Bundled Ecosystem Markets – Are They The Future?

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Abstract

Bundled ecosystem markets may be the next big buzz in environmental policy and ecosystem conservation and restoration. But what does it mean? And what is the feasibility of these markets? While single service ecosystem markets are proliferating, bundled ecosystem markets are not. Using some 'enabling' and 'operating' conditions identified for various single ecosystem markets, I will see how these conditions hold as you move to bundled ecosystem markets. I also outline some of the hurdles that confront the development of bundled ecosystem markets and what may need to be reconciled to move these markets forward. This article is aimed at stimulating greater thinking and promoting more exploration by the policy and research community into the development of bundled ecosystem markets.

Key words: bundled ecosystem markets, market-based instruments, policy, trading, ecosystem services, markets.

Where Are We Today?

There are a burgeoning number of individual ecosystem markets emerging around the world. Greenhouse gas (GHG) and carbon markets are found in Europe, Australia, New Zealand, and the United States; water quality markets in the United States, Australia, and New Zealand; SO_2 markets in the United States, and the list goes on. So perhaps the next step is to bundle these ecosystem services together into one market, especially in areas where one entity can potentially 'play' in more than one market. The concept has been discussed for a number of years by practitioners, such as designers of and participants in single ecosystem markets, but we really have not seen any true bundled markets arise for multiple ecosystem services.

Bundled markets are particularly attractive to sectors such as agriculture and forestry, where the implementation of one practice may have implications on a number of ecosystem services. For instance, a riparian buffer strip will reduce phosphorus and sediment reaching streams, reduce nitrogen losses, increase carbon sequestration and possibly improve wildlife habitat—all positive impacts on a number of ecosystem services. Not all practices have positive benefits across the board though. For example, the establishment of a constructed wetland improves nutrient cycling and wildlife habitat but also increases methane emissions (a potent greenhouse gas).

As the bio-physical, economic, social or legislative conditions will not always exist for bundled markets to make sense or even to be contemplated, the aim of this article is to explore in more detail the feasibility of bundling more than one ecosystem service into the one market. The article is not meant to be the 'final word' on bundled ecosystem markets or even go into significant detail on the various issues; rather it is designed to stimulate discussion and research around how these markets should look (if at all), what they should contain and what needs to be done.

Ecosystem Services

It is important in the context of the following discussion to understand what ecosystem services and ecosystem markets mean, as they can be rather abstract concepts to understand.

Ecosystem services have been defined in a variety of ways. However, this discussion will use the Millennium Ecosystem Assessment (MA 2003) definition and classification of ecosystem services (Figure 1). Ecosystem services are the benefits people obtain from ecosystems and include the provisioning, regulating, and cultural services that directly affect people and the supporting services needed to maintain the other services.

Provisioning Services *Products obtained from ecosystems*	**Regulating Services** *Benefits derived from regulation of ecosystem processes*	**Cultural Services** *Non-material benefits obtained from ecosystems*
• Food and fiber • Fuel • Genetic resources • Biochemical, natural medicines, and pharmaceuticals • Ornamental resources • Freshwater	• Air quality maintenance • Climate regulation • Water regulation • Erosion control • Water purification and waste treatment • Regulation of human diseases • Biological control • Pollination • Storm protection	• Cultural diversity • Spiritual and religious values • Knowledge systems • Educational values • Inspiration • Aesthetic values • Social relations • Sense of place • Cultural heritage values • Recreation and ecotourism
Supporting Services *Services necessary for the production of all other ecosystem services* • Soil formation and retention • Nutrient and water cycling • Primary production • Production of atmospheric oxygen • Provisioning of habitat		

Source: MA 2003

Figure 1. Ecosystems Services

Ecosystem Markets

Ecosystem markets are simply markets for ecosystem services designed to improve the condition of that service. In an ecosystem market, an environmental goal or cap is established and then the cap is allocated between degradation sources. Commodities (i.e., the tradable unit that represent ecosystem services) are traded between people using a pricing mechanism to allocate resources more efficiently, thereby improving ecosystem health.

More often than not when it comes to ecosystems, people tend to think of market-based instruments as a cost-effective way to meet an ecosystem or environmental goal (Tietenburg, 2006). These instruments can cover a myriad of different market forms like auctions, offsets and trading. Most of this article will focus on the latter type of market—trading markets or cap-and-trade/compliance markets for ecosystem services. However, many of the issues outlined in this article will also hold for the other types of markets.

Water quality trading markets are examples of single ecosystem markets for water purification. In these markets the commodity being traded is pollutants that affect the quality (or purity of the water), such as nutrients, sediment, salt, etc. Trading markets are premised on the fact that costs to reduce nutrient discharges, for example, differ between individual entities depending on their size, location, scale, management, and overall efficiency. When nutrient discharges are regulated, trading markets give the regulated entities the flexibility to comply with their regulatory obligations by purchasing equivalent reductions in the relevant commodity elsewhere. The ability to trade discharge allowances or reduction credits creates an incentive for those who can reduce their discharges most cost effectively to do so and sell excess reductions to those for whom the cost of reducing discharges is higher (Greenhalgh and Selman 2008).

There is a quite a lot of literature that discusses the creation of markets for ecosystem services and the corresponding rationale for why these types of markets are important (e.g., address externalities), the challenges with establishing these markets (e.g., poorly defined property rights, supply/demand issues, etc that lead to market failures), and examples of where markets for ecosystem services have arisen (Randall and Taylor 2000; Murtough et al. 2002; King and Kuch 2003; King 2005; Whitten and Shelton 2005; Duraiappah 2006; Whitten et al. 2006).

This article, assuming that these arguments are well understood and establishing a market is an appropriate policy tool to improve the functioning of ecosystem services, instead explores the concept of bundled ecosystem markets where more than one ecosystem service can be transacted in the market. It looks at what is needed for bundled ecosystem markets to occur, where they are most likely to emerge, and the potential commodities these ecosystem markets may trade.

Translating Ecosystem Services to Ecosystem Markets

Translating ecosystem services into a market context can cause some confusion, as we do not trade ecosystem services. Rather, we trade commodities that relate to these services. Using the water quality example above, the commodity could be nutrients like phosphorus or nitrogen, sediment or salt.

Using the MA classification outlined in Figure 1, we find that well-functioning commodity markets already exist for many of the provisioning services (referred to as ecosystem goods in some literature, e.g., Constanza et al. 1997). For instance, there are markets for a vast range of food, fiber, and fuel products, and in these markets, a physical commodity changes hands.

Cultural services are non-material benefits whose level of benefit not only varies depending on the condition of an ecosystem but by an individual's perception of the importance of the various cultural services. The individual preference aspect of these services makes most of them difficult to integrate into a functioning market (MA 2003). Certain types of cultural services such as recreation and ecotourism, however, have been successfully used in a market context as recreation, and ecotourism experiences are regularly bought and sold.

The long-term nature of supporting services means they do not have a direct impact on people and consequently have not led to the development of markets for these services. Supporting services are still important, though, as they affect other services, which in turn impact people. For instance, even though humans do not directly use soil formation services, this service affects the provisioning services provided by food and fiber on which humans depend (MA 2003).

Regulating services are the area with the greatest potential for developing new markets—this is where the relatively recent development of single service ecosystem markets has concentrated. The water quality trading market example above falls into this category. The initial challenge with creating markets for these services is identifying a quantifiable commodity that relates to the ecosystem service in question, as there are no physical commodities changing hands. Table 1 outlines some services that could support markets. The remaining discussion focuses on the establishment of markets relating to those regulating ecosystem services that could support a market.

Table 1. Potential Commodities for Some Regulating Ecosystem Services

Regulating Service	**Possible Commodity(ies)**
Air quality maintenance	Sulphur dioxide, NOx, particulates
Climate regulation	Greenhouse gases, e.g., carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydroflurocarbons (HFCs), peroflurocarbons (PFCs), and sulphur hexafluride (SF_6)
Water regulation	Quantity of surface water or groundwater
Water purification	Nutrients (e.g., phosphorous and nitrogen), salt
Erosion control	Sediment
Pollination	Habitat of a particular type/condition

Bundled Ecosystem Markets

Bundled ecosystem markets are where a market exists that simultaneously incorporates more than one ecosystem service into a single transaction. There are only a few examples of these, one being the EcoTender conducted in Victoria, Australia in 2005. This was is not a trading market but an auction. The EcoTender bundled water quality, greenhouse gases and habitat into a single commodity that was auctioned (Eigengraam et al. 2006). Of the 50 bids in this auction, 62 percent of the bids were accepted (totally around AUD500,000), resulting in 259 ha (or approximately 658 acres) being revegetated or undergoing native vegetation management and 10,078 tonnes of carbon of being sequestered. Few bids had water quality (salinity) benefits.

Rationale for a Bundled Ecosystem Market

The principal reason for considering a bundled ecosystem market is that ecosystem services are typically interlinked, suggesting the aggregation or bundling of ecosystem services is indeed important and is a direction we should take.

However, in reality we are often faced with the noticeable deterioration of one ecosystem service, and policies are formulated to ameliorate that service without explicit (or even implicit) consideration of the impact of that solution on other ecosystem services. One example was the response to excessive sediment loss from U.S. farmland in the 1980s. One option—to subsidize the transition from conventional to conservation tillage to reduce soil loss—was remarkably successful for reducing soil loss but on further investigation had adverse impacts on GHG emissions (Greenhalgh and Sauer 2003). In that same analysis, Greenhalgh and Sauer showed that the most cost-effective mechanism to reduce GHG emissions within the agricultural sector in the United States was to implement a water quality trading program focused on nitrogen rather

than develop a GHG trading program.[1]This illustrates the value of thinking more broadly about other ecosystem services than the one of primary interest.

There are also some practical reasons for pursuing bundled ecosystem markets. One is the potential to reduce transaction costs for market participants and administrators, an important determinant for market participation and the efficiency of a market. Transaction costs are the costs associated with buying and selling commodities, including the cost of collecting information, finding buyers and sellers and processing trades. Bundled markets are likely to reduce costs associated with the collection of information, estimation of the impacts of a management or technological change on various ecosystem services and the actual processing of trades. For instance, market participants only need to deal with one administrator for all commodities and could simultaneously assess the impact of management and technological options on a number of ecosystem services. Bundled markets may also reduce the amount of infrastructure required for markets to function. There is only a need for one market place, one registry to track trades, and one set of rules to govern the market.

Another reason is to help 'thicken' the market. One of the criticisms of some ecosystem markets is the thinness of the market, i.e., there are too few buyers or sellers participating in the market. Widening the number of commodities for sale may stimulate the interest of a greater number of potential buyers and sellers to participate, increasing the efficiency of markets.

[1] This outcome was dependent on the credit prices within the respective trading markets. A nitrogen price of US$5/lb of nitrogen resulted in more GHG reductions than a GHG market trading at US$5 or $14/tonne of CO_2e. However at US$2/lb of nitrogen, a nitrogen trading market only performed better than a GHG market trading at US$5/tonne CO_2e.

When more than one ecosystem market exists then the demand for credits in any of these markets will also depend on the prices in other markets. Therefore, a market participant would need to simultaneously be negotiating or participating in more than one market at a time, placing an even greater burden on the participant (Tietenburg 2006). In a bundled market, there is only one market to participate in.

Simultaneously considering multiple ecosystem services before we make policy or management decisions becomes important if we want to acknowledge the interconnection of our ecosystems. As important is the explicit consideration of the impact of a proposed policy, change in management practice or adoption of technology on different ecosystem services.

The Evolution of Bundled Ecosystem Markets

In an ideal world we would have perfect knowledge and foresight to establish a bundled ecosystem market. However, that is not the world we live in. There are three ways that multiple ecosystem services could be considered in a market context:

- Development of a bundled ecosystem market at the outset.
- Incorporation of additional ecosystem services into an existing single ecosystem market. If the connection between ecosystem services is not formalized then these markets will operate in a similar fashion as the disparate markets outlined below. Should the connection between ecosystem services be formalized they could operate more like bundled ecosystem markets. I will call these 'associated ecosystem markets.'
- Continued evolution of separate single ecosystem markets covering different ecosystem services. This is not a bundled ecosystem market but is the reality of today's ecosystem

markets and will affect how bundled ecosystem market may or may not evolve. I will refer to these as 'disparate ecosystem markets.'

Establishing a Bundled Ecosystem Market

A number of enabling and operating conditions are important for the existence and operation of single ecosystem markets, and these can be translated and compared to the conditions needed for bundled ecosystem markets. While these seem relatively obvious and straightforward, they are worth noting as they are sometimes overlooked in the desire to develop market-based solutions to environmental problems.

Enabling Conditions

Before any type of market is established there should be at least the following pre-existing conditions:

1) Evidence of human-induced degradation in one or more ecosystem services.

Whilst this is obvious, there must be a reason for society (or those entrusted to make decisions on behalf of society) to establish some form of restriction on people's actions because of ecosystem degradation.

This has a number of implications for bundled ecosystem markets. Where a number of ecosystem services are degraded, bundling them into one market makes sense. For example, in New Zealand some watersheds are experiencing problems related to excess nutrients and sediments primarily from agricultural sources, with the agricultural community also facing future GHG regulation. Under these circumstances, questions arise about how the agricultural community efficiently participates in markets for both these commodities, and where will the efficiency gains be?

Another example is Pennsylvania's water quality trading market[2], which currently trades nitrogen and phosphorus, and will likely trade sediment in the future. In its early design phase, GHGs were also considered for inclusion into the program but for various reasons this was not pursued. This market has multiple commodities related to one ecosystem service, namely water purification. It is currently operating as an associated ecosystem market, and does not ask participants to consider how a change in management practice or technology affects all traded commodities. Rather, people may choose to participate in one or both markets. GHG trading programs are also multi-commodity, where more than one commodity is technically traded to improve climate regulation services.

In situations where only one ecosystem service is obviously deteriorating, it is a case of ensuring that the actions taken to address the condition of that ecosystem service do not inadvertently lead to the degradation of other ecosystem services.

2) Sufficient heterogeneity within the geographic area(s) of the market.

Without bio-physical, management, social and/or economic heterogeneity within and across the market's geographic area there will be few incentives to participate in a market, whether for a single or for a bundled ecosystem market. Heterogeneity provides sufficient diversity of conditions between different participants to create opportunities and incentives for trading to occur.

[2] http://www.dep.state.pa.us/river/Nutrient%20Trading.htm#NutrientNet

Heterogeneity is important because potential market participants face different sets of mitigation options, different cost structures, and different management opportunities to reduce their impact on ecosystems, and will affect the initial cost-effectiveness and efficiency of a market (Whitten and Shelton 2005). Heterogeneity provides incentives to trade as trading is more likely to occur where different entities are able to comply or over-comply with their regulatory (or other) obligations at lower financial cost than others.

Bio-physical heterogeneity is when the condition of ecosystem service(s) varies naturally or because of human-induced pressures within a market's geographic area. The variety of options available to market participants to enhance the condition of ecosystem services gives management heterogeneity. Finally, the degree to which market participants have different goals in terms of their management, financial returns, lifestyle, and different preferences relating to environmental consciousness, work load, beliefs and values will affect social and economic heterogeneity.

3) Sufficient buyers and sellers within the geographic area(s) of the market.

There must be a sufficient number of potential market participants to support either a single or bundled ecosystem market. The number is open to debate but it is generally believed that the thicker the market the greater the opportunity for it to be a cost-effective mechanism for improving the state of ecosystem services. It reduces the potential for one participant to gain market power increasing the likelihood of achieving a cost-effective or least-cost solution, and provides greater assurance that competitive market prices will exist (Tietenberg 2006). A greater number of buyers and sellers may also reduce the transaction costs associated with buyers and sellers finding each other.

Without these three conditions, the possibility of a market actually experiencing any transactions will be limited.

Operating Conditions

A number of key 'operating' conditions also need to exist. These conditions or features improve the operation of an ecosystem market.

1) Establishing environmental goals or caps.

Establishing environmental goals or caps are important as they articulate the quantitative goals that any action (whether it be solely regulatory or include flexibility mechanisms such as markets) should achieve. Environmental goals or caps are often thought of as market 'drivers', i.e., the motivation behind establishing a market; without which there is no reason for trading to occur.

The establishment of goals or caps is an area of potential complexity for bundled ecosystem markets. The establishment of more than one ecosystem service goal may lead to misaligned goals. For example, with disparate and possibly associated markets, the goal of one market may impede attaining the goal of another if no consideration is given to the other ecosystem service. Similarly, if one ecosystem service goal is more stringent than others, this goal may dominant, potentially disadvantaging other ecosystem services unless there is a need to consider these other services.

With bundled markets, it may be challenging to establish an overall goal. Questions arise around whether to set explicit goals for each ecosystem service or establish a combined metric goal and, if so, what would such a combined goal look like? If combined metrics are used, do they establish sufficient drivers for a market? What process should be used to set environmental goals?

2) Developing policy, legislation or a regulatory framework to underpin the market.

Developing the underpinning framework establishes regulatory obligations, outlines the rules of the market, and provides the legal framework within which the market will operate. Some of these rules will include eligibility (and additionality), regulated entities, allocating the goal or cap between regulated entities, methodologies to assess the impact of management and technology options on various ecosystem services, and the process for how a trade would occur.

This is an important part of the process to establish a bundled market and will clearly articulate what ecosystem services are covered (e.g., the European Union GHG trading program only covers CO2, while the New Zealand Emissions Trading Scheme covers all six Kyoto GHGs) and how the interaction between services will be handled within the market. In theory, addressing these rules will be similar regardless of the type of market we are dealing with.

Additionality is one issue that does have greater implications for single service markets than for bundled ecosystem markets. Certainly, in GHG markets with uncapped sources, and more recently in water quality markets, the concept of additionality is used to ensure the actions of the non-regulated entities wishing to participate in a market are beyond 'business-as-usual.'

In disparate and associated ecosystem markets where one ecosystem service is regulated and another is not, additionality can have a number of implications. If an action is taken to meet the regulatory requirements for one ecosystem service, then in all likelihood this same action will not result in *additional* improvements in any other non-regulated ecosystem services. Thereby eliminating the ability to gain financially from considering multiple ecosystem services, and perhaps providing a disincentive to make a holistic assessment of the impact of the available actions on multiple ecosystem services.

In a bundled ecosystem market, the administrating body could effectively deal with this issue. One option may be to have a principle ecosystem service that is regulated but to incorporate explicitly into the market rules the need to assess the impact on other ecosystem services and set appropriate rules to compensate for the improvement in all relevant ecosystem services. Alternatively, the market may have one commodity for sale that already bundles the ecosystem services together.

Where an entity is not regulated for any ecosystem services, the three types of ecosystem markets will likely recognize the benefits from a single action on multiple ecosystem services in a similar fashion.

The other issue that has efficiency, equity, supply and demand implications is the allocation of the cap between sources. How a cap is allocated between regulated entities and the stringency and enforcement of these individual limits (or caps) will impact the supply and demand for the commodities being traded (King 2005). Lax regulatory limits means that entities can easily meet their limits and there is no reason to trade. Similarly, stringent regulations with weak enforcement

may mean that participants choose not to comply with regulation because they believe the penalties for non-compliance are less that the cost of compliance (i.e., they 'game' the regulatory program) (Kyland and Prescott 1977; King 2005). In both situations, there is little demand for ecosystem commodities from an ecosystem market.

The allocation issues between all three types of ecosystem markets are similar. Once an overall environmental goal has been established, how do you efficiently and equitably allocate the goal between the various sources of degradation? And what would the initial allocation of the cap look like between the sources? Who are the winners and losers of the various allocation strategies?

With bundled markets there is an additional level of complexity related to the format of the cap. If there are individual caps for different ecosystem services, then individual caps will be allocated to each source for each ecosystem service. If the overall cap is a combined metric then allocating between sources will be less straightforward. Questions arise around is it feasible to efficiently and equitably allocate a combined metric cap? How would you allocate?

Turning to the stringency of the individual limits (which are based on the overall environmental goal or cap), there are questions around what level of stringency is required to stimulate a supply and demand of the ecosystem commodity, and how does this change between a bundled market and multiple single ecosystem markets? If associated or disparate markets exist, what are the implications of a stringent limit and strict enforcement for one ecosystem service but weaker limits and enforcement mechanisms for other ecosystem markets?

3) Developing the necessary market infrastructure.

The operational efficiency of a market is often facilitated by the provision of infrastructure to support the market. This may include a mechanism for buyers and sellers to find each other (e.g., marketplace), the ability to track and monitor trades (e.g., registry), and provisions to streamline the process to approve trades. The steps taken to establish the market infrastructure for bundled ecosystem markets is likely to be similar to those taken for single ecosystem service markets. Well designed market infrastructure will reduce transaction costs and improve the efficiency of any type of ecosystem market.

4) Establishing a consistent estimation (calculation) methodology and/or tool to assess the impact of management and technology options.

Consistent estimation methodologies relate to a market's transaction costs. They are also important for the credibility of markets as they allow the routine and reliable comparison between different market participants, and between different mitigation (both management and technology) options. Some examples of estimation methodologies and tools that could be consistently and transparently used for ecosystem markets are the Revised Universal Soil Loss Equation (RUSLE)[3] for sediment loss from cropping lands in the United States, and the OVERSEER®[4] model for nutrients and GHGs from pastoral lands in New Zealand.

The challenge that arises with estimation methodologies is there may not be sufficient knowledge of some ecosystem services to develop a consistent estimation methodology. Ideally, the one estimation tool or methodology could be used to assess the impact of management and

[3] http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm
[4] http://www.agresearch.co.nz/overseerweb/

technology options on a number of ecosystem services. The more ecosystem services that can be incorporated into the one methodology or tool, and the ease of using the methodology or tool will reduce the transactions costs associated with both participating in a market and verifying the information that supports a trade.

The issues surrounding estimation methodologies and tools is relevant for both single and bundled ecosystem markets, but is more likely to constrain the number of ecosystem services that can be incorporated into a bundled ecosystem market.

Potential Barriers to Bundled Ecosystem Markets

One question to ask ourselves is, given the common-sense logic surrounding the benefits of bundled ecosystem markets, why are they not common place?

Political Will

Perhaps the first reaction is there is not the political will to establish bundled ecosystem markets. This is not surprising, given the challenges many have faced with just developing single ecosystem service markets. The Pennsylvania Department of Environmental Protection took two years of stakeholder consultation to finalize their water quality trading rules. Similarly, Environment Waikato, after six years, are about to enter the New Zealand Environment Court for hearings on challenges to the underpinning policy to support a nutrient market; and many GHG markets are still struggling with issues such as establishing caps, allocating the cap between entities and estimation methodologies. With the cost, both time and financial, associated with these single ecosystem service markets, policy makers are likely reticent to tackle developing even bigger and more complex markets. However, the cost of delay or the cost of individual

entities meeting increasingly more stringent regulation for a growing number of ecosystem services may prove to be even more costly than the task of developing a bundled ecosystem market.

Inadequate Capacity

While ecosystem markets have appeal in a number of policy and environmental contexts there is often a lack of capacity to design ecosystem markets. Despite ecosystem markets being around for a number of years there are still relatively few people with the required expertise, knowledge and skills to develop them and most people with this expertise have their attention focused on single ecosystem markets. This leads to a dearth of people to think through the development of bundled ecosystem markets.

Uncertain Science—Quantifying Impacts

Uncertain science may also be a deterrent, and is one factor that leads to market failures. We do not always know what impact a change in management practice or technology will have on all ecosystem services, which makes it difficult to develop a bundled ecosystem market in some contexts. However, there are some services, such as air quality maintenance, climate regulation, water regulation, and water purification, where we are beginning to get reliable estimation methodologies developed.

Uncertain Science—Quantifying Tradeoffs

The other area that causes angst is how we assess the tradeoffs between various ecosystem services or even between commodities relating to one ecosystem service. When determining the

baseline conditions[5] we only need to know what the effects of current management practices or technologies are on the state of each ecosystem service. For instance, with climate regulation and water purification services we may need to know how many GHGs we are emitting or sequestering and how many nutrients we are leaching.

The challenge arises when assessing the various mitigation options available and their impact on different ecosystem services. Some options will have greater positive or negative benefits on one or more services (or commodities) than others. For participants to make informed decisions on what option to choose, knowing these tradeoffs is important.

Using a simplistic climate regulation and water purification example, a farmer may consider establishing a riparian buffer strip or constructing a wetland adjacent to a stream. The buffer strip assimilates nutrients, reduces the volume of nutrients reaching the stream, intercepts overland sediment flows, and sequesters carbon. The wetland also assimilates nutrients, reduces sediment flows and sequesters carbon but also emits methane. In a bundled ecosystem market, negative and positive impacts are considered; and how the 'commodity' was derived or measured may affect the amount of the commodity available to sell. With disparate markets, participants who decided to construct a wetland could choose to enter the water purification market only (and ignore the adverse effect on climate regulation); if they decided to establish a buffer strip they could potentially participate in both markets (and enhance both ecosystem services). What happens in an associated market will depend on if and how these types of tradeoffs are treated.

[5] This establishes the existing or initial effect on the ecosystem (e.g., amount of phosphorus that is leached to a waterway) against which the change in management or technology is compared.

Where the tradeoffs are of a positive nature, a different set of issues arise. For instance, farmers who are going to establish a buffer strip can choose between a grass and a forested buffer strip. Both options have positive water purification and climate regulation benefits but the magnitude of these benefits is arguably better under forested buffers. If, hypothetically, the farmers were only interested in overland phosphorus flows as it affects water purification they may choose to establish a grass buffer strip, which is cheaper and easier to establish. In doing so they fail to capitalize on the other (and potentially greater) benefits that a forested buffer may provide—reducing the overall ecosystem benefits and potentially the financial gains of their actions. Once again, in a bundled ecosystem market the farmers would have explicitly considered all benefits; in disparate markets they might not have acknowledged the greater carbon sequestration gains of the forest.

Tradeoffs have been addressed in some single ecosystem service markets by creating a common commodity. In GHG markets, the six GHGs covered by the Kyoto Protocol are converted using Global Warming Potentials to carbon dioxide equivalents. In one water quality trading market in the United States, deficiencies in biochemical oxygen demand (BOD) were converted to the tradable commodity, phosphorus, using a 1:8 ratio (WRI 2007).

Scale

Scale may raise some thorny issues for bundled ecosystem markets. With climate regulation being a global issue but water regulation and purification being at a watershed scale, the path to establishing a bundled market could encounter a number of institutional challenges. Different government agencies (or departments within agencies) with differing jurisdictional boundaries may be responsible for protecting the various ecosystem services. Therefore, short of institutional

restructuring, there will need to be clear lines of authority to bring the relevant ecosystem services under one umbrella to enable bundled ecosystem markets to operate.

What is the Future of Bundled Ecosystem Markets?

The question posed is how viable are bundled ecosystem service markets? To answer this we should pragmatically summarise the conditions surrounding today's ecosystem service markets and what questions need to be addressed to mobilize any change toward bundled ecosystem service markets.

A few realities are immediately apparent. First, in the short term bundled ecosystem markets are only likely to incorporate a subset of ecosystem services, with the most likely candidates being air quality maintenance, climate regulation, water regulation, erosion control, and water purification ecosystem services. Inadequate metrics or estimation methodologies and/or the inability to measure the performance of all potential changes in management practices and technologies across an array of ecosystem services will hinder the inclusion of all services into a bundled market. Having said that, the EcoTender auction in Australia represented a positive step towards demonstrating how, in an auction context, some of these issues can be addressed.

Second, disparate markets are likely to exist and continue to grow for some time yet. To ease any transition to bundled ecosystem markets we can take steps during the design of the single ecosystem service markets to recognize this. For example, mechanisms, such as multi-purpose registries, can be developed that allow disparate markets to be linked in the future, and reduce the transaction costs associated with operating a number of simultaneous ecosystem markets.

Third, the sectors that are likely to benefit most from bundled ecosystem markets are the agriculture and forestry sectors, as many of the decisions a producer or forester makes and the scale of these decisions may have measurable impacts of a number of different ecosystem services. This may have implications for the political willingness to develop bundled ecosystem markets. In areas where agriculture and forestry are significant influences on ecosystems, this may be a driver for their development. In areas where they are not, then bundled ecosystem markets may not proliferate.

To help facilitate the development of bundled ecosystem markets there are a number of social, political, economic and bio-physical issues and questions that need further exploration, including:

a) Social—demonstrating there is a societal desire for policy and markets to more explicitly incorporate multiple ecosystem services into decision-making.
b) Political—sending clear messages there is the political will to establish bundled ecosystem markets.
c) Institutional—Identifying solutions to jurisdictional issues related to different ecosystem services.
d) Economic
    - Should disparate markets continue, identifying the most efficient mechanisms to link disparate markets so they mirror the potential benefits of bundled ecosystem markets, or ease the transition to bundled ecosystem markets.
    - Determining how to price commodities. In a bundled market, one action will produce one commodity (assuming some kind of aggregate commodity is created) with one price. However, in disparate (and perhaps associated markets) there will be different commodities sold into different markets with conceivably different prices—raising the

question about how the total cost of making a management or technology change is efficiently attributed to each market, and how a market participant can efficiently participate in more than one market simultaneously.

- Identifying the most efficient and equitable allocation of an environmental cap between the sources of degradation, given a combined metric cap or a series of caps for different ecosystem services.
- Determining the level of stringency and enforcement that will optimally promote participation and efficiency in a bundled ecosystem market.

e) Bio-physical

- Developing methodologies to quantify the effect of various management and technological options on different ecosystem services
- Establishing a metric, index or other relevant method to allow people to weigh the costs and benefits of potential actions on multiple ecosystem services.

While this is not a definitive or even exhaustive discussion of bundled ecosystem markets, and there is still much that needs to be done to assess the feasibility and facilitate the development of these markets, the interconnection between ecosystem services suggests bundled ecosystem markets are worth exploring further. Given this, policy makers, market administrators and the research community should rise to the challenges that bundling ecosystem services and the development of bundled ecosystem markets present, not shrink from them.

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