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Applied ecosystem services in working forests: A direct market valuation

Darin Stuart Hale

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To the Graduate Council:

I am submitting herewith a thesis written by Darin Stuart Hale entitled "Applied ecosystem services in working forests: A direct market valuation." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Forestry.

Donald G. Hodges, Major Professor

We have read this thesis and recommend its acceptance:

Christopher D. Clark, Donald G. Hodges, David M. Ostermeier

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Applied ecosystem services in working forests:
A direct market valuation

A Thesis Presented for the

Master of Science Degree

University of Tennessee—Knoxville

Darin Stuart Hale

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Abstract

Ecosystem services, or the benefits humans obtain from natural ecosystems, have long been recognized as critical to human health. A number of scientists and managers have estimated the non-market values of these services but few have offered a direct market valuation. Increasing awareness, scarcity, and regulation have fostered transactions, and markets are emerging that can allow for direct valuation and could provide landowners the opportunity to merchandize this natural capital. This paper provides a valuation and comparison, as a case study of a traditional management scheme, including the marketing of fiber and recreational leases, and an ecosystem services management scheme including the marketing of fiber, recreational leases, carbon sequestration, watershed services, and biodiversity. The traditional forest management scheme provided an estimated present value at three pricing scenarios ranging from "pessimistic" at $538,714.63 to "optimistic" at $868,528.27 for the 3,976-acre project area. The ecosystem services management scheme produced an estimated present value at three pricing scenarios ranging from "pessimistic" at $621,508.61 to "optimistic" at $1,363,628.13 for the same project area. As a result, an ecosystem services management scheme, even in these early stages of ecosystem markets, may offer more revenue to landowners than a traditional management scheme.

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Introduction

The concept of human welfare depending on environmental health has long been apparent in human thought and existence. From the earliest examples of humans being totally dependent upon their resources at hand for survival to more recent and nuanced benefits and services such as clean air and water, the importance of these products has been recognized. In modern times, this collection of services provided to humans has taken the name of "ecosystem services". A specific definition for ecosystem services has been thoroughly debated, though most have made the critical point of humans obtain benefits from ecosystems. The Millennium Ecosystem Assessment defined ecosystem services as, "the benefits people obtain from ecosystems" (MEA 2005) providing a clear, concise definition that has gained acceptance.

Classical economic theory recognizes human, financial, manufactured, and natural as the four types of capital (Chee 2004). In the case of ecosystem services, current developed economies are trying to transform natural capital into consumer products and services (Hawken et al. 1999). Proponents believe recognizing and valuing natural capital can be useful in assessing management policies, improving ecological understanding, demonstrating the distribution of benefits, and promoting ecosystem management (Armsworth and Roughgarden 2001, Alyward and Barbier 1992, Dasgupta et al. 2000). Given that economics is based on the efficient allocation of scarce resources to satisfy human needs and desires (Tisdell 1991, Tietenberg 1992, Freeman 1993), and ecosystem services are natural capital that provides those needs and services, economic and market principles can be applied to managing natural capital on the part of landowners, or those who possess the rights to that capital.

This project is a case study of an ecosystem services management scheme and its potential values within the current and emerging ecosystem markets that compares these estimated values with those of more traditional forest management practices. The project area is a watershed in southwest Virginia in the southern Appalachian Mountains, on the Cumberland Plateau. This unique area with many valuable ecological qualities, currently under private ownership and management, is representative of much of the forestlands of the region. A current market valuation of a hypothetical, but realistic, ecosystem services management scheme was conducted and then compared to benefits generated from a traditional forest management scheme similar to the current practices. The intent was to provide an economic reference for comparing the different management strategies as well as to demonstrate one management method that could affect the economic framework of management for various landowners. This project calculates a present value of goods (Gilpin 2000) in ecosystem markets, through direct comparison in the real and current economic environment, and may provide insight into values, as they exist.

The specific goals and objectives of this project are to:

- Identify, map, and quantify areas as traditionally managed for timber and recreation on specific project area;
- Identify ecosystem services markets and approximate values of specific services as reflected through current prices;

- Identify, map, and quantify areas suitable for ecosystem services management on specific project area, as a case study, and determine number of units hypothetically available for market under a ecosystem services management scheme;
- Calculate the value of an ecosystem services management scheme and compare to a traditional management scheme values; and
- Estimate the potential for additional revenues generated by including specific ecosystem services management into the portfolio.

History of Ecosystem Services

The first references to ecosystem services in Western culture are generally attributed to Plato, who noticed losses in soil fertility resulting from human actions. He was quoted in Hittel (1992) as stating, “What now remains of the formerly rich land is like the skeleton of a sick man with all the fat and soft earth having wasted away and only the bare framework remaining…” This idea was carried to more modern times by Marsh (1864) who made similar observances stating: “Earth, water, the ducts and fluids of vegetation and animal life, the very air we breathe, are peopled by minute organisms which perform most important functions in both the living and inanimate kingdoms of nature.” Shortly thereafter, Aldo Leopold, Gifford Pinchot, and other Progressive Era conservationists began to speak and write of humans not as a conqueror of nature but more a citizen and steward of the natural world (e.g. Leopold 1949). This recognition of human dependence on natural ecosystems was promoted and adopted as a concept and along with it came the desire to account for and manage the benefits.

Building on this recognition of human dependence and essential values, efforts began modernize the idea of valuing these ecological processes and the benefits they provide to humans in economic terms began in the latter part of the last century (e.g., King 1966, Helliwell 1969, Odum and Odum 1972) and more recently (De Groot 1992, Pearce 1993, Farber 2002). This process, as explained by Daily (1997), was reinitiated most recently with a group gathered at an annual meeting for the Pew Fellows in Conservation in which the conversation began to "lament the near total lack of public appreciation of societal dependence upon natural ecosystems." Some contended that this was a failure of the scientific community, as it had not fulfilled its role to "generate, synthesize, and effectively convey the necessary information to the public" (Ruhl, Salzman 2007). This informal meeting resulted in concerted efforts by these scientists to define the current understanding of the suite of natural services providing benefits to humans and began the work to provide a preliminary assessment of their value. The effort to define and unify the knowledge of these services produced Daily's pivotal work, *Nature's Services* (1997).

As a product of these discussions, Constanza et al. (1997) developed the first effort to provide an overall value of the earth's ecosystems. It was in this paper, through examining a range of ecosystem services, that the global value of ecosystem services was first estimated between $16-54 trillion per year. This estimate demonstrated the importance of ecosystems, as the numbers were approximately equal to or greater than the summed gross national products (GNP) of the world. Although, many analysts (e.g. Pearce 1998) challenged the methods and conclusions of this paper, others supported the work, and these estimates have endured as a basis for the global natural values.

All these labors were exemplified with a market example of how the services provided by nature could have real economic impacts from a paper by Chichilnisky and Heal (1998) on the purchase of watershed rights by New York City in the early 1990s. New York City was assessing its needs for providing a clean and suitable water source for its residents and was facing major facility upgrades or some other method of pre-treatment that would allow its current systems to be maintained and brought into regulatory compliance. Building the new facilities would cost an estimated $6-8 billion, but investing in a variety of watershed protection programs upstream could provide similar results for approximately $1.5 billion (Daily and Ellison 2004). New York chose the watershed protection efforts and provided one of the early and central *payments for ecosystem services* (PES) examples in the US. It was the combination of these works, along with the example of New York City and the various payment and accounting methods developing all over the world, that elevated the concepts of PES so that the inherent values of ecosystem services were increasingly recognized. These ideas now were firmly planted in the minds of managers, administrators, policy-makers, and citizens worldwide and the concepts of assets and natural capital changed to accept them.

Current State of Ecosystem Markets

Due to the recognition of inherent values of healthy ecosystems, and the ability to enhance or improve ecosystem functions and their consequent values to humans, efforts have been made, both privately and publically, to foster programs that do such. While some of these programs have resulted from regulatory actions (as Salzman 2006 and Ruhl 2005 argue is necessary), others have relied on natural market forces. Marketing and valuing ecosystem services have presented a challenge as many qualify as public goods, in that they are non-rival and non-exclusive (Eatwell et al. 1987, Ruhl and Salzman 2007). This means that even though ecosystems on private lands produce benefits, the landowners, as producers, are not able to collect revenues equivalent to the aggregate values of the goods because the public, as consumers, can obtain these products without directly paying for them. This can lead to private owners failing or under providing the goods. It is the public/private nature of ecosystem services and their externalities that hinder their acceptance and valuation as economic goods. Though the values of ecosystem services have been recognized, it is that the benefits are already in the public good, non-exclusive to the owner, and that actions taken with these services may affect others, that have made the creation or success of markets so challenging yet important.

Other issues with marketing ecosystem services, as stated by Chee (2004) in summarizing Sternberg (1996) are, “they tend to have no producer property rights, ambiguous entitlement structures and prohibitive transaction costs”. For example, in many cases, the functions provided by ecosystems are carried out at a scale encompassing many property rights owners. This could be as simple as a stream running across various landowners or conflicts between rights owners such as those with surface rights and those with mineral rights. Often these complex ownership structures require significant preliminary research that can lead to high administrative costs voiding any benefits.

Markets for ecosystem services exist with varying success and problems all over the world. Land and asset managers have worked to define, create, and promote markets of different types. In the United States, robust markets have developed because of regulatory actions such as the Clean Water Act (CWA) that requires mitigation to support its goal of "no net loss" of wetlands and the Endangered Species Act (ESA) that requires mitigation for impacts to listed species. Recent revisions and current enforcement of the CWA and the ESA have allowed markets and private 'banks' to develop, encouraging mitigation efforts. Conversely, voluntary markets, such as over-the-counter (OTC) carbon, have wavered, driven mostly by consumer demand (Cox and Searle 2009). The Conservation Reserve Program (CRP) has experienced great success by providing support and subsidies to farmers for practicing proper conservation methods. This combination of regulatory markets, such as the CWA mitigation, and voluntary markets, such as OTC carbon, represents the current options in the US for marketing ecosystem services.

Another great challenge is bringing these emerging markets to a self-sustaining scale for the realization of capital development and institutional engagement. In order for institutional or other large investors to be willing to invest in ecosystem markets, a stable and transparent exchange must be available at a scale large enough to lower transaction costs (Salzman 2006). As stated previously, regulatory actions have provided a demand in some markets while consumer preference has encouraged other opportunities. Often however, management restrictions, administrative/transaction costs, and lack of understanding have squelched market development. Efforts of non-governmental organizations (NGOs) such as the Katoomba Group and The Nature Conservancy (TNC), and the recently formed Office of Environmental Markets (OEM), under the US Department of Agriculture, have invigorated efforts to provide functioning markets and educate landowners on natural capital. These programs have demonstrated a commitment to marketing ecosystem services and have worked to provide market stability, mitigate investment risks, offer accountability, and provide an information clearinghouse.

While many of the benefits from ecosystem services are generally public goods, the lands that generate these services are largely privately owned. For example, of the approximately 750 million acres of forestland in the US in 2006, approximately 56 percent, around 420 million acres, were privately owned (Heinz 2008). Of the privately owned lands approximately 85 percent of those landowners use the land to produce traditional goods and services (USFS 2010), demonstrating a high level of resource engagement. In addition, land-use modeling efforts such as those undertaken by Wear (1996), Abbitt et al. (2000), and others have demonstrated that managing these private lands, as opposed to just public lands, can have greater positive impacts on overall ecosystem health and therefore societal benefits as well. In order for ecosystems functions, and their provided goods and services, to increase successfully the public benefits, the management will necessarily involve private land.

Land Ownership Patterns

A recent evolution in ownership patterns of large forested tracts from industrial timber and mineral companies to organizations such as Timber Investment Management Organizations (TIMOs) and Real Estate Investment Trusts (REITs) (for more information see Zinkhan 1992, Binkley 1996, Block and Sample 2001, Gunnoe 2010) have altered management goals and strategies. These new owners, often in the interest of recruiting long-term investors and marketing products, have invested resources to maintain and enhance ecological conditions. This is most apparent in the wide adoption of sustainable forest management and the acquisition and maintenance of third party certifications, known as eco-labeling. Additionally, these new institutional owners of private lands differ from previous owners in that they are in the business of sustainably managing natural capital and assets, as opposed to owning land to source other operations such as sawmills and mineral extraction. Approximately 57 million acres, or 13 percent of private forests, are currently owned by these investment organizations (Heinz 2008). These new owners and their management strategies present a good opportunity to increase the scale of ecosystem service markets, as they are already in the business of natural capital asset management. Since TIMOs and REITs are rational actors seeking to maximize investor returns (O'Neill and Spash 2000, IAC 2009), exploring additional revenue streams and asset classes should be a part of their overlying strategy. As a result, marketing these services could not only provide asset diversification, but also provide additional revenue streams from value-added products.

At this time, most of the management of TIMOs and REITs focus on developing and managing timber and the investment value of the property. The immaturity of, and uncertainty surrounding, ecosystem markets have limited large landowners from participating on the scale that could support and sustain long-term market growth and development. However, many landowners have stated a willingness to examine or participate in these emerging markets (Waage 2007). One barrier to participation is that the management of these services may conflict with or encumber traditional management, such as timber harvesting. Another is high administrative costs, as required for the management and compliance, and high transaction costs of selling goods in immature markets, that may outweigh the benefits from marketing these services. These are certainly valid concerns; however, now may be an excellent time to introduce the management of ecosystem services due to the potential for additional revenues, the overlap of management practices, and the increasing scarcity of the ecologic goods (Ahn et al. 2002, Binkley 2006, Murray 2009, Sohngen and Brown 2006, Alig 2007, Fernholz 2007).

Project Area

The study area for this project is the Dumps Creek watershed, locally known as Wilder, in southwest Virginia, on the borders of Russell and Dickenson counties (Figure 1). It is generally a mixed mesophytic forest eco-region (Ricketts et al. 1999) of upland deciduous hardwoods, with the exception of the main corridor of Dumps Creek and the lower-slope cove hardwoods of the corresponding dendritic-patterned perennial drainages (Braun 1950). Timber and mineral extraction has also been present for more than 100 years. The project area has experienced a large assortment of impacts including logging, deep-mining, surface mining, development, and natural gas extraction, plus all auxiliary disturbances.

This region of southwest Virginia has seen significant human impacts since European settlement in the mid- to late 18th century. Originally, Europeans moved into the area to find no major native tribes in residence but a number of tribes using it for seasonal hunting grounds. Settlers worked to establish agriculture, though this proved challenging due to the rough terrain and generally poor soils. Residents soon began exploiting the resources on behalf of interests in New England providing fuels and wood resources to manufacturers during the Industrial Revolution (Eller 1982). The success of these extractive industries led to large forested tracts remaining on the landscape under few owners. There are no residences within the project area but other private landowners have homes and farms in direct proximity.

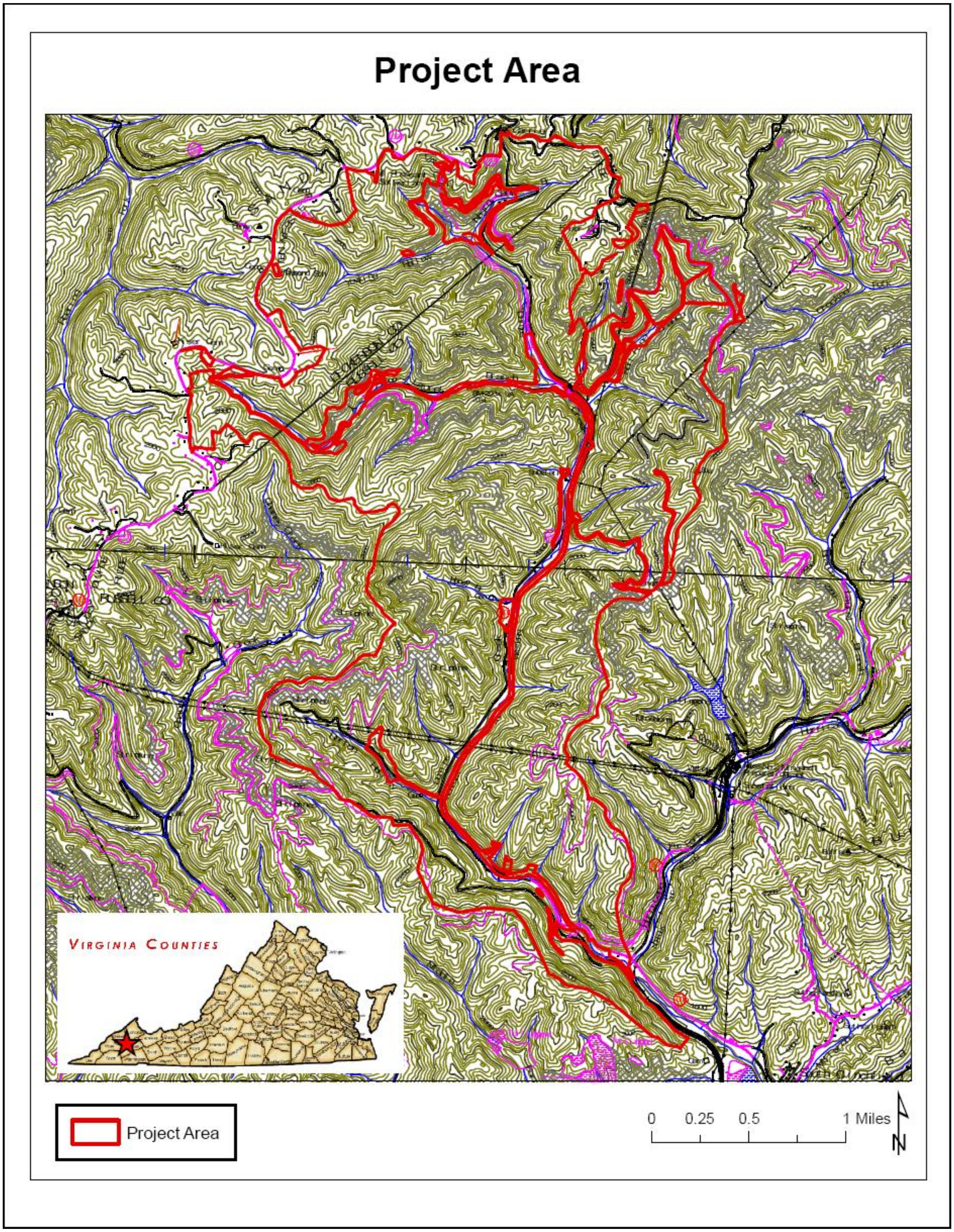

Figure 1. Project Area Map

Though no direct evidence of abandoned home sites was discovered, the presence of several cemeteries and one old school site demonstrate the historical presence of habitation.

Mineral extraction, especially coal, has been, and continues to be, a significant local industry. While this extraction has yielded many financial benefits to the region, it has also altered the landscape and ecosystems significantly. There are active coal deep-mines, coal surface mines, and recent compensatory mitigation projects within the project area. However, all areas currently under mining permits were excluded from the study area of this project. Mineral development will continue in the project area and throughout the region without regard to the surface owners' desires. The project area, like many areas in the region, has different owners for surface, coal, and gas. Since mineral rights have primacy in surface use, the owners of these rights can develop their holdings at will. As stated, these industries became established in the region around the turn of the last century yet remain viable today providing many jobs and economic benefits for the area.

One major legacy of the surface mining in the region is that a significant number of acres (approximately 620 in the project area) have undergone post-mining reclamation. Most current reclamation practices use the Forestry Reclamation Approach (FRA) as laid out by Angel et al. (2005), which has been shown to maintain good site productivity after reclamation (Burger et al. 2009, Aggett 2003). Prior to FRA however, reclamation met the standards of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) by heavily compacting the site and planting species such as fescue (*Festuca* sp.), autumn olive (*Elaeagnus umbellata*), and white pine (*Pinus strobus*). While these plants were effective in accomplishing many of the goals of reclamation, they amounted to a land cover conversion from native hardwoods to grass and shrublands with marginalized site productivity. Furthermore, even over long periods, native hardwoods were not becoming re-established due primarily to the heavily compacted soils (Rodrigue and Burger 2004). Owners near the study site have attempted to rehabilitate pre-FRA sites with the FRA approach. Though results have been positive on many fronts, costs (estimated at $1,200-1,500 per acre) and other challenges have limited many applications (Amichev and Burger 2006). The current state of reclamation projects in the project area, and the region in general, have shifted to the FRA preventing significant land cover conversions post-mining, but many areas remain unforested as a result of earlier reclamation efforts and will remain for the foreseeable future as atypical features.

The most significant biological feature adjacent to the study area is the Clinch River. Dumps Creek flows south out of the project area, after its confluence with Hurricane Fork, and continues approximately 2,500 more feet before entering the Clinch River. The Clinch River is considered one of the most biologically diverse rivers in the region and "harbors the nation's highest concentrations of globally rare and imperiled fish and freshwater mussels" (TNC 2010). Conservation organizations have expended a great deal of effort to protect the Clinch and its resources as evidenced by The Nature Conservancy (TNC) establishing its Clinch Valley program focused on conservation efforts and preserving land along the Clinch in 1990. The presence of the Clinch River, and the project area within the Upper Clinch Watershed (HUC 06010205), provide a biological basis for ecological conservation actions to be considered within the project area.

The majority (approximately 83 percent) of the project area is forested with typical upland hardwoods. Predominant species include mixed oak (*Quercus* sp.) and maple (*Acer* sp.) species, yellow-poplar (*Liriodendron tulipifera*), hickories (*Carya* sp.) and other minor components such as American basswood (*Tilia americana*), American beech (*Fagus grandifolia*), eastern hemlock (*Tsuga canadensis*) and cucumber tree (*Magnolia acuminata*) (Harlow 1996). The species vary across the landscape depending upon site, aspect, and many other conditions. General forest health is good to moderate (Campbell 2010) though past management has in many cases led to poor growth rates of less than 3 percent. Much of the historical management of the property has been the selection and harvest of only the best and highest valued trees, known as 'high-grading', which marginalized the remnant forests, and is verified on the landscape in forest conditions and frequent degraded stands. Within the last 10-15 years, timber management on site has been modernized applying specific silvicultural goals and prescriptions with the results of providing for long-term increased forest health conditions and additional latitude for future management options.

Forest inventories of the project area, and the surrounding properties, estimate volumes in the 3,000-4,700 board feet (BF) per acre range, all sawtimber products combined (Campbell 2010). This includes some areas with volumes ranging from 500 to 1,000 BF and others ranging from 7,000 to 12,000 BF. Forest inventories conducted by the US Forest Service (USFS), as part of the Forest Inventory Analysis (FIA) program, report volumes of all products (greater than 5 inches diameter at breast height (DBH)) to average approximately 6,500 BF per acre (USFS 2008), on private lands in the applicable counties. Harvested volumes, as reported through cutout reports, are generally closer to the 3,000 board feet per acre as much volume, likely through top-wood and poor utilization, remains on site and does not make it to market (Campbell 2010). Site indexes are estimated to be relatively good in the area and a high regenerative capacity is noted. Most of the mature stands are estimated to be in the 60+-year age category, though a few areas exist in the less than 15 years because of recent harvests. Overall, basal areas are estimated in the 80-120 square feet per acre range with the average of approximately 100 square feet per acre considered fully stocked (Campbell 2010). The forests of the project area are typical for the region though some less common communities, such as pockets of butternut (*Juglans cinerea*), have been identified and may present conservation needs and opportunities.

The current ownership has emphasized timber management, with timber harvests occurring within the project area and across the landscape to temper cumulative impacts to any one area (Kaderavek 2010). All management, with the exception of salvage operations, is certified sustainable forestry management through the Forest Stewardship Council (FSC) third-party certification. FSC certification provides a third party testament that forest products are harvested sustainably and in compliance with their principles and criteria that include consideration of ecological and social values. The typical harvest design is variable retention harvests (Brown 2001), meeting the regional FSC 20 ft^2 basal area (BA) retention requirements. In most cases, the current management includes an aggregation of small (less than 10 acres) clearcuts with strips of residual timber maintained. This results in a patchwork of even-aged stands with representative forest age classes existing across the landscape. Other methods such as scattered retention are employed but economic viability and operational concerns limit their applications (Barnett 1995). Post-harvest most areas experience intense regeneration from natural seeding, coppice, and existing pre-harvest advanced regeneration. Additionally, mitigation measures are taken to minimize water impacts and all areas of disturbance are re-vegetated with an approved seed mix, as per state recommended Best Management Practices (BMPs).

Fauna in the project area is typical of that of Appalachia. A significant variety of species resides and migrates through the region. Large numbers of neo-tropical songbirds have been observed in the area, along with a typical assortment of large and small mammals. The region is also known for its diverse populations of amphibians, especially salamanders. No threatened or endangered species as listed under the ESA are known to occur in the project area though similar watersheds to the east and west have Special Conservation Units (SCUs) as designated by the Virginia Natural Heritage Program (NHP) for aquatic species. Over 40 endangered, threatened, or species of concern (TESOC) listed by the US Fish and Wildlife Service (USFWS) are known to occur or have potential presence in the counties of the project area (USFWS 2010).

Recreation, particularly hunting, is of great importance to the region. Hunting is a very popular activity for people living in the area and directly reinforces their ties to the landscape and its services. Currently, approximately 95 percent of the project area is under hunting lease agreements (TFG 2010), providing economic benefits to the landowner. Additionally, more than 19,000 acres, directly adjacent to the project area, is part of the *Public Access Lands for Sportsman* (PALS) and open to public hunting with a permit through the Virginia Department of Game and Inland Fisheries (VADGIF). Permits are sold to the public for $18.00 per person and provide access to this private land, which is under the same ownership as the project area, for hunting (VADGIF 2010). In 2009, over 900 permits were sold indicating significant demand for this service in addition to the hunt lease program (VADGIF 2010). Currently, plans are underway for the re-introduction of native elk (*Cervus canadensis*) species to the area that could increase demand for hunting once they become established. Other important recreational uses that provide economic benefits to the areas include bird watching, hiking, biking, and all-terrain vehicles (ATVs). Though ATVs are not permitted within the project area, a regional trail system is being developed that will provide significant economic benefits to the region (WMTH 2009).

The study area was selected due to its comparability to other areas in the region with regard to its current and historical uses and impacts, its biological features and conditions, and its ownership and management practices. The combination of past and present uses shapes the ecological functions of the area and therefore the services it can provide. Currently, the proposed project area provides a large range of services that could be enhanced or benefit from specific management strategies. It was felt important to include these extended descriptions of the study area to provide not only an image of the landscape being assessed but also to give insight into the suitability of management schemes to other landowners for comparative operations.

Methods

This research was designed to assess the potential economic benefits of incorporating selected ecosystem services into traditional forest management operations. Specifically, the project provides direct value estimates to landowners, as a case study, from which other landowners might draw influence, based on real and current market conditions, if they chose to market their produced ecosystem goods and services. This ecosystem services management option is compared to a profit maximizing timber management scenario, within Forest Stewardship Council (FSC) certification standards. These two alternative management strategies were applied over 15 years to reflect the ownership period for many TIMOs and REITs (Gunnoe 2010). The project area was mapped using geographic information systems (GIS) software (ArcGIS version 9.3), with the areas calculated for both schemes. Prices were determined based on average market conditions and applied to the calculated physical outputs. Lastly, a sensitivity analyses was applied to all calculated units, and adjusted with a five percent discount rate to provide present value estimates. A five percent discount rate was chosen as it is in the typical range (as stated by Henderson and Sutherland 1996, Rinhart 2010) of four to 10 percent. Sensitivity analysis was used to investigate the uncertainty of pricing and provide a scenario analysis representing "optimistic", "most likely", and "pessimistic" outlooks for values (NCEDR 2001).

Much of the work thus far on valuing ecosystem services has fallen into four primary models: 1) direct market valuation, 2) indirect market valuation, 3) contingent valuation, and 4) group valuation (de Groot et al. 2002). Each of these models has contributed to the understanding of ecosystem services values. The direct market valuation approach is often preferred where markets exist. Other models such as indirect market valuation, including Willingness to Pay (WTP) and Willingness to Accept (WTA), contingent valuation posing hypothetical scenarios (Wilson and Carpenter 1999), and group valuation, as derived from social and political theory, have application where the values are not traded on a market, as described by Costanza

(1997). The concept of "value", and especially the value of ecosystem goods and services, has undergone much change and debate, especially with regard to which models function best under which services and whose "values" are best applied (Farber et al 2002).

In most cases, attempts to apply values to ecosystem goods and services have focused on the benefits and values to the public, or the values realized in the public good (e.g. Costanza 1997). This project, however, takes a different approach and uses a direct market valuation to estimate values not to those who receive the benefits (the public), but rather to the landowner who holds the rights of management for the ecosystem goods and services and controls their positive externalities. The approach of real market valuation is not often employed because it, like many current assessments, does not account for the true values of ecosystem goods and services (Norgaard 2000, Hamilton and Lutz 1996, Salzman 2005), and this is often attributed to a market failure of correctly indicating relative scarcity (Norgaard 1990). Yet this approach can provide an estimate of possible monetary returns to landowners and influence management policies. As a result, it is relevant to decision-making, or as stated by Ruhl and Salzman (2007), "putting a dollar figure on services, however controversial among professional economists, makes it easy…to appreciate just how valuable they [ecosystem services] are." The inclusion of approximations of existing market values for ecosystem services may help bring markets to a functioning scale allowing for additional realization of the true value of these good and services. For this reason, a direct value approach of real markets was selected.

This project considered two basic management schemes—one of a more traditional approach managing for fiber production and recreation and the second that incorporates ecosystem services management. These schemes were examined because much of the land under ownership by TIMOs, REITs, and other landowners is not entirely suitable for traditional management and ecosystem management may offer an alternative to their current management strategies. For example, there are often areas that are inoperable or otherwise cannot allow logging for a variety of reasons. Perhaps it is too close to a residence, road, or railroad track or the tract is too small to satisfy the scale requirements to make it economically feasible. Sometimes this is the case with large transfers of property in which there are tracts, in or around communities or culturally significant areas for example, that are not suitable for management. Managing ecosystem services, as other natural assets, may allow landowners to bring these areas into some level of production where now they only represent costs.

Information used for mapping on this project was based primarily on United States Geological Service (USGS) 7.5-minute quadrangles, digital orthographic aerial photos, and historical management data, as obtained from the property management database of the landowner (TFG 2010). Additional public information was gathered from the Virginia Natural Heritage Program (NHP), as administered by the Department of Conservation and Recreation (DCR), and the Environmental Protection Agency (EPA), among others. As much information as possible was obtained from open-source or public information. This was to minimize potential costs to landowners should they apply different management strategies and to demonstrate the information available prior to owning the land. This has use in accounting potential property value in the acquisition process.

Traditional Management Scheme

In order to compare the opposing management schemes, the project area was first mapped under a maximized potential revenue scenario, within FSC certification, and the using the current markets of fiber production and recreational hunt leases, representing a traditional management scheme (Figure 2). This was to provide a baseline, or control, of maximized management potential and represent current management for many landowners. All areas not suitable for these two uses were included with non-forested areas or those mandated not to allow fiber harvests.

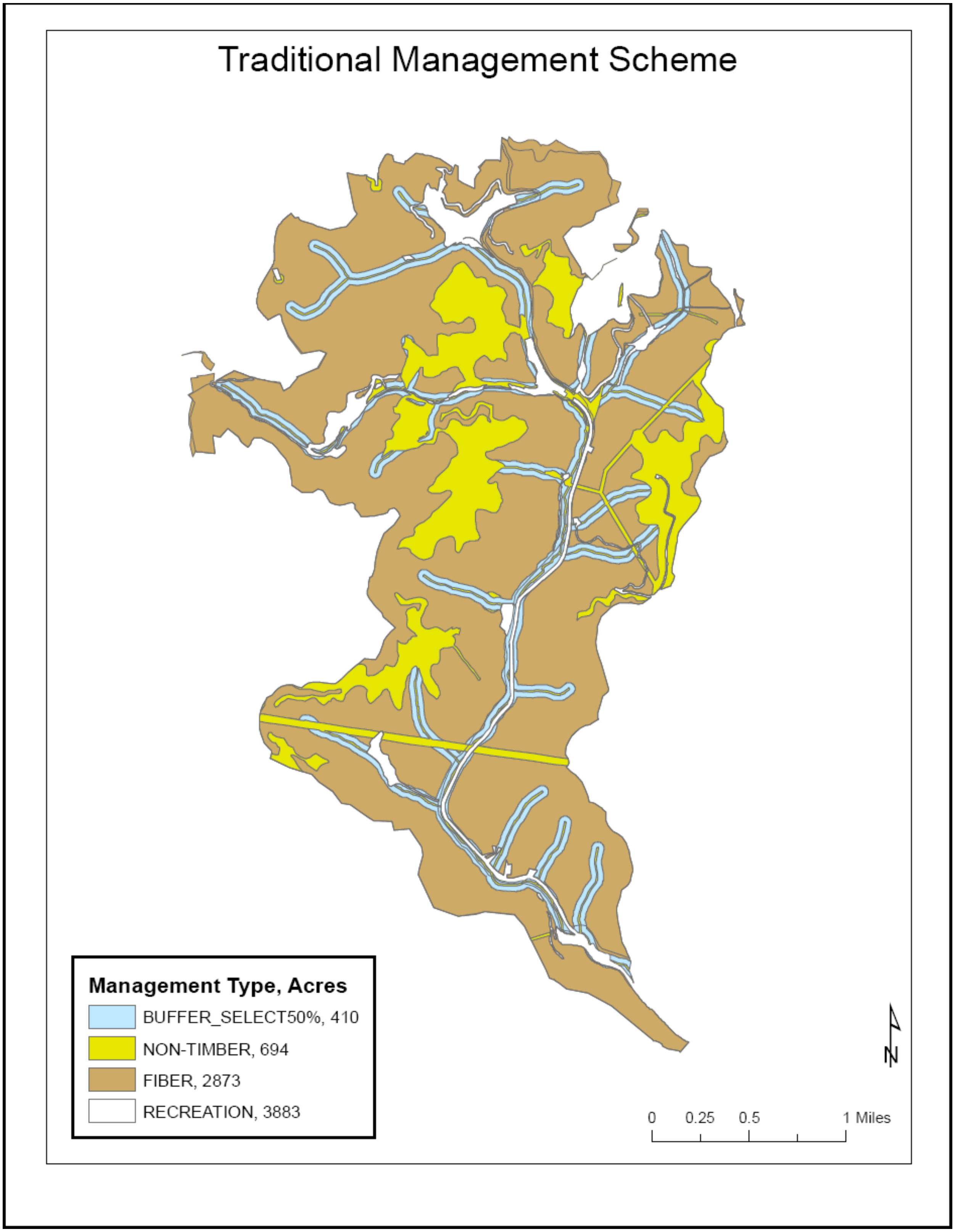

Figure 2. Traditional Management Scheme

The area suitable for fiber harvest was calculated based on methods and requirements of FSC principles and criteria (FSC 2010). This involved removing the 25-foot 'no-cut inner zone' of the perennial streamside management zones (SMZs) and calculating the area for the 'outer zone' SMZs that allows the harvest of up to 50 percent of the basal area. Under FSC protocol, the width of this 'outer zone' fluctuates based on slope. The maximum width of 140 feet was applied to all SMZs (for a total SMZ buffer width of 165 feet) in this analysis because of the overall steep terrain of the landscape and the management considerations of the landowner. These actions provided areas allowing no harvesting of fiber, areas allowing 50 percent of the basal area to be harvested, and areas allowing for all of the basal area to be harvested. Based on the average board foot cutouts from local timber sales, a volume of 3,000 board feet per acre was chosen to be representative. That is, all acres of fiber were assumed to yield approximately 3,000 board feet per acre and areas that allow 50 percent of the basal area to be harvested would yield approximately 1,500 board feet per acre. Though actual volumes per acre vary significantly across the region, including the project area, this number is sufficient for analysis, as it is appropriate to the observed volumes of local harvests and within the range of cruise volumes for sawtimber products. Furthermore, keeping the fiber volumes consistent for all comparisons, means any changes would be relatively represented throughout the results and would not affect the final comparisons. Actual volumes as estimated by the property owner were not used in this project, as they are proprietary information. In addition, the total area of fiber production was reduced by 20 percent to account for the basal area retention requirement of FSC certification.

All harvest areas were then distributed over a typical 15-year ownership period in order to represent sustainable harvesting for the total area *per annum*. Though true sustainable forest management ensures perpetual harvests by keeping harvesting levels below growing levels over an entire rotation, the methods employed here only intended to represent sustainable harvests over the project area based on an area method calculation. This distribution of annual harvests is considered a proxy providing for all areas being managed at sustainable rates and not all impacts occurring in one area at one time.

Next, the area available for recreational hunting leases was estimated as the area that is currently under lease agreements. Though this area could change over time, there is strong demand for hunting leases and all areas in the project area deemed suitable for leasing for recreational hunting were already under lease. The total area of these two services, fiber and recreation, were then applied to present values, annualized and discounted over the ownership period, and combined to provide a total present value for a traditional management strategy.

Ecosystem Services Management Scheme

The project area was then mapped for ecosystem services management by identifying areas where fiber production was not applicable or likely to take place (Figure 3). This included different features that either would prevent harvesting operationally or were unlikely to be harvested for a variety of other reasons.

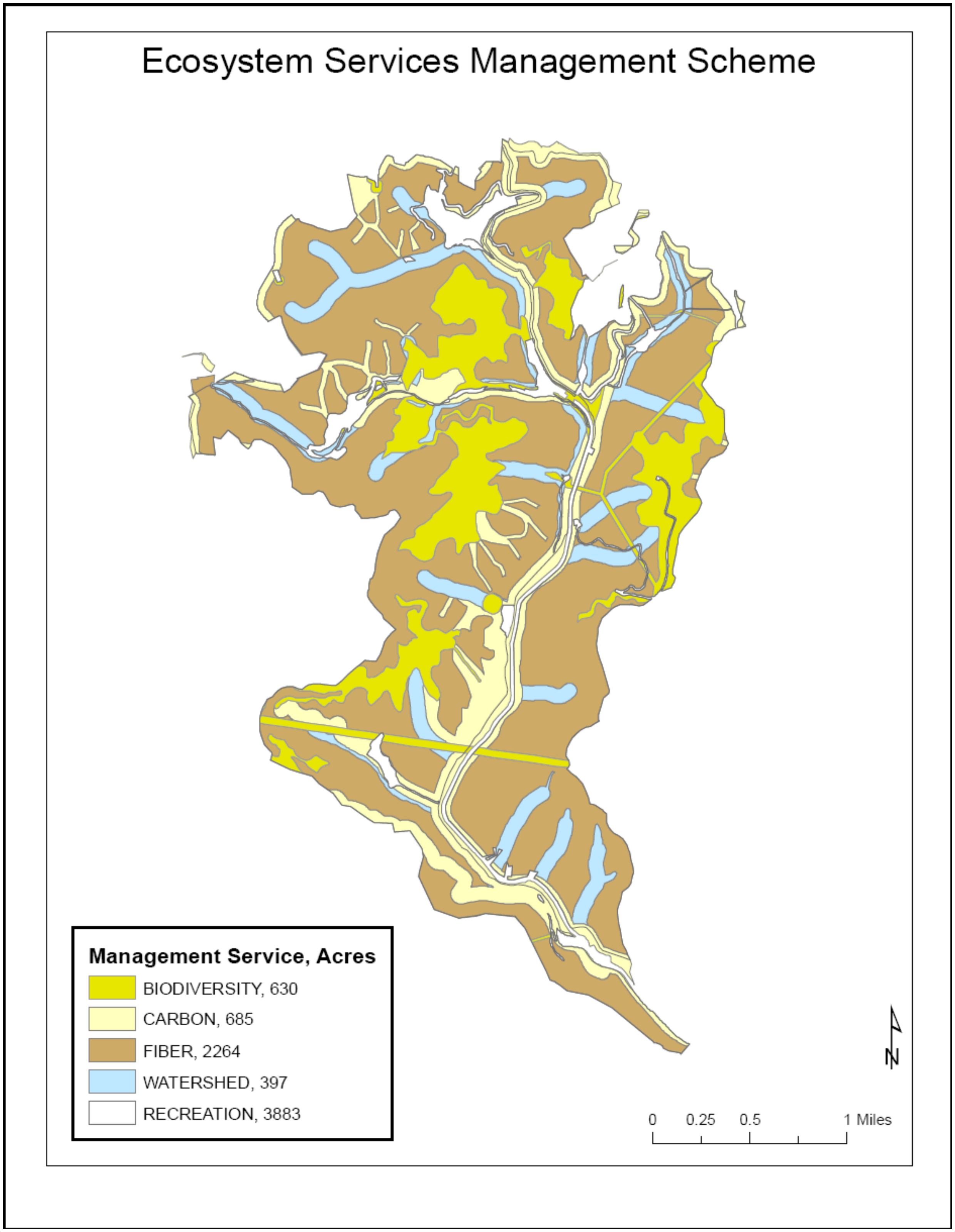

Figure 3. Ecosystem Services Management Scheme

These areas not suitable for fiber harvests were placed under another ecosystem services management category, and included with fiber and recreation to form five identified markets. All markets under this management scenario included: fiber, recreation, carbon sequestration, watershed services, and biodiversity. Table 1 provides a list of features not suitable for timber management and their potential alternative markets. This list and the suitable features and markets can vary depending on region, site, and demand. Suitable markets included primarily existing local markets and those promoted by Ecosystem Marketplace and another organization working in the region, The Bay Bank (Bay Bank 2010). These markets were traditional exchanges as in the case of fiber and recreation, voluntary markets such as carbon, and markets supplied by regulatory demand as in watershed services and biodiversity. The total areas for this management scheme of ecosystem services were then multiplied by the estimated per unit prices compared to that of the traditional management scheme, to estimate which had the greater market value.

Table 1. Alternative ecosystem services markets and identified features of suitability

Ecosystem Market	Example features with potential suitability
Fiber	Areas that are likely to allow active timber management including harvesting
Recreation	Areas that are under recreational hunt lease
Carbon Sequestration	Areas along public roads or with safety concerns; areas near residences; retention areas from recent harvests; areas inaccessible or inoperable; critical viewsheds
Watershed services	Perennial streams and SMZ buffers; wetlands
Biodiversity	TESOC habitat; reclaimed mines sites; other areas with conservation value

Pricing Services

Value per unit determination for the ecosystem markets provided mixed results. While some, such as fiber and recreation, had easily defined prices in existing markets, others such as watershed services and carbon sequestration required significant assumptions and estimations. Biodiversity markets failed to yield any defined prices specific to this project due to extreme site specification and demand requirements of most of their transactions. Suitability with regard to marketing services to specific programs was not examined in this study, as the research goal was an estimated present value comparison of different management schemes and is not to address landowner and program preferences. These programs and their criteria vary widely as do specific landowner goals and objectives. For a thorough examination of markets and conditions, see Stanton et al. (2010), Hamilton et al. (2010), and Madsen et al. (2010).

Several assumptions were made in calculating market prices and enrollment. With regard to fiber, the estimates were maintained as the control values of 3,000 BF per acre with a price range of $100-$150 per MBF examined. Timber prices were based on a range of values from 2007-2010, including the current regional prices as reported by industry analyst (Timber Mart-South 2010). Recreational hunt lease values were determined to be $1.00 to $3.00 acre based on regional and actual hunt lease prices (VDOF 2010).

There are several methods for estimating carbon sequestration, many of which are very complicated (Heath and Smith 2000). In this project carbon sequestration was assumed to be approximately 127 tons per acre (Amichev et al 2004, Turner et al. 1995) including both forest biomass and soil and was valued at prices ranging from $0.10-8.00 per ton based on local transactions (Lachniet 2010). The sequestration rate was derived from Amichev et al. (2004) in which biomass was sampled both above and belowground to estimate carbon of forests in the Appalachian region. These carbon estimation methods and results were consistent with those provided by Anderson (1991), Turner et al. (1995), and Johnson et al. (1995). The prices used were based on a range of prices from 2004-2010 as provided by Hamilton (2010) and in local markets from 2007-2010, confirmed through correspondence with a regional non-profit, the Appalachian Carbon Partnership (Lachniet 2010). The total area for carbon sequestration marketing was divided by the ownership period of 15 years, providing for 46 acres enrolled per year to mitigate of market fluctuations and spread costs over a larger period. Added to this was the area that was maintained in retention from timber harvests, another 30 acres per year, as required for FSC certification, totaling 76 acres enrolled in Years 2-15. Since any timber harvests are forgone under in this scenario, all acres are considered as additionality. Additionality is a term used to describe the additional net gain for a change in actions, in this case it is carbon sequestered in these areas, as they would otherwise be harvested for fiber. Other opportunities for carbon sequestration through additionality such as changes in rotation lengths were not examined as part of this project.

Watershed services values were based on a one percent enrollment of the total linear feet of perennial streams in the project area annually for the 15 years providing a total 15 percent realization. This amount was chosen because not all streams would be suitable for marketing. It also represents the approximate length of other mitigation projects in the area. Conceptually the watershed services programs worked as a mitigation bank in which those requiring mitigation offsets would be allowed to purchase services (see ELI 2006). Mitigation banking is the practice of “restoring, creating, enhancing, or preserving” off-site areas to provide required compensatory mitigation of offset authorized disturbances elsewhere (ELI 2002). These are often on private land and created as not only a means of providing mitigation but also as a method of generating incomes for the owners. Mitigation banks are increasing in popularity as an alternative to other types of compensatory mitigation, especially after the 2008 guidance as issued by the US Army Corps of Engineers (USACE) and the Environmental Protection Agency (EPA) that promoted their use. This is appropriate to the project area in that there are no comparable banks within the region and there is significant demand for compensatory mitigation with area coal extraction (VDEQ 2010). Demand is also provided by the 2009 report for the Virginia Aquatic Resources Trust Fund (VARFT), the Virginia In-Lieu-Fee (ILF) program, which showed a negative credit balance for the stream mitigation credits in the watershed of the of the project area (VARTF 2010). Additionally, the project area itself could offer a good opportunity to make a significant difference as it has heavy historical impacts and significant improvement could be made to downstream water quality by improving the conditions through mitigation projects.

Prices for watershed services, based on linear feet (LFt) estimates and included a 200-feet stream buffer, were estimated at a range of values from $20-35 per LFt to the landowner. This value was derived by taking the national average ILF mitigation prices per LFt, the Virginia, Tennessee, and North Carolina prices and then deducting the average construction costs estimates of $75-400 per LFt (ELI 2007, Jones 2010) for stream mitigation projects and the administrative costs, usually stated at 6-40 percent of total cost (ELI 2007, ELI 2009) (Table 2).

Table 2. Summary of regional ILF prices and sources

ILF Program	Price per unit	Source
National average	$240 per LFt (2007)	ELI 2007
Virginia	$375 per credit (current)	USACE 2010
Tennessee	$200 per LFt (2005)	Woodard 2005
North Carolina	$256 per LFt (current)	NCEEP 2010

Additionally, these numbers were compared to North Carolina's costs, estimated by Templeton (2009) to equal $242.12 per LFt. These ILF prices are thought to be comparable, if not low, to the actual costs of the mitigation, as is a common criticism of ILF programs (ELI 2006); however, they provide a reasonable basis for estimating prices of market transactions. Actual transaction prices of existing mitigation banks are generally kept private and are therefore not available for analysis.

A price range of $20-35 per LFt was determined to be a reasonable payment to the landowner for allowing mitigation to take place, though all of these values have high variability. This price equated to roughly 10 percent of the ILF average price, which leaves the other 90 percent for construction and administrative costs. These prices comply with 2000 guidance that states with regard to fees, "a reasonable cost estimate of all funds needed to compensate for the impacts to wetlands or other water functions that each permit is authorized to offset" (USACE 2000). These methods equate to those used to derive stumpage values of timber in that it provides an “exchange-based, welfare value”, as a “market price net of the costs of bringing goods and services to market” (Farber 2002), and therefore seemed analogous and valid.

Determining prices for biodiversity markets presented additional challenges and has been regarded by some to be a hopeless task (Ehrenfeld 1988). A number of analysts have evaluated various methods for determining these values. Most are directed at public values or values per household, with ranges from a few dollars to hundreds of dollars (Nunes et al. 2001). For example, a study to determine the value of the preservation of aquatic systems in the Adirondack Mountains reported per household values to be $12-18 (Kealy and Turner 1993), while an estimate of the conservation value of protection of groundwater programs in the US ranged from $7-22 per household (McClelland et al. 1992). Nunes (et al. 2001) compiled a collection of biodiversity valuations to determine price ranges of $27-101 per acre for terrestrial habitats and a range of $5-194 per acre of habitat for single or multiple species. Yet, he concluded in stating, “from the review of the economic valuation studies it is clear that the assessment of biodiversity values does not lead to a univocal, unambiguous monetary indicator.” Due to these various features, determining market prices for this project area was unsuccessful.

Biodiversity values are difficult to quantify and most market transactions between parties maintain confidential pricing. Additionally, the transactions that have taken place are very specific spatially and temporally, making comparison for estimating other values, such as in this project, difficult. Biodiversity markets are often, and increasingly, driven by policy demands such as the USFWS’s adoption of ESA enforcement requiring mitigation similar to that of the

CWA and other desires to conserve habitat or provide other qualities important to species. These regulatory applications may reinforce demand and provide more stable markets.

Conservation values, as part of mitigation or otherwise, represents much of the market value with regard to transactions (Twillman 2010). These are typically realized from revenues generated through conservation easements or some other agreement ensuring the desired biological benefits. Some studies of maintaining landscapes and their supported biodiversity, have estimated the value of healthy forests in North Carolina from $18-99 per household per year (Haefele et al 1992, Aldy et al. 1999), and in Virginia, the values of wilderness were estimated to be $12 per day per resident (Walsh and Loomis 1989). Conceptually, conservation of landscapes works in banks similar to those active as part of CWA mitigation. This conservation is often driven through enforcement of the ESA that requires mitigation of impacts occurring on private lands in Section 10. In 2009, more than 95 conservation banks were functioning in the US (Madsen et al. 2010). These banks operate on the principle of, "if you conserve large enough tracts of high quality habitat, provide habitat connectivity to other preserved sites, and manage the land to support species recovery, the species will persevere and thrive despite a net loss of habitat" (Madsen et al. 2010). The conservation values of the project area would likely be related to water resources or other TESOC habitats (Kreps 2010). Other opportunities might exist with habitat improvement for game species for example but these would ultimately be realized in recreation services. A summary of all markets and pricing of services is provided in Table 3.

Table 3. Service markets and pricing summary

Service	Unit	Price per unit	Pricing sources	Assumptions
Fiber	MBF	$100 – pessimistic $125 – most likely $150 – optimistic	• Local prices • Timber Mart-South 2nd Quarter 2010	• 3000 BF/ac • Harvest 80% BA for suitable areas • Harvest 50% BA for outer SMZ buffers • Annual harvest rate of total area/15-year ownership period
Recreation	Acre	$2.00 – pessimistic $2.07 – most likely $3.00 - optimistic	• Local prices • VA DOF	All areas suitable are leased annually based on current conditions
Carbon	Ton	$0.10 – pessimistic $1.00 – most likely $4.00 – optimistic	• Ecosystem marketplace • Appalachian Carbon Partnership	• 127 tons/ac • Annual enrollment rate of total area/15-year ownership period • Additional area from fiber retention in year 2
Watershed	LFt	$20 – pessimistic $25 – most likely $30 – optimistic	• Approximate ILF average price – construction and administrative cost • Approximately 10% of ILF prices	• 1% of total LFt sold annually for 15-year ownership period • Act as mitigation bank • Demand provided through mitigation markets (CWA)
Biodiversity	Acre	$0 for all pricing scenarios	• Transactions are taking place but prices are highly variable and project specific • No local transactions	• Act as a conservation bank • Demand provided by conservation markets (ESA)

The methods used for this study utilized information from several sources to determine per unit values for ecosystem services. Though the intent of this study was to glean values directly from existing markets, inconsistencies in accounting, site and species specificity, spatial and temporal variation, among other factors prevented this in some cases. This lead to some values being taken directly from markets and others determined through comparable transactions. Even though some of the estimated values are from markets not fully formed and functioning, there is still evidence of market transactions and therefore legitimate comparisons.

Results

Traditional Management Scheme

Mapping the project area under the traditional management scenario accounted for the entire 3,976 acres being classified as fiber, recreation, or non-timber management (Table 4). The area for fiber management was separated into those areas that would allow complete removal of all BA (clearcut) and areas along SMZs that would only allow for 50 percent removal of BA (select cut). This separation was due to greater FSC retention requirements for SMZs that state BMPs. Since recreation and fiber management take place on the same areas, recreation acres were not included in the total area to prevent double counting.

Table 4. Areas of traditional management scheme

Traditional management scheme			
Service	**Area (ac)**		
Fiber	2,873 (80% BA harvest)	410 (50% BA harvest)	3,283
Recreation	3,883		NA*
Non-timber	693		693
		TOTALS:	**3,976**

*The area of recreation is considered co-use, in that it provides multiple services, and therefore will only be counted once in total area.

A range of market values was then applied to each of the services, fiber and recreation, and stated with a range of outlooks from pessimistic, to most likely, to optimistic. The categories were based on values from the lower, middle, and upper ranges of the indentified markets. These values intended to provide a range of prices appropriate to current market conditions. No values were provided for the non-timber areas.

The value calculations for fiber were based on harvesting 153 acres per year at 3000 BF per acre and 14 acres per year at 1500 BF per acre. These acres represent the total service area divided by the total ownership period (providing for sustainability), and in the case of the areas for total harvest, reduced by 20 percent annually to represent FSC retention requirements. Prices used were \$100/MBF for a pessimistic outlook, \$125/MBF for a most likely outlook, and \$150/MBF for an optimistic outlook (see Appendix, Table 8 for annualized values) (Figure 4). This range of prices was chosen because it is representative of the pricing levels for mixed hardwoods from 2005 to 2010 (Timber-Mart South 2010). It is not likely that regional stumpage prices would vary significantly from these market conditions. The most likely price represent the approximate current rate received by the landowner (Campbell 2010). The actual value was not used in order to protect proprietary information of the landowner.

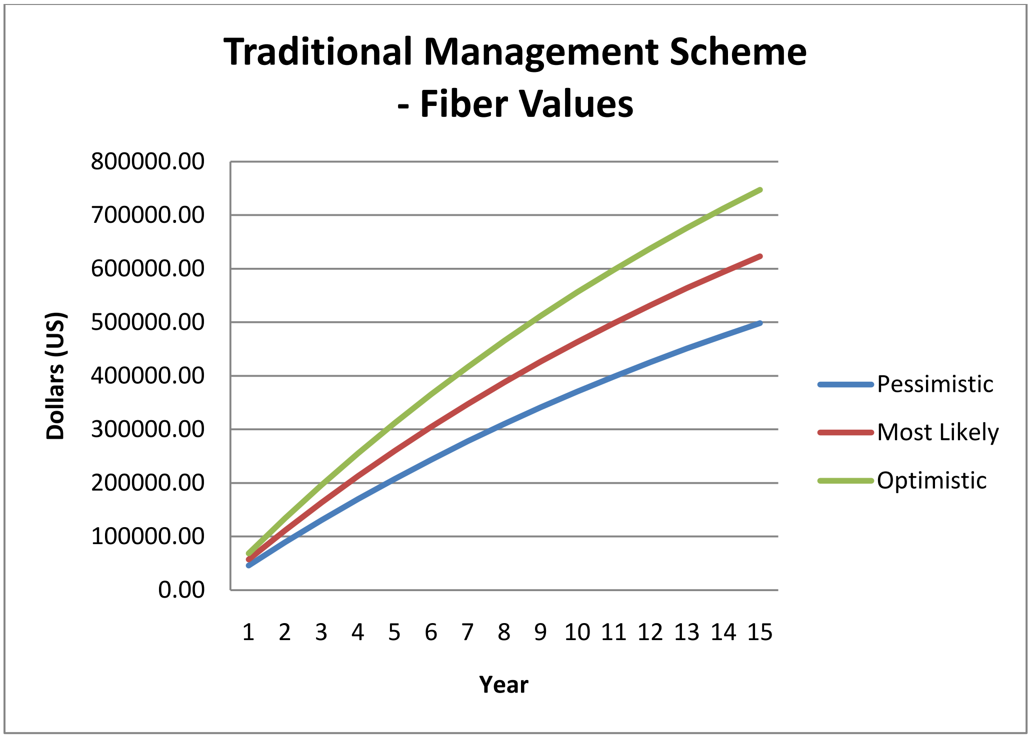

Figure 4. Total values for fiber services in the traditional management scheme

The value calculations for recreation were based on the total area of 3,883 acres being leased each year for the ownership period. Price estimates were $1.00 per acre for a pessimistic outlook, the current price of $2.07 for a most likely outlook, and $3.00 for an optimistic outlook (see Appendix, Table 9 for annualized values) (Figure 5). These prices are within the range of existing recreational hunting lease prices in the region. The average hunting lease price of the 10 southern region states is approximately $1.09 per acre/year (VADOF 2010) providing a baseline of lower price range. The actual price charged by the landowner for this service ($2.07 per acre per year) was identified as the most likely price (Campbell 2010). This value is given as it is considered public information available to anyone interested in leasing from the landowner. The upper or optimistic price limit was chosen because it was in the range of prices and could be feasible given increased demand or improved conditions based on management or other factors, like the establishment of desired species.

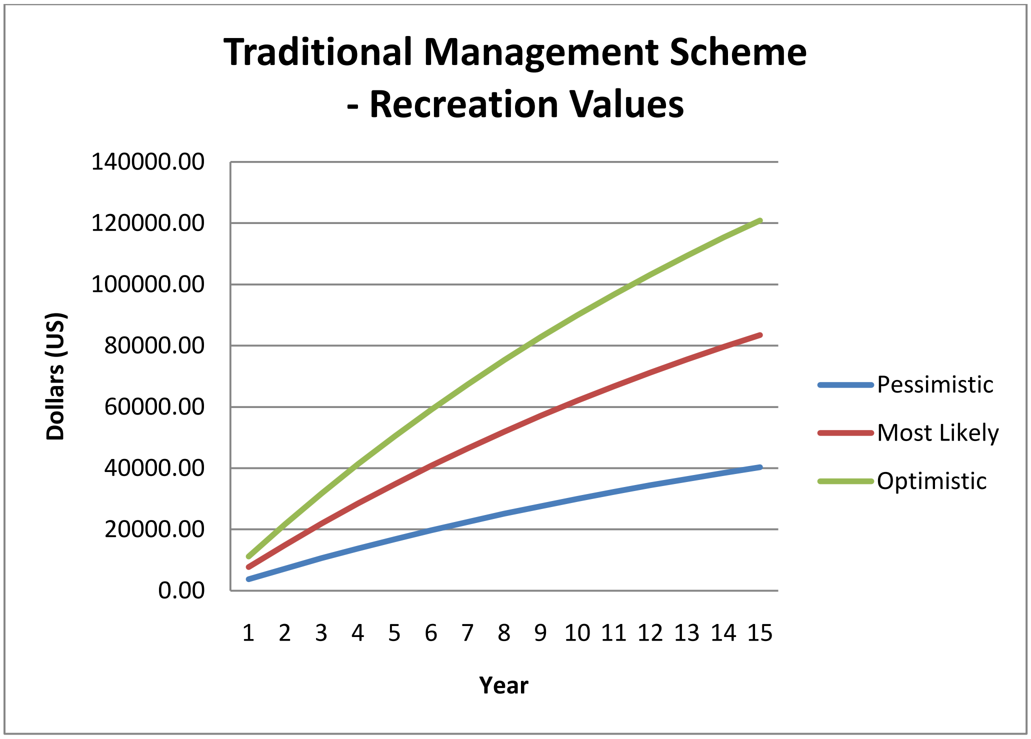

Figure 5. Total values for recreation services in the traditional management scheme

Each of these pricing scenarios was then combined to provide a range of total present values for the traditional management scheme (see Appendix, Table 10 for total annualized values) (Table 5).

Table 5. Total values for the traditional management scheme

Traditional management scheme			
Service	Pessimistic	Most likely	Optimistic
Fiber	498,410.42	623,013.02	747,615.63
Recreation	40,304.21	83,429.72	120,912.64
TOTALS:	**$538,714.63**	**$706,442.74**	**$868,528.27**

The total present value of the traditional management scheme over a 15-year ownership (five percent discount rate) ranged from a pessimistic outlook of $538,714.63 to an optimistic outlook of $868,528.27, with a most likely value being $706,442.74. This translates to a pessimistic value of $135.49 per acre, a most likely value of $177.68 per acre, and an optimistic value of $218.44 per acre for current and traditional services of fiber and recreation.

Ecosystem Services Management Scheme

The results of the ecosystem services management scheme allocated area into one of the five observed markets (Table 6) to account for the entire 3,976 acres. All were calculated in acres with the exception of perennial streams in watershed services, which was calculated in linear feet. The area calculation for watershed services is based on the 200-foot wide, no cut SMZ buffers along the perennial streams. Areas were not applied to value estimates for wetlands, in watershed services, as the NWI showed less than one acre to be present (NWI 2010). Furthermore, these values are highly variable and dependent on site-specific characteristics. In comparison to the traditional management scheme, recreation areas were constant but fiber area was reduced by approximately 30 percent.

Table 6. Areas of the ecosystem services management scheme

Ecosystem services management scheme		
Service	**Area (ac)**	**Linear feet**
Fiber	2,264 (80% BA harvest)	NA
Recreation	3,883*	NA
Carbon	685	NA
Watershed Services	397 (No harvest SMZ Buffers)	94,212
Biodiversity	630 (Non-timber)	NA
TOTALS:	**3,976**	

*The area of recreation is considered co-use, in that it provides multiple services, and therefore will only be counted once in total area.

A range of market values was then estimated for each of the services and stated as a range of outlooks from pessimistic, to most likely, to optimistic. These values intended to provide a range of prices appropriate to current market conditions. No values were provided for the biodiversity areas since no suitable markets were found to currently exist in the project area.

The value calculations for fiber were based on harvesting 121 acres per year at 3000 BF per acre. These acres represent the total area divided by the total service area (providing for sustainability). This was then reduced by 20 percent annually to represent FSC retention requirements. Acres removed from fiber production were added to carbon areas starting in year two. Prices used were $100/MBF for a pessimistic outlook, $125/MBF for a most likely outlook, and $150/MBF for an optimistic outlook (see Appendix, Table 11 for annualized values) (Figure 6). These are the same prices used in the traditional management scheme.

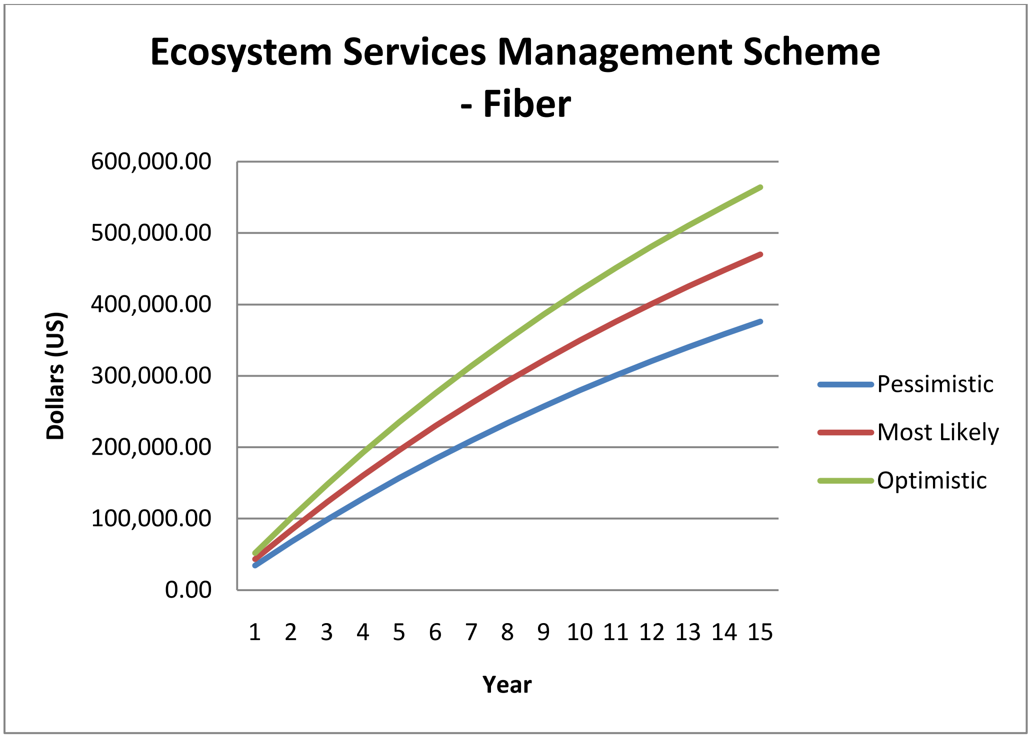

Figure 6. Total values for fiber services in the ecosystem services management scheme

The value calculations for recreation were based on the total area of 3,883 acres being leased each year for the ownership period. Price estimates were $1.00 per acre for a pessimistic outlook, the current price of $2.07 for a most likely outlook, and $3.00 for an optimistic outlook (see Appendix, Table 12 for annualized values) (Figure 7). These are the same prices used and values generated as in the traditional management scheme.

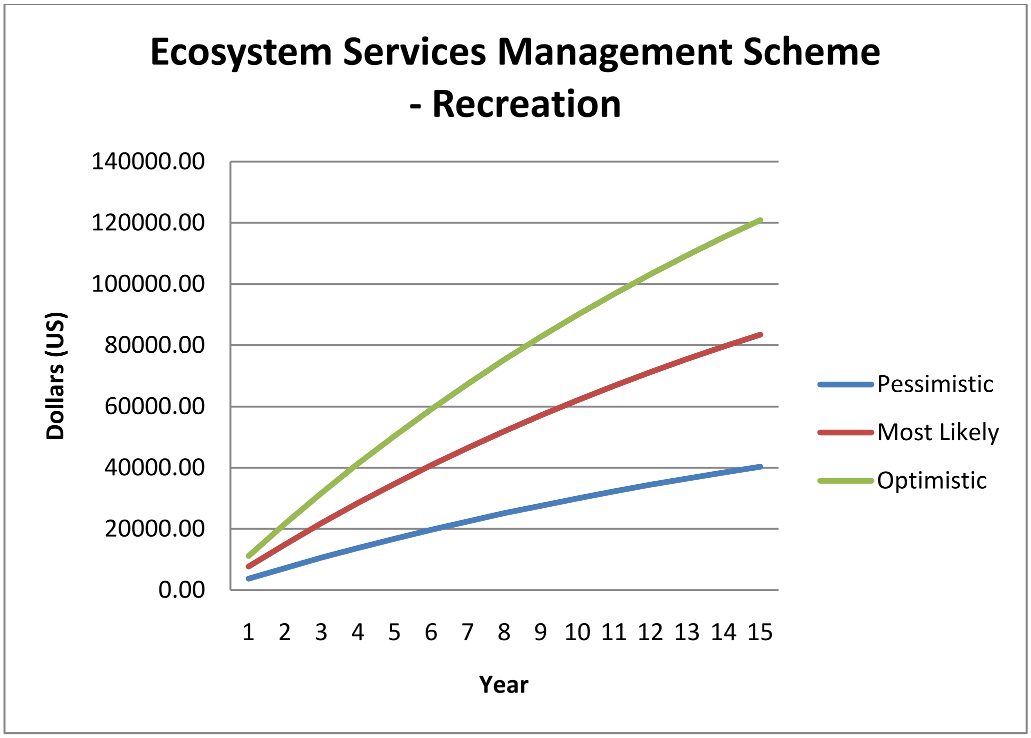

Figure 7. Total values for recreation services in the ecosystem services management scheme

Carbon sequestration services were based on a total area of 685 acres. The additional acres gained from the retention areas of the fiber services were added to this area, annualized over the ownership period, starting in Year 2 (approximately 30 acres per year). This provided 46 acres in the first year and 76 acres for each subsequent year. It was estimated that at an annual rate of 115 tons per acre this would sequester 5,252 tons in the first year and 8,723 tons during years two through 15. Values were estimated to be $0.10 per ton for a pessimistic outlook, $1.00 per ton for a most likely outlook, and $4.00 per ton for an optimistic outlook (see Appendix, Table 13 for annualized values) (Figure 8). These prices were chosen based on the range of historical and projected prices as revealed in the market research. The optimistic price scenario is based on the average voluntary over-the-counter (OTC) exchange price in 2008 which was $4.43 per ton, the most likely price was based on the average voluntary OTC exchange price of $1.20 per ton in 2009, and the pessimistic price scenario was based on the lower prices of 2009 and 2010 (Hamilton et al. 2010). Though there is likely to be continued volatility in carbon markets, these prices demonstrate a range of probable scenarios.

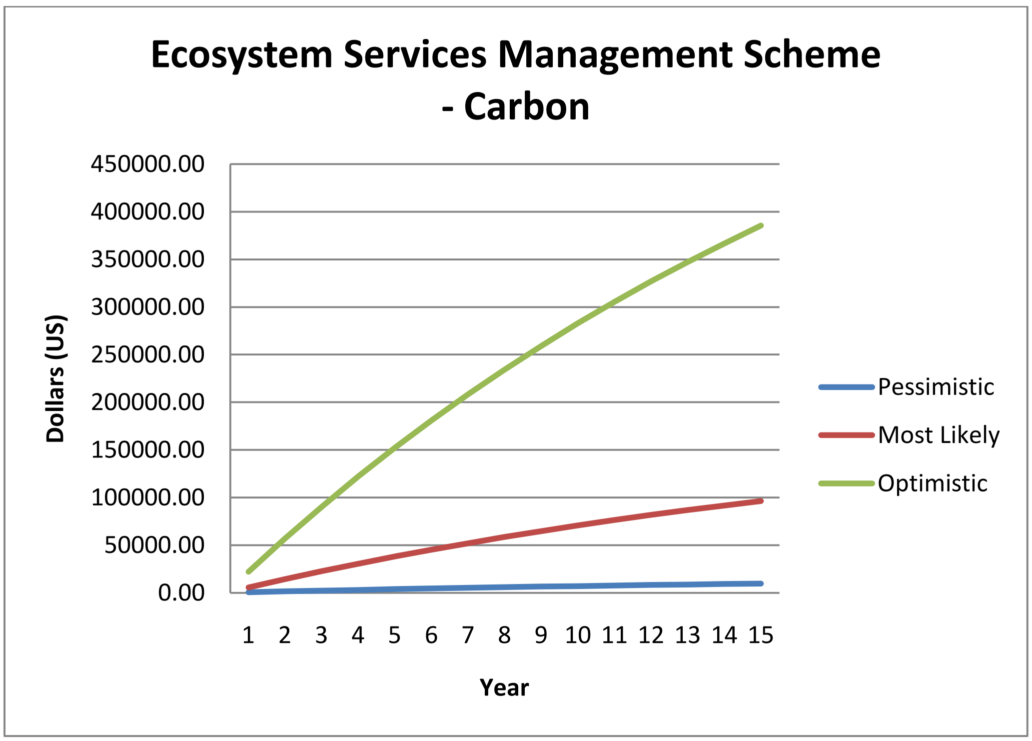

Figure 8. Total values for carbon sequestration in the ecosystem services management scheme

Watershed services were based on one percent of the total linear feet being offered for mitigation annually across the ownership period for a total of 15 percent of the resource to be used. This equated to 942.12 LFt annually, which is comparable to one stream mitigation project, similar to others in the area and at a scale probable to be constructed. Included with these linear feet estimates is a 200-foot wide forested buffer applied to all perennial streams. This buffer would only be required on areas that are part of mitigation projects, however it was removed from consideration for fiber production for all perennial streams and could therefore, if not marketed for watershed services, provide other revenues such as in carbon or conservation markets, but these were not calculated. The determined prices for watershed services were $20.00 per LFt for a pessimistic outlook, $25.00 per LFt for a most likely outlook, and $30.00 per LFt for an optimistic outlook. (see Appendix, Table 14 for annualized values) (Figure 9). These prices were based on construction and administrative costs and compared to ILF mitigation market prices. Actual prices of payments for watershed services through mitigation banks are generally not disclosed however, ILF prices are available and provided the basis for this analysis. It was assumed mitigation bank prices would be comparable to ILF prices in order to provide for a competitive market place. With ILF prices ranging from $200-300 per LFt, the pricing scenario ranges from $20-30 per LFt representing a portion of the total price that could potentially be provided to the landowner.

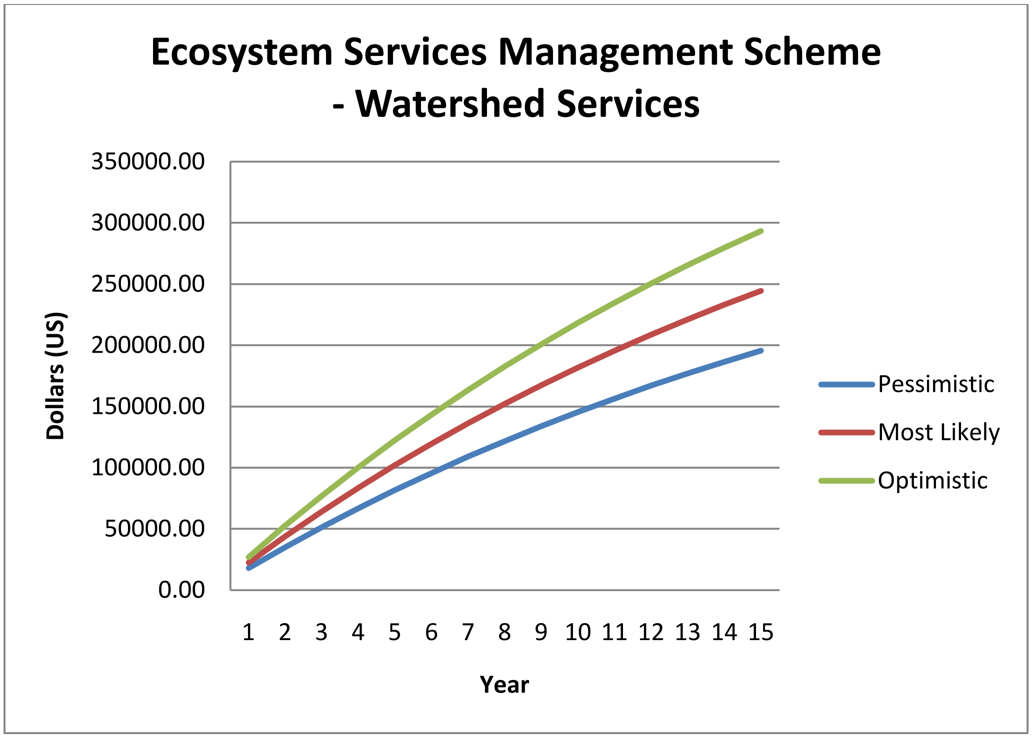

Figure 9. Total values for watershed services in the ecosystem management scheme

Direct market values for biodiversity in the project area were inconclusive. Though markets exist in other areas, none were available in the project area or its vicinity. Most values for biodiversity are very specific to spatial and temporal influences of which cannot be determined in the scope of this project. Values would have been estimated for TESOC species habitat had any been listed by NHP in the project area. Future markets for biodiversity may exist in the project area depending on the applications of the ESA or increasing perceived scarcity by conservation groups. Since this project is based on direct market valuation and no market exists, a value of $0.00 per acre was given for biodiversity (See Appendix, Table 15 for annualized values).

Service prices were combined for the ecosystem services management scheme to yield a present market value. This provided a pessimistic value of $621,508.61 or $156.32 per acre, a most likely value of $894,232.69 or $224.91 per acre, and an optimistic value of $1,363,628.13 or $342.96 per acre (See Appendix, Table 16 for total annualized values) (Table 7).

Table 7. Total values for the ecosystem services management scheme

Ecosystem Services Management Scheme			
Service	**Pessimistic**	**Most Likely**	**Optimistic**
Fiber	375,992.73	469,990.92	563,989.10
Recreation	40,304.21	83,429.72	120,912.64
Carbon	9,634.00	96,339.97	385,359.89
Watershed	195,577.67	244,472.09	293,366.50
Biodiversity	0.00	0.00	0.00
TOTALS:	**$621,508.61**	**$894,232.69**	**$1,363,628.13**

A comparison of the direct market valuation of the management schemes reveals that greater revenues can be gained through an ecosystem services approach. Specifically, the ecosystem services provide greater revenues in the order of $82,793.98 (15.4 percent increase) for the pessimistic scenario, $187,789.95 (26.6 percent increase) for the most likely scenario, and $495,099.86 (57.0 percent increase) for the optimistic scenario (Figure 10).

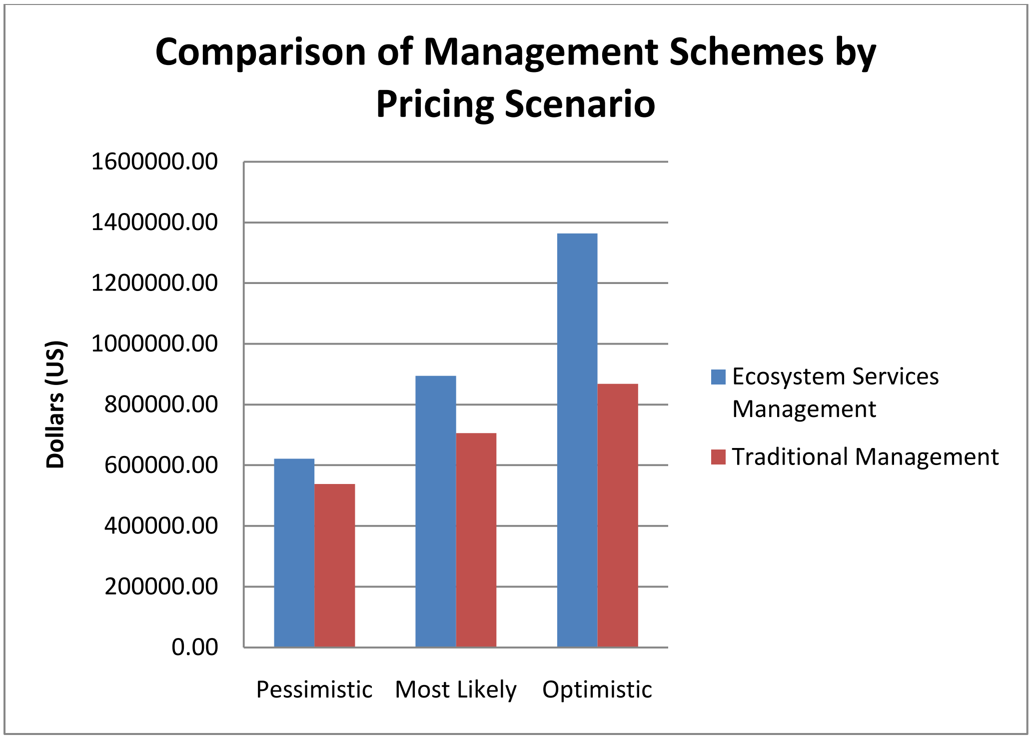

Figure 10. A comparison of the total values for each of the management schemes with all pricing scenarios.

Discussion and Conclusion

The case study demonstrates that ecosystem service markets may offer additional opportunities for landowners to increase revenues through natural capital. The ability to consider natural resources as assets and capital, and analyze management in these terms, as Ruhl and Salzman (2007) put it, "makes land management and nature conservation potentially lucrative to entrepreneurs and financiers". In addition, it can make ecosystem services easier to understand for the public and landowners, provide additional streams of revenues, promote outside investment to growing the asset, and foster market creation (Ruhl and Salzman 2007). Many feel that in order for biological and abiotic conservation to be successful, it must take place on private land (e.g., Morrisette 2001, Hunt 1997, Farrier 1995, Wear 1996), and ecological benefits can sometimes be realized more cheaply through proper management of ecosystem services than with manmade alternatives, such as the upstream water treatments considered by New York City (Logue 2006, Ernst 2004, Chichilnisky and Heal 1998, Ehrlich and Mooney 1983). The results of this study demonstrate that even at the current immature stage of ecosystem service markets, additional revenues may be available to landowners through ecosystem services management, thereby allowing market based solutions to enhance ecologic and ultimately human health.

Several problems currently exist with ecosystem service markets. Though market-based approaches have been widely promoted as a solution to providing ecosystem health and many schemes have been successful around the world (Landell-Mills and Porras 2002, Pagiola et al. 2002), it is not empirically clear that it is the best approach (Gustafsson 1998, Casey et al. 2007). This project relates all services to specific existing and functioning markets, however, in general, ecosystem service markets have been difficult to establish. This can be attributed to several factors. Kroeger and Casey (2007) state that these include, “1) the lack of widely available, easily accessible, and low-cost approaches to quantifying ecosystem service flows; 2) the difficulty of attaching to those flows reliable and low-cost estimates of their economic value; and 3) the public goods nature of many of these service flows, or more specifically, their non-exclusiveness”. They go on to provide additional reasons including a lack of scarcity, in contrast to the MEA (2005), and the spatial non-fungibility of ecosystem services creating small, discrete exchanges (Kroeger and Casey 2007). All of these problems lead to potentially long negotiations between parties, high transaction costs removing economic feasibility, and in some cases unacceptable land use restrictions.

Several solutions and much effort have gone into addressing market issues for ecosystem services and providing for their ability to contribute to the public good (Ruhl and Salzman 2007). These often focus on identifying and accepting typologies and units (Wallace 2007, Boyd and Banzhaf 2007, and Fisher et al. 2009, Daily 2000), providing insurance and liability for services (Gardner 2006), and increasing awareness of costs and benefits. Thus far, most efforts in resolving these issues in the marketplace have occurred through government intervention (Ruhl and Salzman 2007). Conservation programs, such as the CRP and those contained in the 2008 Farm Bill (Section 2709), have met many of these problems and offered viable solutions. Recently, private market mechanisms such as conservation easements held by land trusts, mitigation banking, eco-tourism, and eco-labeling have engaged landowners in ecosystem services markets. It is these tools that are most relevant and employed in this project, demonstrating the market allowances provided through their applications. This is important because, as stated by Kroeger and Casey (2007), “if the clientele for ecosystem services is going to expand beyond the public agency, then these agencies are going to have to play at least three roles: 1) to act as a repository of the services supplied; 2) to monitor that the marketplace is effective and equitable in meeting minimum product standards; and 3) to help facilitate the start-up of market-like approaches”. Organizations such as the Ecosystem Marketplace and the USFS OEM are attempting to provide such services and allow transactions to take place, as described under the premise of this project (Salzman 2006). With regard to the missing requirements for market proliferation and ecological benefits, Kroeger and Casey (2007) concluded, "if these requirements are fulfilled, market-based approaches and the private awareness, initiative and capital they can mobilize may play an important part in overall ecosystem service conservation efforts".

Costs or other management restrictions such as conservation easements or perpetual deed restrictions were not addressed in this project. Costs were not considered because the goal of this project was to evaluate potential revenue streams generated from ecosystem services markets. Additionally, ecosystem services management costs are highly variable, dependent on spatial factors, and are subject to institutional properties and restraints. This was stated by Wear (1996) as, "the plausibility of strategies for ecosystem management will clearly depend on their relative costs, upon site-specific conditions and goals, and upon institutional constraints and inertia". Furthermore, many ecosystem service management activities could be incorporated by existing staffs to minimize costs.

Conservation easements, or other perpetual deed restrictions, are another complex hurdle for ecosystem service market transactions. Most programs require perpetual restrictions to allow areas to be marketed, especially in the case of mitigation or conservation banks (ELI 2002); however, the role and validity of perpetuity has been debated (Jordan 1993, Merenlender et al. 2004). Merenlender (2004) states that, "some flexibility is necessary for a land-management regime" and, "conservation biologists should be concerned with the adequacy of the scientific and policy assumptions that underlie easement specifications" including perpetuity. This addresses the fact that ecosystems and species are dynamic in their roles and functions and that any agreements attempting to provide for them must also be dynamic. There is concern that easements and other perpetual restrictions may preclude better future adaptive management. Merenlender (2004) stated this as, "we might ask whether our scientific understanding of ecosystems and land management is adequate to prescribe legally binding management in perpetuity". Restrictions must be flexible, ensuring ecological functions, but still provide for future management unknowing of what that may be.

Many landowners, especially TIMOs and REITs, are wary of the negative effects to resale values of encumbered property (Kaderavek 2010). Just because the current landowner desires to merchandize the property's natural capital, does not mean future owners will have similar objectives and any restrictions on the property could hinder those differing objectives. Conversely, the restrictions provide much of the conservation value in the first place. Though benefits may be realized to surrounding properties, as these would be considered negative easements or restrictions (Morrisette 2001, Parker 2004), those values may or may not be captured by the landowner offering the restrictions. Related to this, any benefits received through the sale of an easement alone are not likely to offset the costs, including high transaction costs, of putting the easement in place. From the landowner's perspective, conservation values must be worth more than the development rights, or other rights foregone as part of the agreement (Smith et al. 2006). Typical incentives such as property tax benefits would be limited in many cases as land is already valued as agriculture and many factors influence federal tax incentives that may or may not be applicable to any sold easements, especially in the case of TIMOs and REITs. Additionally, in the case of TIMOs and REITs, these organizations have a profit motive and therefore are not as likely to enter into agreements that may negatively impact property values and not meet investor objectives.

Perpetual restrictions should also be considered in other parts of the landowner's decision-making process. Chee (2004), summarizing Fisher and Krutilla (1974), argued with regard to ecological actions, but also applying to economic considerations, "assuming perfect certainty about the cost and benefits of alternative actions, an activity which yields positive results in the short-run and negative thereafter, and which cannot be terminated should perhaps not be taken in the first place". He goes on to state that this coincides with the precautionary principle that "urges conservative policies and erring on the side of caution when faced with uncertainty and actions with irreversible consequences" (Goodland 1995). These factors and concerns all lead to very specific and specialized use of perpetual restrictions such as conservation easements and may totally inhibit larger scale availability of land to ecosystem service markets. These arguments provide further indications that any hesitance on the part of landowners to enter perpetual restrictions may not only be practical financially but also ecologically.

Concerning this project specifically, the ecosystem services offered increased revenues, in directly comparing pricing scenarios. Fiber revenues were the largest proportion of total values for both management schemes, but watershed services increased the ecosystem services management scenarios substantially. Particularly in the pessimistic pricing scenarios, watershed services played a significant role in providing additional revenue over the traditional management scheme (Figures 11 and 12). This demonstrates that even in poor markets asset diversification and exploring other opportunities can help landowners maintain revenue flows and increased profits. This could have special value in portfolio management through mitigating other market fluctuations, because the demand for watershed services is provided through legally required compensatory mitigation. That is, as other markets go through downturns from a lack of demand, watershed services would likely maintain demand and reduce the effects of lost revenues.

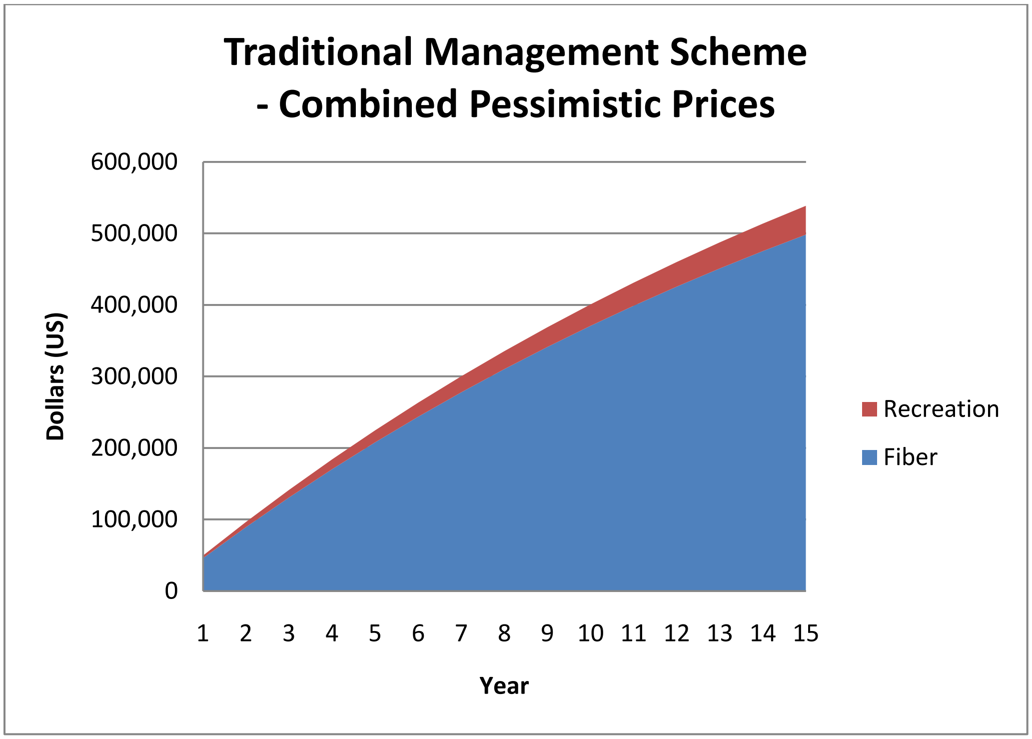

Figure 11. Total pessimistic values for the traditional management scheme

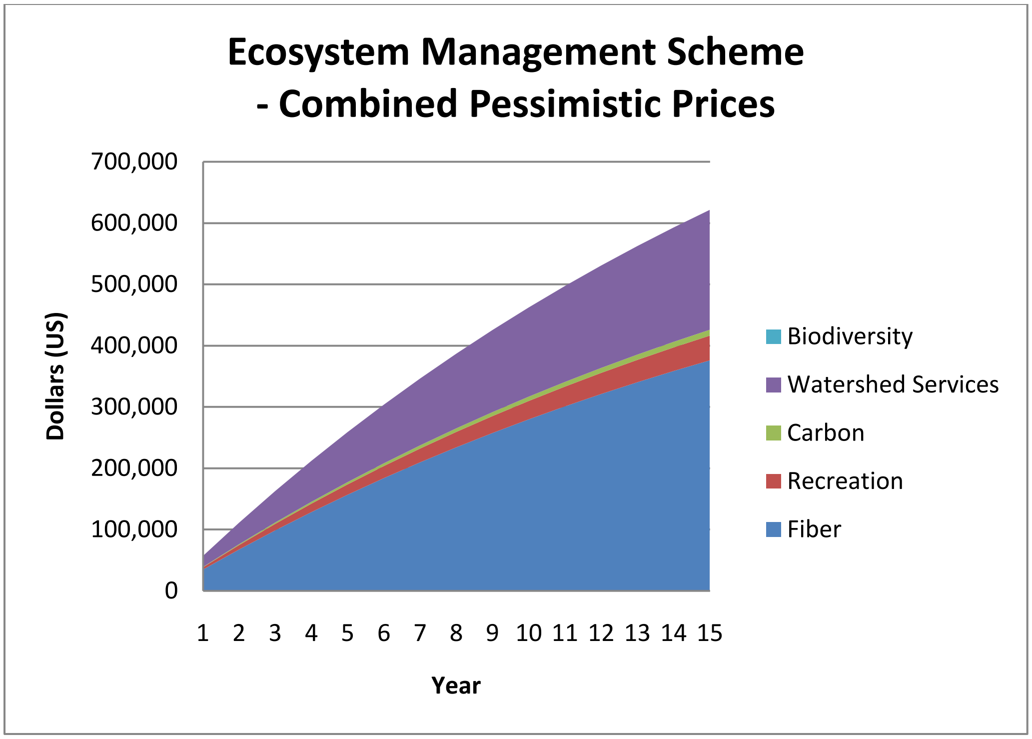

Figure 12. Total pessimistic values for the ecosystem services management scheme

This is further demonstrated by comparing the pessimistic pricing scenario of the ecosystem services management scheme (Figure 12) to that of the most likely scenario of the traditional management scheme (Figure 13). Though in this example the traditional management scheme expects the higher values in this comparison, the losses in a slumping market for the traditional services are greatly reduced as demonstrated when compared to the pessimistic pricing scenario. In other words, there is less downward mobility as market demand decreases, and as demonstrated by Figure 14 and the most likely pricing scenarios for the ecosystem services markets, there is significant opportunity in the current markets to increase revenue through ecosystem services management.

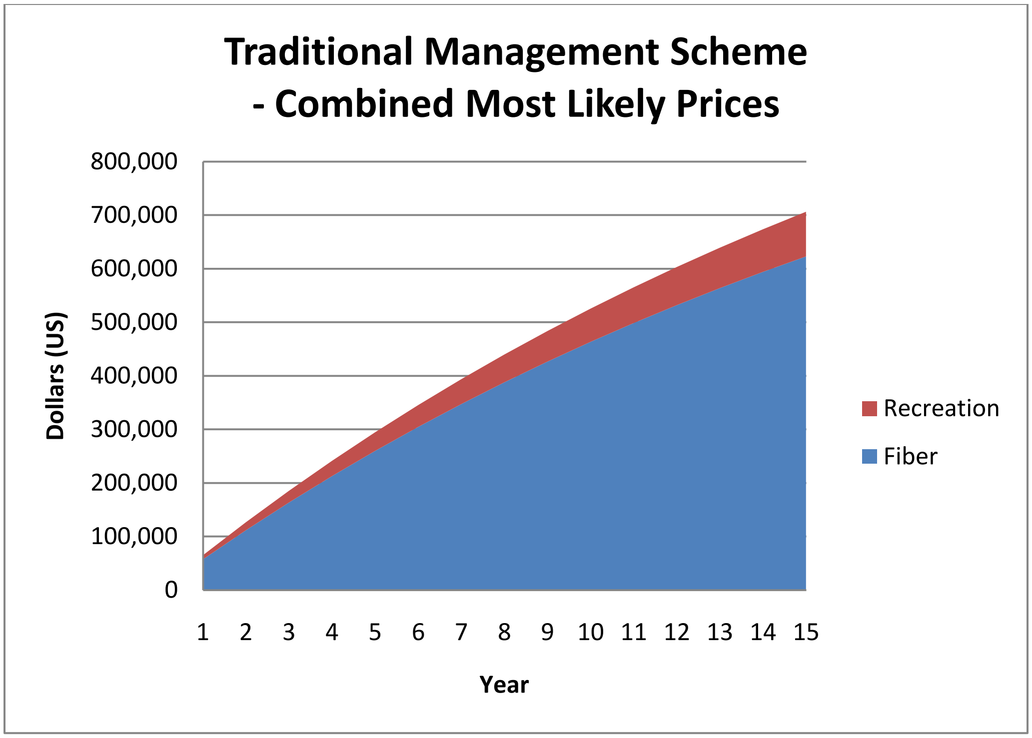

Figure 13. Total most likely values of the traditional management scheme

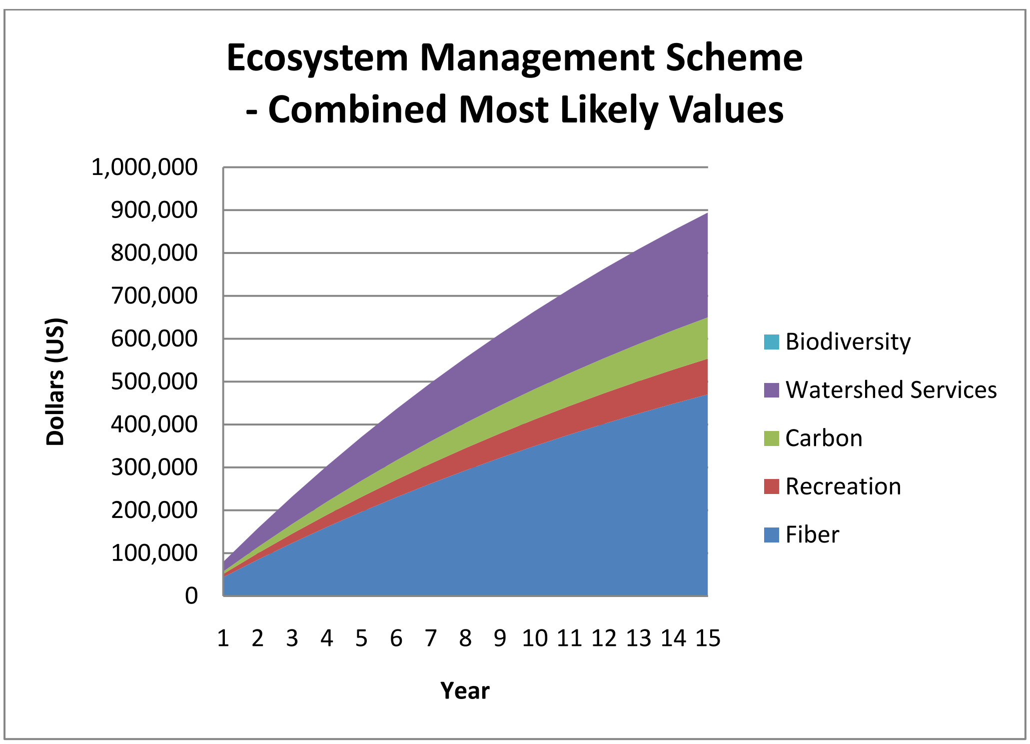

Figure 14. Total most likely values of the ecosystem services management scheme

In the optimistic pricing scenario, upper limits for revenues of the traditional management scheme were slightly more than $800,000 dollars (Figure 15); however, ecosystem services management scheme showed much greater opportunity for growth (Figure 16). For the ecosystem services management scheme, carbon sequestration provided a significant portion of the total value. Though voluntary carbon transactions have decreased substantially in the last few years, this pricing scenario only estimates that value at $4 per ton, which is well within the historical trading range and much less than many voluntary transactions (Hamilton et al. 2010). This demonstrates significant upward mobility for carbon sequestration with regard to position in a diverse portfolio and indicates good potential of management as markets stabilize. Additionally it demonstrates the upward mobility of ecosystem services management in general when compared to the optimistic pricing scenario of the traditional management scheme. Though the estimated prices of the optimistic scenario is much greater on all services than those currently observed, they are not outside of the range of potential prices and could be achieved under near future ownerships.

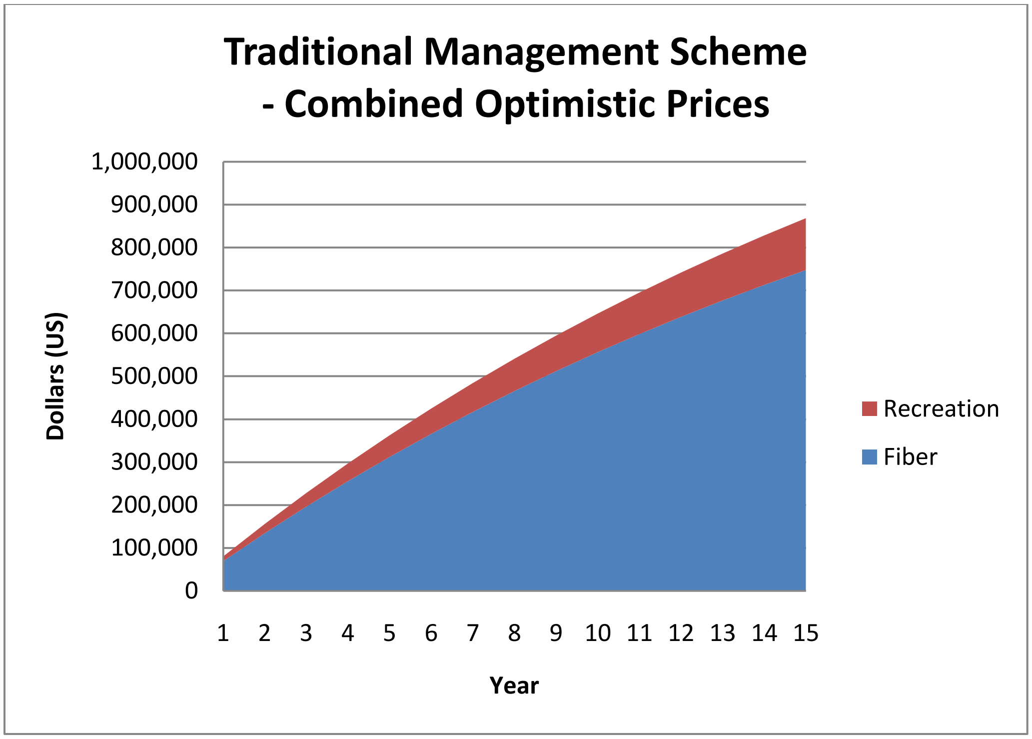

Figure 15. Total optimistic values for the traditional management scheme

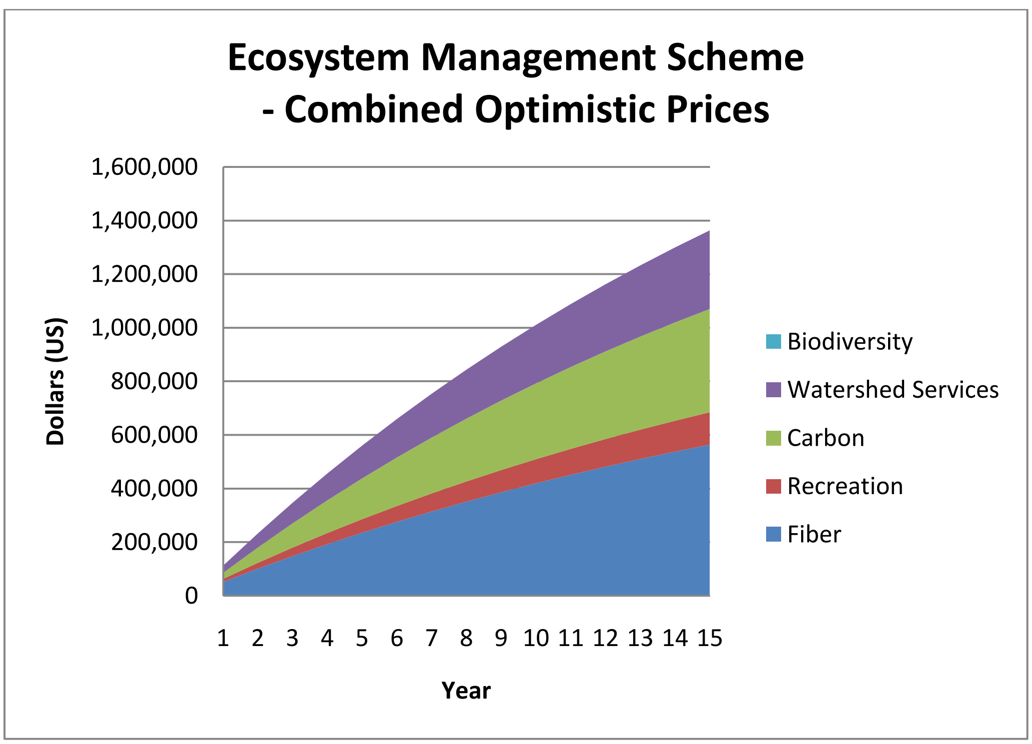

Figure 16. Total optimistic values for the ecosystem services management scheme

Other changes, such as the inclusion of other parties in decisions, would be required in changing management schemes if a landowner manages for ecosystem service markets. However, these changes could be minimized. Initial setup of any mitigation or conservation bank would represent a significant cost in time and money. Even with adequate demand from mining operations, road construction, or other development, developing consensus among operators, regulators, and agency officials would present a significant challenge. Additionally, a third party would likely be necessary to broker any deals and provide insurance that ecological requirements are being met through continued long-term monitoring. These concerns have been well stated by Merenlender (2004) and others.

On-the-ground management would not likely experience any significant change, especially in fiber and recreation services, in adopting an ecosystem services management scheme. Areas that were under some other market, for example riparian corridors, would not experience management such as timber harvests in the fiber program, but in most cases a large portion of them would not have fiber harvests anyway due to forest certification. Any differences in overall values, as highlighted in this project, would be greatly expanded if compared to a non-certified operation. Management that is not certified as sustainable does not have the additional restrictions of most certification organizations and therefore a larger departure in values would be expected. Already in this case the landowner is experiencing some of those cost in providing for eco-labeling and sustainable forest management. Methods such as species focal management, variable retention harvesting, and high conservation value forests (as outlined by Brown 2001 and Franklin 1999), that are a part of current trends and requirements of sustainable forest management, would minimize the effect of ecosystem service market applications on current practices. Additionally, many of these areas are already unlikely to provide harvest opportunities due to limited operability, safety concerns, or other factors. Ecosystem service markets may allow a landowner to recover some of the costs required to maintain third party certification and areas of limited traditional management opportunities.

These methods could be further expanded in terms of enrolled areas, providing more area to manage for ecosystem services markets. In this example, areas along roads or with public safety concerns were removed from fiber production and placed under carbon sequestration management but there are many other areas where this could take place. Areas of low or extremely marginal productivity could have their planned rotation lengths increased and use additionality to market carbon. Watershed services markets could be expanded to include intermittent streams, and depending on policy shifts, may in the future be able to include ephemerals. Biodiversity acres, that are currently given no value could be enhanced to cater to particular species included TESOC such as Cerulean warbler (*Dendroica cerulean*) or desirable game species such as Bobwhite quail (*Colinus virginianus*). Once the methods of defining areas and placing them in ecosystem service markets become established, additional opportunities such as these and others will likely become apparent.

Additional requirements of monitoring and accounting could be added and would represent substantial cost, especially in the case of monitoring banking sites. This monitoring would likely be performed by a third party and in the case of water quality especially, can be quite significant in its requirements (Barbour 1999, Kondolf 1995, VDEQ 2007, VDEQ 2008). Accounting for carbon sequestration and other forest quality variables could likely be captured without significant additional costs if performed during standard forest inventories already conducted every 3 to 5 years.

The results of this project demonstrate the potential for additional revenues in comparing a traditional management scheme with that of an ecosystem services management scheme. These values are based on only the returns to the landowners if such services were marketed and are highly speculative. In this example, the value of changing property management schemes provided an additional $187,789.95 for the mostly likely pricing scenario. This is a 26.6 percent increase in value over the traditional scenario; however, the additional costs, administrative and otherwise, were not analyzed. This additional approximate $188,000 is gains on less than 4,000 acres. If this type of comparison was made on a larger scale, for example an entire property ownership of 150,000 acres or more, the additional returns would be much larger and the per unit administrative costs would likely diminish. If this scale was further expanded to include an entire holding of a typical TIMO or REIT of 2-3 million acres, the value becomes even more apparent. While applications of ecosystem services management schemes would not be appropriate everywhere, careful selections of sites and properties and incorporation with traditional management could greatly increase portfolio values.

The effects of incorporating ecosystem management into large land holdings would have other benefits and values not realized by the landowner but rather by the public. This is the classic value of ecosystems services and it is likely that values will increase as services become scarcer due to human development and expansion. As ecosystem services markets continue to become established and landowners can realize values, more owners are likely to offer ecosystem services and promote basic ecosystem and human health. These benefits and additional values of these services are outside of the market values, as estimated here, and would be realized by the surrounding communities, landowners, and regions. Additionally, any values added to land open opportunities for landowners and in the case of large land-bases could further insure their continuance providing services for the public good. This is the full expression of ecosystem health and services value to market growth potential.

Conclusion

Ecosystems and the benefits they provide are essential for human health and viable communities. Yet humans are exploiting and threatening those resources at increasing rates. The values of their resources are often overlooked and taken for granted, but as they become scarcer, the values will increase and become more apparent. It will likely take an assortment of methods to allow for human growth and development while still maintaining ecosystem health and market solutions have been promoted as one such method using ecosystem services as natural capital. There is much work that must be accomplished in order for markets to succeed, however markets are being established and transactions are occurring. Though much public land is secured to provide these services, public land alone will not be enough. There must be mechanisms to encourage and promote ecosystem management on private land and service markets have potential to contribute should they prove profitable. Current land ownership patterns place large holdings of private land, often in productive areas, under owners accustomed to managing natural capital. Direct market valuations, such as this project, are valuable in demonstrating the values of this natural capital in ecosystem service markets to landowners and policy makers who may help bring markets to a functioning scale. A direct market valuation does not provide the full value of ecosystem services (e.g. those in the public good) but only reflects a value in the markets to the landowner or seller. This project demonstrates that ecosystem services management and marketing are viable alternatives to traditional management and may offer opportunities for additional revenues and benefits to landowners and the public good currently and in the future.

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Appendix

Table 8. Annualized values for fiber services of the traditional management scheme

Fiber			
Year	Price per MBF (all values with a 5% discount rate)		
	$100	$125	$150
1	45,731.43	57,164.29	68,597.14
2	43,553.74	54,442.18	65,330.61
3	41,479.75	51,849.69	62,219.63
4	39,504.53	49,380.66	59,256.79
5	37,623.36	47,029.20	56,435.04
6	35,831.77	44,789.71	53,747.66
7	34,125.50	42,656.87	51,188.24
8	32,500.47	40,625.59	48,750.71
9	30,952.83	38,691.04	46,429.25
10	29,478.89	36,848.61	44,218.33
11	28,075.13	35,093.91	42,112.70
12	26,738.22	33,422.77	40,107.33
13	25,464.97	31,831.21	38,197.46
14	24,252.35	30,315.44	36,378.53
15	23,097.48	28,871.85	34,646.22
Total	**498,410.42**	**623,013.02**	**747,615.63**

Table 9. Annualized values for recreation services of the traditional management scheme

Recreation			
Year	Price per acre (all values with a 5% discount rate)		
	$1	$2.07	$3
1	3,698.10	7,655.06	11,094.29
2	3,522.00	7,290.53	10,565.99
3	3,354.28	6,943.36	10,062.84
4	3,194.55	6,612.73	9,583.66
5	3,042.43	6,297.83	9,127.30
6	2,897.55	5,997.94	8,692.66
7	2,759.58	5,712.32	8,278.73
8	2,628.17	5,440.31	7,884.50
9	2,503.02	5,181.24	7,509.05
10	2,383.83	4,934.52	7,151.48
11	2,270.31	4,699.54	6,810.93
12	2,162.20	4,475.75	6,486.60
13	2,059.24	4,262.62	6,177.71
14	1,961.18	4,059.64	5,883.54
15	1,867.79	3,866.32	5,603.37
Total	**40,304.21**	**83,429.72**	**120,912.64**

Table 10. Total annualized values of the traditional management scheme

Traditional Management Scheme			
Year	Total Values ($) (all values with a 5% discount rate)		
	Pessimistic	Most likely	Optimistic
1	49,429.52	64,819.34	79,691.43
2	47,075.74	61,732.71	75,896.60
3	44,834.04	58,793.05	72,282.47
4	42,699.08	55,993.39	68,840.45
5	40,665.79	53,327.03	65,562.34
6	38,729.33	50,787.65	62,440.32
7	36,885.07	48,369.19	59,466.97
8	35,128.64	46,065.90	56,635.21
9	33,455.85	43,872.28	53,938.30
10	31,862.71	41,783.13	51,369.81
11	30,345.44	39,793.45	48,923.62
12	28,900.42	37,898.53	46,593.93
13	27,524.21	36,093.84	44,375.17
14	26,213.53	34,375.08	42,262.07
15	24,965.27	32,738.17	40,249.59
Total	**538,714.63**	**706,442.74**	**868,528.27**

Table 11. Annualized values for fiber services of the ecosystem services management scheme

Fiber			
Year	Price per MBF (all values with a 5% discount rate)		
	$100	$125	$150
1	34,499.05	43,123.81	51,748.57
2	32,856.24	41,070.29	49,284.35
3	31,291.65	39,114.57	46,937.48
4	29,801.57	37,251.97	44,702.36
5	28,382.45	35,478.06	42,573.68
6	27,030.91	33,788.63	40,546.36
7	25,743.72	32,179.65	38,615.58
8	24,517.83	30,647.29	36,776.74
9	23,350.31	29,187.89	35,025.47
10	22,238.39	27,797.99	33,357.59
11	21,179.42	26,474.28	31,769.13
12	20,170.88	25,213.60	30,256.32
13	19,210.36	24,012.95	28,815.54
14	18,295.58	22,869.48	27,443.37
15	17,424.36	21,780.45	26,136.55
Total	**375,992.73**	**469,990.92**	**563,989.10**

Table 12. Annualized values for recreation services of the ecosystem services management scheme

Recreation			
Year	Price per acre (all values with a 5% discount rate)		
	$1	$2.07	$3
1	3,698.10	7,655.06	11,094.29
2	3,522.00	7,290.53	10,565.99
3	3,354.28	6,943.36	10,062.84
4	3,194.55	6,612.73	9,583.66
5	3,042.43	6,297.83	9,127.30
6	2,897.55	5,997.94	8,692.66
7	2,759.58	5,712.32	8,278.73
8	2,628.17	5,440.31	7,884.50
9	2,503.02	5,181.24	7,509.05
10	2,383.83	4,934.52	7,151.48
11	2,270.31	4,699.54	6,810.93
12	2,162.20	4,475.75	6,486.60
13	2,059.24	4,262.62	6,177.71
14	1,961.18	4,059.64	5,883.54
15	1,867.79	3,866.32	5,603.37
Total	**40,304.21**	**83,429.72**	**120,912.64**

Table 13. Annualized values for carbon services of the ecosystem management scheme

Carbon			
Year	Price per ton (all values with a 5% discount rate)		
	$0.10	$1	$4
1	552.35	5,523.49	22,093.97
2	873.78	8,737.75	34,951.01
3	832.17	8,321.67	33,286.68
4	792.54	7,925.40	31,701.60
5	754.80	7,548.00	30,192.00
6	718.86	7,188.57	28,754.29
7	684.63	6,846.26	27,385.03
8	652.02	6,520.25	26,080.99
9	620.98	6,209.76	24,839.03
10	591.41	5,914.06	23,656.22
11	563.24	5,632.43	22,529.74
12	536.42	5,364.22	21,456.89
13	510.88	5,108.78	20,435.13
14	486.55	4,865.51	19,462.03
15	463.38	4,633.82	18,535.27
Total	**9,634.00**	**96,339.97**	**385,359.89**

Table 14. Annualized values for watershed services of the ecosystem management scheme

Watershed			
Year	Price per linear foot (all values with a 5% discount rate)		
	$20	$25	$30
1	17,945.14	22,431.43	26,917.71
2	17,090.61	21,363.27	25,635.92
3	16,276.77	20,345.97	24,415.16
4	15,501.69	19,377.11	23,252.53
5	14,763.51	18,454.39	22,145.27
6	14,060.49	17,575.61	21,090.73
7	13,390.94	16,738.68	20,086.41
8	12,753.28	15,941.60	19,129.92
9	12,145.98	15,182.47	18,218.97
10	11,567.60	14,459.50	17,351.40
11	11,016.76	13,770.95	16,525.14
12	10,492.15	13,115.19	15,738.23
13	9,992.53	12,490.66	14,988.79
14	9,516.69	11,895.87	14,275.04
15	9,063.52	11,329.40	13,595.27
Total	**195,577.67**	**244,472.09**	**293,366.50**

Table 15. Annualized values for biodiversity services of the ecosystem management scheme

Biodiversity			
Year	Price per unit (all values with a 5% discount rate)		
	$0	$0	$0
1	-	-	-
2	-	-	-
3	-	-	-
4	-	-	-
5	-	-	-
6	-	-	-
7	-	-	-
8	-	-	-
9	-	-	-
10	-	-	-
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
15	-	-	-
Total	**0.00**	**0.00**	**0.00**

Table 16. Total annualized values of the ecosystem services management scheme

Ecosystem Services Management Scheme			
Year	Total Values ($) (all prices with a 5% discount rate)		
	Pessimistic	Most likely	Optimistic
1	56,694.63	78,733.79	111,854.54
2	54,342.62	78,461.84	120,437.27
3	51,754.88	74,725.57	114,702.16
4	49,290.36	71,167.21	109,240.16
5	46,943.20	67,778.29	104,038.24
6	44,707.81	64,550.75	99,084.04
7	42,578.86	61,476.91	94,365.75
8	40,551.30	58,549.44	89,872.15
9	38,620.28	55,761.37	85,592.52
10	36,781.22	53,106.06	81,516.69
11	35,029.74	50,577.20	77,634.94
12	33,361.65	48,168.77	73,938.04
13	31,773.00	45,875.02	70,417.18
14	30,260.00	43,690.49	67,063.98
15	28,819.05	41,609.99	63,870.46
Total	**621,508.61**	**894,232.69**	**1,363,628.13**

Vita

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