradeoffs involved with an offsets arrangement will cause no net reduction in ecosystem services. This is evident from the US experience with wetland banking.

A lack of buyers or sellers is a particular concern for tradeable schemes because one party (or a group acting in collusion) may be able to manipulate the price of the new property right. Competition for the new property right could then lead to a suboptimal outcome in the sense that one party could be made better off without making others worse off.

Another important consideration is that regulation is not redundant in cases where market creation is appropriate. It just takes on a different form. In particular, there need to be clear rules underpinning a market creation scheme. For example, it is important to specify clearly the property right associated with an ecosystem service, the process for registering its exchange, and the procedures used to enforce it.

Where a cap or limit is set on a certain activity (such as emissions), this is established by regulation rather than being determined in a market. Such regulation needs to limit the scope for an undesirable activity to be concentrated in a particular region or time period if that would adversely affect the environment. It also needs to limit the possibility of irreversible damage.

1 Introduction

This paper investigates how well environmental problems related to salinity, biodiversity and climate change can be addressed by creating markets for *ecosystem services*.

Ecosystem services are the functions performed by ecosystems that lead to desirable environmental outcomes. They include air and water purification, drought and flood mitigation, and the stabilisation of climate. Ecosystem services are distinct from, but not unrelated to, the goods harvested from ecosystems, such as food, fibre, timber, and biomass fuels. For example, crops may be produced using the ecosystem services of salinity mitigation and climate stabilisation as inputs.

While most goods harvested from ecosystems are traded in markets, there are few markets for ecosystem services. This absence of markets could lead to a less than optimal supply of ecosystem services, since it means that parties receive few financial incentives to supply those services. For example, it is often difficult for farmers to make a living from maintaining native vegetation on their properties, despite the potential benefits of salinity mitigation and biodiversity conservation. Rather, there is usually an incentive to clear native vegetation to produce goods that can be sold in markets.

In some cases, a market for an ecosystem service would form of its own accord if only regulatory impediments were removed. For example, the supply of certain aspects of biodiversity conservation appears to be hindered by rules for land tenure, competitive neutrality, and taxation (Productivity Commission 2001). This paper does not examine such cases. Rather, the focus is on ecosystem services that, regardless of regulatory barriers, would not be traded in a market because ownership cannot be enforced. For example, it is impossible to enforce ownership over atmospheric processes that lead to a stable climate.

We use the term *market creation* to refer to government intervention to indirectly form markets for ecosystem services whose ownership cannot be enforced. Such intervention involves the definition of a new *property right* that is both linked to an ecosystem service and can be exchanged for reward. A property right is an entitlement to use a particular good or service in a certain way. For example, the property right for a car entitles its owner to use the car, prevent others from using it, and to sell it to another party. Similarly, a property right could be established for the carbon sequestered in forest plantations. Use of this right is not an ecosystem service per se. However, it could be a proxy for climate stabilisation services, since the process of sequestering carbon may mitigate the greenhouse effect. The mechanics of market creation is discussed further in chapter 2.

The use of market creation for ecosystem services is still at an early stage in Australia, with a number of pilot schemes in operation and proposals being developed. Examples include credits for salinity mitigation, auctions for biodiversity conservation grants, and tradeable permits for carbon emissions and sequestration (see chapter 4). Such policy approaches are increasingly being seen by policy makers as a way to address environmental problems (see for example DLWC 2001a, 2001b; DNRE 2001; Howard 2000; Salinity Experts Group 2000).

The growing enthusiasm for market creation schemes seems to be supported by two factors. First, a realisation that governments have limited resources to address environmental problems. Second, a hope that market creation will minimise the social dislocation associated with resolving environmental problems. In particular, market creation may provide new revenue streams for landholders that enable them to both change land use practices and retain a viable business. However, as we show in this paper, market creation is more likely to be successful when certain conditions are met. Market creation may also involve some risk of adversely affecting the environment.

The next chapter outlines a conceptual framework for analysing market creation, including the conditions under which such government intervention is more likely to be successful. In chapter 3, we consider whether these conditions are generally satisfied for three of the most significant environmental issues facing Australia — salinity, biodiversity, and climate change. To reinforce our findings, in chapter 4 we apply our framework to existing and proposed schemes that create markets. In doing so, we draw on the extensive experience with market creation in the United States. Finally, in chapter 5 we make some concluding comments about the merits of creating markets.

2 Conceptual framework

The idea of creating markets for ecosystem services can sound relatively straightforward at first glance. However, closer inspection reveals that market creation is more likely to be successful when certain conditions are met. This chapter explains why this is the case and then discusses the conditions under which market creation is more likely to be effective.

2.1 Why create markets?

Ecosystem services affect the wellbeing of individuals and the performance of firms. Yet this is rarely reflected in the financial incentives that parties face. Typically, those who supply ecosystem services are not rewarded for all the benefits they provide to others, and those who reduce ecosystem services do not bear all the costs they impose on others. This phenomenon is termed an *externality*.

The presence of externalities matters because it can lead to what is known as *market failure*. In particular, allowing parties to act in their own private interest can result in fewer ecosystem services than is optimal for society as a whole.

By definition, an externality occurs because there is no market for something that people care about (Arrow 1970). A market may not exist because one or more of the following factors applies:

- large transaction costs;
- high uncertainty about the attributes of a good or service;
- asymmetric information (sellers are much better informed than buyers, or vice-versa);
- few buyers and sellers; or
- ownership cannot be defined and enforced, or it is very costly to do so.

It is plausible that one or more of these properties applies to many ecosystem services. Arguably, the most prominent problems are high uncertainty about ecosystem processes and an inability to define and enforce ownership. Asymmetric information could also be important.

Uncertainty exists because it is often unclear how ecosystem processes lead to a given ecosystem service. For example, it would be difficult to know the timing and extent of any benefits from salinity mitigation services, such as those resulting from planting native vegetation. A related problem occurs when important information about an ecosystem service does exist but is only available to either a buyer or seller (but not both). Such an information asymmetry can reduce the willingness of the less informed party to trade because they face the prospect of being deceived. In the extreme, no market will exist and so opportunities for mutually beneficial trades will be unrealised (Akerlof 1970).

Defining and enforcing ownership can be difficult because ecosystem services are often *nonexcludable* in consumption. This means that it is hard to prevent parties who do not pay for an ecosystem service from benefiting from it. For example, it is impractical to exclude people from enjoying a stable climate. Thus, nonexcludability gives consumers the opportunity to *free-ride* by using ecosystem services purchased by others.

The problem of nonexcludability can be characterised as being due to the lack of an enforceable *property right*. A property right entitles a party to use a particular good or service in a certain way. For example, the property right for a car entitles its owner to use that car, prevent others from using it, sell it, or benefit from any income derived from using it. Such a property right is typically established by registering ownership with a government licensing organisation and is enforceable through the courts. In contrast, it is often difficult to enforce a property right over an ecosystem service, such as the atmospheric processes that stabilise climate.

Remedies for the absence of markets

In theory, the problems arising from the absence of a market can be remedied by government intervention. Such intervention can take the form of regulation and/or market–based approaches. Regulation typically involves command-and-control measures prescribing actions that must or must not be undertaken. Market–based approaches change financial incentives in favour of the supply of ecosystem services. This involves the use of one or more of the following:

- taxes;
- subsidies; and
- market creation.

Taxes and subsidies

The use of taxes and subsidies to remedy the consequences of an absence of markets is based on the pioneering work of the economist Arthur Pigou early last century, and has since been widely used to address environmental problems. The underlying idea is to change the incentives parties face so that they reflect the costs and benefits to society of certain actions.

For example, a tax could be imposed on carbon dioxide emissions so that emitters bear the cost of any climate changes they cause. Alternatively, a subsidy for pollution controls could reward parties for their contribution to climate stabilisation. In the presence of such taxes and subsidies, parties acting in their own private interest can in theory achieve an outcome that is optimal from society's perspective.

Taxes and subsidies are generally seen as being more efficient than regulation because they provide an incentive to minimise the cost of providing an ecosystem service. At a given point in time, parties will find it preferable to provide an ecosystem service if the cost of doing so is below the tax that would otherwise be incurred or subsidy that would be received. Thus, low cost opportunities to provide an ecosystem service (those below the tax or subsidy) would be undertaken in preference to higher cost options. Over time, parties would also be rewarded for adopting new less costly technologies because this would increase the financial benefit of avoiding the tax or receiving the subsidy. This is in contrast to regulations that prescribe what technology should be used and so limit the scope to reduce costs over time.

However, the case for taxes and subsidies assumes that governments have sufficient information to set them at an appropriate level. Ideally, a tax or subsidy should be set so that the cost of supplying the last unit of an ecosystem service equals its benefit to society. This places a demanding informational requirement on governments. A further complication is that the benefits associated with an ecosystem service can vary across regions because of the localised nature of many ecosystem processes. This provides a case for having a different tax or subsidy at each location, but it would come at the cost of greater administrative complexity. In addition, the optimal environmental tax or subsidy cannot be determined without taking account of what distortionary taxes are used elsewhere in the economy (Bovenberg and Goulder 2001).

Similar problems can arise with regulation, since governments may need considerable information to design rules that will lead to the level of ecosystem services that maximises society's welfare. As noted above, regulation has the additional problem that it can also hinder innovative new approaches to ecosystem services.

The demanding informational requirements of regulation and taxes/subsidies are somewhat like those encountered in attempting to run a centrally planned economy. For the system to work at its best, governments need to be omniscient, which is unlikely. In contrast, markets can, under certain conditions, lead to an improved outcome for society even though no party has complete information.

Market creation

Government intervention to create a market for an ecosystem service may be considered in cases where such a market does not currently exist because ownership cannot be defined and enforced. This approach is based on the ideas of Ronald Coase (1960), who argued that externalities can be removed by clearly defining property rights.

The policy of market creation can be implemented in many different ways. Examples include credits for salinity mitigation, auctions for biodiversity conservation grants, and tradeable permits for carbon emissions and sequestration. However, a common feature of market creation schemes is that they transform a nonexcludable ecosystem service into something that is excludable and hence can be traded in a market. This is done by defining a new commodity that is both excludable and a proxy for a nonexcludable ecosystem service. A market is then formed for this proxy commodity, which in effect creates a market for its corresponding ecosystem service.

The proxy commodity is defined by constructing a new property right. One example is the recent legislation in several Australian states establishing a separate right over the carbon sequestered in forest plantations (see chapter 4). Use of this right is not an ecosystem service per se. However, it could be a proxy for climate stabilisation services, since the process of sequestering carbon may mitigate the greenhouse effect.

Governments play an important role in market creation schemes by setting the rules by which the market operates. In particular, they specify the property right associated with an ecosystem service, the process for registering its exchange, and the procedures used to enforce it. Where a cap or limit is set on a certain activity (as in a market for tradeable emission permits), this is established by regulation rather than being determined in a market. In some cases, governments may also participate in the market by buying or selling the proxy commodity. The next section outlines the various types of market creation schemes.

2.2 Different forms of market creation

Market creation can be divided into four categories based on whether the relevant property right is *tradeable* and if it involves an *offset arrangement* (table 2.1).

Table 2.1 **Different types of market creation**

	No offsets[a]	*Offsets*[a]
Non-tradeable[b]	Parties sell their property right to undertake a certain activity, such as emitting pollutants. The relevant property right is transferred between parties only once. Example: Farmers compete in an auction to receive biodiversity conservation grants for maintaining native vegetation on their land. Grants are awarded to those offering the most ecosystem services per dollar granted.	A party can undertake an activity that reduces an ecosystem service if it also undertakes (or purchases from another) a separate activity which increases the ecosystem service by at least the same amount. Where the offsetting activity is purchased, the property right for that activity can only be exchanged once. Example: A firm can increase emissions from one factory if it reduces them by at least the same amount at another factory.
Tradeable[b]	An upper limit is set on a certain activity, such as emitting pollutants. Parties who hold the (limited) right to undertake the activity may sell that right to another party. Example: Tradeable permits to emit carbon dioxide.	A party can undertake an activity that reduces an ecosystem service if it also pays another party for a separate activity that increases the ecosystem service by at least the same amount. The property right for the offsetting activity may be exchanged via an intermediary before being used as an offset. Example: A firm can increase its carbon emissions if it pays another party (via a broker) to sequester at least as much carbon in a forest plantation.

[a] Under an offset arrangement, a party can undertake an action that reduces ecosystem services if they also undertake (or purchase from another) a separate action that increases ecosystem services by at least the same amount. [b] A tradeable market creation scheme involves a property right that can be transferred between parties more than once prior to being used. In other words, there is a secondary market for the property right.

A property right is tradeable if, prior to being used, it can be bought by one party and subsequently sold to another. In other words, there is a secondary market for the property right. An example is the tradeable salinity discharge permits used under the Hunter River Salinity Trading Scheme. These permits entitle a party to discharge a certain amount of saline water into a river when it is in high flow (see chapter 4 for details). Alternatively, a permit holder can reduce its saline discharges and sell its unused permits to another party. Another example is the tradeable carbon emission permits being proposed to address climate change. Holders of such permits would be entitled to emit a certain amount of carbon or alternatively sell their unused permits to another party.

A property right is non-tradeable if it cannot be exchanged more than once (because there is no secondary market). An example is the Victorian Government's pilot BushTender scheme. This involves the Government purchasing a farmer's right to use part of their property for purposes other than growing native vegetation. Once purchased, this right is not re-sold (chapter 4).

Under an offset arrangement, a party can undertake an action that reduces ecosystem services if it also undertakes (or purchases from another) a separate action that increases ecosystem services by at least the same amount. Thus, an offset arrangement enables one action to be matched with another so that there is at least no net reduction of ecosystem services. In some cases, the requirement may be to produce a net increase in ecosystem services.

An offset scheme is non-tradeable if:

- the desirable and undesirable actions must be undertaken by the same party; or
- the property right for the desirable action can only be exchanged once.

An example of a non-tradeable offset is the South Creek Bubble Licence Scheme. This imposes an overall limit on the phosphorous and nitrogen that Sydney Water can discharge from its sewage treatment plants, rather than limits for each plant (chapter 4). This enables Sydney Water to offset discharges from one plant against reduced discharges from another.

An offset scheme is tradeable if the property right for the desirable action can be exchanged more than once prior to being used as an offset. One example is the use of wetland banking in the United States. Wetland banking allows a party to substantially alter a wetland only if they purchase the credits earned by another party for the protection, restoration and/or enhancement of another wetland (chapter 4). Such credits are traded through an intermediary known as a wetland bank. Another example is the carbon sequestration credits being proposed by various parties. These credits would enable a carbon emitter to offset its emissions against the carbon sequestered in another party's forest plantation (chapter 4). Such credits could be exchanged between various parties, including an intermediary, prior to being used to offset emissions.

In theory, the Victorian Government's BushTender scheme could also be transformed into a tradeable offset arrangement. Farmers would then maintain native vegetation in order to earn credits that they could sell to other parties that wanted to clear native vegetation. However, implementing such a scheme could be hindered by the lack of a robust measure of the ecosystem services provided by native vegetation (see chapters 3 and 4).

2.3 Conditions under which market creation is more likely to be effective

The limited experience to date with creating markets for ecosystem services suggests that innovative approaches will often be needed to deal with the unusual aspects of particular environmental problems. Thus, it is difficult at this stage to provide a definitive guide to how to create markets. Nevertheless, it is possible to list a number of conditions that, if satisfied, are more likely to lead successful market creation.

In essence, market creation addresses one of the potential reasons why a market may not exist — an inability to define and enforce ownership. This problem is overcome by defining a new property right. However, clarifying property rights will not necessarily create a market if one of the other potential barriers to market formation also exists. These barriers are large transaction costs, high uncertainty about the attributes of a good or service, information asymmetries, and a lack of buyers and sellers.

Therefore, market creation is a policy approach that is best suited to situations where a number of criteria are met. Most of these criteria can be specified in relation to the newly defined property right (table 2.2). Recall that this new property right is for a commodity that acts as a proxy for an ecosystem service.

The key purpose of the proxy commodity is to make an ecosystem service excludable. Therefore, it is essential that ownership of the proxy commodity can be defined and enforced. This requires the new property right to be specified so that its:

- nature and extent is unambiguous (criterion 1 in table 2.2);
- use can be measured at reasonable cost (criterion 2); and
- ownership can be enforced at reasonable cost (criterion 3).

Additional criteria are used to ensure that the formation of a market is not prevented by high uncertainty or a lack of buyers and sellers. In particular, it is important that:

- there are parties willing to buy and sell the new property right (criterion 4);
- the new property right can be exchanged between parties (criterion 5); and

- any uncertainty associated with the new property right is not so high that it prevents a market forming (criteria 6 and 7).

Table 2.2 **Desirable property right characteristics for creating markets**

Property right characteristic	*Description*
1. Clearly defined	Nature and extent of the property right is unambiguous.
2. Verifiable	Use of the property right can be measured at reasonable cost.
3. Enforceable	Ownership of the property right can be enforced at reasonable cost.
4. Valuable	There are parties who are willing to purchase the property right.
5. Transferable	Ownership of the property right can be transferred to another party at reasonable cost.
6. Low scientific uncertainty[a]	Use of the property right has a clear relationship with ecosystem services.
7. Low sovereign risk[a]	Future government decisions are unlikely to significantly reduce the property right's value.

[a] Low in the sense that it does not prevent a market from forming. Moderate levels of risk and uncertainty are not necessarily insurmountable barriers to the operation of a market.

Scientific uncertainty (criterion 6) is relevant because the link between ecosystem processes and a given ecosystem service is often poorly understood. In many cases, uncertainty is not an insurmountable barrier to the operation of a market. However, there will be some cases where scientific uncertainty is so high that the proxy commodity is not representative of the relevant ecosystem service. For example, there is no consensus on what proxy could be used for all aspects of biodiversity. In such circumstances, market creation is less likely to achieve its environmental objectives. This is of particular concern when offset arrangements are used, since environmental harm is supposed to be cancelled out by environmental good. If the relevant science is not well understood, then the offset arrangement could in reality lead to a net reduction in ecosystem services.

The scientific relationship between use of a property right and environmental outcomes is not confined to the ecosystem service for which a market is being created. For example, a native vegetation offset scheme may seek to ensure no net decline in the total area of native vegetation. However, it could change the geographic location of native vegetation and this may adversely affect biodiversity, such as through 'islandisation'. The underlying issue here is that many ecosystem services are joint products and so cannot be considered in isolation.

Sovereign risk (criterion 7) refers to the likelihood that future government decisions will diminish the value of the new property right. To some extent, this depends on how effective the government is in establishing a system of ownership for the proxy commodity (criteria 1 to 3) and the level of scientific uncertainty (criterion 6). Governments are more likely to change a market creation scheme in the future if there are problems with ownership or the science.

The relevant government(s) used to assess sovereign risk will depend on the ecosystem service in question. For example, climate stabilisation could involve many foreign governments, since the greenhouse effect is a global issue (chapter 4). A very localised issue may only involve a local council.

In creating a market, consideration also needs to be given to whether asymmetric information and/or a lack of buyers and sellers is a problem. Where information asymmetry leads to the absence of a market, it may be possible to address this through creative market design. For example, the Victorian Government's BushTender trial uses an auction process to get landholders to reveal what they are willing to accept in return for supplying ecosystem services (chapter 4).

A lack of buyers or sellers is a particular concern for tradeable schemes because one party (or a group acting in collusion) may be able to manipulate the price of the new property right. Competition for the new property right could then lead to a suboptimal outcome in the sense that there is an alternative outcome that makes one party better off without making others worse off.

In summary, this chapter has examined market creation largely at a conceptual level. The next step is to apply these concepts to practical examples. This is the purpose of the following two chapters. Chapter 3 focuses on three of the most significant environmental issues facing Australia — biodiversity, climate change, and salinity. Chapter 4 analyses existing and proposed market creation schemes.

3 Biodiversity, salinity and climate change

The design of ecosystem markets depends in large part on the characteristics of the environmental problem being addressed. In this chapter, the relevant characteristics of three of the most significant environmental problems facing Australia are discussed — biodiversity loss, salinity and climate change. Many scientific linkages between these problems exist. For instance, by altering temperature and rainfall levels and patterns, climate change may adversely affect ecosystems and biodiversity (CSIRO 2001). This implies that, while adding complexity, it can be important to consider environmental problems concurrently rather than in isolation.

3.1 Threats to biodiversity

Biodiversity is defined as:

> … the variety of all life forms — the different plants, animals and microorganisms, the genes they contain, and the ecosystems of which they form a part. It is usually considered at three levels: genetic diversity, species diversity and ecosystem diversity (Commonwealth of Australia 1996, p. 50).

Apart from providing goods, such as food and fibres, biodiversity plays a major role in maintaining the functions that provide ecosystem services. In particular, biodiversity underpins the processes that maintain and regulate water resources, atmospheric quality, soil formation, and the cycling of nutrients (SEAC 1996). It also provides ecosystems with resilience — the ability to recover from natural disasters such as drought, fire, and climate change (Brown et al. 1993).

Species extinction is a natural process, but rapid species loss in recent times has been largely attributed to human activities (Kahn 1995; Tisdell 1991). These have resulted in the loss and modification of habitat, excessive harvesting of individual species, and competition from exotic species (SEAC 1996). Adverse impacts on biodiversity occur at a local, regional or national scale and can often cross jurisdictional boundaries as many living resources:

- are shared by more than one jurisdiction (more than one country in a global context or more than one state in a domestic context);

- move between jurisdictions (for example, mobile or migrating species);
- exist permanently beyond one jurisdiction (for example, in international waters); or
- are located in one jurisdiction but are affected by activities occurring in another jurisdiction (for example, the adverse environmental effects in particular regions of global problems such as climate change) (James 1997; Tisdell 1991).

Biodiversity may not be adequately conserved because markets typically exist only for goods derived from biodiversity, such as those from harvesting plants and animals. Most ecosystem services resulting from biodiversity are not traded in markets and hence are largely ignored in decision making about natural resource use (Pearce and Moran 1994). These services include aesthetic and recreation benefits; and flood control, nutrient cycling and waste assimilation. Furthermore, many people derive non-use benefits such as bequest values — the desire to transfer the benefits of biodiversity to future generations — and existence values — the benefits people derive from merely knowing that biodiversity exists (Freese 1998; Tisdell 1991).

The absence of markets for many of these services means that resource owners have few incentives to conserve biodiversity. In contrast, the market value of competing uses (such as agricultural production) for the land and natural resources on which biodiversity depend are well reflected in markets.

There is a lack of knowledge or certainty about the significance of actions that may adversely affect biodiversity. In fact:

> Even basic facts such as the total number of species on earth and the rate of species extinction worldwide are not fully clear. (World Bank 2000, p. 102)

Scientific uncertainty about ecological processes is compounded by irreversibility which can occur at a species level — once extinct, a species cannot be restored — and at an ecosystem level — once ecological functions fall below a certain threshold level, an ecosystem may collapse with irreversible consequences. These thresholds are often not known, making if difficult to manage for these potentially serious losses (Tacconi 2000). According to the World Bank (1992, p. 59), this means that environmental changes as a result of the loss of species or habitats has 'consequences that are among the least predictable of environmental changes'.

Articulating biodiversity conservation goals, and assessing how successfully they are met, is a difficult task in the context of ignorance about biodiversity and a lack of consensus on how to define and measure it (Freese 1998). Further, a fundamental feature of ecosystems and species populations is that they are highly dynamic and change in unpredictable ways both with and without human intervention

(Freese 1998). Essentially, this means that biodiversity conservation is a ‘moving target’.

Moreover, even if a unit of measurement were agreed, difficulties would arise in comparing different ‘components’ of biodiversity (although attempts have been made in some programs to develop indices of biodiversity benefits for this purpose (chapter 4)). A component of biodiversity, such as a habitat (for example, a wetland), or a particular species rather than biodiversity itself is typically measured (Brown et al. 1993).

It is also difficult to define which biological resources are sufficiently substitutable that they may be traded or exchanged. This difficulty arises particularly in the context of offset schemes where an ‘equivalent’ is required to ‘replace’ the original environmental asset that is destroyed or damaged. In some cases, this may be near to impossible as biodiversity can often be highly localised or unique to an area.

Policies that aim to contribute to biodiversity conservation by targeting particular species to ensure their abundance may not be sufficient to protect biodiversity. They may fail to account for important factors, such as the relative abundance of species and interdependencies between them:

> … we cannot easily tell a priori what species are essential and what are not. There is often a risk that an apparently small change in a set of species will have effects far beyond those initially anticipated. The degree of interdependence between different species is great, so that human beings may depend on many more species than we would expect from a first analysis of the situation. (Heal 1999, p. 10)

Indeed, many ecologists consider that a species focus is not the best approach for conserving biodiversity and that conservation at an ecosystem level is required to ensure preservation of both the constituent species and ecosystem functions (Brown et al. 1993). However, defining and measuring biodiversity at this level is considerably more complex, given the number of species involved and the interactions between them. Further, the set of species needed for a certain ecosystem to function may vary from region to region, and no single subset of species would be sufficient to provide all ecosystem services in all areas of the world (Heal 1999). This reflects the fact that while some ecosystems or species are common to many areas, others are rare or located only in limited areas (Industry Commission 1998).

As a result, the specific causes of biodiversity loss, and potential solutions to stem the loss, will vary on a case-by-case basis according to ecological and economic factors (Tacconi 2000). This means that it is difficult to foresee the consequences of a given action on all ecosystems and that policy approaches that aim to have a beneficial effect on biodiversity by, for example, restricting a certain action may have unanticipated or adverse consequences in certain locations. Thus, a key problem in designing conservation policies is to identify the links between actions and their site-specific impacts on biodiversity.

Maintaining biodiversity can be compatible with other forms of resource use. For instance, the conservation of biodiversity may in some cases be an incidental joint product of activities such as planting trees for carbon storage. The links between environmental concerns, if exploited, can reduce the costs of achieving environmental goals and can also potentially improve the financial viability of ecosystem services as a commercial enterprise.

However, designing an ecosystem service market that simultaneously delivers biodiversity, salinity, and climate change benefits or outcomes is likely to be challenging. For example, there may be few types of tree planting for generating carbon sequestration credits for sale in one market that will also deliver biodiversity benefits. Similarly, some outbreaks of dryland salinity are likely to occur in lower rainfall zones where forestry is currently not commercial in its own right (Heaney and Levantis 2001). Moreover, if the trees were felled, some sequestration, salinity and biodiversity benefits would be lost with implications for environmental effectiveness and the value of the property right traded.

3.2 Salinity and water quality

Salinity

Some salinisation occurs naturally. Salinity can occur as land salting (dryland salinity and irrigation salinity) and in-stream salinity. All types of salinity are linked yet are often managed separately. A reported 70 per cent of the land area affected by dryland salinity is in the south west of Western Australia (Industry Commission 1998). In the eastern states, land salting is largely located within the Murray-Darling Basin, which also experiences in-stream salinity (Industry Commission 1998; Quiggin 2001).

The causes and impacts of salinity can be diffuse and widespread. Salinity reduces agricultural productivity and can result in damage to infrastructure such as roads and buildings. Thus, salinity is not just a rural or agricultural problem. Increased salt levels in rivers and streams also reduce water quality with adverse effects on water users and biodiversity by, for instance, affecting non-salt tolerant vegetation species or by affecting habitat (Industry Commission 1997; NLWRA 2001).

The effects of salinity appear and spread with a long time lag. Hence, it may not be immediately apparent that a given activity in a certain location will contribute to salinity. For instance, it can take 50 to 60 years for saline seepage to appear after land clearing has occurred in recharge zones (Poulter and Chaffer 1992).

Measures to address salinity are very costly, can take a long time to take effect and have, at times, been ineffective (PMSEIC 1998). The fact that land use change to address salinity problems may not provide returns for a long time (or the returns expected) may reduce the incentive to invest in such actions through a market-based scheme. Lengthy time lags imply that salinity is likely to get worse in the future despite immediate efforts to address it now. Moreover, Pannell (2000) argues that much of the damage caused by salinity is irreversible.

In some cases, the cause and resulting impact of dryland salinity occur mainly on the one property and so the associated costs and benefits are largely borne by the property owner. This is generally the case with salt scalds, which occur when saline subsoils are exposed due to the excessive loss of vegetation cover and erosion of topsoil (Industry Commission 1997; Watson, Morrissey and Hall 1997). Salinity caused by inefficient irrigation practices can also be largely confined to one site or within a single irrigation region, unless the salt is exported to waterways through runoff or subsoil drainage (Industry Commission 1998).

In other cases, the actions that cause salinity occur in one location while its impacts become apparent in another. Dryland salinity in the form of saline seepage occurs when an increased quantity of water infiltrates to the groundwater system causing the water table to rise under certain conditions. This brings dissolved salt to the soil surface or to surface water bodies where the water evaporates leaving high concentrations of salt (Grist et al. 2001). A cause of saline seepages is the wide-scale removal of native vegetation and its replacement with agricultural crops and pastures that use less water, allowing more rainfall to enter the groundwater system (Poulter and Chaffer 1992).

The rate at which water enters the groundwater system depends on a range of factors, such as the distribution and amount of rainfall, vegetation characteristics, and permeability of soils and subsoils (Poulter and Chaffer 1992). Further, whether the impacts of land clearing are experienced on the property where clearing occurred or elsewhere depends on the location of discharge zones (where the groundwater flows onto the land surface or a waterway). Thus, land clearing does not have the same effect on salinity regardless of its location. In particular, the effects of land clearing are greatest when it occurs on recharge areas (where water moves down the soil profile and enters the water table) but resulting salinisation occurs primarily in discharge areas (Quiggin 2001).

Where activities undertaken on one property impose salinity problems on properties in other areas, an externality occurs (chapter 2) and market creation may be an appropriate response. Similarly, an externality occurs when saline runoff from properties affected by salinity enters river systems and reduces water quality for downstream users and potentially reduces biodiversity.

Pannell, McFarlane and Ferdowsian (2001) acknowledge that past land clearing has resulted in off-site impacts from salinity but they argue that (at least in Western Australia) the role of externalities has been over-emphasised. These authors argue that the causes and impacts of dryland salinity can often occur on the one property because, for a large proportion for the landscape, little ground water moves across property boundaries (one factor affecting this would be the size of properties). If this is the case, there may not be a case for market creation.

Actions to address land salinity and in-stream salinity include land use change, improved irrigation practices and engineering works (Heaney and Levantis 2001). However, the success and cost-effectiveness of a given mitigation action will depend on its location due to a range of factors such as those outlined above. This implies that potential 'solutions' need to differ across regions or at a local or catchment scale to reflect the characteristics of each region, while acknowledging that the effects of salinity may extend beyond the boundaries of a catchment (Industry Commission 1997).

In some cases, local engineering treatments are expected to be more effective for addressing both land and in-stream salinity than large scale treatments higher up in the catchment (Pannell 2000). Similarly, there is no single plant–based solution considered applicable to all regions and to all biophysical conditions (Auditor General Victoria 2001). While revegetation of a catchment can be effective for preventing salinity of some rivers in the long term, in other cases river salinity is unresponsive to revegetation of the surrounding catchment (Pannell 2000). In the Murray Darling Basin, Heaney and Levantis (2001) consider that actions to address dryland and in-stream salinity in the southern parts of the Basin may not be directly transferable to the northern parts of the Basin because of variations in climate and topography.

While a regional or local approach is likely to be required, it can be difficult to identify and measure the individual contributions to salinity of various actions undertaken at each source. The consequences of salinity can be the cumulative impact of many decisions taken by many individuals in a region (Industry Commission 1998). For instance, it is difficult to identify the exact source of recharge to the water table and the location where discharge will occur without extensive knowledge of local geology (Poulter and Chaffer 1992). It is also difficult to determine the relative impacts on in-stream salinity from saline surface runoff, seepage of saline groundwater into rivers, or saline runoff from irrigation areas .

While the basic processes causing salinisation are relatively well understood, further information is required to understand how such site-specific factors affect the success and cost-effectiveness of proposed salinity mitigation measures (Pannell 2000). In particular, the National Land and Water Resources Audit of dryland salinity (NLWRA 2001) notes that the extent, causes and management options for irrigation salinity are well understood but that in most States and Territories dryland salinity has received less attention until recently. In some cases, there is also a considerable degree of uncertainty surrounding the potential net benefits of salinity mitigation measures:

> [there is a] substantial risk that the actions we take today may not deliver the benefits they intended. (Heaney and Levantis 2001, p. 13)

Similarly, Grist et al. (2001) argue that the benefits of broad-scale reforestation for managing dryland and in-stream salinity are 'uncertain at best' and that there may be many cases where there are no mitigation policies that are expected to deliver potential net benefits. This uncertainty can make it difficult to establish a market for salinity mitigation.

Water quality

There is an important link between salinity and the quality of surface water. Water quality is often reduced because rivers and streams are intentionally used for waste disposal or because pollutants, such as salt, sediment, and nutrients, enter these bodies inadvertently. The water returned to rivers and streams after it has been used as an input to production is also often of diminished quality (Kahn 1995). In addition, changes to the quantity of flows can affect aquatic environments. The pollutants that can affect surface water quality arise from various sources including nonpoint sources, such as agricultural and urban runoff, and point sources such as dairy sheds and discharge from sewage treatment plants.

Surface water quality issues are generally best handled at catchment level but major river systems (such as the Murray-Darling) can span jurisdictional boundaries. The development of policies to address water quality issues therefore requires interstate (and, in some cases, international) cooperation. A similar need arises for addressing salinity as groundwater movements may extend across jurisdictional boundaries and as actions in one state causing saline runoff into rivers may affect those located in another state (Poulter and Chaffer 1992; Watson, Morrisey and Hall 1997). The geographic breadth of the market may also have implications for the potential number of participants that the market will involve, with consequences for market efficiency.

Water trading (and allocating water to the environment) is a major part of national water reforms required by the Council of Australian Governments. In theory, measures to ensure full cost pricing of water and tradeable water entitlements can result in more efficient use of water with resulting beneficial impacts on salinity (Industry Commission 1997). This is because pricing that reflects the scarcity value of water provides incentives to use it efficiently, potentially reducing salinisation linked to irrigation. However, this may not necessarily be the result in practice. For instance, a recent review of pilot inter-state water trading (Young et al. 2000) found that this trading has, so far, had a negative impact on river salinity. The review considered that this is because most water has been transferred to land in South Australia that has not previously been irrigated (as explained earlier, irrigation may contribute to salinity depending on a range of factors). However, the review noted that the long term net effects on salinity could be neutral if adequate arrangements are put in place to ensure that salinity impacts remain within acceptable levels (later trades are subject to salinity prevention obligations). This example illustrates that market creation designed to deliver improvements with respect to one environmental issue may have unanticipated adverse effects on other aspects of the environment, and that measures to address these may need to be introduced.

3.3 Climate change

Climate change is viewed by many as a concern because of its possible effects on sea levels, biodiversity, agriculture and human welfare. Some of these effects may be positive in some respects as, for example, higher temperatures and rainfall can improve plant growth which might improve agricultural output. This depends, however, on various factors, such as the regional distribution of variations in temperature and rainfall and the effects of these variations on weed growth and pest populations (Kahn 1995).

Unilateral action to reduce greenhouse gas emissions is unlikely because it could impose large costs on the country undertaking the reductions while a large proportion of any benefits are likely to accrue to foreigners. Further, those benefits may be negligible if other countries do not also reduce their greenhouse gas emissions (Industry Commission 1991). The need for a global approach to this problem has been recognised through the Kyoto Protocol, an international agreement to reduce greenhouse gases from anthropogenic (human-induced) sources.

If it entered into force, the Kyoto Protocol would oblige Annex I (developed) countries to reduce their aggregate human-induced greenhouse gas emissions to levels at least 5 per cent lower than 1990 levels for the first commitment period (2008-2012). Developing countries do not currently face emissions reduction targets, although they are involved through a system of limited and voluntary cooperation. This may result in 'leakage' — the possibility that companies will move their greenhouse gas generating activities from developed to developing countries to avoid limits. While developed countries are responsible for most of the increase in greenhouse gas emissions to date, greenhouse gas emissions from developing countries are expected to expand significantly (World Bank 2000).

Six gases responsible for global warming are covered by the Kyoto Protocol. The most significant are carbon dioxide, methane, and nitrous oxide (Beil, Fisher and Hinchy 1998). Greenhouse gases have differing atmospheric lifespans ranging from 10 to 100 years. Thus, once released, there is a long time lag between emissions and the end of their effects on the environment (Haites 1998). The benefits of controlling greenhouse gas emissions will only become apparent in the long term while the costs of mitigation will be incurred immediately. From a policy perspective, this time lag may enhance opportunities for communities to adapt to climate change thereby reducing its effects. However, the time lag also complicates policy making due to uncertainty.

The impact of greenhouse gas emissions on climate change depends primarily on their concentrations in the atmosphere, rather than the location of emissions (Haites 1998). Therefore, the geographical location of reductions in emissions (or their reduction through absorption by sinks) is not important for mitigating the overall effects of climate change. However, damage from climate change will vary across countries and regions. The location and type of greenhouse gas emissions reductions would matter where reductions in greenhouse gas emissions bring about secondary benefits by reducing local air pollutants, such as particulate and sulphur oxides (Haites 1998).

Many scientists agree that global warming is unlikely to be due solely to natural causes and that it is at least partly attributable to human activity (Watson 2000). However, scientific uncertainty remains for many aspects of climate change. In its third assessment report, the Intergovernmental Panel on Climate Change (IPCC 2001, p. 17) considered that the understanding of climate processes has improved but that further research is needed to:

> … improve the ability to detect, attribute and understand climate change, to reduce uncertainties and to project future climate change.

While carbon dioxide emissions from many sources can be measured reasonably accurately, there is considerable uncertainty about the level of greenhouse gas emissions from most non-energy sources, such as land clearing, deforestation, and some land management activities. In Australia, major sources of human-induced emissions are activities such as grazing, cropping, and land clearing but current estimates of these sources and sinks are considered to be 'out by as much as 70%' (AGO 2000b, p. 1). There is also a high degree of scientific uncertainty associated with measuring the amount of carbon dioxide sequestered by various forestry and agricultural activities:

> We do not fully understand the processes that control how much carbon dioxide is absorbed by vegetation and soils acting as land carbon sinks. Furthermore, we need more reliable methods of quantifying and verifying the contribution of sinks towards targets set by the Kyoto Protocol. Carbon sinks remain a point of dispute between countries … (British Royal Society 2001, p. 1)

Further measurement difficulties arise because vegetation that is burnt or harvested (and not regenerated) results in the carbon being returned to the atmosphere over time (AGO 2000a).

The Kyoto Protocol has defined a tradeable commodity for greenhouse gases. This commodity would most likely be expressed as one tonne of carbon dioxide equivalents (CO_2-e) (AGO 1999a). Although different gases contribute to climate change, it is possible to express them in a uniform way in terms of their total warming effect over time. This could allow for the definition of a standardised and homogenous commodity for trading purposes (Beil, Fisher and Hinchy 1998). This could be achieved by using the internationally agreed 'global warming potentials' of each gas to convert emissions into carbon dioxide equivalents. For example, one tonne of methane has 21 times the global warming potential of a tonne of carbon dioxide (Beil, Fisher and Hinchy 1998). However, Kahn (1995) notes that these conversions do not account for variations in the lifespan of the gases — some gases have a short lifespan but a strong warming effect, others have long lifespans but a weaker warming effect over that time. These time profiles may be significant if environmental damage depends on the ability of ecosystems and communities to rapidly adjust to climate change.

The ability to express greenhouse emissions in terms of carbon dioxide equivalents potentially allows a trading system to include emissions abatement in all gases, sectors and sinks covered by the Kyoto Protocol, provided the benefits of monitoring and trading permits for all of these sources and gases exceed the costs of doing so. In practice, various activities result in sources or sinks of greenhouse gas emissions and the net benefits of including these is likely to differ. For example, some are nonpoint sources, such as motor vehicles and ruminant stock. These sources are numerous, mobile and individually generate relatively low levels of emissions. Others, such as the flue stacks of power plants, are point or stationary sources of relatively significant amounts of greenhouse gas emissions.

3.4 Implications

Table 3.1 indicates how well biodiversity, dryland salinity and climate change meet the conditions under which market creation is more likely to be effective (as discussed in chapter 2). It seems that climate change is the environmental problem that is most suitable for market creation. The greatest difficulties in creating markets are likely to arise for biodiversity conservation, as opposed to conservation of particular species.

In the case of climate change, it is relatively clear what a proposed market is designed to achieve — a reduction in climate change through a reduction in net greenhouse gas emissions. Further, a homogeneous unit of trade can be defined and measured, enhancing the security of the unit being traded. However, there is continued debate surrounding the measurement and verification of carbon sequestration for a tradeable scheme including offsets. Depending on the eventual design of a carbon trading market, it is likely that many participants will be involved and that significant cost differences in abating greenhouse gas emissions exist across the world, providing an incentive to trade.

For biodiversity, in contrast, it is not necessarily clear what outcome a market would be designed to deliver as there is no broad consensus on how biodiversity can or should be measured (although it may be possible to measure separately some components, such as certain species, of biodiversity). It is therefore difficult to define a unit of trade or a property right for biodiversity as a whole. Buyers of these rights may be unable to fully stipulate, describe and enforce exactly what they are buying, undermining the security and enforceability of owning the property right. Moreover, even if such a property right were defined, the impacts of exercising that right would likely differ according to location. This does not arise in the case of greenhouse gas emissions which have a uniform impact on climate change regardless of their source. Where the site-specific links between exercising the right and environmental outcomes are not known, there is a possibility that environmental goals could be compromised in some areas, or that perverse outcomes could arise.

Table 3.1 **Biodiversity, salinity, climate change and the desirable conditions for market creation**

Property right characteristic	*Biodiversity conservation*	*Salinity mitigation*	*Climate stabilisation*
Definition	May be able to define particular aspects of biodiversity. Difficult for transboundary issues and biodiversity as a whole.	Mitigation actions can be defined in many cases.	Can be defined using the proposed measure of tonnes of CO_2 equivalent, based on global warming potentials of different gases.
Verifiable	Possible for particular aspects of biodiversity. No consensus on a comprehensive measure of biodiversity.	Partly (for example, area planted with trees).	Likely. Measurement protocols already exist or are under development.
Enforceable	Only in certain cases.	Yes, for point source problems. Difficult for nonpoint sources.	Yes.
Valuable	Likely to be few buyers other than governments and philanthropic groups.	Yes, salinity affects the production of primary commodities. But property right would be worthless in cases where salinity is irreversible.	Likely. Emissions an unavoidable byproduct of activities that are valued.
Transferable	In some cases.	In some cases.	Probably, given established unit of exchange (tonnes of CO_2 equivalent).
Scientific uncertainty	High. Particularly a problem for offsets. Impacts likely to differ by location. Irreversibility could be a problem.	High. Relationship between mitigation activities and salinity often unclear. Impacts likely to differ by location. Long time lag between mitigation and outcomes. Some problems are irreversible.	Relatively low, since majority of scientific opinion supports a link between emissions and climate change. Carbon sequestration is more contentious.
Sovereign risk	Probably high, given scientific uncertainty.	Probably high, given scientific uncertainty.	High, unless there is a comprehensive global agreement on climate change.
Sufficient buyers and sellers for a tradeable scheme	Unlikely unless reductions in biodiversity must be offset against increases.	May be unlikely, given problems often highly localised.	Yes, given common unit of exchange that is associated with many economic activities.

The site-specific effects of exercising a property right may also pose a difficulty in designing a market for dryland salinity. This is because the impacts of a given activity encompassed by a property right will vary according to factors such as soil type, slope, rainfall and location. It may be possible to address this to some extent through the use of 'exchange rates' (chapter 4). Further, given current monitoring technologies, the nonpoint source nature of dryland salinity makes it inherently costly to infer, from ambient pollution levels, the effects of individual polluting actions (or of refraining from them). If the effects of reducing adverse environmental effects from nonpoint sources cannot be measured at reasonable cost, it will be difficult to establish a market for them. Nevertheless, a pilot has been proposed for a salinity offset scheme where credits and debits would be calculated according to the predicted effect of various activities on long term recharge (Salinity Experts Group 2000). Further, some salinity outcomes, such as salinity loads in rivers from point sources, are amenable to control through market creation schemes (chapter 4).

In the case of biodiversity and dryland salinity, where actions can have site-specific effects, it may be difficult to define a homogenous unit for trade unless several markets are created, each comprising a small number of a right that reflects the site-specific effects of exercising the property right. In such a case, the property rights being traded would bear a strong relationship to the environmental outcome being sought but may result in markets involving too few participants and trades, compromising market efficiency. Defining the property right more 'loosely' or broadly to increase efficiency would come at a cost since use of the property right may bear a less reliable relationship to the environmental outcome being sought. Alternatively, it may be possible to increase market size through the use of exchange rates that account for the variation in impacts of exercising the right in different locations.

In terms of both dryland salinity and biodiversity, the potential difficulties of designing tradeable rights that reflect site-specific effects are exacerbated by information shortcomings, which also complicate the selection and operation of any policy option addressing these issues. In terms of biodiversity, many components and roles of biodiversity and ecosystem function are not well understood and information asymmetries may occur where landholders, for example, are aware of the existence of certain species on their properties but policy makers are not. Indeed, many species are yet to be discovered and classified. Uncertainty about the stock of biodiversity and about its optimal level and mix affects the ability to identify which actions harm or enhance biodiversity and in what way, making it difficult to define a unit for exchange that has a predictable effect on biodiversity. It is also difficult to define a product that captures the diversity of species and the interactions between them that together comprise biodiversity. There is a possibility that the creation of markets to address other environmental issues may deliver outcomes consistent with protecting biodiversity. This is because changes to biodiversity can be an indirect outcome of the application of markets to other environmental problems. It might be argued that market creation can be used in this indirect way to protect biodiversity. However, such an approach is likely to address only one component of biodiversity (for example tradeable quotas for fisheries).

Over time, market based approaches (or other policy options) may also result in improvements in the stock of information and in the understanding of environmental processes by identifying the types of information and data that are lacking and thereby encouraging the search for them.

Ultimately, the success of markets for ecosystem services depends not only on the technical attributes of the environmental problem being addressed but also on the design of the market and the extent to which a market for ecosystem services provides financially viable business opportunities for participants. In the following chapter, several existing and proposed market schemes to address climate change, biodiversity loss and salinity are explored to highlight various market design issues.

4 Existing and proposed markets

In this chapter, examples of existing and proposed market creation schemes are examined. The examples are categorised according to whether the relevant property right is tradeable in a secondary market and if it involves an offset arrangement (table 4.1). The strengths and weaknesses of the examples are assessed against the desirable conditions for market creation listed in chapter 2.

Table 4.1 **Examples of existing and proposed market creation schemes**

	No offsets	*Offsets*
Non-tradeable	• Conservation Reserve Program (United States) • BushTender trial (Victoria)	• South Creek Bubble Licensing Scheme (New South Wales)
Tradeable	• Hunter River Salinity Trading Scheme (New South Wales) • Regional Clean Air Incentives Market (RECLAIM) (Los Angeles region)	• Wetland banking (United States) • Native vegetation offsets proposal (New South Wales) • Carbon sequestration credits

4.1 Tradeable schemes without offsets

Tradeable schemes without offsets typically involve a limit or cap being set on an environmentally harmful activity, such as emitting pollutants. The cap is set after considering how the activity affects the supply of ecosystem services. A new property right is then constructed that allows parties to undertake the damaging activity. The availability of this right is restricted in aggregate to the cap by issuing a set number of permits. Each permit holder is allowed to undertake the environmentally harmful activity (eg. generate emissions) up to the level allowed by the permits held. Alternatively they may sell their surplus permits to another party.

It is not necessary for the regulator to know each party's private abatement cost structure for tradeable schemes to improve efficiency. Trade in permits should give parties with relatively low abatement costs the incentive to abate an activity and sell their permits to another party with a high abatement cost. This will minimise the economywide cost of achieving a given cap on that activity.

Such tradeable permit schemes have been used to control air pollutants, water use, and salinity. They have also been proposed for biodiversity conservation. As the United States has considerable experience with tradeable permit schemes, it is worth noting the lessons learned there. We do this by examining a US emissions trading program. We also analyse an Australian tradeable permit scheme for river salinity.

Regional Clean Air Incentives Market (RECLAIM)

RECLAIM was launched in 1994 to improve air quality in the South Coast Basin (Los Angeles region). Any stationary sources emitting more than 3.6 tonnes (4 tons) per year of sulphur dioxide (SO_2) or nitrogen oxide (NO_x) emissions were included in the program. In 1996, there were 353 facilities in the nitrogen market (95 per cent of permitted nitrogen emissions) and 41 in the sulphur market (65 per cent of permitted sulphur emissions) (Stavins and Whitehead 1996).

Participants were allocated permits giving them the right to emit a certain amount of pollutants in a given year. However, property right allocation was circumvented in a legal sense by an explicit denial that RECLAIM trading credits constitute a security or any other form of property. The cap on emissions is reduced each year until 2003 by reducing the quantity of pollution allowed per permit. Trade in permits is restricted by geographical region and the number of permits required per unit of emissions depends on the location of the emitter. The overseeing authority maintains records of all emissions and permit transactions to ensure compliance and may impose penalties on participants exceeding permitted emissions.

By 1996, more than 90 700 tonnes (100 000 tons) of NO_x and SO_2 emissions had been traded through RECLAIM, at a value over $US10 million. The NCEE (2001) argued that RECLAIM has been successful in achieving reductions in air pollutants at significantly lower cost than would have been achieved with a traditional regulatory approach — actual and forecast permit prices for all years from 1994 to 2010 were much lower than the marginal control costs that would be incurred under enacted or proposed regulations.

Measurement of emissions is undertaken by continuous end-of-pipe monitoring, with a computer link to the overseeing agency. This ensures that use of permits is verified and enforced. However, participants initially criticised the cost of this monitoring and enforcement (NCEE 2001). Nevertheless, NCEE (2001) estimated savings in compliance costs of around $US580 million over a ten year period compared to regulating limits on emissions.

Positive reviews of RECLAIM's achievements are not, however, universal. CorpWatch (1998) suggested the program is associated with an estimated 36 300 tonne increase in industrial NO_x emissions over what would have resulted under a regulatory approach. This reported failure to achieve positive environmental outcomes may be associated with the baseline emission allocations under RECLAIM, which were chosen after heavy lobbying by industry to reflect pre-recession industrial activity and emissions. CorpWatch (1998) claimed that the increase in emissions associated with RECLAIM may also be a result of perverse reporting incentives. Under the regulatory approach, companies used to underestimate their emissions to reduce their emissions charges, but under RECLAIM they report elevated levels of emissions to increase their permit allocations.

In RECLAIM's first three years of operation, trade in permits expanded from $US2 million to $US21 million. This suggests that abatement costs vary between participants and this variation was increasingly exploited to ensure the cap on NO_x and SO_2 emissions was achieved at least cost by participants.

RECLAIM has been criticised because it lacks a centralised clearing house where parties can find trading partners. This could result in high transaction costs. Gangadharan (1998) estimated that transaction costs under RECLAIM were substantial in its initial years and suggested that this may have reduced the probability of trading by up to 40 per cent. For example, only 27 per cent of eligible firms participated in the RECLAIM market for NO_x in 1995. This has been attributed to high information and search costs (Gangadharan 1998).

The impact of transaction costs has also been apparent in other US tradeable permit schemes. For example, the US EPA's Emissions Trading Program imposes high search costs on buyers and sellers trying to find each other because there are no brokers (Ganghadaran 1998). This may reduce the volume of trade. In contrast, the US EPA's leaded gasoline phasedown was very successful and had high levels of trading. Stavins (1998) attributed this to low administrative requirements and participants who were already experienced in dealing with one another. This meant that there was little need for intermediaries (Stavins 1998).

RECLAIM did not endure California's electricity supply crisis of 2000 unscathed. The weather-induced surge in demand and an associated inability to access electricity from the interstate grid meant electricity utilities were required to greatly increase their production and therefore emissions (Joskow 2001). Permit prices soared — there was a ten-fold increase in the price of NO_x emission permits used by power plants. In response, electricity generation plants were removed from RECLAIM by disallowing them to purchase permits on the open market. An alternative $US7.50/pound penalty for excess emissions was implemented, and electric generators were required to install pollution control equipment (Joskow 2001).

Tradeability of pollution permits creates the potential for pollution ‘hot spots’, in the sense that the pattern of permit acquisition may result in a region or regions experiencing high levels of environmental damage (Stavins 1998). Hot spots are likely to cause not only environmental impacts, but also health risks to local populations. Hot spots can be managed within a tradeable permit scheme, so long as the underlying regulation specifies limits on pollution in both a geographical sense and within given time periods. However, localised caps may impact on market size and efficiency, as there may be insufficient buyers and sellers to generate least cost abatement.

Hunter River Salinity Trading Scheme

The Hunter River Salinity Trading Scheme controls discharges of saline water into the Hunter River by twenty coal mines and two power stations. The Scheme divides the River’s flow levels into three categories: ‘low’, ‘high’ and ‘flood’. The rules for discharging salt into the River are based on these categories.

When the River is in low flow, no discharges are permitted because this is when natural salt concentrations in the River are highest and there is greater demand for water extraction.

In high flows, discharge of salt is allowed but maximum river salinity is capped, with the cap shared out using a system of salinity credits. Each of the 22 participants in the Scheme has been given tradeable credits entitling them to discharge a certain amount of saline water when the River is in high flow.

In flood flows, credits are not required for discharge, which provides greater flexibility to industry at times when there is a lower risk of exceeding the salinity targets.

There is a total of one thousand credits for use in high flow events, each entitling the holder to discharge 0.1 per cent of the total allowable salt discharge in a particular ‘block’ (the amount of water passing Singleton in a 24 hour period). However, in both high and flood flows, participants must not exceed any tributary protection limit specified in their environment protection licence. Discharges are managed so that salinity in a specified block does not exceed 900 EC at Singleton and 600 EC at Denman. A ‘sector credit discount factor’ may be applied, if necessary, to protect water quality if too many credits are acquired by participants in a particular sector.

The NSW Environment Protection Authority (NSW EPA) and Department of Land and Water Conservation (DLWC) implemented the Hunter River Salinity Trading Scheme as a pilot in January 1995. The NSW EPA had previously regulated salinity by using a ‘trickle discharge’ system. This allowed licensees to release a small amount of saline water at any time, irrespective of river flow. Thus, salinity levels could reach extremes in periods of low river flow. Licensees could not discharge large amounts of saline water during periods of high or flood river flow even though such discharges were less likely to have an adverse environmental impact. The NSW EPA (2001) was eventually forced to require new licensees to operate without discharging any saline water. Therefore, the trickle discharge policy failed in terms of both environmental goals and efficiency.

The introduction of continuous in-stream salinity monitoring prompted a trial discharge scheduling system that led to the pilot Salinity Trading Scheme. The limited number of industrial polluters in the catchment meant that it was feasible to regulate the quantity and timing of discharges from each site to manage the cumulative impacts and protect water quality.

Since the inception of the Hunter Scheme, discharges by participants have not caused river salinity levels to exceed target levels (Gilligan, Hannan and Smith 2001). However, drought conditions in the Hunter region during the early years of the Scheme meant that participants did not have a great need to discharge saline water. This is because most of the saline water that participants need to discharge originates from rainwater that has dissolved salt in disturbed soil around active mining areas. A limited need to discharge resulted in few credit trades prior to 1998. It therefore seems that the tradeable aspect of the Scheme was not fully tested in its first three years. However, since 1998 the number of trades has increased considerably, with 57 trades occurring in 2001 (Stace, J., NSW EPA, Sydney, pers. comm., 26 February 2002).

Credit trading is increasing as Scheme participants become more familiar with the operation of the Scheme and following the introduction of an on-line trading facility in August 2000. This removed the need for the NSW EPA to manually process credit trades and reduced search costs associated with trading. Thus, transaction costs have been reduced. The on-line trading facility also ensures participants can trade at short notice whenever opportunities arise due to changes in river flows.

At the time of writing this paper, a new regulation to transform the Hunter River Salinity Trading Scheme from a pilot to an established policy was being finalised. The draft regulation proposes, among other things, to improve the certainty of the scheme by instituting credits with a ten year life span (NSW EPA 2001). Credit longevity under the pilot scheme was 12 months, although credits were occasionally renewed for a period of two years. Extending the life span of credits may provide greater certainty for participants and so encourage more trades.

Future growth in economic activity in the Hunter region could raise concerns about the fixed supply of credits, especially if credits have long life spans. In particular, new entrants will have to either refrain from discharging except in flood flows, or purchase credits from existing holders. Proposals are being considered to ensure incumbents are not given an unfair competitive advantage over new entrants and to re-auction credits at regular intervals (NSW EPA 2001). For example, to facilitate entry into the market, the draft regulation proposes reallocating 20 per cent of credits by auction every two years.

While market expansion will provide challenges, market size is an important determinant of the efficiency of an emissions trading scheme. The larger the number of participants, the greater the potential for variance in abatement costs and hence the likelihood of greater efficiency gains through redistribution of credits. With 22 participants, the market size of the Hunter Scheme is small but is probably sufficient for the scheme to operate efficiently. While in theory the small market size could be overcome by including nonpoint source polluters in the Scheme, the high cost of monitoring nonpoint sources is currently an obstacle to this policy (NSW EPA 2001). Although the inclusion of nonpoint source polluters may have environmental benefits, these benefits cannot be accurately quantified in the absence of a cost effective monitoring arrangement.

4.2 Tradeable schemes with offsets

Tradeable schemes with offsets allow one party to undertake an activity that reduces ecosystem services if they offset this against a credit earned by another party for increasing ecosystem services by at least the same amount. Credits may be exchanged between parties more than once before being used as an offset.

Offsets are typically built into a tradeable permit scheme to allow additional activity that in isolation would reduce ecosystem services but with an offset does not breach the relevant cap. This section examines three such schemes — wetland banking, native vegetation offsets, and carbon sequestration credits.

Wetland banking

Wetland banking allows a party to substantially alter a wetland only if they purchase the credits earned by another party for the protection, restoration and/or enhancement of another wetland. Such credits are traded through an intermediary known as a wetland bank. The objective is to ensure no net reduction in ecosystem services due to land use changes, such as for property development and the expansion of farming.

Wetland banking has been used extensively in the United States. In early 2001, there were around 100 US wetland banks and more were in advanced stages of planning (NCEE 2001). This trend has been encouraged by, among other things, the requirements of the US Clean Water Act and the establishment of the Wetlands Reserve Program.

A major concern for US wetland banking schemes has been scientific uncertainty. In particular, it has been difficult to ensure no net reduction of ecosystem services when replacing one wetland with another. No two wetlands are identical and so the ecosystem services they provide will be different. In addition, these ecosystem services are often related to biodiversity which is difficult to quantify.

US schemes have attempted to address scientific uncertainty in various ways. First, they may require the credit-earning activity to occur prior to the activity leading to a debit. This seeks to provide some reassurance that the credit creating activity actually results in a viable wetland. However, wetland offsets are associated with high failure rates (meaning the created or enhanced wetland fails to maintain its level of ecosystem services or the ecosystem collapses), and while they may be successful in the short term, they can fail in the longer term. This means there is a substantial risk of significant environmental harm if the policy fails by permitting wetland degradation before effective and sustainable offset credits have been generated.

Second, those destroying a wetland are typically required to offset their actions in the same biotic region and hydrological basin. This may increase the chances that like with like tradeoffs are made.

Third, a conservative offset ratio may be used. This ratio specifies the exchange rate at which wetland destruction must be offset by wetland improvements. A conservative ratio may, for example, require each hectare of wetland destroyed to be replaced by two hectares of new wetland. In addition, more offset credits are required where development affects an endangered community, species, or strategic zone. Similarly, more credits are earned for remedial works that rehabilitate strategic sites (particularly those identified in a Regional Conservation Plan).

Nevertheless, studies of US wetland banks raise doubts about their success in ensuring no net loss of ecosystem services (Adler 1999; Johnson et al. 2002; NRC 2001). For example, in summarising the effectiveness of the US Wetlands Reserve Program, Young et al. (1996, p.121) concluded that:

‘… at least in the forms used so far, wetland mitigation schemes are not a dependable means of conserving biodiversity’

Adler (1999) argued that the failure rate of wetland offsets in the US may be as high as 50 per cent. A study carried out in Virginia found that only 9 wetland creation projects out of 32 had been successful (Young et al. 1996). A more recent study of wetland banks in the state of Washington found that only 65 per cent of lost wetland area was replaced by creating or restoring other wetlands (Johnson et al. 2002). This confirms that offset projects are risky and this should be taken into account when establishing offset ratios (DLWC 2001b).

Adler (1999) also mentioned a US Department of Agriculture (USDA) finding that, nationwide, the Wetlands Reserve Program was 47 000 acres per year short of achieving no net loss of wetland acreage. This may be due to failed wetland offset programs, or the fact that many thousands of acres of wetland are destroyed without permits. It has been estimated that 80 per cent of gross wetland losses occur without permit approval (Adler 1999). This suggests an urgent need to increase the stringency of regulation, and particularly enforcement.

It is not only wetland area that must be protected. Wetland offset arrangements can lead to fragmentation and wetland of much lesser quality and diversity than the areas they replace. Randall and Taylor (2000) argued that the effectiveness of constructed wetlands is uncertain and may be inferior to natural wetlands. However, wetland banking does have the potential to improve connectivity and quality of wetland. Wetland offset schemes could also improve wetland quality if damage to low quality wetland is offset against improvements to the quality and/or extent of other high quality wetland.

The Wetlands Reserve Program has also been criticised for its lack of enforcement. Project plans have sometimes not been carried out, or where they were carried out, were not effectively monitored and maintained (Adler 1999).

The US experience with the Wetlands Reserve Program highlights that, unlike timber, water or CO_2, the uniqueness of biodiversity is not an easily tradeable object— once lost, it is lost forever. If tradeable offsets are to be viable for biodiversity, it will be necessary to have in place more stringent rules and requirements than would operate under (for example) a carbon sequestration credits scheme.

Lack of scientific knowledge about wetlands and biodiversity in general means we cannot be sure that like is replaced with like. Since biodiversity can often be highly localised or unique to an area, it would not be rational to propose offsetting the loss of one type of ecosystem for another. For instance, it may be unacceptable to offset wetland with forest, or to offset natural habitat with revegetated areas.

The unique nature of biodiversity means that schemes such as the Wetlands Reserve Program are likely to be costly because each offset would have to be assessed on a case-by-case basis and monitored over a long timeframe. It is debateable whether the time and money involved is warranted given the apparently high failure rate associated with constructed wetlands.

Federal US wetland regulations may have inhibited private wetland conservation efforts (Adler 1999). First, they apply equally to natural and constructed wetlands, so some landholders may avoid private conservation efforts for fear that it will trigger land use controls. Second, regulatory requirements can delay proposed wetland restoration or construction, which may significantly increase the cost of such plans.

Such impediments to private wetland conservation are an unfortunate drawback of wetland offset legislation, particularly given estimates that private programs restored around 160 000 acres of wetland per year from 1992 to 1996 for around $US1 000 per acre. This may be a significant hindrance, given that the cost of compulsory wetland offsets can be over $US30 000 per acre (Adler 1999).

Proposed native vegetation offsets

In July 2001, the New South Wales Government released a discussion paper on options for a native vegetation offsets scheme (DLWC 2001b). Such a scheme would require parties who clear native vegetation to offset this against improvements in native vegetation. The scheme could, in theory, involve a system of tradeable credits for native vegetation improvements. In any case, the key benefits of such a scheme would be to maintain biodiversity and limit dryland salinity.

Proposed offset activities included improving the management of existing native vegetation, restoring or regenerating degraded native vegetation, and revegetating cleared areas.

Proposed principles for the offset scheme included that:

- it should lead to a net gain that improves the condition of the environment;
- it should not lead to permanent environmental costs due to the delay before offsets yield environmental benefits;

- clearing should only proceed when the offset is making progress towards the anticipated ecological state and is legally secure; and
- it should be consistent with relevant government policies.

As with wetland offset schemes, there is a high level of scientific uncertainty associated with native vegetation offsets. However, the complexity of native vegetation offsets may be less than for wetlands, and therefore more feasible.

A system of tradeable credits and debits has been proposed that would be calculated according to a set of environmental variables, such as habitat structural diversity, presence of weeds, topographic complexity, species richness and the uniqueness of a particular site. One of the major difficulties associated with a native vegetation offset scheme is defining equivalent units of destruction and replacement. It may be challenging to design a credit scheme that can replace all the values, including quality and extent, associated with each cleared area. However, intent to pursue a comprehensive method of offsetting such as this may be preferable to the alternative, which may be to trade off quality for extent, or vice versa.

It would be important to ensure that participants' investments cannot be eroded by changing policy (DLWC 2001b). For an offset market to be viable, investors must be confident about the potential credit value of undertaking environmentally beneficial actions. Sovereign risk may be minimised by implementing policies and targets with fixed timeframes for review, so that landholders undertaking environmentally beneficial activities are more certain of the value of their investment within the defined period.

Transaction costs are also liable to affect the viability of such a market. Costs of administration will depend on the offset scheme's complexity. For example, whether it incorporates exchange rates to take differences in impacts into account. Search and information costs will depend in some part on whether the government implements the proposed register of credits and debits to provide participant information. The necessity for case-by-case evaluation of clearing and offset sites could also add significantly to the costs of administration and enforcement.

For a proposal such as the native vegetation offset scheme to be successful, current legislation will need to be amended. While the proposal indicates the need for offset actions to be effective for the period that clearing has an impact, this would currently not be possible given that existing NSW legislation only requires an offset area to be retained and managed for the period of the clearing consent, namely two to five years (DLWC 2001b). This means any offset benefits maintained after five years would be voluntarily upheld. Given the incentives for landholders to use their land for production, damage to environmental services could merely be delayed.

The use of offset arrangements may only be applicable to some clearing of native vegetation. Land clearing incidental to agricultural use (within a certain limit) does not require government permission at all, so this type of clearing would be unlikely to trigger offset requirements. Further, offset arrangements are likely to be unacceptable, or at least far more complicated, where threatened species are involved. Under threatened species legislation, special permits and environmental impact statements are required for any activity that may harm or disturb them (Bates, G., ANU, Canberra, pers. comm., 22 October 2001).

This is likely to mean offset arrangements involving threatened species would be highly controversial. However if an offset agreement is reached in such a case, then the regulator should engage in a formal land management agreement with the landholder that is attached to the land and therefore binds future owners (Bates, G., ANU, Canberra, pers. comm., 22 October 2001).

In October 2001, the South Australian Government introduced into Parliament proposed amendments to the *Native Vegetation Act 1991*. These included the introduction of an offset arrangement for cleared areas approved by the Native Vegetation Council, the introduction of a credit system for native vegetation where credits could be traded across properties within a region, and requirements to revegetate illegally cleared areas (DEH 2001). However, the amendments were not passed prior to the South Australian election in early 2002. At the time of writing this paper, it was unclear whether the new State Government would introduce similar legislation.

Carbon sequestration credits

A carbon sequestration scheme allows emitters of carbon dioxide (CO_2) to offset their emissions against additional carbon absorbed and stored in vegetation. The intention is to reduce the net addition of carbon to the atmosphere and so minimise climate change. Vegetation which has a *net* uptake of carbon dioxide is referred to as a carbon sink.

Carbon is absorbed by plant matter during photosynthesis from atmospheric CO_2. Approximately 50 per cent of the dry weight of a forest's biomass is carbon and this makes forests an effective means of locking away carbon derived from the atmospheric CO_2 source (AGO 1998). Since carbon sequestration is a biological process, the uptake quantity is a variable determined by many factors including rainfall and sun, temperature and the species of forest. This means that exact measurement presents a problem.

The National Carbon Accounting System is working towards establishing a method for quantifying sequestration and providing a transparent and verifiable reporting method for sequestration in carbon sinks (AGO 1999b). A Cooperative Research Centre (CRC) for Greenhouse Accounting was also established in 1999 to improve the scientific certainty associated with estimating the carbon stored in woody vegetation.

Another significant issue is the permanence of the carbon capture. This arises because forestry projects tend to be temporary in nature. Thus, CO_2 captured during forest growth is potentially released upon harvest. This depends on the end-product use of the timber. The CRC for Greenhouse Accounting has a project to examine the fate of carbon stored in forest products through wood life cycle analysis.

Quantitative analysis by Appels (2001) found that the optimal time between the planting and harvest of trees would be lengthened by implementing a carbon sequestration scheme. Cacho and Hean (2001) showed that forest management decisions are sensitive to the use of different accounting methods to pay for carbon sequestration, such as year by year or in full (at either the planting or harvest of the crop). They also looked at the value of deferring the CO_2 emission impact on the atmosphere by temporary sequestration, versus preventing the emission altogether.

To date, carbon sequestration credits have only been used in demonstration projects because of uncertainty about a global agreement on greenhouse gas emission reductions. Nevertheless, several Australian states have introduced legislation (Victoria, New South Wales, Queensland and proposed in Western Australia) establishing a new property right over the carbon sequestered in forest plantations. This allows forest owners to enter into an agreement to transfer, separately from land and timber, the right to carbon sequestered in their forests.

Tokyo Electric Power Company (TEPCO) and Hancock New Forests Australia signed a contract to engage in carbon offset trading. Under the terms of the contract, TEPCO purchased the right to the carbon content (and associated carbon sequestration credits) of Hancock's 150 000 hectare plantation forest in Victoria. TEPCO also proposed a joint venture in the same vein with North Ltd. Under this arrangement, North Ltd would supply 23 000 hectares of plantation forest as a carbon sink to offset emissions produced by TEPCO.

However, such schemes are unlikely to be widely adopted until restrictions are placed on carbon emissions. Otherwise, carbon sequestration credits will not have much value for emitters. In the meantime, there is a high degree of sovereign risk, as well as the scientific uncertainty mentioned previously.

4.3 Non-tradeable schemes without offsets

Non-tradeable market schemes without offsets involve parties selling their right to undertake a certain activity, such as emitting pollutants. The relevant property right is transferred between parties only once, where the buyer of such a right is typically a government.

Auctions

Auctions for biodiversity conservation have been under way in the United States since the 1980s, when the Conservation Reserve Program (CRP) was introduced (box 4.1). In Australia, an auction scheme similar to the CRP is being trialed by the Victorian Department of Natural Resources and Environment (DNRE) (box 4.2). This scheme is called BushTender and seeks competitive bids from landholders to undertake conservation activities. Another Australian scheme using auctions is being trialed by the Liverpool Plains Land Management Committee and the World Wide Fund for Nature (WWF). This involves the auctioning of grants for biodiversity conservation and salinity mitigation in the Liverpool Plains (Moss 2000).

Box 4.1 **US Conservation Reserve Program**

The Conservation Reserve Program (CRP) run by the US Department of Agriculture (USDA) offers compensation to private landholders to divert agricultural land from production to the supply of biodiversity conservation. Originally established in 1985 to reduce soil erosion, the program has expanded to include the objectives of improving water quality, providing wildlife habitat and addressing other environmental concerns. Each Conservation Reserve contract runs for ten years, after which time it expires.

The CRP uses auctions to obtain bids from landholders for the minimum annual rental payment the landholder will accept from government to divert land from agricultural production to the establishment and maintenance of vegetation or to other approved conservation practices. Landholders may choose to place a bid that reflects the full cost of the service provision, or some portion of the total cost. Bids may be discounted by the landholders' expected private benefits, which may include personal satisfaction from undertaking environmentally beneficial activities.

The cornerstone of the auction system is the environmental benefits index (EBI) which ecologists constructed to express the relative scarcity of different environmental goods and services. By establishing priority activities and areas, this index assists the USDA in ranking applications for funding, based on the cost effectiveness and priority value of the bids.

In 1999, 36 million acres of land were under contract to the CRP.

Sources: Amosson et al. (2000); Wiebe, Tegene and Kuhn (1996).

Box 4.2 Bush Tender pilot auction scheme

BushTender is similar in concept to the Conservation Reserve Program (see box 4.1). Sealed bids are sought from private landholders to undertake conservation activities on their land, such as maintaining 100 hectares of native forest weed free with no grazing or firewood harvesting. Successful bids will be determined on the basis of value for money and environmental priority. Priority is determined using a biodiversity benefits index, which measures the aspects of biodiversity that are relevant to the Victorian Government's policy objectives. Thus, a partial measure of biodiversity is used.

The Victorian Department of Natural Resources and Environment (DNRE) initiated the BushTender pilot in June 2001 with an information campaign in the North-East and North-Central regions of Victoria. Landholders expressing an interest in the scheme were mailed further information and subsequently contacted to arrange a property visit by DNRE officers. The visits were used to assess the quality and significance of native vegetation on the property and discuss management options with the landholder. A draft management plan was then developed based on the actions that a property owner was willing to undertake. Landholders had the option to subsequently submit a bid for what they were willing to accept in return for implementing their draft management plan.

As at February 2002, there had been 126 expressions of interest in the trial and 98 landholders had submitted bids. Land management agreements will be established with successful bidders for a duration of three years. These will be a contract registered with landholders rather than on title. Compliance will be monitored by using random inspections.

Sources: DNRE (2001); Gilligan, Hannan and Smith (2001); Stoneham et al. (2002).

Auctions have the advantage that they encourage landholders to reveal information about the cost of supplying an ecosystem service. This is important when sellers of ecosystem services would otherwise be much better informed than buyers (asymmetric information). In such circumstances, governments seeking to buy an ecosystem service face the risk that, without an auction process, they would pay far more than is necessary to achieve a particular outcome. Thus, auctions can provide a means for governments to achieve their environmental objectives at a lower cost than would otherwise be possible (Latacz Lohmann and Van der Hamsvoort 1997). Auctions also have the advantage that they can be designed to take account of marked differences between regions in the social benefits delivered by an ecosystem service (Stoneham et al. 2002). This is done by assessing bids in terms of their benefits per unit of expenditure. Another advantage of auctions is that they can reduce search costs by facilitating the discovery of landholders willing to provide an ecosystem service.

The CRP and BushTender pilot establish a property right to conduct environmentally beneficial activities on private land. This right is exercised by the relevant government. The USDA enforces its right by conducting random audits of land under contract. It also has the power to impose penalties by way of repayment of funds, fines or removal from the program in case of violation of the specified agreement. Similar conditions apply to the BushTender trial.

A possible limitation of auctions is that they are voluntary. If an environmental problem is highly localised or of high priority, then a government may need to negotiate specific management agreements with landholders or impose regulations rather than rely on a voluntary auction process.

A major benefit of the BushTender system is that it reduces the incentive for landholders to avoid revealing the existence of rare and endangered species on their land for fear of triggering land control measures. Under the auction system, the existence of endangered species improves the value of the landholder's bid to the Victorian Government and so increases the likelihood that the landholder will receive funding.

BushTender may be criticised from a scientific perspective for using a biodiversity benefits index that assigns arbitrary weights to the various components of landholder bids. However, this approach does help determine priorities and highlights where additional information may need to be gathered to improve the current system. It may also be true that auctioning conservation grants using an imperfect benefit index may be preferable to alternative policy approaches, including inaction.

While there may be some scientific uncertainty about activities funded by BushTender, failure is unlikely to reduce ecosystem services from what they would have been in the absence of intervention. This is because BushTender only funds environmental improvements without offsets. Thus, the worst outcome is probably that land will remain as it was prior to funding.

Exchanges without auctions

State Forests of New South Wales and Macquarie River Food and Fibre (MRFF) have launched a pilot non-tradeable scheme that does not involve an auction. This pilot is being conducted in the Macquarie River catchment and involves the mitigation of salinity.

There is just one buyer (MRFF – the industry body for irrigators in the region) and one seller (State Forests NSW). On behalf of MRFF, State Forests pays landholders in the upper catchment an annuity in return for planting and managing native forest on their land. This controls salinity by removing water from the ground via transpiration, which in return is correlated with reduced ground water ascension in the lower catchment area. All timber and carbon rights resulting from the new forests are retained by State Forests.

While this scheme could potentially provide some benefits to the broader community, it would seem that the main benefit accrues to MRFF's members, the irrigators. Not only do they benefit from lowered ground water (which reduces salinity), but they also receive any indirect benefits arising from their environmentally friendly gesture, such as positive community sentiment.

A similar scheme is being conducted by State Forests NSW and Integral Energy in the Cumberland Plains. This scheme is intended to mitigate salinity, sequester carbon, and conserve biodiversity. A preliminary agreement has been negotiated between the two parties to conduct a trial on five hectares of land in the Cumberland Plains Woodland, which is an endangered ecological area.

Integral Energy will receive any benefits associated with carbon sequestration from the new forest, and suggests that the community will benefit from additional biodiversity and salinity control. However, given that this project involves only five hectares of new forest, the motivation would appear to have been to improve the company's image rather than to generate large environmental benefits per se.

The multiple objectives of this scheme raises a potential conflict. In particular, it must be noted that the benefits of salinity mitigation, carbon sequestration and biodiversity conservation can be joint products. If at some future time the timber is harvested, then all of the benefits will be lost. It could be necessary for MRFF to enter into perpetual contracts with forest holders if it plans to maintain ecosystem services from the scheme into the future.

4.4 Non-tradeable schemes with offsets

Non-tradeable schemes with offsets allow a party to undertake an action that reduces ecosystem services if they also undertake (or purchase from another) a separate action that increases ecosystem services by at least the same amount. In cases where the offsetting activity is purchased, the property right for that activity can only be exchanged once. Thus, a party undertaking damaging activities must purchase exactly the right amount of offsets for its needs. Otherwise, it will end up with surplus offsets that it cannot on-sell.

There are few examples of non-tradeable schemes incorporating offsets. This may be because most market-based offset schemes need to be tradeable to ensure a market large enough to be viable. Perhaps situations that require offsets indefinitely would be good candidates for a non-tradeable offset scheme. The supplier of offsets could generate long term benefits, say for use as salinity offsets, by undertaking revegetation at strategic locations, and sell them to irrigators to offset their detrimental contributions to salinity. A hypothetical example of such a scheme would be an MRFF type arrangement (see section 4.3) that was extended to allow offsetting.

Another form of non-tradeable offset scheme is a 'bubble' arrangement. An Australian example of this is the South Creek Bubble Licence Scheme (box 4.3). This scheme enables Sydney Water to offset discharges from one sewage plant against reduced discharges from another of its plants.

Box 4.3 **South Creek Bubble Licence Scheme**

The South Creek Bubble Licence Scheme was introduced by the NSW EPA in 1996 to reduce phosphorus and nitrogen levels in the Hawkesbury-Nepean River system. Phosphorous and nitrogen loading, which increases nutrient levels in the River, can lead to negative environmental impacts such as algal blooms and the destruction of aquatic ecosystems.

The NSW EPA sets the aggregate level of phosphorus and nitrogen pollution loads for the Scheme and allows Sydney Water to determine how the level will be allocated between its sewage treatment plants. Nutrient discharges (in sewage) from one plant may be offset against discharges from another plant within the bubble, so long as the overall limit is not exceeded. Pollution reduction also forms part of the arrangement and includes requirements such as installation of equipment for better removal of nutrients, and improvements in the reliability of treatment processes. Compliance is established by discharge monitoring and the overall success of reducing nutrient loads is assessed by water quality monitoring.

Sources: NSW EPA (1996, 2001).

An advantage of a bubble licence arrangement over regulation that specifies pollution limits for each source (such as a single plant) is that it is more flexible in achieving a given cap. In particular, participants have the opportunity to concentrate pollution abatement at locations with the lowest abatement costs. The bubble system also provides greater flexibility in capital works planning, and greater scope for changing operating and management procedures. These efficiency advantages hopefully encourage better environmental outcomes and in less time than would be possible using regulations (NSW EPA 1996).

4.5 Summary

Table 4.2 summarises how well the schemes analysed in this chapter meet the desirable conditions for market creation. The results are mixed, with some schemes appearing to meet their goals efficiently while others have not. Overall, it is possible to make the following general points:

- a tradeable scheme may be inefficient if there is no centralised clearing house (which may include an on-line clearing house) for parties to exchange property rights (RECLAIM);
- offset schemes can lead to a net reduction in ecosystem services when scientific uncertainty is high (wetland banking);
- verification can be costly when there is a high level of scientific uncertainty, since each transaction may have to be assessed on a case by case basis (wetland banking and possibly native vegetation offsets);
- schemes need to be designed so that they do not allow the concentration of an undesirable activity in a particular area or time period (RECLAIM and Hunter River Salinity Trading Scheme);
- where permits have long life spans, market entry may be facilitated by reallocating permits by auction at regular intervals;
- point source problems are more amenable to market creation schemes than nonpoint source problems (Hunter River Salinity Trading Scheme);
- auctions can be used to overcome the problems of asymmetric information and a limited number of buyers and sellers (CRP and BushTender); and
- market creation is unlikely to have any notable effect if the relevant property right is not valuable (carbon sequestration credits without restrictions on carbon emissions).

Table 4.2 **Property right characteristics of existing and proposed schemes**

Property right characteristic	*RECLAIM*[a]	*Hunter River Salinity Scheme*	*US wetland banking*	*Native vegetation offsets proposal*
Definition	Emissions of SO_2 and NO_x.	Discharge of saline water from point sources into Hunter River.	Destroy, improve or create wetland.	Destroy or improve native vegetation on private land.
Verification	Site inspections and continuous end-of-pipe emissions monitoring systems with computer link to overseeing agency.	Salinity monitoring stations in river.	Site inspections.	Accreditation and registration.
Enforcement	Reduced future permit allocation, financial penalties and/or loss of operating licence.	Forfeiture of permits and/or removal from scheme.	Low. Not often specified. Civil penalties and/or financial penalties.	Proposals include contracts and monetary bonds.
Valuable	Yes. Emissions cap in place. SO_2 and NO_x are byproducts of production.	Yes. Cap on saline emissions. Mines have saline byproducts of production and limited holding capacity.	Yes. Required by legislation. Property development and agriculture sometimes requires wetland reclamation.	Yes. Proposal to introduce legislation requiring offsets. Production and development require land.
Transferable	Yes. Could be improved by establishing central clearing house.	Yes. 24 hour on-line trading.	Yes.	Yes. But costly if need case-by-case approval.
Scientific uncertainty	Low. Regional limits to prevent concentration of pollutants in particular locations.	Low.	High.	High. Difficult to replace like with like. Exacerbated by time lags.
Sovereign risk	Moderate. Legislation in place but property rights not given property right status.	Low. Piloted. Regulation proposed establishing 10 year permit longevity.	Low. Regulation in place.	Unknown. Lower if has legislative/ regulatory basis.
Sufficient buyers and sellers for a tradeable scheme	Yes.	Probably (22 participants).	Yes. Envisage more buyers than sellers.	Depends on rules of scheme, such as location of offsets and scope for clearing.

(Continued on next page)

Table 4.2 (continued)

Property right characteristic	*Carbon sequestration credits*	*Conservation Reserve Program*	*BushTender trial*	*South Creek Bubble Licence Scheme*
Definition	Sequestration of CO_2.	Undertake environmentally beneficial activities on private land.	Undertake environmentally beneficial activities on private land.	Emission of phosphorous and nitrogen into Hawkesbury-Nepean River.
Verification	Scientific calculations closely related to quantity and age of trees.	Environmental Benefits Index. Random audit by overseeing agency.	Biodiversity Benefits Index. Annual report by participants. Random audit by overseeing agency.	In-stream monitoring.
Enforcement	Legal title to sequestered CO_2.	Penalties, removal from program.	Cessation of annual payments, removal from program.	Review. Penalties.
Valuable	Yes. Provided that emissions are restricted.	Yes. Government cannot provide all conservation on public land.	Yes. Government cannot provide all conservation on public land.	Yes. Nutrients produced as byproduct of sewage treatment and there is limited holding capacity.
Transferable	Yes.	Yes, between government and landholder.	Yes, between government and landholder.	Yes, between management units within Sydney Water, but no external transferability.
Scientific uncertainty	Moderate.	Low.	Low.	Low.
Sovereign risk	Possibly high, given no international consensus.	Low. 10 year renewable contracts.	Low. 3 year contract.	Low.
Sufficient buyers and sellers for a tradeable scheme	Probably. Much higher if an international trading regime for credits is adopted.	Not a tradeable scheme.	Not a tradeable scheme.	Not a tradeable scheme.

a Regional Clean Air Incentives Market used to improve air quality in the South Coast Basin (Los Angeles region).

5 Concluding comments

The analysis in this paper suggests that creating markets for ecosystem services can, under the right conditions and with appropriate market design, be an efficient way to achieve certain environmental goals. However, as we have shown in this paper, market creation is more likely to be successful when certain conditions are met. Drawing on the results of our applied analysis, this concluding chapter highlights three key issues faced by policy makers in designing ecosystem service markets. These are scientific uncertainty, market liquidity, and the role of regulation.

5.1 Scientific uncertainty

How an ecosystem service responds to different actions is often poorly understood. For example, it is rarely possible to forecast the precise timing and extent of any reduction in salinity due to planting native vegetation. Such uncertainty is not necessarily an insurmountable barrier to the operation of a market. However, there will be cases where scientific uncertainty is so high that market creation will not achieve its environmental objectives.

As noted in chapter 2, market creation involves the definition of a new commodity that acts as a proxy for an ecosystem service. Finding a suitable proxy can be difficult when scientific uncertainty is very high. For example, there is no consensus on what proxy could be used for a scheme of tradeable biodiversity credits. Using an imperfect proxy (such as trees per hectare) which has a weak relationship with the ecosystem service (all aspects of biodiversity) may not achieve the policy's environmental objective. Alternatively, there may be a proxy that is closely related to the ecosystem service but is very costly to define, verify and/or enforce. For example, a comprehensive proxy for biodiversity could in theory be developed but this may be costly to implement due to the need to assess properties on a case-by-case basis.

Policy makers should be particularly cautious in implementing offset arrangements when scientific uncertainty is very high. This is because it is difficult to be sure that the trade offs involved with an offsets arrangement will cause no net reduction in ecosystem services. This is evident from the US experience with wetland banking (chapter 4).

It may be possible to accommodate a moderate level of scientific uncertainty in an offset arrangement by setting the rate at which environmental harm can be offset against environmental good at a conservative level. For example, a scheme could allow one hectare of land to be cleared only if it was offset against two hectares of land with newly planted native vegetation. A similar approach has been proposed for a native vegetation offsets scheme in New South Wales (chapter 4).

Policy makers should also be mindful of how a lack of scientific knowledge may cause them to overlook the joint nature of ecosystem service production. In particular, the operation of one ecosystem service market could affect the supply of other ecosystem services. For example, planting trees to sequester carbon can also affect biodiversity and salinity. Without an adequate understanding of the mechanics of joint production, it is possible that market creation will have unintended adverse effects.

If policy makers proceed with market creation despite a very high level of scientific uncertainty, then the resulting scheme could be subject to considerable sovereign risk. In particular, there may be a high probability that rules would need to be changed in the future because the scheme had an adverse environmental impact and/or new scientific discoveries had been made. Sovereign risk diminishes the value of property rights and hence the likelihood that market creation will be effective.

5.2 Market liquidity of tradeable schemes

A lack of buyers or sellers is a particular concern for tradeable schemes because one party (or a group acting in collusion) may be able to manipulate the price of the new property right. Competition for the new property right could then lead to a suboptimal outcome in the sense that one party could be made better off without making others worse off.

There are two possible reasons why there may not be a sufficiently large number of buyers and sellers for an ecosystem service.

First, there may be a tradeoff between market liquidity and scientific certainty. For example, it is desirable to limit a native vegetation offset scheme to a particular catchment or biotic region. This is due to the uncertain impact of offsetting land clearing in one region against land rehabilitation in another distant region. But limiting a scheme to a confined area will reduce the number of potential buyers and sellers.

Second, there may be few parties willing to pay for the property right associated with an ecosystem service. For example, carbon sequestration credits will not attract many buyers while there continue to be few restrictions on the emission of greenhouse gases (chapter 4).

5.3 Regulation

As noted in chapter 2, the case for regulation often depends on governments being better informed about an ecosystem service than they typically are. In addition, regulation can hinder innovation if it prescribes what technology should be used to address an environmental problem. In contrast, creating markets provides a means to harness the information held by nongovernment parties about an ecosystem service and to reward innovation (subject to the qualifications noted in previous sections).

However, regulation is not redundant in cases where market creation is appropriate. It just takes on a different form. In particular, there need to be clear rules underpinning a market creation scheme. For example, it is important to specify clearly the property right associated with an ecosystem service, the process for registering its exchange, and the procedures used to enforce it.

Where a cap or limit is set on a certain activity (such as emissions), this is established by regulation rather than being determined in a market. Such regulation needs to limit the scope for an undesirable activity to be concentrated in a particular region or time period if that would adversely affect the environment. The possibility of irreversible damage also needs to be avoided. In addition, regulation should not impede efforts at private conservation, as seems to occur with US wetland banking schemes (chapter 4).

Glossary

Biodiversity	The variety of all life forms (biological diversity). This is a function of diversity within a single species, between different species, and between ecosystems.
Biodiversity benefits index	A weighted index used to classify and rank land offered for conservation under the Victorian BushTender trial.
Bubble arrangement	An arrangement where an overall limit or bubble is placed over a group of emission sources. Emissions from one source in the bubble may be offset against those of another source, provided that the overall limit for the entire bubble is not exceeded.
Carbon sequestration	A process that removes carbon dioxide from the atmosphere through the absorption and storage of carbon in vegetation or other matter.
CO_2-e	Carbon dioxide equivalent. This is a standard of measurement used to express different greenhouse gases in common units. The unit of measurement is the global warming potential of carbon dioxide.
Dryland salinity	Salting of nonirrigated land.
Ecosystem	A community of organisms and the physical environment with which they interact.
Ecosystem services	The functions performed by ecosystems that lead to desirable environmental outcomes, such as air and water purification, drought and flood mitigation, and climate stabilisation.
Environmental benefits index	A weighted index used to classify and rank land offered for conservation under the US Conservation Reserve Program.
Environmental hot spot	A situation in which an adverse environmental effect is concentrated in a particular region or time period.

Externality	A product or action whose creation by one party affects the wellbeing of others without being reflected in market prices.
Free-ride	To benefit from a good or service without contributing to the cost of its provision.
Irrigation salinity	Salting of irrigated land.
Market	Any context in which the sale and purchase of a good or service takes place
Market creation	A policy approach that, under certain conditions, transforms a nonexcludable ecosystem service into something that is excludable and hence can be exchanged for reward. This is done by defining a new property right for a commodity that is (a) excludable in consumption; and (b) a proxy for a nonexcludable ecosystem service.
Market failure	Individuals acting in their own private interest produce an outcome that is inefficient in the sense that it is possible to make somebody better off without making others worse off.
Nonexcludable consumption	A party cannot be excluded from the consumption of a good or service once it has been supplied to another party.
Nonpoint source pollution	Pollution for which it is difficult to identify the precise source, such as that linked to runoff from agricultural land.
Nonrival (joint) consumption	One party's consumption of a good or service does not diminish the supply of that good or service to other parties.
Offset arrangement	A policy that allows a party to undertake an action that reduces ecosystem services if they also undertake (or purchase from another) a separate action that increases ecosystem services by at least the same amount.
Point source pollution	Pollution that arises directly from an identifiable source, such as a pipe or other conveyance.
Property right	An entitlement to use a particular good or service in a certain way. This entitlement may be restricted to specific aspects of the good or service.

Sink	A mechanism, process or activity (such as vegetation growth) which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere.
Sovereign risk	The likelihood that future government decisions will diminish the value of a property right.
Tradeable property right	A property right that can be exchanged more than once, provided it has not been exercised. In other words, there is a secondary market for the property right.
Transaction costs	The costs associated with buying and selling, such as those associated with collecting information and processing trades.
Wetland	Land inundated with temporary or permanent water that is usually slow moving or stationary, shallow, and either fresh, brackish or saline.
Wetland banking	An arrangement that allows a party to substantially alter a wetland if they purchase the credits earned by another party for the protection, restoration and/or enhancement of another wetland. These credits are purchased from an intermediary known as a wetland bank.

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