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Bundling of ecosystem services to increase forestland value and enhance sustainable forest management

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ABSTRACT

There has been increasing interest in the use of market-based approaches to add value for forestland and to assist with the conservation of natural resources. While markets for ecosystem services show potential for increasing forestland value, there is concern that the lack of an integrated program will simply add to the complexity of these services without generating significant public benefits. If not designed properly, these fragmented programs can result in the restoration of many small sites that lack ecological integrity and are unlikely to provide the benefits from protecting larger and more contiguous areas. An integrated approach that combines or bundles services and provides financial incentives for forest landowners may be more effective to achieving broad conservation goals, including enhancing fish and wildlife habitat, improving watershed health, sequestering carbon to mitigate climate change, and providing other ecosystem services at an ecologically relevant scale. We outline some of the policy and regulatory frameworks for some of the emerging markets for ecosystem services in the United States, and discuss the role that different regulatory agencies play for each of these services. We then assess the potential benefits for bundling different ecosystem services such as water quality, wetlands, species conservation, and carbon and describe an integrated accounting protocol for combining these services.

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1. Introduction

Worldwide, there is increasing interest for enhancing the conservation of clean water and air, healthy foods, and the services provided from functioning ecosystems (Costanza et al., 1997; Daily, 1997; MEA, 2005). In the United States (U.S.), the public is demanding greater environmental protection and conservation of natural resources from its public and private lands (e.g. Clean Water Act and Endangered Species Act, USFWS, 1988). These environmental concerns come at a time when forest lands are rapidly being lost to development and conversion to non forest use (Alig et al., 2003; Butler et al., 2004; Stein et al., 2005). In the 1990s the U.S. lost more than 1000 ha of forest each day, with more forest area being impacted by fragmentation (Alig, 2007). Adding to the conservation challenge, the majority of U.S. forests are privately owned, with about 70% of the forest land being owned by either industrial or nonindustrial private landowners (Smith et al., 2004). Private landowners want to be regarded as good land stewards but they are further challenged by additional regulations and the difficulty in meeting those regulations while providing both forest products and public goods such as fish and wildlife habitat, water resource protection and recreation (Kline et al., 2004; Pouta, 2005; Donnegan, 2007). Public lands in the U.S. also face a dilemma; these lands are no longer managed primarily for wood production and there is a strong need to quantify the value of some of the public goods and services provided from these lands (Kline, 2006; Boyd and Banzhaf, 2007; Collins and Larry, 2008). Emerging markets for ecosystem services present some new opportunities for forest landowners and managers. Besides the economic contributions of timber and other forest products, there is increasing recognition of the importance of ecosystem services and the values (public goods) these services provide (Costanza et al., 1997; Casey et al., 2006; Farley and Costanza, 2010). These emerging markets offer financial incentives for landowners to maintain and manage their forests rather than developing these lands. There is a compelling need to assess some of the different ecosystem services provided from forest lands and the potential role of market-based incentives to maintain these services.

The importance and value of ecosystem services are being recognized from local to global scales (Costanza et al., 1997; Daily, 1997; Kroeger and Casey, 2007; Farley and Costanza, 2010; LaRocco and Deal, 2011). The term "ecosystem services" was popularized by ecologists who recognized the value of natural processes and products, and their intrinsic importance to enhance human well being and ecosystem services were defined as the "biological underpinnings

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essential to economic prosperity and other aspects of our well being" (Daily, 1997). The internationally recognized Millenium Ecosystem Assessment further developed this concept (MEA, 2005) and economists reported the value of the world's ecosystem services to be in the range of US$ 16–54 trillion per year (Costanza et al., 1997). The Millenium Ecosystem Assessment (MEA, 2005) provided a simple definition of ecosystem services as "the benefits people obtain from ecosystems" and this typology highlights the wide-ranging importance and value of these services for both people and the environment. The MEA divided up these services into four categories including provisioning, regulating, supporting and cultural services (Table 1). Provisioning services are a familiar part of the economy that provides goods such as food, freshwater, timber and fiber for direct human use. Regulating services maintain a world in which it is possible for people to live, and provide benefits such as flood and disease control, water purification, climate stabilization and crop pollination. Supporting services are the underlying processes that maintain the conditions for life on Earth and include nutrient cycling, soil formation and primary production for our ecosystems. Cultural services make the world a place where people want to live and include recreational, spiritual, esthetic and cultural values. However, the MEA definition of ecosystem services is excessively broad and includes both supporting ecosystem functions, and goods and services for people. This broad typology creates problems for economists who wish to quantify values from ecosystem services (Boyd and Banzhaf, 2007; Kroeger and Casey, 2007; Farley and Costanza, 2010; Muradian et al., 2010). Boyd and Banzhaf (2007) developed a more quantifiable definition of ecosystem services that focused on final products or services to avoid the potential problem of double counting services. They defined ecosystem services as "components of nature, directly enjoyed, consumed or used to yield human well being." Many economists and ecologists have trouble agreeing on the appropriate typology or definition of ecosystem services (De Groot et al., 2002; Boyd and Banzhaf, 2007), however; the critical importance of ecosystem services is widely recognized.

Healthy, functioning ecosystems have an important role for mitigating pollution, maintaining biodiversity and improving overall global health. Forests play a major role in the global carbon cycle through the ability of trees to withdraw or sequester carbon, and forests serve as a terrestrial carbon sink during most stages of forest development. Forests also have high conservation value for a number of threatened and endangered species, for mitigating pollution, for flood control and for other ecosystem services. Direct government payments for ecosystem services and mitigation markets based on regulations are two common examples of financial incentives for the provision of ecosystem services, and market-based mechanisms for ecosystem services may have an important role to play in ecosystem protection (Kroeger and Casey, 2007; Muradian et al., 2010; Broughton and Pirard, 2011). These markets can generate financial resources by providing new revenue streams for landowners, and create incentives for investment by increasing the involvement of the private business sector in environmental management (Boyd, 2004; Heal et al., 2005). The concept of providing incentives, through market mechanisms, has helped stimulate interest in market-based programs for ecosystem services. Although other public policies such as regulations and zoning, tax credits, conservation easements and other incentive payments have important policy roles for ecosystem protection, the recent emergence of market-based incentives for carbon, water, wetlands and biodiversity has enlisted a broad suite of new stakeholders. Ecosystem services when considered as "natural capital" leads land owners and managers to regard landscapes as natural assets that requires accounting for different ecosystem services and ensuring the people who rely on these services know their value and the cost of losing them (Kline, 2006; Collins and Larry, 2008).

Markets for ecosystem services are increasingly recognized as having an important role to play in ecosystem protection. Combining or "bundling" of ecosystem services may also provide a more administratively efficient process for integrating different ecosystem services (water, wetlands and endangered species for example) that are managed by different regulatory agencies (Chan et al., 2006; LaRocco and Deal, 2011). However, reducing transaction costs and streamlining the regulatory and policy constraints of these emerging markets is critical to develop functioning markets for these services (Chan et al., 2006; Kline et al., 2009). These new financial incentives expand opportunities for forest landowners to gain revenue from their lands while also providing public goods to society. The objectives of this paper include: 1) describe the policy and regulatory frameworks of emerging markets for ecosystem services in the U.S. and assess the role of market incentives for maintaining these services, 2) evaluate the potential benefits of bundling ecosystem services and/or stacking credits as an incentive to keep forestlands in forests, 3) describe a case study in Oregon using an accounting protocol to integrate different services into a multi-ecosystem service marketplace. Lastly, we will evaluate some of the opportunities and challenges related to bundling of ecosystem services and their potential to enhance sustainable forest management and help maintain a broad suite of ecosystem benefits.

Table 1
Typology of ecosystem services provided by nature. Modified from the Millenium Ecosystem Assessment (MEA, 2005).

Ecosystem services	
	Provisioning Services
	Food (crops, livestock, wild foods, etc....)
	Fiber (timber, cotton/hemp/silk, wood fuel)
	Genetic resources
	Biochemicals, natural medicines, pharmaceuticals
	Fresh water
Supporting Service	**Regulating Services**
Nutrient cycling	Air quality regulation
Soil formation	Climate regulation (global, regional, and local)
Primary production	Water regulation
	Erosion regulation
	Water purification and waste treatment
	Disease regulation
	Pest regulation
	Pollination
	Natural hazard regulation
Cultural Services	**Cultural Services**
	Esthetic values
	Spiritual and religious values
	Recreation and ecotourism

2. Markets for ecosystem services

Land use policy and regulations have an important role for establishing markets for ecosystem services, and market-based programs have developed in response to regulations for wetlands, water, and endangered species. Examples of regulation-driven markets for ecosystem services include wetland mitigation banking and water quality trading (Gaddie and Regens, 2000; Brauman et al., 2007) authorized under the Clean Water Act (33 U.S.C. 1344), and species conservation banking (USFWS, 1988; Carroll et al., 2007) implemented under the Endangered Species Act (33 U.S.C. 1344). Cap-and-trade programs are also being successfully applied in several important U.S. programs to reduce pollution, including the effort to control acid rain by limiting SO_2 emissions (Stavins, 1998, 2005). For example, fossil fuel electric power plants are issued permits by the U.S. Environmental Protection Agency for a certain amount of SO_2 emissions. However, these different ecosystem services are regulated and controlled by several different federal and state agencies with their own sets of policies and regulatory frameworks. For instance, at the national level, air and water quality is regulated by the Environmental Protection Agency (EPA), wetlands are regulated by the Army Corps of Engineers (USACE) and species conservation is controlled by the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). Similar regulatory controls exist at the state level (e.g. in Oregon, different state agencies regulate land, water, soil and native flora and fauna). In Oregon, to address conflicting regulations, a state policy bill regarding ecosystem services was introduced in 2011 (Oregon House Bill 3109) to integrate many of these services and to empower ecosystem services markets but the Oregon legislature did not vote on bill. Increased agency coordination could help landowners to participate in more than one payment program, while potentially reducing transaction costs and addressing multiple services in a landscape context. Several markets for ecosystem services are emerging in the U.S. with new revenue streams for forest landowners. These new markets offer potential financial incentives to landowners to maintain and manage forestlands rather than converting these forests to other uses. To provide an understanding of policy and regulatory frameworks, brief overviews of U.S. wetland and species mitigation banking, water quality trading, and carbon credits are outlined here.

2.1. Wetland mitigation and species conservation banking

The most mature market for ecosystem services in the U.S. is wetland mitigation banking and wetlands are regulated by the USACE and a number of different state regulatory agencies. These markets are based on a statutory mandate that requires developers to obtain a permit to offset any loss of wetland or habitat before they are allowed to harm a wetland or an endangered species. Implementing regulations require the developer to avoid and minimize any impacts, and when necessary, mitigate for these impacts. Compensatory mitigation options typically include an in-lieu fee payment to the state, permittee-responsible restoration, or credit purchases from a wetland mitigation bank. Wetland mitigation banking has developed into a well-established, market-based system where buyers and sellers of credits conduct transactions through wetland banks. As of January, 2010, more than 950 wetland and stream mitigation banks were operating in the US that included about 384,000 ha of restored habitat (NMBA, 2010) and prices ranging from $1200 to $240,000/ha (Ecosystem Marketplace, 2011). Wetland ecosystems provide a broad range of ecological services and studies have shown the importance of services provided by wetlands including improving water quality and quantity, increasing the quality of recreation and wildlife habitat, controlling floods and intercepting pollution (Azevedo et al., 2000; Hoehn et al., 2001). However, on-site wetland mitigation has been largely unsuccessful for restoring original wetland functions but larger off-site wetland banks are now recognized for their broader functionality and production of multiple ecosystem services (Gaddie and Regens, 2000; Willamette Partnership, 2009a).

Species conservation banking, the creation and trading of credits that represent wildlife conservation values on private lands, is more than a decade old, and conservation banking is regulated by the USFWS, NMFS and a variety of different state regulatory agencies.

A conservation bank is a parcel of protected natural land that is authorized to sell a set number of credits, usually in the form of land area of habitat, to the customer that is required to mitigate their impact to the same species and habitat on nearby land. Private landowners reported that financial motives were behind most of their interest in conservation banking but bureaucracy was the biggest challenge with the average time for establishing banks more than 2 years and varied from 8 months to over 6 years (Fox and Nino-murcia, 2005). The state of California, which is notorious for complex regulations, has developed most of the conservation banking agreements in the U.S. but the fact that banks are profitable is an indication that conservation banking offers viable incentives to protect species on private land (Fox and Nino-murcia, 2005).

2.2. Water quality trading

Ecosystem services for water include water supply, water damage mitigation, and water-related cultural services (Brauman et al., 2007). Water quality trading is regulated by the EPA and a number of state regulatory agencies and markets for water quality credits are established from a regulatory structure that producers or developers must follow in order to acquire permits for their operations. Market-based schemes for improving water quality are generally limited to local or regional programs within a specific watershed. Water quality trading provides a market-based process for polluters to pay for the reduction of pollutant levels to achieve targets for a watershed. When conservation and protection efforts are employed by landowners, additional benefits to the watershed include flood and erosion control, habitat retention and wetland restoration. Water quality trading programs must include key components that define the types of pollutants that can be traded, who can trade, when trades can occur and standards for enforcement, verification and liability (Boyd, 2000). Water quality trading involves discharges of point source pollution; these dischargers would be the buyers of credits. Dischargers buy credits from sellers, who can be either point sources or non-point sources of pollution or providers of improved habitat to mitigate pollution. In 2010, there were 72 water quality trading programs in the world with the majority (66) in the US (Stanton et al., 2010). However, of these programs, only 27 had completed a market design and were ready to support transactions and only 14 programs had actually seen a trade (Stanton et al., 2010). One of the primary benefits of water quality trading to the buyer is that it lowers the transaction costs of permit requirements. Forest landowners and farmers can be included as sellers of water quality credits in many programs. Other participants include water quality permitting authorities, third-party brokers, conservation organizations, watershed councils and private industry groups. Local examples of water quality trading include the EPA watershed-based permit for the Tualatin River in Oregon that allows trading to achieve the permit requirement for temperature (Cochran and Loque, 2011). Here, instead of installing refrigeration systems at two Tualatin River treatment plants (at a cost of $60 million), the wastewater utility paid upstream farmers to plant shade trees in the riparian areas (at a cost of $6 million). The total maximum daily load (TMDL) for water temperature reduction is closely monitored by the EPA and Oregon Department of Environmental Quality (ODEQ) and although future temperature reduction and temperature credits will depend on shade from riparian trees, the temperature credit calculation is based on the robust Shade-a-lator model developed in Oregon (Lambrinos, 2010; ODEQ, 2010).

2.3. Carbon markets in the U.S

The United States is not a signatory of the Kyoto Protocol (UNFCCC, 2007) and the U.S. does not have a comprehensive national policy mandating limits in CO_2 emissions. Instead, the U.S. has voluntary, or state and region-based programs to reduce greenhouse gas emissions. Since about 20% of human-induced carbon dioxide emissions are due to land-use change and deforestation (FAO, 2005), sustainable forest management can play an important role in climate change mitigation. Forestry offsets also provide a range of environmental benefits, such as wildlife habitat and water quality improvement. Due to the absence of a comprehensive greenhouse gas (GHG) regulatory emissions reduction standards, such as national cap-and-trade legislation, voluntary carbon markets have dominated in the U.S. and state and region-based programs are being developed to reduce greenhouse gas emissions. Regional programs include the

Regional Greenhouse Gas Initiative (RGGI) in the Northeast U.S. (RGGI, 2007), the Western Climate Initiative (WCI) in the Western U.S. (Capoor and Ambrosi, 2008) and the Climate Action Registry (CAR, 2010). However, due to different regulatory frameworks being developed in each region and state, there is a need to develop national standards to help develop the registration and trading of carbon offset projects (Sampson, 2004). Ruddell et al. (2007) further suggested that in the absence of such national standards, forestry offset projects will continue to be limited and inconsistent.

The voluntary U.S. carbon market is small compared with the global carbon market estimated in 2009 at about $130 billion ($US). However, the U.S. voluntary carbon market increased by 200% in 2007 with 13% of the carbon trading including carbon sequestration or forestry credits (Forestry Source, 2007). By comparison, no forestry credits are accepted under the European Union Emission Trading System (EU ETS) and less than 1% of total transactions of 475 million tons made under the Kyoto Protocol's Clean Development Mechanism involved forestry-based credits (UNFCCC, 2007). A regulated cap-and-trade mechanism would provide higher prices than current carbon values and the allowance of forest carbon offsets could provide a huge incentive for forestry. However, it is important that these forestry offsets provide high-quality carbon sequestration credits in order to assure early investors in the carbon market that these carbon offsets are credible and provide true reductions in GHG emissions.

To address GHG policy, the forestry community has a significant opportunity to shape what kinds of forest projects are included. Lawmakers in the U.S. have approved some legislation including the 2008 Farm Bill, and 2009 American Clean Energy and Security Act but other legislation that would have included forestry offsets as part of overarching climate change legislation (2010 Waxman–Markey Bill) died in Congress without a vote. Three key components for any forestry offset projects include keeping forestland in forests, reforestation including restoration of forest landscapes, and increasing carbon sequestration through improved forest management (Canadell and Raupach, 2008). One new opportunity for earning forestry carbon credits is included in the revised forestry project protocols developed in the Climate Action Registry (CAR, 2010). CAR has forestry protocols that can earn carbon credits for improved forest management practices and avoided conversion to keep forestlands from being lost to development. However, many landowners are reluctant to join CAR due to the 100 year requirement of projects (CAR, 2010). In summary, there are also a number of important policy issues to incorporate in forestry offsets including clear definitions for carbon baselines and additionality, permanence and leakage, possible inclusion of wood products for the long-term storage of carbon, and projects that promote additional carbon sequestration and discourage conversion of forests to other land uses (Cathcart, 2000; Ruddell et al., 2007).

3. Bundling or stacking payments for ecosystem services

Each of the previously discussed markets for wetland mitigation, species conservation banking, water quality trading, and carbon credits has the potential for providing additional revenue for landowners while also providing public goods to society. However, the current markets for these services are operated as separate programs, each with their own set of specific regulations. This often leads to management of one resource without any attempt to include other ecosystem services into a broader, more integrated ecosystem framework. This fragmented approach can lead to competition among services with little consideration of the other potential benefits that could be provided by integration of the full suite of ecosystem services. Failing to recognize the interconnectedness among ecosystem services on a landscape can lead to their degradation, and emphasis on one ecosystem service could undermine the provision of another (Salzman and Ruhl, 2000). One management option is to combine these services into a single credit type to create a "bundle" of services. Another option is to stack multiple ecosystem credits and sell these credits into specific regulatory markets. The concepts of bundling and stacking ecosystem services payments can promote the integration of multiple ecological values and greater ecological benefits than a single-program or market approach (Chan et al., 2006; Farley and Costanza, 2010; LaRocco and Deal, 2011; Venter et al., 2009).

"Bundling" ecosystem services refers to merging multiple values from a piece of property under a single credit type. For example, if a landowner restores an area of riparian forest, it results in improvements to more than one ecosystem service, including reducing stream temperature, improving wildlife habitat, sequestering carbon and mitigating potential floods (Larocco and Deal, 2011). Bundling allows these services to be sold under a single credit type—e.g. an ecosystem credit—and market rules will ultimately determine whether or not a bundled credit can be sold into a regulatory market. Bundling might provide a way for landowners to get paid for the broader benefits they are providing, while also giving buyers flexibility in meeting regulatory needs or voluntary investments. However, bundling of services under a single credit type may require buyers to purchase services that they do not want (Chan et al., 2006; Kroeger and Casey, 2007) and it is important to be able to "unbundle" services from a broader suite of services to meet regulatory requirements for a specific service. Ideally, an integrative accounting system would "bundle" ecosystem services at a landscape scale and accommodate current jurisdictional limitations by separating out regulated credits and "stacking" them alongside other parts of the bundled services.

"Stacking" is a concept closely related to bundling. Stacking allows credits to be generated from a single hectare using multiple market-based strategies. Credits are sold separately into each market and for each credit type, the applicable market rules will apply. For example, if a landowner restores a single hectare of riparian forest, it could produce water quality credits, carbon credits, riparian habitat credits, and conservation banking credits that the landowner could sell into each respective market. Whereas a bundled credit is a bunch of services grouped together from the same area under a single credit type, stacked credits are generated from the same area, but accounted for and sold separately into each market structure. Bundling or stacking of payments for ecosystem services could both increase forestland value and encourage managers and landowners to consider their land as natural assets that provide a suite of different ecosystem services (Collins and Larry, 2008; Farley and Costanza, 2010; LaRocco and Deal, 2011).

3.1. Willamette Partnership example: counting on the environment

In September 2009, a group of 25 federal, state, and local government agencies, conservation groups, landowners, buyers, and sellers of ecosystem services signed a Joint Statement (Willamette Partnership, 2009a) agreeing to pilot the Counting on The Environment (COTE) standards for trading in multiple types of ecosystem services in the Willamette Basin, Oregon over the next two years. The Willamette River Basin encompasses 29,727 km^2 between the Cascades and Coast Range mountains in western Oregon with two thirds of the basin in forested uplands, and agricultural land and 68% of Oregon's population in the lowlands (Baker et al., 2004). The COTE process recognized that landowners doing restoration and conservation created a broad suite of environmental benefits from their actions, benefits that were not well recognized by existing regulatory frameworks or narrowly-defined ecosystem services markets. These stakeholders, facilitated by the Willamette Partnership (a nonprofit coalition of business, environmental, agricultural leaders), wanted to provide direct incentives to landowners to restore whole ecosystems, not just pieces or individual services of these ecosystems.

The COTE protocols and standards attempt to restore ecosystems using an integrated process for landowner involvement. First, landowners can get four different ecosystem services credits for wetland, salmonid, upland prairie, or water quality benefits they provide from their actions. Each of these credit types is tied to a separate regulatory driver of demand (some are described in previous ecosystem services markets section). The Willamette Partnership hypothesized that if landowners are given the choice of getting multiple credits for broader restoration, they will generally pursue those credits as opposed to maximizing land use for one credit type (e.g. carbon or water quality) (Willamette Partnership, 2009b). Anecdotally, experience from early markets like Clean Water Services' temperature management plan in the Tualatin River hinted that restoration opportunity was limited when only one credit type was being considered (Guillozet, personal communication, 2008). Clean Water Services, the local wastewater utility, has a business reason to invest in riparian forest restoration to shade streams, as these temperature credits created by riparian shade can be used to offset its clean but warm water discharges further downstream. Yet, they found that if a landowner was interested in forest restoration along streambanks, they were also willing to do instream restoration (e.g. place large wood, stabilize streambanks, and other actions beneficial for salmon). The marginal cost of this additional work was minimal compared to the costs of securing land rights and mobilizing restoration crews, yet quantifying and providing additional credits for buyers and sellers was not possible under the current program. The COTE standards provide the opportunity for groups like Clean Water Services, the Freshwater Trust, and landowners to capture those additional benefits and turn them into assets (Willamette Partnership, 2009b; Freshwater Trust, 2011).

Second, the standards include eligibility requirements that demand high quality restoration for multiple benefits. If landowners want water quality credits from planting trees, they need to plant a diversity of native species. The use of a variety of native species ideal for riparian zones safeguards against the potential of things like planting hybrid poplars along streams, these are great for shade, but not very useful for salmon or many other ecosystem services. Third, the credit metrics themselves capture a broad suite of ecosystem services, so landowners get more credit for providing high quality restoration in defined priority areas. Fourth, when issuing multiple credits from the same plot of land, a clear policy was established on stacking of credits. The COTE stakeholders group considered three options for landowners: 1) the landowner was asked to choose which credit type they would like to sell at the beginning of the project, 2) landowners were allowed to sell all the credits accruing from a single action like planting riparian forest, or 3) landowners were allowed to choose which credits would provide the most revenue after restoration was complete. Stakeholders generally selected option three. To facilitate this process, a project is divided into common landcover areas, called accounting areas, and credits are allocated to those areas. Within each accounting area, as a landowner sells something like 50% of the associated wetland credits, their ledger for the other credits is reduced by 50%. In this way, more than one credit can be sold from the same project area, but not from the same action, preventing "double dipping" or double counting of credits for the same action. The COTE stakeholders discussed and debated this double dipping issue extensively and compromised by maximizing choices for landowners in a way that is transparent and acceptable to regulatory agencies governing these ecosystem services markets.

The COTE standards and protocols were designed in a way that could be easily applied to new ecosystem credit types in Oregon and other locations. For example, in the next two years, nutrient, instream flow, and other habitat credits will be added to the portfolio of credit types available in Oregon. Watersheds in the states of Oregon and Washington are actively applying the COTE standards to jump-start markets in their areas. Exploration is also occurring on applying the performance tracking elements of COTE to communicate the outcomes of grant programs or aid in public land management decisions. However, there are limits in what the COTE standards and protocols can accomplish. COTE still trades in individual ecosystem services credits, rather than bundling them together, limiting the ability to articulate trade-offs between ecosystem services. The framework is an initial step to combine multiple ecosystem services credits but there remains a need to truly integrate these credits or bundle these services to optimize ecosystem uplift.

4. Discussion

4.1. Markets and incentive programs for sustainable forest management

The Millennium Ecosystem Assessment recently evaluated the state of the world's ecosystems and the study found that about 60% of all ecosystems are rapidly degrading or are used unsustainably (MEA, 2005), and strategies are being discussed at local to global scales about how to better conserve our natural resources (Daily, 1997; Boyd, 2004; Heal et al., 2005; Oliver and Deal, 2007). There is increased interest in exploring market-based approaches to conserving ecosystem services. Market mechanisms can be used to provide incentives to private forest landowners to enhance provision of ecosystem services, often with the associated objective of providing a counterbalance to financial incentives to convert forests to other land uses (Kline, 2006; Casey et al., 2006; LaRocco and Deal, 2011). These market-based mechanisms include both government payment programs and mitigation markets, and other policy instruments including a number of regulatory and incentive programs to conserve natural resources (Casey et al., 2006; Farley and Costanza, 2010; Muradian et al., 2010) Markets for ecosystem services are increasingly recognized as having an important role to play in ecosystem protection; however, market-based incentives are but one of several public policies that could be used to maintain ecosystem services and enhance sustainable forest management. Bengston et al. (2004) summarized some of the important policy instruments for protecting open space (and associated ecosystem services) and these polices include public acquisition of land, regulatory approaches and incentive-based approaches. Examples of public acquisition include public ownership of parks, forests and wildlife refuges. Regulatory approaches include zoning laws and setting urban growth boundaries, as well as mitigation banking programs. Incentive-based options include transfer and purchase of development rights, and tax benefits associated with conservation easements (Bengston et al., 2004; Beuter and Alig, 2004).

Market-based approaches such as mitigation markets, or direct government payments, along with incentive based options and regulatory approaches all have important roles for conserving natural resources and providing for a variety of social benefits associated with forest land including scenery, wildlife habitat and water resource protection (Kline et al., 2004; Farley and Costanza, 2010). In regulated markets, demand is determined by government imposed caps and restrictions and unless designed carefully there can be little interest for private firms or industries to provide public goods beyond what is required (Kroeger and Casey, 2007). One of the challenges for implementation of market-based programs has been to define the appropriate role of governmental regulations and coordination of regulatory agencies. Many of the different ecosystem services in the U.S. are regulated and controlled by different federal agencies with their own sets of policies and regulatory frameworks. Economists have consistently advocated the use of market-based programs, principally, pollution taxes and tradable permit systems, rather than command-and-control instruments, such as design standards and uniform performance standards (Pierce, 2004; Muradian et al., 2010). At least in theory, market-based programs have the advantage of being cost-effective, that is, they can minimize transaction costs for industry and hence for consumers of achieving some given environmental target (Kroeger and Casey, 2007; Vatn, 2009). Before markets can function efficiently, there are numerous market issues that need to be addressed including the roles of multiple jurisdictions and regulators, linking the accessibility and transaction costs with transparent and credible transactions, and markets based on sound science and biological integrity (Randall, 1987; Gottfried et al., 1996; Costanza et al., 1997; Salzman and Ruhl, 2000; Heal et al., 2005). However, for many business leaders, there has been a shift from thinking about conservation as a burden or endangered species as a liability to the concept of restoration and stewardship of ecosystem services as a profit making enterprise and market-based approaches to conservation are now considered as an integral part of many businesses plans (Heal et al., 2005; Collins and Larry, 2008; Farley and Costanza, 2010; Park and Pavlosky, 2010).

4.2. Benefits of bundling ecosystem services

There are several potential benefits involved with combining or bundling ecosystem services. Most ecosystem services are produced as joint products or bundles of services from intact ecosystems. Bundling ecosystem services offers the potential for reducing the high transaction costs of establishing individual markets for carbon, water, wetlands and species conservation. Bundling may also reduce trade-offs that would occur across ecosystem services, promoting synergies at the same time. There is potential to reap additional dividends if conservation of one ecosystem service leads to the conservation of other services including biodiversity (Venter et al., 2009). However, for efficient decision making, managers must account for the full bundle of ecosystem attributes that are affected by any management action (Armsworth and Roughgarden, 2001; Vatn, 2009; Muradian et al., 2010). Some of these benefits of bundling include consolidating regulatory requirements, providing deeper markets that are more economically viable, and connecting broader markets for wetlands, water quality and quantity, carbon and species conservation. Other important considerations for bundling include demonstrating additionality and avoiding double-counting of credits when bundling several services together such as combining credits for wetlands, habitat and carbon (Cathcart, 2000; Boyd and Banzhaf, 2007). A multi-resource market would also provide a greater suite of environmental benefits and a broader, more ecologically effective strategy than would be possible by management of any one service.

The terms "bundling of services" and "stacking of credits" are often used interchangeably and there is confusion about how best to combine different types of services. Regulated services with clearly defined obligatory requirements and credits based on regulations are different than public goods or services. One approach to combining or bundling services would be to separate these types of services into one group of markets with stacked credits, and another group of broadly bundled services. For instance, one group would combine services that require buyer and seller verification of credits to meet regulatory requirements and this group might be best suited to a stacking of credits approach. Examples would include regulatory markets for wetlands, endangered species and water quality trading that are based on clear regulatory requirements (King and Kuch, 2003; Kroeger and Casey, 2007; Vatn, 2009). However, there are many other services that could bundled together for biodiversity, habitat and other services, many of which do not have existing markets (Heal et al., 2005; Collins and Larry, 2008; Venter et al., 2009). This set of bundled services includes a wide variety of critical services and this group of bundled services could provide greater ecosystem uplift than is possible with just individual services with current market structures (Vatn, 2009; LaRocco and Deal, 2011). The best example might be conservation easements that limit landowners from developing property and have certain long-term restrictions on the property. Many of these conservation easements are based on property value if land were to be developed, and in some cases this value can be substantial (Sauer, 2002). The concepts of bundling and stacking ecosystem services payments can promote the integration of multiple ecological values and greater ecological benefits than a single-program or market approach (Collins and Larry, 2008; Venter et al., 2009; LaRocco and Deal, 2011).

There are several groups and organizations in the U.S. that are interested in developing an ecosystem marketplace that could buy and trade different ecosystem services (Katoomba, 2007; Willamette Partnership, 2009a; Bay Bank, 2010). A multi-credit marketplace is different than individual markets that focus on specific environmental values. This marketplace could help a single large landowner or a group of landowners sell wetland, endangered species, water quality and carbon credits from the same piece of land. For example, in Oregon, the Willamette Partnership received a NRCS Conservation Innovation Grant to develop a multi-credit accounting tool to measure and account for multiple types of ecosystem service credits for use within the Willamette Ecosystem marketplace (Willamette Partnership, 2009b). This multi-credit marketplace would be able to take advantage of efforts to combine different ecosystem services. Landowners were given the choice of getting multiple credits for broader restoration, and they generally pursued this multiple credit approach as opposed to maximizing land use for one credit type at the possible expense of other ecosystem services. However, it is critical to avoid "double dipping" or double counting of credits for the same action. The Willamette COTE project addressed this issue by dividing projects into common landcover areas and credits were allocated by credit type within these areas. Regardless of whether credits are stacked or services are bundled into an integrated ecosystem service credit the development of a multi ecosystem service marketplace has great potential of increasing revenue sources for landowners and providing a broader suite of services into the marketplace. These markets offer financial incentives for landowners to maintain rather than develop their lands, and these emerging markets highlight the potential use of market-based incentives to maintain a broad suite of ecosystem services. Ecosystem services have provided a new framework for a diverse coalition of conservationists, forest landowners and other stakeholders to work together to develop strategies for conserving ecosystem services. These new financial incentives expand opportunities for landowners to gain revenue from their lands while also providing public goods and services to society.

5. Conclusions

Ecosystem services provide provisioning, supporting, and regulating services that maintain the conditions of life on Earth and provide natural assets that are intrinsic components of our economy. There is increasing interest in the use of market-based approaches to add value for these services and assist conservation of natural resources. The interest in markets for ecosystem services markets shows potential for increasing forest value, but there is risk that the lack of a coordinated, integrated approach will simply add to the complexity and cost of these services without generating significant public benefits. The current market approach is to develop separate programs, each with its own set of regulations, for each ecosystem service. These fragmented programs often result in the restoration of many small sites that lack ecological integrity and are unlikely to provide the benefits from larger more contiguous areas. An integrated approach that combines or bundles services and provides financial incentives for forest landowners may be more effective to achieving broad conservation goals, including enhancing fish and wildlife habitat, improving watershed health, sequestering carbon to mitigate climate change, and providing other ecosystem services at an ecologically relevant scale.

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