UNDERSTANDING PRIVATE FOREST OWNER PARTICIPATION IN FUTURE CARBON OFFSET PROGRAMS IN THE CATSKILLS REGION: A CONTINGENT VALUATION APPROACH

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Derek Phillip Stenclik

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ABSTRACT

Forest carbon sequestration and storage is increasingly being considered as an attractive climate change mitigation strategy across the Northeast, the United States and the world. Recent research indicates that a significant percentage of U.S. reductions in carbon emissions could be achieved through improved forest management at costs competitive to other mitigation strategies and technologies. Given that the majority of forestland throughout the country is owned by many diverse private forest landowners, the success or failure of forest carbon management programs may depend on the willingness of these landowners to participate in voluntary carbon offset programs. The goal of this thesis is to provide a better understanding of future landowner participation in forest management programs specifically targeting carbon benefits. Using a mail survey of 1,200 landowners in the Catskills region of New York State, a landowner's willingness to accept incentive payments in return for improved forest management is determined using a contingent valuation approach. The landowner's utility-maximizing participation decision is estimated using a logit econometric model. Results of this study indicate that there is a strong interest among a broad spectrum of landowners for forest management, especially among those concerned with climate change issues. Participation rates ranged from 30 percent at relatively low incentive payment offers to 85 percent at high incentive payment offers. The median incentive payment necessary to induce participation is between \$14 and \$19 per acre, per year. The participation decision is influenced by the amount of incentive payment offered, property size, different ownership objectives, attitudes towards climate change issues and political orientation. These results indicate that forest management could be an efficient and effective climate change mitigation policy in the Catskills region of New York State, and possibly beyond.

BIOGRAPHICAL SKETCH

Derek Stenclik is originally from Rochester, NY and attended the State University of New York, College at Geneseo between 2005 and 2009 where he graduated Summa Cum Laude and Phi Beta Kappa with a major in International Relations. Upon completion of his undergraduate degree he enrolled in Cornell University's Department of Applied Economics and Management for a Master of Science degree. During this time he focused his efforts in the field of Environmental and Resource Economics. From August to December 2010 he held an internship with the New York State Department of Environmental Conservation and New York State Energy Research and Development Agency where he provided support and economic analysis for New York's 2010 Climate Action Plan. In January 2011, Derek began a career with the Power Economics group of GE Energy Consulting in Schenectady, NY. In this role he conducts economic analyses on domestic and international electricity markets.

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LIST OF ABBREVIATIONS

ACR	American Climate Registry
CAR	Climate Action Reserve
CCX	Chicago Climate Exchange
CO_2	Carbon Dioxide
CV	Contingent Valuation
EFA	Exploratory Factor Analysis
FAQs	Frequently Asked Questions
GHG	Greenhouse Gas
IFM	Improved Forest Management
IPCC	Intergovernmental Panel on Climate Change
MGGRA	Midwestern Greenhouse Gas Reduction Accord
MtC/ac	Metric tons of carbon per acre
NIPF(L)	Nonindustrial Private Forest (Landowners)
RGGI	Regional Greenhouse Gas Initiative
UNFCCC	United Nations Framework Convention on Climate Change
VCS	Voluntary Carbon Standard
VIF	Variation Inflation Factor
WAC	Watershed Agricultural Council
WCI	Western Climate Initiative
WTA	Willingness to Accept

CHAPTER 1

INTRODUCTION

Climate change mitigation strategies have increasingly sought innovative policy solutions to help decrease greenhouse gas emissions (GHGs) and to reduce atmospheric CO_2 concentrations. One approach being widely considered is increasing forest carbon sequestration and storage across the world's forest ecosystems. Forests naturally store carbon in aboveground biomass, soils and wood products. Terrestrial carbon sinks, estimated at nearly 10 billion acres globally and comprising 30 percent of the earth's landmass, hold more than double the amount of carbon currently in the atmosphere (Canadell and Raupach, 2008). Yet, there is still a large potential to increase the rate of forest carbon sequestration and enhance the benefits these ecosystems provide. Recent research indicates that a large percentage of U.S. reductions in CO_2 could be achieved cost effectively through forest carbon sequestration and improved forest management. One estimate is that 500 million tons of carbon per year, amounting to fully one-third of U.S. emissions, could be sequestered at costs similar to those of other mitigation strategies (Stavins and Richards, 2005).

Despite these benefits, forests can also be a liability to climate change mitigation efforts. For example, nearly 20 percent of all CO_2 emissions globally arise from deforestation and land conversion (Canadell and Raupach, 2005). Although this occurs almost entirely outside the United States, increased forest fragmentation, parcelization and urbanization threaten to change the role of U.S. forests in climate change mitigation policies. Recent reports have found that sequestration rates across the country are declining and net sequestration is likely to decline to zero by the year 2100 under a "business as usual" approach (Maness, 2009). This is largely because recent gains in forest cover and sequestration rates were the result of reforestation projects on marginal agricultural lands, much of which had previously undergone deforestation in the settlement period. During the 1930s in New York State, for example, years of drought and the onset of the Great Depression caused much of the State's agricultural land to be abandoned. Since then, forest cover throughout the state has recovered significantly. However, unfortunately for climate change mitigation efforts, very little marginal agricultural land remains for future reforestation projects (Department of Environmental Conservation, 2010). Thus a valuable asset to climate change mitigation efforts may be lost. In addition, an already changing climate throughout the United States could drastically alter forest ecosystems. If this were to occur – whether from changing weather patterns or the effects of pests and invasive species – vast quantities of stored carbon could be released into the atmosphere.

The negative feedback loops stemming from climate change, decreasing rates of carbon sequestration, and increasing threats of land conversion together create uncertainty about the role of U.S. forests in climate change policy. Policymakers and the forest industry cannot take for granted that forests across the U.S. will forever provide climate benefits. Improved forest management techniques are available to help preserve existing carbon stocks and to increase the rate of carbon sequestration above naturally occurring levels. By decreasing harvest volumes, lengthening harvest rotations, maintaining appropriate stand volume and promoting general forest health, rates of carbon sequestration can be increased by one to three tons of additional carbon per acre, per year (Stavins and Richards, 2005; Congressional Budget Office, 2007; Hoover and Stout, 2007; Perschel et al., 2007; Fletcher et al., 2009). Therefore, the forestry sector should be included in any comprehensive energy and climate policy in order to achieve increased, socially optimal levels of carbon sequestration and storage. Recognizing the continuing demand for wood products, this should be done while simultaneously allowing for the forest product industry to maintain its economic competitiveness and viability. In order to safeguard existing carbon stocks, policies should also support healthier forests and adaptation policies that will make forests more resilient to a changing climate. Fortunately, improved forest management has become an integral piece of the discussion and negotiations in climate policy at the global, national, regional, and local levels.

Policy mechanisms proposed to achieve these GHG reductions vary widely. For example, command and control policies can use rules, regulations and restrictions to decrease emissions from some sources. The government can mandate minimum building codes for energy efficiency, impose fuel mileage standards on new cars being produced, or in the case of forestry, limit the allowable size and regularity of timber harvests. However, the economics literature has found that command and control policies often lead to inefficient use of resources to achieve social benefits (Perman et al., 2003). This inefficiency is a result of imperfect knowledge by regulators and uniformly applied standards that do not take into account the costs of pollution abatement at an individual firm or polluter level.

Therefore, the use of market mechanisms to curb emissions is becoming increasingly popular. For example, a carbon tax levied on a ton of carbon emissions would increase the price of carbon-intensive activities and allow firms and individuals to find cost-effective ways to reduce their energy consumption. Another market mechanism available to policy makers is a cap-and-trade program. Under a cap-and-trade system, a limit is set on carbon emissions across an entire sector of the economy and emitters of carbon are required to have a permit for each ton of carbon they emit. Firms are then able to trade permits amongst one another to comply with the regulated cap. The forestry sector could participate in this type of program by providing carbon offsets. A carbon offset is generated for each ton of carbon removed from the atmosphere.

Polluting firms would then have the option of reducing their own emissions or purchasing a carbon offset from a forest landowner. As a result, carbon becomes a tradable commodity and a market for CO_2 emissions and offsets is created (Perman et al., 2003; Stavins and Richards, 2005). With a cap-and-trade system, landowners who own forested land would have the right to sell additional carbon sequestered on their property through a credit and offset system.

Finally, the government has the option to provide subsidies for techniques or technologies that reduce carbon emissions or decrease energy consumption. In the case of forestry, one option for the government is to subsidize forest carbon sequestration through better forest management. Rather than using taxes to limit poor management activities, incentive payments would promote better forest management and increased carbon sequestration and storage. Instead of allowing the free market to set the price for carbon offsets, a fixed price would be set by the government program and paid to landowners directly. Landowners would then decide whether or not they want to participate or not at the fixed price. Both the forestry and agricultural sectors have a long history of government policies subsidizing improved land management practices and techniques (Kline et al., 2000; Langpap, 2004; LaPierre and Germain, 2005). Regardless of the mechanism used, it is clear that forest landowners have the potential to play a pivotal role in future climate mitigation.

Currently, New York State is drafting a comprehensive Climate Action Plan that includes new policies designed to help achieve the State's climate goals of an 80 percent reduction in greenhouse gases by 2050. This multi-sectoral approach includes forestry as a key policy arena to achieve GHG reductions. For example, Agriculture, Forestry and Waste Policy #7 specifically targets improved forest management as a relevant mitigation policy. The policy calls for (New York State Climate Action Council, 2010):

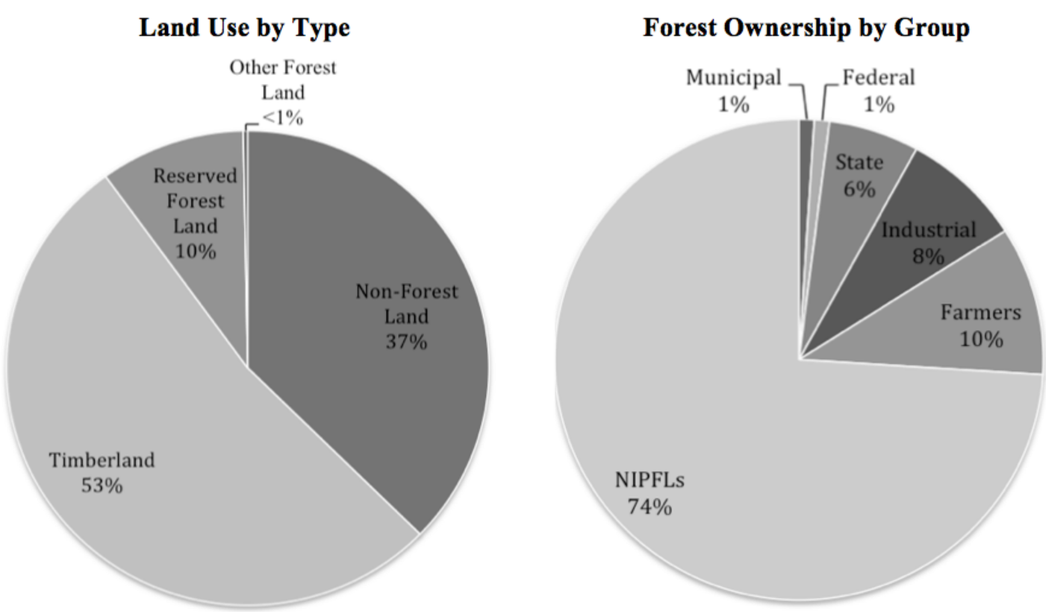
> *"managing forests to optimum stocking levels; developing management plans that increase forest productivity, health and benefits while simultaneously increasing the rate and levels of carbon sequestration; and maintaining the health and longevity of existing trees by supporting prevention, early detection and rapid response to invasive and destructive pests."*

According to the Climate Action Plan, forest restoration has the potential to sequester 49 million metric tons of carbon in New York State by 2030, at a cost-effective price of six dollars per metric ton. This represents only one local example of new forest management policies being considered around the world. Similar approaches are also being contemplated within the highest policy circles at the national and international levels.

Unlike other mitigation strategies, such as a carbon tax or cap-and-trade program that deal with reducing emissions from a relatively small number of upstream sources, carbon programs in the U.S. forestry sector would need to be implemented across a large number of private forest landowners. As a result, programs would need to effectively reach out to a large, diverse set of landowners, many of whom have very different land management objectives. Although previous research has attempted to quantify the potential for carbon reductions through better forest management, there is a significant lack of understanding about whether or not landowners would be willing to participate in future carbon management programs. Even less is understood about the potential payments necessary to change the behavior or decision-making of private forest landowners to engage in management practices specifically targeting increased carbon sequestration and storage. This study attempts to estimate potential future landowner enrollment in carbon management programs and to understand the level of incentive payments required for forest landowners to manage their land particularly for carbon benefits.

Understanding the motives and the decisions that nonindustrial private forest landowners (NIPFLs) make is an important and often-researched area of forest economics. Of the 620 million acres of forested land across the U.S., two-thirds is owned privately. Due to early settlement, this proportion is much larger throughout the East, where private owners represent over 80 percent of forest ownership (Butler and Leatherberry, 2004). Among this type of ownership, small private family forests under 50 acres are most common. In addition, the majority of timber harvests within the United States also originate from these NIPFLs rather than traditional industrial timber companies. New York State has more forested land than any other Northeastern state. Throughout the state, 18.5 million acres of forests cover 64 percent of the land. Although the Adirondack, Catskill and other State Parks include 3 million acres of public land, the other 84 percent of forested land is privately owned. Overall, nonindustrial private forest landowners in New York State own 13.2 million acres of forested land whereas industrial landowners own only 700,000 acres (New York State Department of Environmental Conservation, 2010). Figure 1 provides a breakdown of land ownership across New York State. This includes both the state's land use by type and forest ownership by group.

Figure 1: Summary of Land Use in New York State



Source: New York State Department of Environmental Conservation (2010)

A necessary precursor to good forest and climate policy is a better understanding of the incentive payments necessary for forest landowners to participate in improved carbon management programs. An important aspect of this is also a better understanding of the characteristics, objectives, attitudes, and motivations of a diverse group of NIPF landowners throughout New York State and the country. This is often made difficult due to the large number of landowners involved, heterogeneous objectives, diverse demographics, and geographic dispersion. Making matters even more complex, private forest landowners often base their economic decisions on non-timber values, such as aesthetics, recreation and wildlife related objectives, in addition to timber production (Amacher et al., 2003). As a result, landowners often respond to markets and incentives in unpredictable, and sometimes contradictory, ways (Kline et al., 2000).

Not only are landowner motivations and attitudes difficult to understand, but forestry issues and trends are also in constant flux. For instance, the forest landowner population is aging and the future of their properties is uncertain. Due to turnover in land ownership, it is likely that the next couple of decades will bring major and uncertain changes in forest ownership (Birch and Butler, 2001). For instance, the parcelization of large tracts of forestland into many smaller properties is increasingly common. As a result, average property size across the state is steadily decreasing, which is often a precursor to increased development and land use change (LaPierre and Germain, 2005; Kay and Bills, 2007; Davis and Fly, 2010). Forest parcelization also increases the difficulty in actively managing forest stands. Finally, because the number of leases for timber harvesting on public lands have decreased in recent years and the demand for wood products continues to increase, there is additional need for private forest landowners to supply an even greater share of the timber supply (Beach et al., 2005). This may result in increased timber harvests in the Northeast, although much of this demand is likely to be met from the Southeast and abroad due to lower opportunity costs of land, faster growing trees, lower labor costs, and less stringent environmental regulations.

With a diverse landowner base and an evolving forestry industry, there is a need to better understand the factors influencing landowner decision-making and to determine how private forest landowners may respond to, and participate in, incentive programs. This is especially true for improved forest management and climate change policy. Although there is a long history of research on landowner incentive program participation and harvesting decisions, landowners who would participate in an incentive program specific to climate change may respond differently than to other programs already investigated in the research literature (Langpap, 2004). As a result, there is a need to investigate NIPFL willingness to participate in a climate change mitigation program similar to those being discussed in the regional, national, and international policy arenas. In light of this need, this study attempts to provide an exploratory analysis of potential future landowner participation in carbon management programs.

Using a mail survey of 1,200 landowners in the Catskills region of New York, this study attempts to gain a better understanding of landowners' willingness to participate in carbon management programs, their perceptions of climate change and forest management, the reasons they own their forested land, and future plans for their forests. This survey will provide policymakers with information about the types of landowners most likely to participate, the incentives needed to induce participation, and the barriers limiting further participation. This thesis thus attempts to provide essential information that will be useful during the future development of New York State and national policies seeking to efficiently promote increased forest carbon sequestration. The specific goals of this study thus are: 1) to determine NIPFL willingness to participate in an improved forest management program that generates carbon sequestration benefits; 2) to identify key property and demographic variables that may influence that participation; and 3) estimate a supply curve for forest carbon sequestration within the Catskills region of New York State that provides a comparison with other mitigation options with respect to cost and efficiency.

Chapter 2 provides a review of relevant literature on forest climate mitigation, improved forest management, carbon-offset programs and prior surveys of nonindustrial private forest landowners. Chapter 3 describes the methods used in this study, including the geographic scope, survey instrument design, landowner sampling, and an overview of the data collected from the survey. The following chapter (Chapter 4) provides the theoretical and econometric models used to analyze survey responses and estimate landowners' willingness to accept payments for participation in a carbon storage program. Following the modeling section, the econometric results are provided in Chapter 5. The paper then concludes with a discussion of policy implications, study limitations and suggestions for future research in Chapter 6.

CHAPTER 2

LITERATURE REVIEW

A wide variety of research on forest carbon sequestration has been conducted over the past decade as the future potential of forest carbon management and policy becomes more apparent. This research has focused on both the science of forest carbon sequestration as well as economic decision-making and policy development surrounding this issue. When combined with the previous literature pertaining to nonindustrial private forest landowners, valuable conclusions can be drawn that are relevant to the analysis conducted in this study.

2.1 Forest Management as a Mitigation Option

Although the exact impacts of climate change are still shrouded in debate and uncertainty, there is a general consensus forming that is evident from the most recent Intergovernmental Panel and Climate Change (IPCC) report (2007). This consensus includes several points: 1) warming of the climate system is unequivocal; 2) most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropocentric greenhouse gas emissions; and 3) actions taken today to mitigate greenhouse gas emissions and reduce the growth of atmospheric CO_2 concentrations will be much more efficient than delaying action into the future. Although some warming is inevitable due to climatic inertia, many climate scientists believe that the success of climate mitigation strategies will ultimately determine whether or not future climate changes would be below a threshold that allows the human and natural environments to adapt, or will result in climate changes that permanently alter the planet's ecosystems. The goal of many policymakers around the world is to identify and implement effective and efficient strategies that stabilize greenhouse gas emissions at levels that avoid these significant and detrimental problems.

Although the level of this threshold is debated, a scientific consensus on the causes and outcomes of climate change is increasingly growing. As a result, policymakers are now seeking innovative, viable and efficient solutions to combat climate change.

There are a variety of options to mitigate the effect of carbon on the earth's atmosphere, ranging from natural to technological solutions. The most common mitigation strategies proposed are ones that focus on decreasing the amount of fossil fuels being burned for energy. When coupled with dramatic energy efficiency programs that conserve energy use, there is a large potential to decrease further GHG emissions and reduce the impact of climate change (New York State Climate Action Council, 2010). A second approach to climate change mitigation is to remove some of the carbon already present in the atmosphere through carbon sequestration. This will likely be achieved either in the form of technological sequestration or natural sequestration. Technological sequestration removes carbon, for example, from a power plant's emissions or directly from the atmosphere and stores it permanently in underground reserves. Natural sequestration uses the biological process of photosynthesis to store carbon in plant matter, biomass and durable wood products (Congressional Budget Office, 2007; Perschel et al., 2007). In order to achieve mitigation goals and to decrease the impact of climate changes, many scientists argue that a wide variety of these strategies need to be implemented simultaneously.

Forest carbon sequestration provides an often-overlooked mitigation tool to reduce carbon emissions and atmospheric concentrations. Forest and tree growth naturally sequester and store carbon in aboveground biomass, soils and durable wood products. Forests around the world already store vast quantities of carbon. As previously mentioned, terrestrial carbon sinks currently hold more than double the amount of carbon in the atmosphere (Canadell and Raupach, 2008). In the United States, the current carbon stock in forests amounts to approximately 41 billion metric tons. This is equal to nearly 25 years of U.S. emissions at 2006 levels (Maness, 2009). As forests grow, they continue to sequester additional amounts of carbon. At a global scale, it is estimated that 2.7 – 3.1 billion tons of carbon are sequestered annually (Woodbury et al., 2007). This represents about ten percent of the world's annual CO_2 emissions, which were estimated at 30.3 billion tons of per year in 2009 (United States Energy Information Administration, 2011). In the United States, forests currently sequester 200 million tons of carbon annually, amounting to about five percent of annual emissions from the consumption of energy (Ruddell et al., 2007; United States Energy Information Administration, 2011). Although already an effective form of carbon sequestration, managing forests for climate change mitigation could be increased dramatically and cost-effectively.

Increased climate benefits from forestry can be achieved by two main objectives (Maness, 2009). The first is to preserve existing carbon sinks and protect ecosystems from land use changes. As indicated above, forests already represent large stores of carbon, and conversion of forests to other land uses causes significant carbon emissions. Deforestation and associated land use changes are estimated to account for 20 percent of total carbon emissions globally (Canadell and Raupach, 2008). Not only does deforestation increase carbon concentrations in the atmosphere, it also limits the ecosystem's ability to sequester additional carbon. Current rates of deforestation are estimated to be close to 33 million acres per year globally, producing net emissions of 1.5 billion tons of carbon annually (Canadell and Raupach, 2008). Although deforestation for wood production and agricultural expansion is not a significant concern within the U.S., development pressure does create significant land use change. According to Perschel et al. (2007), over the next 25 years, three million acres of forestland in the Northeast alone may be lost to development. Given that one acre of a forest's aboveground biomass stores around 51.8

tons of carbon (Stavins and Richards, 2005), this would result in an immediate and permanent release of nearly 155 million tons of carbon.

The second objective that can enhance carbon sequestration is to manipulate ecosystems to increase the rate of carbon sequestration beyond naturally occurring levels. This can be done through various mechanisms: increased forest cover through afforestation and reforestation; improved forest management; and expanded use of forest products to replace fossil fuels and building materials. It is estimated that at a national level, reforestation could sequester 160 million to 1.1 billion tons of carbon per year; the results of potential management activities could be comparable (Canadell and Raupach, 2008). In addition, forest management would be an important contribution in making ecosystems and carbon stores more adaptive and resilient to an already changing climate. According to Stavins and Richards (2005), there are nine forestry practices available to landowners to increase both the rate and stock of sequestered carbon:

1. Afforestation of agricultural land,
2. Reforestation of harvested or burned forestland,
3. Modification of forest management practices to emphasize carbon storage,
4. Adoption of low-impact harvesting methods to decrease carbon release,
5. Lengthening forest rotation and entry cycles,
6. Preservation of forestland from conversion,
7. Adoption of agro-forestry practices,
8. Establishment of short-rotation woody biomass plantations, and
9. Urban forestry practices.

The many options listed above demonstrate several different ways in which forest ecosystems can be manipulated to increase carbon sequestration and/or storage. Although some of these options are more applicable to certain regions than others, it is likely that globally all will play an important role in future forest carbon programs.

According to the Congressional Budget Office (2007), the technical potential for biological sequestration throughout the U.S. is about 40 – 60 billion metric tons over the next 50 years. This includes land use changes in both forest and cropland-soil management. The Congressional Budget Office (2007) analysis further estimates that a price of $5 per ton of CO_2 emissions would prompt land use changes resulting in an additional 250 million tons of carbon sequestration per year. At a price of $50 per ton, it is expected that the technical carbon sequestration potential across the United States would be fully exploited. Another study by Stavins and Richards (2005) estimates that a carbon price of $30 - $90 dollars per ton could sequester 500 million tons of carbon annually. Canadell and Raupach (2008) also estimate that after combining all forestry activities together, there is an economic potential to achieve 400 million tons of carbon reductions by 2030 with a carbon price of $20 per ton . In addition, other studies indicate that the marginal cost of sequestering a ton of carbon ranges from less than $10 per ton to over $500 per ton. However, most of these studies propose a marginal cost range of between $20 and $50 dollars per ton (Stavins and Richards, 2005).

Any value within this range of marginal cost estimates would likely make forest carbon sequestration an attractive mitigation strategy and comparable to many suggested alternatives. According to Creyts et al. (2007), active forest management may be more efficient than onshore wind, solar photovoltaic technology and car hybridization, though less efficient than new nuclear plant installations, increased utilization of combined heat and power technology, and increasing vehicle fuel efficiency. Importantly, using forests as part of a mitigation strategy would not require technological advances. Forest sequestration practices could be implemented by landowners immediately and therefore could play an important role in achieving short-term CO_2 reductions over the next 50 years. This effort would essentially “buy time” until new technologies and more encompassing mitigation strategies could be implemented (Northeast State Foresters Association, 2002). Other environmental services associated with enhanced forest productivity and health, such as increasing air and water quality, species habitat, recreation and aesthetic values provide further support for promoting better forest management. However, any policy or market to promote improved forest management or increased carbon sequestration would require significant participation by a large number of non-industrial private forest landowners.

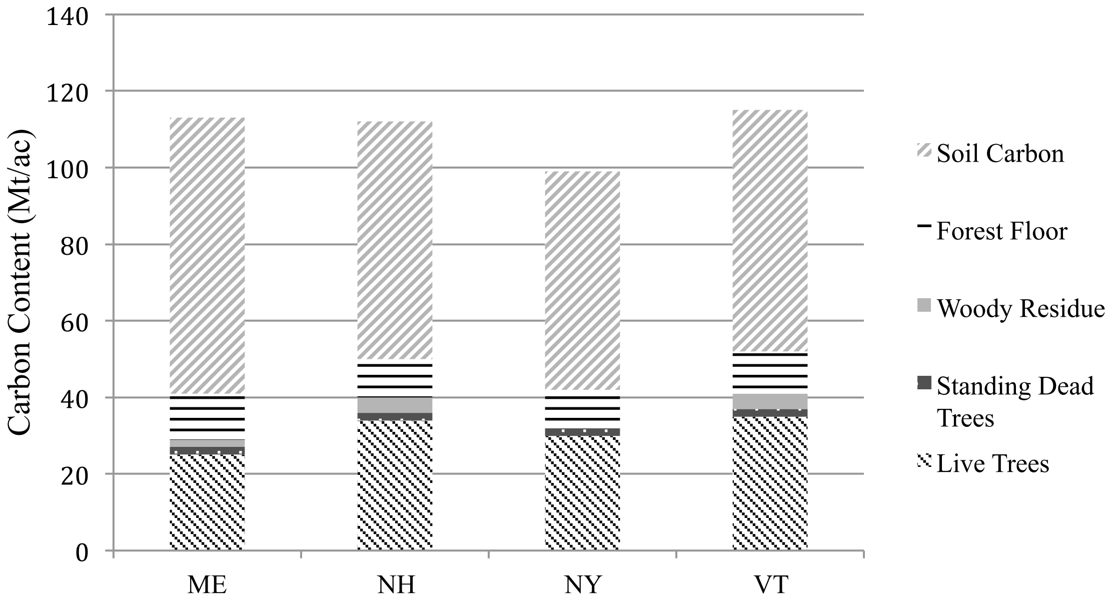
2.2 Improved Forest Management Techniques

Although each of the nine forestry practices and goals identified above are important for carbon sequestration, given that this study has a regional focus, only the following are considered: (2) reforestation of harvested or burned forestland; (3) modification of forest management practices to emphasize carbon storage; (4) adoption of low-impact harvesting methods to decrease carbon release; (5) lengthening forest rotation and entry cycles; and (6) the preservation of forestland from conversion. These practices, henceforth referred to as improved forest management (IFM), were chosen for reasons similar to Perschel et al. (2007), because they are related to natural forest dynamics, are applicable to the Northeast, and are compatible with forestry practices already in use throughout the region. Although afforestation of agricultural land could result in dramatic CO_2 reductions across the country, the applicability to New York and the rest of the Northeast is minimal. This is because most marginal agricultural lands throughout the state have already been reforested and the remaining agricultural lands have productivity levels that create exceedingly high opportunity costs of land conversion (Perschel et al., 2007).

Although the reforestation potential is low, there is reason to believe that the state does have a strong potential for increasing the carbon content on its existing forested land. As seen in Figure 2, when compared to Maine, New Hampshire, and Vermont, New York lags behind in terms of tons of carbon stored per acre of forested land (Northeast State Foresters Association, 2002). Given relatively similar forest types across the region, this implies that significant room for improvement exists on current forested land. For instance, given similar forest structure, New York forests on average store less than 100 metric tons of carbon per acre (Mt/ac) whereas Maine, New Hampshire and Vermont Forests store between 110 and 115 tons per acre.

Despite the significant attention that improved forest management and carbon sequestration have drawn in the recent literature, there remains significant scientific debate on which specific practices will most efficiently sequester additional forest carbon. Some researchers suggest that sustainably managed forests have the potential to sequester more carbon than unmanaged forests, while other studies argue that unmanaged forests sequester greater levels (Nunery and Keeton, 2010). This thesis does not attempt to solve this ongoing debate, but instead covers a wide variety of potential management techniques that have been proposed. Although there is debate on whether or not management practices will sequester carbon at rates above unmanaged forests, there is significant agreement that when comparing actively managed forests to one another, implementing specific management actions can improve carbon storage. Knowing that wood products will continue to be an important commodity in the future, it is important to understand how carbon sequestration compares among different forest management objectives (Hoover and Stout, 2007).

Figure 2: Carbon Content on Forested Land in the Northeast



Source: North East State Foresters Association (2002)

A number of forest management practices are commonly discussed in the industry and there are a few fundamental aspects of all management options that are important to consider. First, improved forest management (IFM) techniques should only be considered if they maintain other ecosystem benefits at an acceptable level. Other benefits include providing wildlife habitat, air and water purification, and aesthetic and recreational benefits. Second, it is important to distinguish between carbon sequestration and carbon storage. The first term generally refers to the *rate* at which carbon is stored, whereas the latter term refers to the overall *amount* of carbon stored in a given area. While it is important to increase rates of carbon sequestration, this must be done in a way that preserves and builds on the existing carbon storage base. Lastly, IFM is highly site-specific and depends on unique forest stand and property characteristics. Although the techniques discussed below may improve carbon sequestration and storage "on average," careful management planning is required on a case-by-case, individual site basis. Whenever possible, this section attempts to discuss management techniques specific to the New York State region.

2.2.1 Forest Growth and Maturity

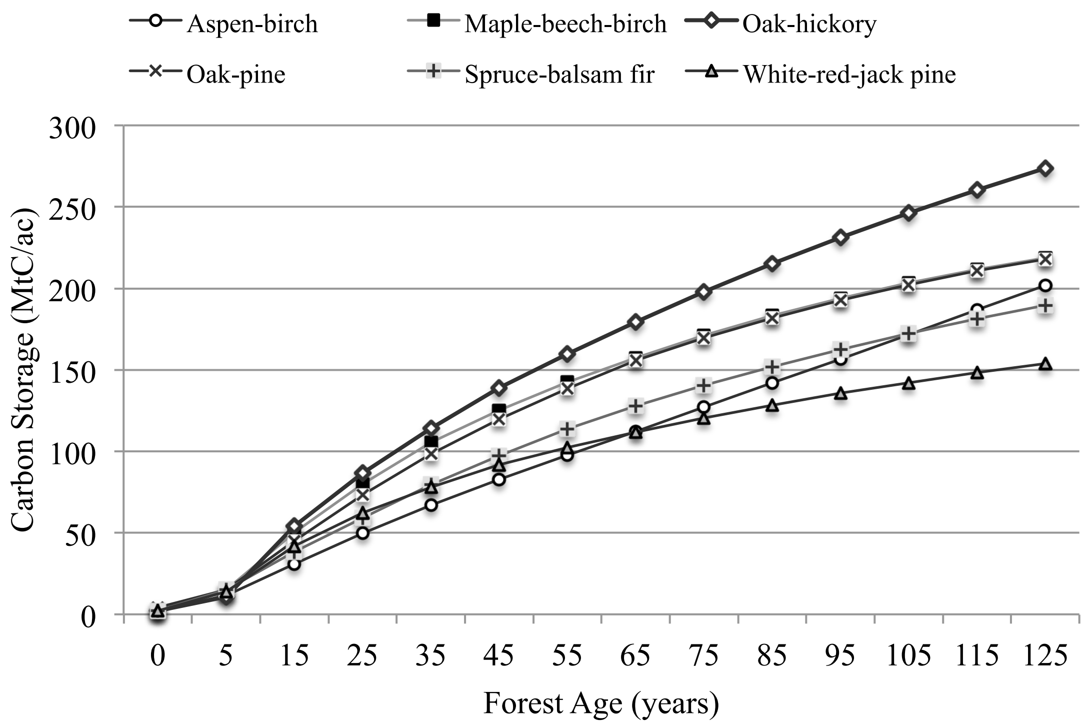
In general, any given forest stand has a maximum potential productivity regarding carbon storage. This level represents a biomass ceiling based on basic constraints such as fertilization, irrigation, and drainage of the site. However, most forest stands, especially in the eastern United States, are not at their maximum potential due to significant logging during the 19th and 20th centuries (Carroll and Milakovsky, 2009). These extensive clear-cuts across the state left many forest stands at irregular and unnatural stocking levels and species diversity. In these forest stands, poor forest health limits the amount of tree growth and carbon sequestration and storage. As a result, management strategies that encourage the growth of larger trees, that reduce waste and damage to residual trees during harvests, and that minimize soil disturbance all improve carbon sequestration (Northeast State Foresters Association, 2002). Sequestration rates can also be increased by choosing particular tree species, timing of harvests, and through better management of pests and forest fires (Congressional Budget Office, 2007).

In order to fully understand the potential forest management techniques outlined here, it is useful to first briefly review some basic principles of forest growth and maturity. As forests age, they pass through four stages of growth: stand initiation, stem exclusion, understory initiation, and old growth. Stand initiation takes place following a disturbance or during reforestation and occurs when a large number of small trees begin quickly growing from seeds or sprouts. After this stage, stem exclusion refers to the stage of forest growth where young trees compete for natural resources such as sun, water, and nutrients. High levels of tree mortality characterize this stage, while the remaining trees rapidly grow and absorb nutrients and carbon.

Understory initiation follows and the remaining trees slow their resource assimilation and allow new vegetation to begin filling in the understory. Finally, the old growth stage is characterized by the death of older trees and the recycling of nutrients into the understory. During this final stage the forest is composed of different age stands and foliage evenly distributed throughout the canopy (Covey and Orefice, 2009).

Early stages, mostly the stem exclusion phase, represent a period of rapid growth and the highest levels of carbon assimilation. Young forest stands are therefore associated with high rates of carbon sequestration, while older forest stands are associated with high levels of carbon storage. Mature trees will eventually sequester decreasing levels of carbon as they become larger due to physical growth limitations (Covey and Orefice, 2009). As a result, the total carbon sequestration in a forest is increasing at a decreasing rate over time and marginal sequestration rates are nonlinear. Figure 3 illustrates the amount of carbon stored on an acre of forested land in the Northeast for different tree species over a 125-year timeframe. This includes carbon stored in live trees, standing dead trees, understory cover, downed dead wood and forest floor litter, but does not include soil carbon. The figure indicates that rates of carbon sequestration and storage decrease as forests age, and different tree species have different sequestration rates (Smith et al., 2006). In general the forests throughout the Catskills region are dominated by hardwood species, including sugar maple, red maple, black cherry, white ash, yellow birch, and red oak. In addition, softwoods such as white pine, Eastern hemlock and Eastern red cedar are present (New York State Department of Environmental Conservation, 2010).

Figure 3: Northeast Carbon Storage Over Time



Source: Smith et al. (2006)

According to Perschel et al. (2007), as a result of past clearcutting and poor management practices, many of the forests in the Northeast are not mature and therefore still sequester significant amounts of carbon annually. Some researchers believe this represents an advantage for forest landowners in the region. The use of IFM techniques has the potential to sustain high sequestration rates after the forests would normally slow down their growth and carbon sequestration rates (Ruddell et al., 2007). However, conflicting recent research indicates that old growth forests are not only storing carbon, but also are continuing to sequester significant amounts annually. Although the rate of sequestration may gradually slow, the level of carbon sequestration may not appear to level off until trees are 300 years old, well beyond the current age of most New York forests (Song and Woodcock, 2003; Covey and Orefice, 2009). In general, the management of young, productive forests will promote maximum carbon uptake, while maintaining old growth forests will lead to larger on-the-ground carbon stocks (Carroll and Milakovsky, 2009)

2.2.2 Harvesting, Stocking and Thinning

It is important to note that tree harvesting, no matter the size or type, leads to both an immediate and gradual release of large quantities of carbon into the atmosphere. However, forest management practices can be adopted that reduce this impact (Carroll and Milakovsky, 2009). For example, any harvest will reduce on-site carbon storage, but off-site storage may increase (Perschel et al., 2007). According to Ruddell et al. (2007), if harvested wood is used for durable wood products such as building materials, carbon can be stored for long periods of time. Harvested wood products can also be used as a fuel, both for electricity generation and heating, to offset emissions from fossil fuels. Also, when compared to materials that often substitute for wood, such as steel, aluminum and plastics, wood is favorable in terms of carbon emissions and energy intensity (Northeast State Foresters Association, 2002). However, carbon stored in wood products will not be stored in permanence and the carbon will slowly be released into the atmosphere (Smith et al., 2006).

Despite the potential for carbon to be stored in durable products, a site harvested with high-grade liquidation cuts will only store one-third of the harvested carbon in the final product. The rest is left in the forest, some of which will be stored in soil carbon while much of it is released into the atmosphere. High-grade liquidation cuts are a type of timber harvest that select the largest, most profitable trees in an effort to maximize profits with little concern for future forest health or productivity. For all of these reasons, durable wood products are an imperfect form of carbon storage. Unfortunately, even when harvested wood products are used to offset fossil fuel use, a significant carbon debt is created. Carbon debt refers to the amount of time required to pass before the original level of carbon storage is reached again (Searchinger et al., 2008). Although using harvested wood and biomass to substitute for energy-intensive products is imperfect, the net carbon effect of forest management can be significantly altered when these secondary carbon pools are accounted for (Nunery and Keeton, 2010).

Harvesting methods also make a difference in the amount of carbon being released into the atmosphere. For example, leaving more harvest residues in the forest after a harvest and avoiding damage to residual trees will both help to minimize emissions (Carroll and Milakovsky, 2009). According to Perschel et al. (2007), the types of trees cut, operator skill, and the type of logging machinery used can reduce residual stand damage and minimize waste, all while increasing harvest yields and economic productivity. In general, lower level intensity harvests are an important method of decreasing carbon release (Nunery and Keeton, 2010). Unfortunately, the most common types of large-scale harvesting on private forestlands across the region are high grade, liquidation cuts. This form of harvesting often removes the largest and most valuable trees on the land, destroys much of the future value of the forest, reduces growth rates, increases vulnerability to disturbances, and damages aesthetic quality along with dramatically reducing carbon storage (Perschel et al., 2007). By avoiding this type of timber harvest, improved forest management could lead to dramatically increased levels of carbon sequestration and storage.

Finally, one of the most successful methods for carbon management arises from the lengthening of forest rotations compared to a "business as usual" approach. A forest stand managed for maximum profit would lead to harvests at an age well before maximum forest growth is reached. Forest stands that are managed for maximum sustained yield store only around one-third of potential carbon whereas forests managed for their financial optimum only sequester 20 percent of the total potential (Carroll and Milakovsky, 2009). According to Perschel et al. (2007), large amounts of carbon could be sequestered in a short period of time by increasing rotation length beyond the financially optimal ages. Studies that look at rotation ages being increased by 5, 10 and 15 years indicate that an additional 1.2 tons of CO_2 per acre per year could be sequestered (Perschel et al. (2007).

Increasing stocking levels in an understocked forest stand can also enhance increased levels of carbon sequestration and carbon storage. Forest stocking refers to manipulating the density of trees in a given forest stand. By definition, understocked stands are not taking full advantage of the site's potential to sequester carbon or produce forest products. In some cases, low stocking levels impede a stand from transitioning into an old growth, mature condition. The stocking level can be enhanced by specialized harvests and replanting, while the desired forest structure can be manipulated or maintained by selected management techniques. Across the Northeast approximately 4.6 million acres of forested land are understocked (Perschel et al., 2007). Low stocking levels is usually a result of inadequate past forest management, haphazard harvesting practices, high-grade liquidation cuts, and general overcutting. Unfortunately, understocked stands over the age of 40 years cannot be corrected through natural growing patterns and forest stand dynamics. Instead, this requires human intervention and active forest management (Perschel, et al., 2007). Although forests may appear healthy and fully stocked to the casual observer, actual forest stand dynamics tell a different story. Increasing stocking levels across the region's forests will lead to increased forest health, improved economic potential, and significant carbon benefits.

One of the most debated improved forest management techniques, but one that could have the greatest potential for improving carbon sequestration, is forest thinning. In stands that are not understocked, thinning refers to management that lowers stand density through the removal of a small portion of the standing volume of timber to allow regular spacing of the remaining trees (Carroll and Milakovsky, 2009). Although this may seem contradictory to the stocking discussion above, the opposing methods highlight the site specificity involved with this type of management. According to Strong (1997), light to moderate thinnings have the potential to increase carbon stored in the remaining stems. This is a result of decreased biological competition for nutrients and sunlight, with adequate spacing between trees. According to Perschel et al. (2007), crown thinnings have the potential to increase sequestration while enhancing forest structure and function by removing less vigorous trees and concentrating growth in a select number of remaining trees. Estimated effects of this practice could be substantial, leading to increased carbon storage of 22.3 to 32.1 tons per acre in the Northeast above an unmanaged level. When done over time, landowners could manage their forests in a manner that would create carbon inventories for participation in carbon markets and programs.

There has been very little field research investigating the carbon sequestration consequences of stand thinning. Hoover and Stout (2007) used results from a 25-year study of thinning in northwest Pennsylvania that compared stands using three different thinning techniques to an unmanaged control stand. The three thinning techniques included thinning from above, thinning from the middle, and thinning from below. Thinning from above selectively harvests the largest, oldest, and most valuable trees first, whereas thinning from below leaves abundant trees in the forest stand that have already shown evidence of fast growth. The first is often done for financial objectives whereas the latter is often done to increase forest health and timber stock for future harvests.

After 25 years of active management and observation, this study found that the average amount of carbon contained in the forest stands had increased in the control plots (.53 mtC/ac) and in the plots thinned from below (.59 mtC/ac), but had declined in the plots thinned from above and middle (-.4 mtC/ac). The plots thinned from below were found to sequester greater amounts of carbon than the unmanaged forest, but this difference was insignificant. These results indicate that the choice of thinning matters and has the potential to alter the stand's ability to sequester carbon. Over a five-year period, a 100-acre plot thinned from below could be expected to sequester an additional 195 tons of carbon compared to the control plot. Not only can carbon sequestration goals be achieved, but thinning from below also increases the merchantable volume of potential wood and thus increases the value of the wooded land (Hoover and Stout, 2007).

The scientific literature has yet to establish a consensus on the potential implications of thinning practices for carbon management. Although sequestration rates undoubtedly increase, there is still some uncertainty regarding the overall levels of carbon storage. Some researchers believe that although thinning increases residual tree biomass, the net increase in carbon stock is limited due to natural constraints on tree growth. Under these assumptions, thinning will always be a carbon-negative – or at best a carbon-neutral – management option. However, if carbon is stored in separate pools, such as durable products or fuels, then increased carbon stocks are possible. Ideally, as science progresses, landowners would be able to use IFM techniques to harvest a small portion of their land annually, and then use appropriate thinning practices on the remaining land to overcome and absorb short-term losses that occur during final harvest and stand replacement. Small private forest landowners could also join cooperatives and collaborate to achieve these goals at an economically feasible level (Hoover and Stout, 2007).

2.2.3 Increasing Resilience

One of the most important aspects of improved forest management techniques is to increase forest resilience to disturbances, both natural and man-made. These disturbances, including fire, disease, insect outbreaks, storm damage and climate change, can all dramatically influence a forest's mitigation potential. Whenever forests are disturbed, some trees die, decompose and release large quantities of carbon. Not only will this decrease the overall rate of forest carbon sequestration, it has the potential to reverse a forest from a net carbon sink to a net carbon source (Carroll and Milakovsky, 2009). For example, forests across North America have recently seen a large influx of mountain pine beetles. In western Canada, the pine beetle has destroyed several hundred million cubic meters of wood. This epidemic is threatening to reverse Canada's forest carbon flow from a net carbon sink to a net carbon source. Some researchers project that the region could release 990 million tons of CO_2 over a 20-year period as a result of this disturbance, significantly more than the annual emissions of the entire country (Kurz et al., 2008). In New York State, other pests and potential disturbances could have a similar effect. The prevalence of previous poor management across the region and the prospect of future climate change make many forests in New York especially susceptible to catastrophic disturbances similar to the Canadian pine beetle example.

As a result, increasing forest resilience should be a top priority among forest landowners. Resilience refers to the capacity of a forest to absorb a disturbance and reorganize while retaining essentially the same function, structure and ecosystem service (Carroll and Milakovsky, 2009). In order to achieve this goal, forests may have to be managed at below-optimal densities for carbon sequestration and financial return. So stand health and resilience may require management to reduce the risk of catastrophic losses from wind, fire, pests and climate change.

As a result, some sacrifices in total carbon sequestration may be necessary to ensure that the carbon stocks are stored for long periods of time. IFM therefore needs to find a balance between increasing carbon sequestration and increasing the assurance of long-term storage (Carroll and Milakovsky, 2009). Appropriate carbon management practices should therefore maximize carbon storage while simultaneously minimizing the risk of losing these stores. As a result, forest management must be an ongoing, flexible and adaptive process.

Windthrow occurs when large areas of trees are uprooted due to severe winds or storms. Although this can serve important biological and ecological purposes, storm damage in poorly managed forests can exceed the acceptable levels of damage and release vast amounts of carbon. According to Carroll and Milokovsky (2009), unlike fire risk, the risk of windthrow depends less on stocking levels and more on stand composition. Management that develops stand structure and increases the diversity of tree species will help prevent against excessive wind damage and subsequent carbon release.

Currently, fire plays only a minor role in New York's forests, but other regions often face a large forest fire threat. According the New York State Department of Environmental Conservation (2010), there have been approximately 5,600 suppressed forest fires statewide between 1985 to 2009. These forest fires contributed to over 2,500 acres of destroyed forest cover each year, with some years seeing over 11,000 acres destroyed. In addition, climate change may bring with it an increased threat of fire that is uncharacteristic of past history. If fire becomes an increasing threat to forest landowners in the region, forest density may require thinning or controlled burns to minimize fire potential. This threat, however, is currently not the region's greatest concern (Carroll and Milakovsky, 2009).

Pests and invasive species are one of the largest risks to forest landowners across New York State. According to the New York State Department of Environmental Conservation (2010), the state's forests are seeing accelerated threats from invasive species due to increased international trade and changing climate patterns. This threat has the potential to destroy millions of acres of forests and quickly release their carbon into the atmosphere. Elm, chestnut and butternut tree species have already been lost almost entirely throughout the state due to introduced diseases. Currently, a variety of insects, pests and diseases all threaten the state's forest and the respective carbon pools. In New York State, some of the more intrusive pests and diseases include the Asian longhorned beetle, the emerald ash borer, oak wilt, and the overabundance of white-tailed deer. Additionally, the New York State Department of Environmental Conservation (2010) recognizes dozens more pest and disease threats in the region. On a national scale, New York and the rest of the Northeast are especially prone to severe non-native forest pests.

Unfortunately, climate change will only exacerbate the risk of forest disturbances discussed above and represents a potential negative feedback loop. As global and regional temperatures increase, habitats for pests will change, bringing new species to the region, severe drought will increase fire potential, and increased extreme weather events will cause greater storm disruption. If the climate changes substantially, some current native tree species of New York may no longer have viable habitats within the state. Active management may therefore be necessary to increase the forest ecosystem's ability to adapt to future climate change by protecting unique habitats and increasing genetic reserves. This will allow ecosystems and individual species to transition to new climates (Perschel et al., 2007). A changing climate suggests that forest management needs to be flexible due to uncertainties involved with future temperatures, precipitation patterns, and species. Active management will also be an important contribution to climate change adaptation by protecting unique habitats that may not be able to expand into new areas fast enough.

For all of the reasons discussed above, forest management that targets resilience and risk reduction strategy will be important for decreasing potentially large emissions of carbon into the atmosphere. Management should focus in part on increasing forest diversity because mixed forests contribute significantly to ecological stability by increasing resistance and resilience. IFM should increase this diversity by promoting the growth of forest stands of multiple ages and by decreasing forest fragmentation. These actions may decrease carbon sequestration rates and financial returns, but tradeoffs such as these may be a necessary component of a compressive and long-lasting management plan.

2.2.4 Barriers to Improved Forest Management as a Mitigation Option

Although improved forest management has the potential to contribute significantly to climate change mitigation and adaptation efforts, there are a variety of obstacles that have impeded further development and application. The fundamental barrier limiting forest carbon offset programs[1] is the lack of a standard and accepted national or international price for carbon. Without this price, implemented either through a carbon tax or "cap-and-trade" system, the negative externalities associated with carbon emissions will not be internalized. Without this price, no incentives for improved forest management exist and forest landowners have little reason to increase the supply of a public good.

Even with a price associated with carbon emissions there are several limitations to improved forest management. In large part, these problems arise due to difficulties in ensuring and verifying increased sequestration and storage. Limits to the current science underlying the

[1] See discussion in Section 2.3 for more details on carbon offset programs

carbon cycle, problems with additionality[2], leakage[3] and permanence[4] all cast a shadow of doubt on forest carbon sequestration, in general, and improved forest management, specifically. The United Nations Framework Convention on Climate Change (UNFCCC) outlines several of these issues and how they pertain to improved forest management. Although guidelines from the UNFCCC highlight the importance of these issues, they provide few solutions (Ruddell et al., 2007).

As with many climate change issues and mitigation strategies, the scientific uncertainty surrounding carbon sequestration leads to uncertainties in policy and management. Many of these uncertainties were highlighted in the previous section. Although generalizations can be made about different forestry practices and which ones are best for carbon sequestration, quantifying carbon storage and sequestration rates is also difficult and is site-specific. Carbon sequestration rates and overall carbon storage depend on a stand's composition of tree species, stocking level, soil quality, and other forest characteristics. Due to site specificity, verification of carbon sequestration by a trained forester is required at the individual forest stand level. Although advances have been made in this respect, a better understanding of the carbon cycle is necessary. In addition, this understanding must be specific and relevant to small geographic regions and their respective forest structure and species composition.

Improved forest management techniques must also demonstrate "additionality" in order to be an effective form of climate change mitigation. The increase in carbon stocks and rate of sequestration was discussed in the previous section, but additionality also fundamentally depends

[2] "Additionality" refers to sequestering levels of carbon *over and above* the levels that would have occurred in the absence of a program or improved forest management activities.
[3] "Leakage" occurs when emission abatement in one region is replaced by an increase in emissions in another region.
[4] "Permanence" is assured when sequestered carbon is stored without threat or depletion from human or natural disturbances.

also on what baseline is being used. Some programs and offset markets define additionality as carbon sequestration occurring above *natural* sequestration rates. This is a relatively conservative approach that only ascribes additional sequestered carbon to practices that are above what a natural, unmanaged forest would sequester. As seen in the previous section, this makes IFM techniques a difficult proposition under current assumptions and favors practices such as afforestation and reforestation. Other programs define additionality as carbon sequestration occurring above a *business-as-usual* baseline. This method takes into account current management practices and tree harvesting being conducted on forest lands and seeks to increase the amount of carbon sequestration assuming active management. This method also allows for management that promotes adaptation objectives. Additionality under this scenario is somewhat less stringent and allows for continued timber harvests, albeit at levels below the economic optimum. Although these levels will not sequester the maximum levels of carbon, they will still be additional to what would have occurred in the absence of the program (Carroll and Milakovsky, 2009; Maness, 2009). Often, establishing a baseline will require some form of modeling, further increasing the potential for uncertainty and debate.

"Leakage" is another potential problem associated with forest carbon sequestration identified by the UNFCCC. In the case of forestry, a decrease in harvesting and forest land conversion in one area will potentially lead, to some degree, to an increase in harvesting or land conversion in another region. This occurs because – unless demand for forest products decreases or development on forested land subsides – supply will simply be diverted to other areas, adjusting to changing patterns of forest use (Ruddell et al., 2007). For example, a decrease in harvested timber in New York State will decrease the available supply of lumber, in turn increasing the price of wood products in the region, and thus leading to an increase in imports from other regions. Because CO_2 is a uniformly mixing pollutant, an emission reduction in one region and an emission increase in another do not change the overall greenhouse gas emissions outcome. Leakage can be significant; some economists argue that the level of leakage can range from anywhere between 10 and 90 percent (Murray et al., 2004; Boyland, 2006). As a result, leakage reduces the net benefits from forest sequestration and leads to inefficiency and an increased cost of climate mitigation. Complete elimination of leakage is not possible, but it can be limited. The more regions and countries that adopt programs or policies for improved forest management, the less potential there is for a leakage problem. This lends importance to national and international efforts to promote widespread adoption across the county and internationally, but contrarily, hampers efforts at regional leadership.

Once carbon sequestration is proven additional and leakage is minimized, another potential barrier to forest carbon management is the issue of "permanence." Due to the longevity of climate mitigation strategies and the intergenerational time frame involved, forest carbon sequestration and storage must continue for many years into the future. At a minimum, forest carbon sequestration must continue until technological solutions to climate mitigation become economically feasible as a substitute. The types of forest disturbances outlined in the previous section, as well as anthropocentric land use changes and harvesting decisions, all bring uncertainty into the question of the permanence of forest carbon storage. Ruddell et al. (2007) suggest that ensuring complete permanence is impossible and forest managers should instead establish a goal of maintaining a forest system to promote long-term stability. To further increase the likelihood of permanence, programs should be crafted in a way that places some restrictions on future land use. This can be achieved through the use of conservation easements, insurance or contracts, maintaining financial offset reserves, and by including penalties for failing to meet management goals.

Finally, proper verification of IFM and carbon sequestration is necessary to ensure accurate carbon accounting. Scientific uncertainty, site specificity, additionality, leakage and permanence are all factors that influence proper verification. As a result, verification of carbon sequestration by a trained forester is required at the individual forest stand level in order for this to be a legitimate mitigation option. Given the large number of landowners and the wide geographic scope, the need for on-site verification dramatically increases the transaction costs associated with forest carbon sequestration. These transaction costs will continue to make it difficult for small landowners to enter into carbon offset programs. Although aggregators may be able to bring together groups of small private forest landowners, this remains a major obstacle. In the future, increased use of aerial imaging technologies such as LIDAR may become pivotal tools in accomplishing carbon accounting and verification as they reduce transaction costs substantially.

2.3 Carbon Markets and Programs

A variety of existing and proposed programs and legislation allow landowners to benefit from carbon sequestration projects on forested land. Currently, carbon sequestration projects can either take place in the context of voluntary carbon markets or as offsets within mandated cap-and-trade programs. Some of these programs are currently in place and available to New York landowners, while others are in early stages of planning and development. Each program differs in terms of allowed practices, stringency, program length, and how potential problems, such as additionality, leakage and permanence, are overcome. Despite their differences, these programs appear to have several fundamental program characteristics in common amongst one another.

These characteristics may become part of possible future federal and state legislation and accordingly were used (selectively) in the development of the hypothetical forest carbon storage program outlined in this study.

2.3.1 Voluntary Carbon Markets

In the absence of formal national legislation addressing climate and energy policy, a variety of voluntary carbon markets have emerged that allow emitters of carbon, including both businesses and individuals, to be compensated for reducing their emissions. These voluntary markets often include the option of purchasing carbon offsets originating from forest sequestration and improved forest management. Being voluntary, much of the trading in this market arises from altruistic businesses and individuals or those looking to improve their environmental image rather than simply complying with legal responsibilities. Each of the voluntary carbon markets outlined in this section – the Chicago Climate Exchange, Climate Action Reserve, Voluntary Carbon Standard, and the American Carbon Registry – all have established protocols that outline the rules and regulations of carbon offset projects. The variations in these protocols highlight the complexity and lack of complete knowledge about forest management, but they also provide common reference points for future regulatory efforts (Carlson and Olivas, 2009).

Launched in 2002, the largest voluntary carbon market is the Chicago Climate Exchange (CCX) (Carlson and Olivas, 2009). CCX offset projects include afforestation, reforestation, and sustainably managed forests and their products. Potential projects are permitted anywhere in the United States or by any country participating in the Kyoto Protocol. Although participation in CCX carbon markets is voluntary, once a landowner joins the market, commitments to sequester additional carbon become binding through legal contracts. Program entrants must have a carbon inventory conducted on their land, which then becomes the baseline for future projects. Participation in the program is required for 15 years, with a signed statement of intent for long-term forest management beyond the program's length. The landowner is then credited when his/her forest generates positive amounts of stored carbon and debited when forests release carbon. All projects in CCX markets must be voluntary and must not be a required management objective by any federal, state or local regulation. Evidence of leakage is not required, but permanence is safeguarded by holding 20 percent of the offset permits in a Forest Carbon Reserve Pool escrow account for the extent of the program in the case of catastrophic carbon losses. Increases in carbon stocks in both forest and long-lived wood products are considered an accounted carbon pool, so harvesting is permissible given the timber's end use. Finally, forest projects must be actively managed and certified by a third-party certification program such as the Sustainable Forestry Initiative or the American Forest Foundation (Chicago Climate Exchange, 2009).

Currently, the cost of participation is high due to inventory requirements and third-party monitoring, while carbon emission prices necessary to induce carbon offsets and emission reductions have been low for much of the program's history. As a result, participation costs are often too high for family forest owners to act individually, but CCX does allow the use of aggregators. These aggregators are forest management organizations that bring together a group of many small, private forest landowners to participate in carbon markets. Recently, for example, the Michigan Conservation and Climate Initiative included an aggregate group of forest landowners that were able to receive about eight dollars per acre per year in return for the additional carbon offsets generated from forest management (Dickinson, 2010). Despite this early success, in January of 2011, CCX indefinitely shut down its carbon trading operations, highlighting the difficulty of creating robust voluntary markets and the need for a federal climate policy.

A second example of a voluntary offset market is the Climate Action Reserve (CAR). The CAR originated in California to establish regulatory standards for the development, quantification, and verification of forest carbon offsets. The protocol established by the CAR includes a detailed overview of program requirements for improved forest management projects and may evolve into the rules established in a national cap-and-trade program (Carlson and Olivas, 2009). The CAR protocol allows for reforestation projects and IFM projects, as well as avoided conversion projects. Avoided conversion projects pay a landowner to conserve his or her forested land in a situation where future development or land use change is imminent, in an effort to decrease the opportunity costs facing a forest landowner. In order to be eligible for avoided conversion offsets, the landowner must demonstrate a significant threat of conversion to a land use other than forest (Climate Action Reserve, 2010). In addition, all forestry projects allowed in the CAR must be located in the United States. IFM projects may include natural forest management or commercial harvesting and must be conducted for a minimum of 100 years. Additionality is established using a modeled baseline of standard practices compared to forest owners with similar land and property characteristics. Eligible management activities include increasing the overall age of the forest by increasing rotation frequency, increasing forest productivity by thinning diseased and suppressed trees, managing competing brush and short-lived forest species, and increasing the stocking of trees in understocked areas. Under IFM projects, commercial harvests are still permitted, but they must meet sustainable harvest practices certified by the Forest Stewardship Council, the Sustainable Forestry Initiative, or the Tree Farm System. Sustainable harvesting must adhere to a renewable long-term management plan that demonstrates permanently sustainable harvest sizes, uneven-aged forest stands, and canopy cover averaging 40 percent across the forested land (Climate Action Reserve, 2010).

A third voluntary offset program is the Voluntary Carbon Standard (VCS). Work to develop the Voluntary Carbon Standard was initiated by The Climate Group, the International Emissions Trading Association and the World Economic Forum in late 2005. VCS hopes to become the international standard upon which forest carbon offsets are based. Accepted projects include afforestation, reforestation, and IFM projects, along with the possibility of expanding to include avoided conversion in the future. Unlike the previous two programs, VCS projects can only be implemented on forests that have been previously managed for wood products including sawtimber, pulpwood, and fuelwood. These include predesignated, sanctioned or approved sites determined by national or local regulatory bodies (Voluntary Carbon Standard, 2007). As a result, this program may only be applicable to some forest landowners in New York and inherently gives preference to larger, more commercially oriented landowners.

Allowable IFM practices under the VCS focus mostly on improved harvest techniques including transition from conventional logging to reduced logging. Reduced logging includes improved selection of trees for harvest, improved planning of skid trails, reduced size of logging roads, and other forms of low impact harvests. Other allowed practices include the conversion of logged forest to protected forest, extending harvest rotation ages from an economic optimum to a optimum for carbon sequestration, and improving stocking levels on poorly stocked lands. The program also includes reducing emissions from deforestation and degradation, but this is mostly limited to projects in developing countries. Permanence is assured by a required project length between 20 and 100 years. The carbon inventory baseline is established based on current and past management records for the past 5-10 years. Participants are also required to assess and manage leakage of timber harvests. For example, reduced impact logging contributes no leakage, extended rotations shift harvests across time and therefore exhibit relatively low levels of leakage, and reduced harvest size may lead to moderate or high levels of leakage. However, most small landowners would be exempt from this requirement (Voluntary Carbon Standard, 2007).

The American Carbon Registry (ACR) is a fourth voluntary carbon offset program that was founded in 1996 by the Environmental Defense Fund and the Environmental Resources Trust. Similar to the Chicago Climate Exchange and the Climate Action Registry, this program outlines a protocol of acceptable forest carbon offset projects (American Climate Registry, 2010). However, unlike the previous three programs, ACR's improved forest management projects can only be applied to industrial timberlands with 1,000 acres or more of managed land. As a result, it is not directly applicable to most private forest landowners in New York, but its protocol may shed light on important IFM program elements. Further, landowners must prove that timber sales have been conducted in the past ten years and they must have a long-term management plan that outlines a primary use of engaging in timber sales. Applicable carbon pools include above- and below-ground biomass, harvested wood products, standing and lying dead wood, but do not include litter or soil carbon (American Climate Registry, 2010).

ACR's protocol includes a unique assessment of additionality. Not only does carbon need to be sequestered above normal rates, but the IFM must pass a "three-prong additionality test." The first prong is a Regulatory Surplus Test. This requires that IFM techniques must be beyond the minimum standards required by law. The second prong is the Common Practice Test, which requires that improved forest management techniques exceed the common practices of similar landowners managing similar forests in the region. Finally, the third prong of additionality is the Implementation Barrier Test. This requires that in order for an offset project to be considered additional, the project must face financial, technical, or institutional barriers that limit its implementation in the absence of carbon offset revenue. If all three additionality tests are passed, the baseline is established by modeling the legally permissible harvest scenario that maximizes the net present value of perpetual wood products and harvests. Finally, in order to ensure permanence, the program length must be at least 40 years in length and landowners must conduct regular risk assessments to prevent against catastrophic forest changes (American Climate Registry, 2010).

The four voluntary forest carbon offset programs outlined above highlight both the similarities and differences among programs. Currently, there is little participation from the forest sector in carbon offset projects due to the low carbon prices offered, lack of technical experience, and regulatory and legislative uncertainty. The programs outlined above are still in the early stages of development and implementation, but all hope to become the standard of a future legislated cap-and-trade program either nationally or internationally. These early attempts may not provide immediate options to forest landowners in New York State, but they do emphasize the important issues that are likely to be addressed in future programs should a national climate policy be adopted.

2.3.2 Cap-and-Trade Programs

In addition to voluntary offset programs, there are cap-and-trade programs currently in place or being discussed in the legislative process, both regionally and nationally. A cap-and-trade program places a legal limit (or cap) on permissible tons of greenhouse gas emissions for particular sectors in a particular region. Once the cap is set, permits are allocated, either for free or by auction, to GHG emitters. For each ton of GHG emitted, a firm is required to hold an equivalent number of permits. Firms are then able to trade or sell any additional permits to other firms looking to emit additional GHGs. Actors outside of the regulated sectors are able to participate by decreasing their levels of GHG emissions. In doing so, an offset is created for each ton of GHG reduced, which can then be sold to emitting firms that are required to hold permits for their emissions. As a result, forest landowners are able to increase carbon sequestration and sell this as a carbon offset. In doing so, carbon becomes a tradable commodity amongst emitting firms and forest landowners.

Currently the only operating cap-and-trade program in the United States is the Regional Greenhouse Gas Initiative (RGGI), which is composed of electricity generators in ten Northeast states from Maine to Maryland. Emission permits are allocated by a competitive auction and emitters are able to trade amongst themselves or to purchase offsets from outside of the electricity sector (RGGI Inc., 2010). Landowners within the region are able to join in RGGI by creating forest carbon offsets through afforestation projects only. Therefore, the only acceptable projects are tree plantings on land that was previously used for other purposes, such as agriculture, and that have not been forested for the past ten years. Additionality is established by a base-year approach that measures carbon levels before the project and then at regular intervals throughout the program's length. In order to participate, landowners must enroll their land in a legally binding permanent conservation easement. This conservation easement must require that all land included in the offset project be maintained as forest in perpetuity. The conservation easement must also include a requirement that the carbon density on the land be maintained in perpetuity at or above the levels achieved at the end of the project, and that the land be managed in accordance with environmental and sustainable forest practices determined by the Forest Stewardship Council, the Sustainable Forestry Initiative, and the American Tree Farm System.

Permanence is further assured by discounting carbon credits by 10 percent in the case of reversal or catastrophic damages (RGGI Inc., 2010).

When compared to the voluntary offset programs, the RGGI offset program is much more stringent in terms of allowed practices, making current participation in the region negligible. Similar cap-and-trade programs are forming in other regions throughout the United States, including the Western Climate Initiative (WCI) and the Midwestern Greenhouse Gas Reduction Accord (MGGRA). These cap-and-trade programs are only in the initial stages of creation and have yet to establish a legal cap or to require emission permits. However, both include a provision for forestry offsets similar to RGGI, but are not yet completely detailed. There has also been significant discussion of a national cap-and-trade program. Although legislation has yet to be passed and may take years to materialize, there have been bills passed in both the House and Senate (Carlson and Olivas, 2009). Most recently, the Senate's Kerry-Lieberman American Power Act of 2010 and the House's Waxman-Markey American Clean Energy and Security Act of 2009 both outlined a prospective national cap-and-trade program. Both pieces of legislation also outlined prospective carbon offset programs allowing for up to two billion tons of required emission reductions to be accounted for by carbon offset projects. However, the details of such a program have not been identified, consensus in the U.S. Congress does not currently exist, and there is currently little movement toward a national cap-and-trade program.

As a result of legislative gridlock, the current state of a national climate and energy policy is uncertain. It is likely to take many years before the policy and regulatory environment become clear. Despite the lack of legislation, recent proposals do suggest that forest carbon offsets will play an integral role in a future cap-and-trade program. Therefore, actions taken by landowners now will greatly increase their ability to participate in future carbon offset programs.

Although the above programs represent a wide variety of potential forest management programs, they do provide some semblance of consensus. Most proposed programs allow for improved forest management offsets and therefore create a potential opportunity for forest landowners to benefit economically from these programs.

A common theme that runs through all of the programs outlined above is a carbon price that is currently too low to create many, if any, carbon offsets from improved forest management. Coupled with large upfront costs that deter small private landowners and a large degree of confusion and uncertainty, there has been limited knowledge or active participation among the forest landowner community. Although potential interest in carbon offsets and improved forest management may be strong among many landowners, the current systems in place are not considered sufficiently desirable to induce significant participation.

2.4 Nonindustrial Private Forest Landowner Surveys

As the previous sections suggest, there has been significant attention given to forest carbon sequestration over the past decade. Much of the academic literature surrounding the topic has been focused on either the biophysical methods of forest sequestration or on the technical potential that forest carbon sequestration could play in climate change mitigation strategies. This research has determined the extent of carbon sequestration on particular forested plots, and has often concluded that forest carbon sequestration can, and should, be used as an economically viable way of mitigating greenhouse gas emissions and addressing climate change. However, in most states, nonindustrial private forest landowners own 70 percent or more of forested land. This constitutes a large, diverse cohort of the population, whose management activities and actions are often hard to predict due to a variety of attitudes and motivations concerning forest and land management (Amacher et al., 2003). As a result, the success of forest carbon sequestration as an effective climate change mitigation policy depends on the willingness of non-industrial private forest landowners to participate in voluntary carbon management programs. It is therefore necessary to better understand the management objectives and necessary incentives for NIPFL participation.

One of the best ways to increase the knowledge of NIPFLs is to survey a representative sample of the population. Although not conducted with specific attention to carbon management programs, there is a long history and extensive literature comprising NIPFL surveys. These types of surveys are common in the forestry sector and cover a large spectrum of forest economics and policy issues. Not surprisingly, over time there has been a general progression in the literature towards research and survey topics that mirror the policy objectives of the time (Vokoun et al., 2003). Given the recent policy attention to climate change, climate mitigation options, and forest carbon sequestration, this study is a logical extension of the NIPFL survey literature toward the latest policy objective and much can be learned from the prior research experience.

Early research using NIPFL surveys focused on harvesting and reforestation decision making (Amacher et al., 2003; Conway et al., 2003; Beach et al., 2005). This research estimated the probabilities of harvesting or reforesting land based on a variety of landowner, plot, and market characteristics. However, according to Conway et al. (2003), focusing too much attention on harvesting and reforestation decisions creates an incomplete picture of forest landowner concerns for policy purposes. Private landowners may be less interested in purely market-based objectives and more interested in other, nontimber-oriented, objectives. As a result, survey research began to transition in the late 1980s and early 1990s to focus more on the interrelationships between nontimber-oriented activities – such as recreation, aesthetics, and environmental benefits – compared to the more traditional management objectives of timber harvesting and reforestation (Amacher, et al., 2003). This new focus of forest landowner research suggests that the probability of a landowner undertaking a given forest management activity is related to prices, management costs, interest rates, physical land characteristics, landowner demographics, and, increasingly, the role of landowner preferences.

This transition in research highlights the dominance of landowners with multiple objectives with respect to their property and forest management. These objectives may include generating income from timber harvests, enjoying the land's aesthetic benefits, preserving the environment and protecting nature, land investment, privacy, hunting, or participating in other forms of recreation. Each landowner is likely to have a diverse set of objectives guiding his or her forest management decisions, placing dissimilar weights on different objectives. As a result, forest landowner research has shifted from assuming that NIPFLs are guided strictly by maximizing profits (or maximizing the net present value of timber income), towards the assumption that a landowner instead chooses to maximize utility (Amacher et al., 2003). For example, nontimber management goals are now considered an integral part of the objective function for NIPFLs, representing the dual use of forests for both timber-based income and for other forest amenities. This assortment of different objectives has made predicting timber supplies from NIPFLs very difficult, despite the important role they play in the timber and wood products industry. It can therefore be expected that the uncertainty and difficulty in predicting landowner behavior will be even greater when explaining potential participation in future carbon offset programs.

According to Amacher et al. (2003) and Langpap (2004), recent research has given primary attention to four types of forestry issues: timber bequests to future generations (Amacher et al., 2003; Conway, et al., 2003); environmental benefits (Kline et al., 2000; Pattanayak et al., 2002; Conway et al., 2003); the intensification of forestry practices (Hardi and Parks, 1996); and the effects of incentive programs (Ervin and Ervin, 1982; Kline et al., 2000; Smith et al., 2006). The rest of this literature review will focus mainly on NIPFL surveys specifically addressing environmental benefits and incentive programs for improved forest management, which are closely related to the objectives of this study.

Joshi and Arano (2009) used a mail survey of 2100 randomly selected West Virginia NIPLs to evaluate factors that influence NIPFLs' decisions to engage in four types of forest management activities: timber harvesting, silviculture activities, property management activities, and wildlife habitat management, alongside recreational improvement. Improved forest management for increased carbon sequestration requires a combination of these four types of activities, so the conclusions of this study are important for the current analysis. In general, the authors found that timber harvests were the least frequent of the four types of management activities, occurring on 28 percent of properties. This reinforces the significance of multiple objectives among landowners. The authors also found that younger landowners and landowners driven by nontimber-oriented objectives were more likely to engage in habitat management or recreational improvement activities, whereas landowners that have professional careers or who reside further from their forested land were less likely to engage in any type of forest management activity, especially timber harvests. The most important results relevant to this study were that NIPFLs were found to engage in active forest management regardless of whether they have timber or non-timber-related objectives. Landowners who were actively engaged in one type of forest management activity were more likely to engage in other activities (Joshi and Arano, 2009). As a result, it can be expected that landowners would likely be interested in managing their forest for carbon benefits along with, and in addition to, their primary management objective.

Rasamoelina et al. (2010) also investigated factors influencing woodland management practices. Their study of 3,435 randomly selected forest landowners in Virginia was used to predict the probability of adopting management practices based on landowner demographics and the use of educational, financial, and technical assistance. They concluded that even though it is widely accepted that NIPFLs do not own their land strictly for economic purposes, economic incentives are the most powerful predictor of a particular woodland management practice. Therefore it can be assumed that the most important aspect of a forest carbon sequestration program is the payment offered to the landowner. Another important observation is that extension service and forestry agency programs are factors likely to increase forest management, and therefore will play a critical role in an IFM program for carbon sequestration as well.

Another type of survey looked at NIPFL participation in forestry programs and the effects of financial incentives on participation (Nagubadi et al., 1996). This study of 789 Indiana landowners examined actual, observed participation in statewide and national forestry programs. The authors found that landowners with larger tracts of land and more exposure to information sources are more likely to participate in incentive programs, whereas a longer duration of ownership decreases this likelihood. Although this study observed management programs that were general in nature, it is expected that these conclusions can be applied to carbon sequestration programs specifically.

Although managing forests for carbon sequestration purposes is site-specific and depends on individual forest and landowner characteristics, this will almost always require a landowner to decrease harvest size and regularity from a financial optimum to an optimum for carbon storage.

As a result, NIPFL surveys that look at the willingness of landowners to forego timber harvests lend useful information to this study. Amacher et al. (2003) investigated the relationship between the decision to forego harvesting and a combination of landowner and property characteristics in an attempt to understand why some landowners choose to harvest while others do not. Using a mail survey of 1,240 landowners in southwest Virginia, the authors found that land and personal characteristics do indeed play a significant role. Furthermore, a landowner that is employed outside of agriculture or forestry is more likely to indicate a willingness to forego harvesting. Another important factor in the decision to harvest is the number of miles of road on the forested property (Amacher et al., 2003). Landowners may choose to forego harvesting their forests because they lack appropriate roads and infrastructure, technical knowledge, or financial need, and not necessarily due to an environmental ethic or a high value placed on recreation and aesthetics.

Other studies look at the willingness to forego harvesting specifically for environmental goals and objectives. These studies are highly applicable to examining landowners' prospective participation in carbon sequestration management programs. Kline et al. (2000) looked at the willingness of NIPF landowners to accept incentive payments in return for adopting harvest restrictions in an effort to improve wildlife habitat and riparian buffers. Using a telephone survey of 1,731 NIPFLs in Oregon and Washington, the researchers asked landowners whether or not they would be willing to accept reductions in federal income taxes to participate in a forest management program. The program was 10 years in length and required forest landowners to forego harvesting timber to improve wildlife habitat. Participation offers were for $25, $50, $100, $500 and $1,000. The analysis segmented landowners into four groups: timber producers, multi-objective owners, recreationists, and passive owners. Their results indicate that multi-objective owners and recreationists were more likely to participate in a program that foregoes timber harvests than either timber producers or passive owners. Moreover, they found that although forest owners of all types perceived significant opportunity costs when foregoing harvests, incentive payments for nontimber services can be a successful alternative to regulatory approaches (Kline et al., 2000).

Langpap (2004) conducted a similar study that examined landowner and property characteristics affecting participation in a program to provide habitat for endangered species. The study compared how program characteristics important in endangered species programs may be different from characteristics associated with more general management incentive programs. Using a mail survey of 1,500 NIPFLs in Oregon and Washington, respondents were asked whether or not they would participate in a hypothetical incentive program designed specifically to benefit endangered species. Respondents were additionally asked which of three types of incentives they would prefer: cost sharing to offset project management costs, direct compensation of lost income, or assurances of no further regulatory control or restrictions. The results indicated that younger landowners, landowners with larger plots, and owners who acquired their land more recently all placed more importance on wildlife habitat and were more likely to participate in a conservation program. According to Langpap (2004), this suggests that landowners participating in this type of program may respond to different motivations than participants in more traditional programs designed for economic motives and large-scale timber harvesting studied in previous research. Landowners that are willing to participate in environmental programs were found to be less likely to manage land for profit and to be more supportive of environmental issues, conservation, and endangered species. It is therefore likely that landowners willing to participate in a program designed for climate change benefits will react to incentives in similar ways.

LeVert et al. (2009) also surveyed NIPFLs about their willingness to join a program targeting improved environmental benefits. Rather than investigate management programs, their study looks at landowners' willingness to sell permanent conservation easements and how landowner and property characteristics may affect that decision. Using a mail survey of 2,900 forest landowners in Vermont and Massachusetts, they found that it would cost $700 per acre to entice about one-half of Massachusetts' landowners and one-third of Vermont's landowners to permanently conserve their land. More importantly, their results indicate that willingness to participate in such a program depends on several different variables. Potential participation is greater for more educated and absentee landowners, members of forest management and harvesting cooperatives, landowners more concerned about environmental protection and recreation, and those with written management plans (LeVert et al., 2009). These results also highlight the importance of regional differences and the need to understand NIPFLs at a local and regional scale. Again, due to the overlapping and similar nature of a forest management program designed to address climate change, it can be expected that similar trends will be found in this study.

As a relatively recent issue of considerable policy attention, climate change and carbon sequestration have been under-studied in the private forest landowner community. As a result, very little is known about forest landowners' perceptions of climate change and/or their willingness to participate in programs designed to address it. The only study to be published thus far directly eliciting responses from NIPFLs about their willingness to manage their forests for carbon sequestration benefits was a pilot study of 17 landowners in Massachusetts conducted by

Fletcher et al. (2009). This study was conducted to better understand private landowner attitudes and potential participation in carbon registries. Rather than investigating price offers necessary for participation, the study investigated specific aspects of potential programs that would appeal most to landowners. The results indicate that landowners are positively influenced by incentive payments, while not being influenced by timber prices or the underlying timber market. Initial responses appear to indicate that landowners with heightened environmental and climate change awareness are more likely to participate. Interestingly, programs that are longer in length were more attractive to the landowners surveyed (Fletcher et al., 2009). However, the authors highlighted the important limitation of a very small sample and recognized the need for a more robust study. The present study uses a much larger sample size to provide a more robust analysis regarding this issue, albeit using a different methodology and in a different location.

The nonindustrial private forest landowner literature cited above represents examples of related studies investigating landowner participation in forest management programs for enhanced timber supply and/or environmental benefits. However, to the author's knowledge, no study to date has adequately addressed the willingness of NIPFLs to participate in a potential climate change mitigation program. The present study draws on the previous survey-based literature on NIPFLs, and extends that literature's findings and methods – including development of a survey instrument, choice of analytical variables, and econometric modeling approaches – to the objective of examining carbon sequestration and improved forest management as a climate change mitigation option.

CHAPTER 3

METHODOLOGY AND SURVEY RESULTS

There are numerous details in the design and implementation of a survey that are based on important decisions and trade-offs available to the analyst. For example, a survey can be implemented using face-to-face interviews, mail, telephone, or Internet-based instruments. Second, the geographic scope of the landowner population is of critical importance. Different regions are characterized by different landowner demographics, attitudes and objectives. Given time and financial constraints, a narrowly defined region was required for this study. Also, the survey instrument itself must be crafted in a way that elicits proper responses through clear wording consistent with other contingent valuation surveys. These important details are discussed below along with the reasoning behind the important implementation decisions. This section also provides results of the pretest and full implementation of the survey, prior to the coding and use of the variables used in the econometric modeling chapters.

3.1 Choice of Available Survey Methods

When surveying nonindustrial private forest landowners there are four methods available to elicit responses: face-to-face interviews, and telephone, mail, and Internet-based surveys. Although face-to-face interviews are a method of first choice in many contingent valuation surveys (Arrow et al., 1993; Carson et al., 1996), with forest landowners, this is often infeasible due to prohibitive costs and a large, geographically dispersed absentee landowner population. Internet surveys are also becoming increasingly common for studying the general population, but are not appropriate for the rural forest landowner population. One reason is that Internet access is not universal in New York, especially in rural areas, and may bias the results. In addition, Internet-based surveys encounter a problem in finding complete and accurate sample contact information for the entire landowner population that is necessary for random sampling. Although forestry groups and organizations may maintain an e-mail contact list, this would constitute selective sampling and might bias the results. Currently, the most practical method of obtaining a random sample is with the use of publicly available county tax records that classify property owners across the state.

As a result of these factors, most analysts use either telephone or mail surveys as an alternative approach. This study uses a mail survey because it appears to be the method most common in the NIPFL survey literature and because the mailing addresses could be easily obtained from county level tax records. A mail survey also overcomes the obstacle of geographic dispersion of the landowner sample. In the database used for this study, primary mailing addresses for forest landowners in the Catskills were dispersed over 25 states due to absentee ownership. This dispersion made face-to-face interviews infeasible. A mail survey was also used in this study because it allowed the respondent an adequate amount of time to think through responses adequately before answering questions on complex issues regarding climate change and forest management. Finally, the mail survey instrument was selected in an effort to be consistent with the other relevant forest survey literature. Of the several NIPFL surveys described in the previous section, only one, Kline et al. (2000), used a telephone survey while the rest relied on traditional mail surveys.

In order to increase the response rate and quality of responses – typically a weak point of mail surveys – the steps and methods described in *Mail and Telephone Surveys: Total Design Method* (Dillman, 1978) were used wherever applicable. The methodology suggested by Dillman (1978) is commonly used in many mail surveys, including the NIPFL surveys described in the previous section. This methodology provides important recommendations regarding the appropriate length of the survey, format and wording of individual questions, the use and timing of multiple mailings, and in the crafting of the cover letter in a way to convey the overall importance of the study and the participant's individual responses.

3.2 Geographic Scope

Given financial and time constraints, the geographic scope of this study had to be narrowly defined to ensure proper implementation. Forest characteristics and landowner demographics will vary regionally and, hence, identifying the region of focus was a necessary first step in this study's design. Within New York State, there are several distinct regions with different forest and landowner characteristics. Recognizing the regional differences across the state, this study limited its geographic scope to the four counties in the Catskills region: Delaware, Greene, Ulster and Sullivan Counties. These four counties include nearly 300,000 acres of protected forest in the Catskills Forest Preserve. New York State publicly owns land within the preserve and timber harvesting is not permitted. However, the Catskills region contains an even greater share of privately owned forested land that is relatively free from forest management regulations.

Although restricting the geographic scope of the study limits, to some extent, the ability to generalize findings across the state, the Catskills region provides a useful area of study for a variety of reasons. The region is characterized by a large percentage of forested land, relatively large plot sizes, increased parcelization and urbanization pressure, a heterogeneous population, and the potential for an increased environmental ethic. Each of these characteristics, outlined in greater detail in this section and throughout the paper, is recognized to play a unique role in potential participation in carbon management programs.

In general, the Catskills region is one of the most heavily forested areas of the state. Sullivan County is the most densely forested county in the state, with private timberland constituting 74 percent of the total land area. Delaware County is the fourth most densely forested county and contains the second most acres of private timberland in the state. Finally, Greene and Ulster Counties are also heavily forested, with 61 percent and 56 percent, respectively, of total acres owned as private timberland (United States Department of Agriculture Forest Service, 2010). This study also focuses on the Catskills because, as a region, landowners hold relatively large plot sizes; the region has the second largest plot sizes in the state behind the Adirondack region (Birch and Butler, 2001). Larger plot sizes are likely to be a significant determinant in potential adoption of a carbon sequestration program due to the economies of scale necessary to earn an appropriate return. As a result, this study only sampled landowners with at least 25 acres of forested land, which required a focus on a region with relatively large parcel sizes.

Despite historically large plot sizes, the Catskills region is also unique in that it is undergoing rapid changes in forest holdings due to increased parcelization and urbanization pressure. According to LaPierre and Germain (2005), although forested area in the region appears to be stable, there is a serious and under-recognized threat of forest parcelization. This is an important driver of forest fragmentation and often a precursor of urban or suburban development. These changes could have drastic implications for how forestland in the region is managed, both for timber products and environmental benefits. Given the aging landowner population and the relatively high property tax structure across the state, many landowners stated in their survey comments that they plan to sell some or all of their land in the near future due to the high property tax burden. As a result, the Catskills region is important to study because existing carbon stocks appear to be at risk and landowner demographics and management preferences are changing quickly.

Another important characteristic of the region is the relatively diverse landowner population. Due to its proximity to New York City, a large number of forest landowners in the Catskills are absentee landowners who own their property for use as a vacation, second home, or recreational property. Landowners in this group, likely to be wealthier and more often engaged in professional employment, are also likely to manage their land differently than the resident population which is more involved in farming and timber harvesting. Although previous research has devoted some attention to the differences in management objectives of resident and absentee landowners (Vockoun et al., 2003; Fletcher et al., 2009; Joshi and Arano, 2009), it is unclear which group will be more likely to engage in forest management for carbon benefits. Therefore, the heterogeneous landowner population in the Catskills region, while still maintaining relatively homogeneous *forest* characteristics, is another reason for devoting research attention to this region.

Finally, the Catskills were chosen because the region has historically been targeted for forestry programs concerning environmental benefits. In the late 1980s, the United States passed the Federal Safe Drinking Water Act Amendments of 1986. Under this law, the Environmental Protection Agency required that all surface drinking water sources must undergo filtration, unless human activities in the region could be controlled to decrease water pollution (LaPierre and Germain, 2005). The majority of New York City's water supply, serving millions of consumers, originates from within the Catskills Watershed. Rather than construct and operate a large and costly water filtration plant, which was expected to cost several billions of dollars, New York City chose to try to improve land management practices in the Catskills and Delaware River water systems to achieve better water quality (LaPierre and Germain, 2005).

In response to this need, the Watershed Agricultural Council (WAC) was formed in the early 1990s to address water pollution at its source, through better land management in the Catskills watershed. In addition to a strong agricultural focus, part of the WAC's (and other) programs specifically target forest landowners to implement active forest management. These includes incentive programs to increase tree planting, riparian improvement, invasive pest control, timber stand improvement and wildlife improvement. Also included is a best management program for loggers, foresters and landowners to control erosion and sedimentation resulting from improper timber harvesting techniques (Watershed Agricultural Council, 2011). Although climate change is a different public issue than water quality, the issues are directly related. In order for land to provide optimal levels of ecosystem services and social benefits, whether in the form carbon sequestration, water quality, or wildlife habitat, proper incentives need to be put in place. As a result, it is likely that the prior experience with, and the legacy of managing land for, environmental benefits in the Catskills region will make landowners more aware of programs such as the one proposed in this study.

To sum up, it is important to emphasize that the Catskills region, which is the focus of this study, is not meant to be necessarily representative of the entire state. Instead, the region was chosen for specific reasons that are recognized to influence potential landowner participation in carbon management programs. Yet, focusing on this region will still provide important insights for other regions in New York State, the Northeast, and elsewhere where forest carbon management programs may be considered.

3.3 Survey Design

The mail survey in this study consisted of a 12-page booklet questionnaire containing roughly thirty questions. Along with each questionnaire, sampled landowners received a cover letter, a "frequently asked questions" (FAQs) insert, and a business return envelope. The FAQs insert was provided due to the complexity of the issues involved and the likely lack of familiarly with these issues among some, if not most, landowners (see Appendix C for a copy of the FAQs insert). The survey questions asked of landowners are further described later in this section, but generally focused on property characteristics, landowner demographics, management objectives, knowledge and attitudes towards climate change, general political beliefs, and willingness to participate in forest carbon management programs. The survey started with questions on property characteristics and transitioned into questions based on past and planned forest management practices and attitudes. These questions were placed in the beginning of the survey in order to encourage respondents to think more closely about why they own their land and better understand their management objectives before they started to consider the option of participation in a carbon management program. The survey itself was the design of the author, however, some questions were borrowed from other mail surveys such as the National Woodland Owner Survey, studies conducted by Cornell University's Human Dimension Research Unit, and other forest owner surveys in order to allow direct comparison to previous studies (Birch and Butler, 2001; Kay and Bills, 2007; Allred et al., 2010; United States Department of Agriculture Forest Service, 2011). See Appendix B for a complete sample of the survey used in this study.

The landowner sample was randomly selected from publicly available county-level tax records and included properties with 25 acres or more of potentially forested land. The 25-acre minimum plot size was used because it is often referred to in the literature as the minimum acreage required for legitimate forest management and timber harvesting (Butler and Leatherberry, 2004). Further, it is the minimum acreage required for a parcel in New York State to be considered a forested property by county tax assessors (Kay and Bills, 2007). Additionally, plots classified as farmland over 100 acres in size were also included because farmland in the region often contains significant amounts of forest cover, especially on marginal lands. This methodology was also used to enable comparison with other New York State NIPFL surveys previously conducted by Cornell University (Kay and Bills, 2007; Allred et al., 2010). Limiting the sample to landowners with 25 acres of or more of forested land overlooks a broad contingent of the private landowner community with small acreage holdings. Despite the difficulties of active forest management with these small land holdings, collectively these owners will still be important in climate and forest policy. Nevertheless, conclusions drawn from this study are limited to only landowners with 25 acres or more of forested land.

In addition, given that landowners were identified by individual property plots, this random sampling might have cause confusion among landowners who own multiple plots or properties. For this reason, the survey asked respondents to answer all questions based on their *largest* forested property only. Although this may bias responses because landowners may have different management objectives for different plots and properties, it was necessary for purposes of eliciting clear responses. A focus on the largest property of the landowner was chosen in this study because it is the property most likely to be enrolled in a forest management program for carbon sequestration.

Landowners with potentially forested properties were determined by property classifications established by the New York State Office of Real Property Services (ORPS). Local property assessors use ORPS codes to classify the predominant use of each parcel for local tax assessment purposes. For example, Private Forest Land coded between 910 and 920 was included in this study. However, limiting the study to only these properties would have biased the results. It is often the case that land not classified as private forests is still covered predominantly by forestland. To adjust for this potential omission, properties not classified as Private Forest Land were also considered. These included Rural Residential (coded as 320 – 323) and Vacant Land (240 – 260). By including these categories, a relatively large number of non-forested landowner responses were expected, but this was considered a better alternative than missing a potentially broad spectrum of the forest landowner population. For the same reason, agricultural lands – ORPS Codes 105, 110, 112, 113, 114, and 116–128 – were also sampled if the plot size exceeded 100 acres.

The survey was conducted between January and May, 2011. In an effort to follow the Total Design Method and maximize response rates, each sampled landowner was initially mailed a survey followed by a reminder postcard one week later (Dillman, 1978). For a copy of the reminder postcard see, Appendix C. For landowners who did not respond to the first mailing or to the reminder postcard, a third mailing was sent two weeks following the initial survey mailing to provide another copy of the survey. The only difference between this mailing and the first was that a revised cover letter was included. Finally, non-respondents were contacted a fourth time with another reminder postcard one week following the second survey mailing. Until a response was received, each landowner was contacted a maximum of four times.

3.4 Pilot Study

Before administering the full survey, the survey was pretested using a random sample of 150 NIPFLs to ensure that the questionnaire was understood by participants, that it adequately assessed variables of concern, that it identified the appropriate range of willingness-to-accept values (see discussion in Section 3.5), and to ensure that all logistical issues were addressed. At the end of the pretest response period, of the original 150 pretest surveys mailed, six were undeliverable and eight were returned stating that the respondent did not own more than 25 forested acres. As a result, the final pretest sample size was 136. Sixty-two of the remaining subjects responded, eight of whom were people choosing not to participate; 56 surveys were fully completed and usable. Therefore, the usable response rate for the pretest was 46 percent. The response rate was calculated using the following formula (Dillman, 1978):

$$Response\ Rate = \frac{\#\ Returned}{\#\ in\ Sample - (noneligible + nonreachable)} x\, 100$$

This response rate is considered acceptable in comparison to the studies discussed in the previous section, in which response rates ranged from 32 to 58 percent (Kline et al., 2000; Conway et al., 2003; Langpap, 2004; Belin et al., 2005; LaPierre and Germain, 2005; Fletcher et al., 2009; Jacobson et al., 2009; Joshi and Arano, 2009; LeVert et al., 2009).

Results of the pretest indicated that questions were generally well understood by respondents and elicited the range of expected responses. With the exception of income, which was often left blank by survey respondents, no question was consistently left blank, either on purpose or by mistake. Eleven respondents, or 19.6 percent of the total, chose not to answer the income question, but it is likely that any framing of the question would have elicited lower response levels than other questions due to its sensitive nature.

Using the findings from the initial pretest, the survey was revised to address the questions that arose in the pretest and to clarify any sources of ambiguity. These changes included the removal of the timber income question discussed above and the inclusion of a multi-stage question about political attitudes and beliefs. The political attitudes and beliefs question was included following the pretest's question on attitudes towards climate change, since many respondents' comments indicated that personal political beliefs were a strong determinant of their decision of whether to participate or not in the hypothetical carbon sequestration program. In addition, the front and back covers were printed in color to provide a more visually appealing survey in an effort to build an increased sense of importance of this survey among potential respondents and therefore increase the final response rate. With these changes, the full implementation of the survey was conducted beginning in late January 2011 with a sample of 1,200 NIPF landowners using the same survey and mailing practices as the pretest.

3.5 Contingent Valuation Framework

In order to measure the willingness of landowners to participate in an improved forest management program for carbon sequestration, the most important section of the questionnaire was a detailed contingent valuation (CV) question. A contingent valuation, stated preference approach to measure participation was necessary because there is currently no carbon sequestration program or offset market with enough participation to use a revealed preference approach. A revealed preference approach would analyze how landowners enroll in actual, existing programs to determine landowner characteristics and the appropriate willingness-to-accept incentive payments. Unfortunately, due to the preliminary status of carbon markets and programs, this was not a viable option. Instead, the CV question was included in the survey instrument to ask landowners about their willingness to participate in a potential*,* hypothetical carbon management program.

After briefly explaining the purpose of such a program, its environmental benefits and the potential economic benefits to forest landowners, the survey included a five-point outline of the proposed forest management program. The program overview and requirements for landowners choosing to participate in the carbon management program is outlined in Figure 4. These five program characteristics were included based on their respective potential contributions to a hypothetical forest carbon management program, as suggested by the previous literature and the author's judgment of what an actual carbon management program would likely entail.

Figure 4: Program Outline Used in Contingent Valuation Question

This section outlines a potential forest management program to increase carbon storage on forested land across New York State. This program would offset upfront management costs, provide necessary technical assistance, and pay forest landowners for the increased carbon their forests store.

CARBON STORAGE FOREST MANAGEMENT PROGRAM

- ◊ Establish and follow a written forest management plan with the help and monitoring of a certified forester,
- ◊ Reduce size and regularity of timber harvests,
- ◊ Thin and remove diseased, deformed, or dying trees to increase size, quality and species diversity of the remaining trees.
- ◊ No high-grade clear cutting or developing land for uses other than forest,
- ◊ Participation in the program for a minimum of 20 years.

Immediately following the delineation of hypothetical program, respondents were asked whether or not they would be willing to enroll in the management program if they were compensated a specific amount per acre, every year for the duration of the program. There are a variety of options available to the researcher to measure responses to the willingness-to-accept question. Two of the most common methods are the payment table format and the dichotomous choice format (Welsh and Poe, 1998). A dichotomous choice format offers only one payment to the respondent, who then has the choice to either accept or refuse the payment. Conversely, the payment table format provides the respondent several potential payment offers; the respondent is then asked to decide whether or not they would participate in a program at each offer amount (Boyle and Bishop, 1988; Welsh and Poe, 1998). Examples of these methodologies applied to the context of this survey are provided in Figure 5 for the payment table method (used in the pretest) and Figure 6 for the dichotomous choice format (used in the full implementation survey).

Figure 5: Payment Table Contingent Valuation Format

Would you enroll in the carbon storage forest management program detailed above if you were paid one of these amounts per acre, every year for the extent of the program (20 years)? *(Check one box for each payment amount)*

Payment to you per acre, per year	Definitely No	Probably No	Not Sure	Probably Yes	Definitely Yes
$ 1	☐	☐	☐	☐	☐
$ 5	☐	☐	☐	☐	☐
$ 10	☐	☐	☐	☐	☐
$ 25	☐	☐	☐	☐	☐
$ 50	☐	☐	☐	☐	☐
$ 75	☐	☐	☐	☐	☐
$ 100	☐	☐	☐	☐	☐
$ 200	☐	☐	☐	☐	☐
$ 400	☐	☐	☐	☐	☐

Figure 6: Dichotomous Choice Contingent Valuation Format

Would you enroll in the carbon storage forest management program detailed above if you were paid ***$_____ per acre***, every year for the extent of the 20-year program? *(Check one)*

_____ Yes
_____ No

The decision on which method should be used should not be taken lightly; systematic differences arise in the results using both methods (Welsh and Poe, 1998). The payment table method is useful when the starting points of the appropriate incentive payments are not known (Boyle and Bishop, 1988). Therefore, the pretest used a payment table. Ideally only a dichotomous choice method would have been used, but this method is information poor with small sample sizes. With the small sample size dictated by the pretest, a dichotomous choice format would not have provided enough responses to accurately understand changes taking place under different payment offers. To overcome this problem, the pretest used a payment table to provide a larger number of payments given limited responses. Therefore, the results of the payment table provided guidance on the appropriate range of payment offers used in the dichotomous choice question, which was used in the survey's full implementation.

The payment table approach was not used in the full implementation of the survey because it is not considered incentive-compatible, which may be particularly influential in a WTA framework. When respondents view the potential higher payment offers, they have a tendency to choose higher values than they would if they were not aware of the offer range. On the other hand, when given only one value and asked for a "yes" or "no" participation response, as with the dichotomous choice approach, the respondent is forced to make a decision solely regarding the single payment offer and is unaware of potentially larger payments. As a result, it was expected that responses to dichotomous choice WTA question would be significantly lower than those using the payment table approach.

A potential range of offers that landowners would likely require to enroll in such a program was established using findings from similar studies, advice from forest industry experts, and the results of the pretest. Expert estimates ranged from relatively low values, $5-10 per acre, to relatively high values, $200-300 per acre. From the previous literature, estimates also varied widely. For example, Kline et al. (2000) found that landowners would require $38 to $137 annually per acre to forego harvests near riparian areas to protect habitat, and $185 to $314 annually per acre to forego harvests on an entire property to protect wildlife habitat. Lower ends of these ranges were for recreational and passive landowners, whereas the upper ends of the estimates were for landowners managing their land for economic benefits, e.g., timber production. This wide range of potential estimates represents the uncertainty in NIPFL behavior and thus need for the type of analysis conducted in this study. Johnson et al. (1994) found an annual opportunity cost of $760 per acre to permanently forego timber harvests on Douglas fir stands in Western Oregon. This represents an upper bound because it allows for no timber harvesting, is located in a more productive region of the country for timber, and is a permanent restriction. Fletcher et al. (2009) suggest a much lower range of payments, $5 - $30, as potential carbon offset offers because improved forest management still permits some timber harvesting and has a finite time period. The wide range of values, both from experts in the industry and within the literature, strengthens the need for more research investigating the incentives that landowners would require to manage their land at an optimum for carbon sequestration.

In the payment table, landowners were given a range of annual payment offers between $1 per acre and $400 per acre and asked whether or not they would enroll in the hypothetical program at each offer amount. When choosing the values for the payment table and willingness-to-accept format, the goal was to achieve high levels of “definitely no” responses at the lower end of the spectrum and a high proportion of “definitely yes” responses at the upper end of the spectrum. Responses were expected to follow a gradual switching pattern from “definitely no” to “definitely yes” responses. The values of interest in the payment table were the ones where respondents tended to switch from “probably no” to “not sure” and from “not sure” to “probably yes” because these regions of frequent switching are expected to simulate when respondents would switch from “no” to “yes” in a dichotomous choice setting (Welsh and Poe, 1998).

The results of the payment table are included in Table 1 and provide a matrix of response frequencies at each payment offer and response option. The results confirm the expected trend of responses moving from a high proportion of “definitely no” responses at lower payment levels ($1 - $25) to a high proportion of “definitely yes” responses at the higher end of the payment spectrum ($200 - $400). For example, at a payment offer of $1, 79.5 percent of pretest respondents said they would definitely not participate in the program, and no respondents replied “probably yes” or “definitely yes.” Similar results were found for the $5 payment offer, where two-thirds of respondents said they would definitely not participate in the program and no one replied with “probably yes” or “definitely yes.” At the $400 payment offer level, the opposite was true, wherein 78.6 percent of respondents claimed they would probably or definitely participate in the forestry program. As expected, the intermediate values show a high level of switching from different payment levels as payments gradually increased. Table 1 also provides the frequency of each payment offer being a transition point into and out of different levels of confidence. Offers associated with a high level of switching, from $25 - $100, are considered the most important values for the dichotomous choice question (Welsh and Poe, 1998).

Table 1: Pretest Payment Table Results

Frequency of responses in each category[5]

Payment to you, per acre, per year	Definitely No	Probably No	Not Sure	Probably Yes	Definitely Yes
$1	31	3	5	0	0
$5	28	3	6	0	0
$10	26	4	7	3	0
$25	22	7	5	7	0
$50	16	6	8	5	4
$75	15	4	11	2	5
$100	12	3	9	9	5
$200	9	2	7	9	10
$400	5	1	3	9	24

Frequency of the first time a respondent selected each category ("switch in")

Payment to you, per acre, per year	Definitely No	Probably No	Not Sure	Probably Yes	Definitely Yes
$1					
$5			1		
$10		1	2	1	
$25		3		4	
$50		5	5	3	4
$75			3		2
$100		2	4	6	1
$200		1	2	5	4
$400			1	5	14

Frequency of the last time a respondent selected each category ("switch out")

Payment to you, per acre, per year	Definitely No	Probably No	Not Sure	Probably Yes	Definitely Yes
$1	1				
$5	3		1		
$10	5		2		
$25	6	4	3	3	
$50	1	2		3	
$75	4	3	5		
$100	1	2	4	4	
$200	2		5	5	
$400			1	9	21

[5] Total sample size for the pretest payment table is 56, however not every respondent provided an answer for each payment level.

Using these results, the survey's full implementation used a referendum voting (yes or no), dichotomous choice approach. This method is preferable to the payment table approach because it is considered to be incentive compatible as landowners make only a "yes" or "no" decision to a single payment offer (Lohr and Parks, 1995; Champ et al., 1997; Cummings et al., 1997; Welsh and Poe, 1998; Champ and Bishop, 2001). Payment offers included in the study ranged from \$5 to \$200 and included payment values of \$10, \$25, \$50, \$75, \$100, and \$150. In producing the survey, each landowner was randomly assigned one of the eight payment offers; each respondent was thus unaware of the other possible payment offers. Surveys containing each of the eight payment offers were sent to an equal number of 150 respondents.

Participants were also asked to answer a follow-up question to determine the certainty of their responses. This is especially important due to the lack of knowledge on the subject of carbon sequestration as well as the inflated enrollment levels that are inherent in many contingent valuation studies. Using a method similar to Champ et al. (1997), Champ and Bishop (2001), and Poe et al. (2002), landowners who responded "yes" to the dichotomous choice participation question were then asked how certain they were of their answer. Certainty was measured on a scale from 1 (very uncertain) to 10 (very certain). Results from the certainty question allow for model calibration and variable recoding, if necessary, as in Champ et al. (1997) and Champ and Bishop (2001). These studies found that in a WTP dichotomous choice question, certainty levels can be used to deflate WTP values to allow convergence between actual and stated contributions. Although the previous literature used these methods in a WTP contingent valuation format, this study applied a similar methodology in a WTA context.

Under many enrollment programs landowners may choose to either enroll all of their forested land or only a portion. Asking landowners for a discrete response involving an "all-or-none" decision may therefore provide inaccurate results. To correct for this potential problem, landowners who answered that they would be willing to participate in the program were also asked how many acres they would be willing to enroll. As suggested by Lohr and Park (1995) and Hardi and Parks (1996), this reflects the more accurate two-step nature of decision-making: the discrete choice of whether or not to participate, and the subsequent continuous decision regarding participation intensity (acreage). Lohr and Park (1995) found that, "by ignoring the interactive nature of the participation and enrollment decisions, single-equation methods are subject to selectivity bias errors, which may lead to incorrect conclusions about the factors affecting behavior."

Of the participants, 70 percent stated they would enroll all of their forested property in the carbon management program. Of the remaining participants that chose only to enroll some of their forested property, 20 percent stated they would enroll over 90 percent of their property. The two-step acreage enrollment decision model is often used in research surrounding participation in farm programs and is less prevalent in the forestry literature. Given the smaller acreage and smaller opportunity costs associated with forested land when compared to agriculture, it is not surprising that so many respondents chose to enroll all of their forested property. As a result, it was determined that the two-step decision model was not necessary to apply to this study.

Nonparticipants were also given separate follow-up questions to determine why they chose not to participate. One of the response options was, "I would not participate no matter how much I was paid." This was included in an effort to identify potential "protest" responses – that is, respondents who based their participation decision on reasons other than the payment offer or on economic fundamentals. Of the 186 nonparticipants, 23 (13 percent) stated they would not participate no matter how much they were paid. This was the lowest of the eight reasons listed for participation / non-participation, the highest of which was the desire to control what happens on private land (75 percent of nonparticipants). As a result, it is likely that protest votes are not a primary concern for the CV analysis.

CV surveys oftentimes struggle with the validity and authenticity of a hypothetical program in attempting to elicit accurate survey responses. In order to avoid this problem, a carefully worded cover letter accompanied the survey, suggesting the importance of the landowner's input, and its implications for state-level policymaking. This was done to make the survey consequential and to increase the quantity and quality of responses. According to Carson and Groves (2007),

> *If a survey's results are seen by the agent as potentially influencing an agency's actions and the agent cares about the outcomes of those actions, the agent should treat the survey questions as an opportunity to influence those actions. In such a case, standard economic theory applies and the response to the question should be interpretable using mechanism design theory concerning incentive structures.*

The written and verbal comments returned with the surveys suggest that this CV question (Figure 6) was highly believable. For example, despite multiple attempts to convey the hypothetical nature of the CV question, numerous respondents followed up with phone calls or mailings inquiring about when the program would actually start and what the next step was in the enrollment process. Also, many surveys were returned with comments suggesting that the respondent was hesitant to provide a "yes" or "no" answer to the question because not enough information was given for them to make an *actual* participation decision. Normally this increased believability generates more accurate WTA/WTP results. In this case, however, even given the apparent believability of the CV question, there may have been a bias against participation due to a lack of information *if* the respondent was under the impression that his or her decision was for actual enrollment.

3.5 Survey Results

In January, surveys were sent out to 1,200 randomly selected landowners in the Catskills, including landowners throughout Delaware, Greene, Sullivan and Ulster counties. When the study was finished, the sample included 68 undeliverable surveys and 513 returned surveys. Of the surveys returned, 57 were returned blank stating that the respondent did not own more than 25 acres of forested land and 5 were returned with comments suggesting the respondent did not want to participate in the study. Therefore, 451 of the returned surveys were adequately completed and usable. Using the equation given in the pretest section above, the study concluded with a total response rate of 42 percent. Similar to the pretest results, the final response rate is considered successful in the sense that it falls in the range of similar studies. The following section summarizes the responses to key questions throughout the survey. The results included in this section are included to provide a descriptive overview of the sample and data prior to any discussion of the modeling and decision-making framework elaborated in the following section. Tables are provided for a variety of questions, but for complete summary results for each survey question, see Appendix C. This section does not summarize the exact variables used in the subsequent econometric analysis (Chapters 4 and 5), but rather how the questionnaire itself was answered prior to any coding of variables. Unfortunately, due to incomplete responses, not all observations could be included in the model estimation. Instead, the summary results provided below are for the complete sample with more observations included than in the summary statistics included later in the modeling sections.

The average landowner in the sample was 63 years old, 80 percent were male, and over 50 percent were retired. The average landowner in the sample was also highly educated. Fifty percent of respondents had received at least a college bachelor's degree and 26 percent had received a graduate or professional degree. Additionally, average incomes were also relatively high, with over 50 percent of the respondents stating a household combined annual income over \$100,000. The average landowner's largest forested property was 121 acres (median = 80 acres), the largest of which was 1,200 acres. The average amount of forested land on these properties was 85 acres (median =55). Although this indicates a relatively large average property size, most landowners in the sample owned 25-50 acres of land, thus signifying a skewed distribution of size of acreage. The large number of relatively small landowners is consistent with other studies, and is representative of the many small and diverse private landowners who collectively own a large amount of forested land in the region (Birch and Butler, 2001; Butler and Leatherberry, 2004).

The properties included in the sample have been owned by the landowner and his/her family for an average of 39 years, with a maximum ownership duration of 200 years. The relatively long duration of land ownership is likely due to a large number of landowners who acquired their land from inheritance, nearly 20 percent of the survey sample. Although land has consistently been owned for long periods of time, it would be imprudent to assume that properties will not change ownership or be sold off into many small parcels in the future. Given the aging landowner population, much of the land will likely change ownership over the next couple of decades, either being sold to new owners or inherited by the landowner's family. Both outcomes have the potential to significantly alter the forest landscape in the region. If sold to new owners, it is likely that many properties will be converted into smaller parcels for vacation homes. On the other hand, properties inherited by family members may be less actively managed due to lower overall interest in forest ownership and possibly increased absenteeism. As a result, the relatively long ownership trend in the region, common among all Northeastern NIPFLs, may be indicative of an impending changing landscape rather than a future of stability (Birch and Butler, 2001; LaPierre and Germain, 2005; Kay and Bills, 2007; Department of Environmental Conservation, 2010).

As expected, the sample also included a large number of absentee landowners. Only 40 percent of the sample had their primary residence located on the forested property and nearly half lived more than 50 miles away. The average landowner who did not have a primary residence on the forested property lived 127 miles away, the furthest of which was over 3,500 miles. The relatively large number of absentee landowners is common in the NIPFL literature and is likely further inflated in the Catskills region due to the number of vacation homeowners from the nearby New York City metropolitan area.

A critical objective of this study is to determine the reasons landowners in the Catskills own their land, and what influence that will have on potential participation in carbon management programs. In general, most of the landowners surveyed stated that the most important reason for owning their forested land was to enjoy beauty or scenery and as part of a home or vacation home. Other important reasons for owning forested land were to protect nature and biological diversity, for privacy, and for recreation. The following ownership objectives are significantly less important among respondents: for production of sawlogs, pulpwood or other timber products for commercial sale; harvesting firewood; as part of a farm; or for land investment. These results, detailed in Table 2, are consistent with the general trend that forest landowners are generally less concerned with the financial and productive uses of their land than they are for reasons such as enjoying nature, privacy and recreation. This is especially true among Northeastern forests (Birch and Butler, 2001; Butler and Leatherberry 2004). These results highlight the importance of multi-objective landowners in the region.

Table 2: Reasons for Owning Forested Land

"Importance of Owning Land for the Following Reasons"*	Not (1)	Somewhat (2)	Important (3)	Very (4)	Average	Most Important**
Enjoy beauty or scenery	2%	8%	27%	59%	3.50	18%
Protect nature and biological diversity	4%	14%	34%	42%	3.20	7%
For land investment	20%	28%	29%	16%	2.44	5%
To participate in carbon storage or offset markets	35%	30%	15%	8%	1.94	1%
Part of a home or vacation home	10%	8%	22%	52%	3.26	17%
Part of my farm	45%	10%	14%	22%	2.13	5%
For privacy	8%	12%	31%	43%	3.15	6%
To pass land on to my children or other heirs	16%	17%	26%	37%	2.87	8%
For production of firewood or biofuels	38%	25%	17%	14%	2.06	2%
For production of sawlogs, pulpwood or other timber products for commercial sale	47%	22%	17%	9%	1.87	0%
For hunting or fishing	27%	14%	19%	36%	2.66	13%
For recreation, other than hunting or fishing	11%	14%	33%	37%	3.01	3%

n = 430
*Multiple responses allowed.
** Identified as the *most* important reason for owning forested land

The relatively low levels of recent forest management and timber harvesting represent the passive ownership trend and low priority of active management and timber harvesting among forest landowners in the region. For example, 38 percent of respondents claimed that they do not conduct any forest management on any of their land and only 46 percent stated they have harvested trees for any reason in the past five years. Of those respondents who have harvested trees in the past five years, the most important reason for harvesting trees was to improve the quality of remaining trees (64 percent), personal use such as obtaining firewood (55 percent), because the trees were mature (34 percent), or to achieve the objectives of a forest management plan (33 percent). Interestingly, only 28 percent of respondents claimed that tree harvests were done for monetary or financial returns.

Respondents were also asked about their forest management practices. The most common management practices identified in the sample were harvesting firewood for personal use (56 percent), to mark property boundaries (43 percent), and building or maintaining roads or trails (43 percent). Plans for future management followed similar trends, although fewer respondents planned on leaving their forest as it is. This suggests a desire among forest landowners to manage their land better, but also underscores an important disconnect with actual implementation. Only five percent of respondents had a working conservation easement on their land and only 17 percent had an active written management plan. About half of landowners (52 percent) received no assistance or information about forest management from a professional source. Those that did receive technical or management information or assistance commonly utilized NYS Department of Environmental Conservation foresters (14 percent), private consultants (18 percent), or logging contractors (18 percent). However, despite the relatively low levels of historic management, there does seem to be a general level of interest in more intensive forest management in the future. As a result, a push for greater knowledge and understanding along with stronger incentives for improved management may be successful in increasing future levels of forest management in the region. For example, 67 percent of respondents agree that their forested property *should* be actively managed, thus indicating room for improvement and addressing existing barriers that limit further management.

The survey also included several questions to gauge respondents' knowledge of climate change issues, attitudes towards climate change, and their general political beliefs. Respondents were first asked to rank, on a scale from one to four, the extent of their personal knowledge about climate change and related issues. The question was posed to respondents as follows:

> *How familiar are you with the following terms and concepts often used in discussions involving climate change? (Check one box for each item listed).*

The terms and concepts included were "climate change or global warming," "forest carbon storage or sequestration," "carbon offsets," and "cap-and-trade." The results of this question are shown in Table 3.

Table 3: Knowledge of Climate Change Terms and Concepts

Climate Change Concept	Not Familiar (1)	Somewhat Familiar (2)	Familiar (3)	Very Familiar (4)
Climate Change / Global Warming	5%	19%	34%	42%
Carbon Storage / Sequestration	43%	22%	19%	15%
Carbon Offsets	42%	23%	19%	13%
Cap-and-Trade	47%	18%	18%	15%

n = 448

Not surprisingly, of these four categories, respondents ranked their knowledge of general climate change and global warming highest, with 42 percent claiming to be very familiar of the issue (the highest possible ranking). However, when asked about forest carbon sequestration specifically, respondents were much less knowledgeable: 43 percent of respondents indicated no familiarity with forest carbon storage and sequestration. Similar results were also found for carbon offsets and cap-and-trade, where 42 percent and 47 percent of respondents indicated that they had no familiarity with the respective issues. This admitted lack of knowledge demonstrates low levels of awareness among the forest landowner community regarding these key issues.

Despite the low levels of knowledge and familiarity, respondents often stated highly polarized views about climate change. The survey included five carefully worded statements to measure attitudes and beliefs about climate change. Respondents were asked to respond with how strongly they agreed or disagreed with each statement on a scale from 1 to 5 with the following question (Stedman, 2004; Williamson et al., 2005):

> *To what extent do you agree or disagree with the following comments about climate change? (Circle one number for each comment listed)*

An answer of 1 indicated that the respondent strongly disagreed with the statement or comment whereas an answer of 5 represented strong agreement. The exact statements and comments included in the survey are shown in Table 4. These questions asked respondents their views about the severity of future climate change, the urgency involved, and about general scientific findings. Although the results, also included in Table 4, indicate a slight bias supporting climate change as a serious issue and scientific reality, a strong sentiment of skepticism about the existence and severity of climate change was also evident. This finding is similar to other research about public perceptions towards climate change and indicates similarities between the forest landowner community and the general public (Leiserowitz and Smith, 2010).

Table 4: Landowner Attitudes Towards Climate Change Issues

Statements about climate change	Strongly Disagree (1)	(2)	Neutral (3)	(4)	Strongly Agree (5)
"Climate change is a serious problem that requires immediate action"	12%	9%	22%	20%	35%
"Concern about climate change is overblown"	32%	13%	20%	16%	17%
"Climate change is a threat to my forest and local community"	14%	13%	32%	19%	20%
"Generally, the science of climate change is inconclusive"	25%	15%	24%	16%	18%
"My personal actions can have an influence on climate change"	11%	8%	30%	25%	23%

n = 442

When asked whether or not "climate change is a serious problem that requires immediate action," a slight majority of respondents (55 percent) ranked their agreement as either a four or five. Respondents who strongly agreed constituted the largest group (35 percent), whereas only 12 percent were in strong disagreement. In general, respondents answered consistently when given a similar statement that "concern over climate change is overblown." In this case, 32 percent of respondents strongly disagreed and 17 percent strongly agreed. The third statement, "climate change is a threat to my forest and local community," was more neutral. For this statement the ranking level three (neutral) was answered the most often (32 percent), whereas 39 percent of respondents agreed and 27 percent disagreed with this statement either somewhat or strongly. The following two statements - "Generally, the science of climate change is inconclusive," and "My personal actions have an influence on climate change" - both elicited similar results to the third statement above, with the neutral category receiving the most answers and a slight bias towards acceptance of climate change science. Overall, these results indicate that the forest landowners in the survey, on average, tend to have a slight agreement towards statements showing concern and urgency over the future of climate change and agreement with climate science. However, it would be inaccurate to assume that individual respondents are neutral in their beliefs or attitudes. Instead, respondents as a whole often gave offsetting polarized responses, either strongly in favor or strongly against climate change science and policies.

Finally, landowners were also asked to respond to statements regarding their fundamental beliefs in political and economic systems. The format of this question was the same as the one discussed above regarding attitudes towards climate change issues. The exact wording of the statements and the aggregate results are provided in Table 5. The first statement, “A first consideration of any good political system is the protection of private property rights” elicited the strongest set of responses with 60 percent of respondents strongly agreeing and 19 percent somewhat agreeing to the statement. At the other extreme, only seven percent of respondents registered any level of disagreement. This is not surprising given that the sample is comprised exclusively of private landowners. The strong support for private property rights is consistent with other research that finds a strong desire for autonomy among the private forest landowner community (Fischer and Charnley, 2010). Not surprisingly, respondents also agreed consistently with the statement “government has a basic responsibility to protect our natural environment” with 39 percent ranking their agreement a five and another 32 percent ranking their agreement a four.

Interestingly, the average landowner was inclined to agree with the statements “government provides valuable and necessary services to society” and “the best government is the one that governs the least.” Overall, 54 percent and 49 percent of respondents, respectively, indicated some form of agreement with these statements, and only 19 percent and 23 percent, respectively, indicated some sort of disagreement. Conversely, there was disagreement with the statement “decisions about development are best left to the economic market,” with 52 percent reporting disagreement (a ranking of either a one or two) and only 18 percent with some level of agreement (a ranking of either a four or five). Overall, the results from the survey are similar to previous research and the responses follow similar trends and expectations. The next section discusses how the survey questions and answers were coded into variables for use in the econometric models and analysis.

Table 5: Landowner Political Attitudes and Beliefs

Statements about political views	**Strongly Disagree** (1)	(2)	**Neutral** (3)	(4)	**Strongly Agree** (5)
“A first consideration of any good political system is the protection of private property rights”	3%	4%	13%	19%	60%
“Government provides valuable and necessary services to society”	8%	11%	26%	26%	28%
“The best government is the one that governs the least”	10%	13%	26%	18%	31%
“Government has a basic responsibility to protect our environment”	4%	5%	18%	32%	39%
“Decisions about development are best left to the economic market”	28%	24%	27%	10%	8%

n = 445

CHAPTER 4

ECONOMETRIC MODEL

This study estimates the levels of payments necessary to induce landowners to manage their forests using the improved forest management practices and techniques outlined previously. To do so, a dichotomous choice contingent valuation approach is used, in which the respondent is asked whether or not he/she would be willing to participate in a hypothetical forest management program at a specific price. As in Kline et al. (2000), a forest landowner will decide to enroll or not enroll in a proposed program by comparing his or her expected utility with and without the program. It is expected that a landowner's utility function is influenced by a variety of forest management preferences, property characteristics, and landowner characteristics.

4.1 Forest Landowner Random Utility Model

Modeling the participation decision is a two-step process: the first step is to develop an algebraic formulation of the random utility model and the second step is to assume a distribution for the error term. A random-utility model is used to predict a landowner's willingness to accept a payment for program participation. The random-utility model assumes that the responses to the contingent valuation question are the outcome of a utility-maximizing choice among a full suite of forest management options. Amacher et al. (2003) demonstrate that landowners derive utility by managing their lands for both timber harvest benefits and a variety of non-timber-related activities such as recreation, aesthetics, privacy, and wildlife. When given the option of participating in an improved forest management (IFM) program, a landowner's enrollment decision can be characterized by the utility function (Hanemann, 1984; Kline et al., 2000):

(1) $u(j, y; l, m, o, a, d)$

where ***j*** is a discrete variable representing participation in the improved forest management program, and ***y*** represents a landowner's income including any payment received from forest management. Additional vectors of exogenous variables ***l, m, o, a,*** and ***d*** are also included in the random utility model as they may influence a landowner's participation decision. Term ***m*** refers to a vector of forest management characteristics, ***l*** refers to a vector of property and land characteristics specific to the landowner's forest, ***o*** refers to a vector of ownership objectives, ***a*** refers to a vector of variables measuring a landowners attitudes and beliefs, and ***d*** refers to a vector of demographic variables. The participation decision can then be modeled as

(2) $u_1 = u(1, y_1; m, l, o, a, d)$ if a landowner chooses to enroll in the program and agrees to forest management requirements and restrictions, or

(3) $u_0 = u(0, y_0; m, l, o, a, d)$ if landowner chooses *not* to enroll in the program and maintains a full suite of management options.

Following Hanemann's (1984) presentation of the random utility model for discrete choice contingent valuation, the landowner is assumed to know, with certainty, his or her own utility function, but there are some components of the utility function that are unknown to the researcher. As a result, these unobservable variables produce the random and stochastic nature of the statistical binary response model (Hanemann, 1984; Hanemann and Kanninen, 1996). To the researcher, u_1 and u_0 are both random variables with the same probability distribution. The observable utility function is defined by $v(1, y_1; m, l, o, a, d)$ and $v(0, y_0; m, l, o, a, d)$, and the utility function can then be represented by,

(4) $$u(j, y; m, l, o, a, d) = v(j, y; m, l, o, a, d) + \varepsilon_j \qquad (j = 0,1)$$

where ε_1 and ε_0 are independent and identically distributed random variables with zero means.

When offered an incentive payment, $\boldsymbol{p}$, the observed utility function becomes,

(5) $v(j, y+p; m, l, o, a, d) + \varepsilon_j$

and the landowner will choose to participate if

(6) $v(1, y+p; l, m, o, a, d) + \varepsilon_1 \geq v(0, y; m, l, o, a, d) + \varepsilon_0$ or,

(7) $v(1, y+p; l, m, o, a, d) - v(0, y; m, l, o, a, d) \geq \varepsilon_0 - \varepsilon_1$

and will choose not to participate in the program otherwise.

Using the conceptual framework and economic model outlined above, a landowner's willingness to participate in an improved forest management program for carbon benefits is modeled here using standard statistical and econometric techniques. This section formulates the appropriate statistical model that is consistent with the economic model outlined above. Using a split sample design, individual landowners were asked if they would participate in the IFM program if they were compensated with one of eight randomly assigned annual incentive payments. The dichotomous structure of the participation decision and the subsequent discrete dependent variable support the use of a variety of statistical models. In this study, the error term ε^*, the difference between $\varepsilon_1 - \varepsilon_0$ in equation (7), is assumed to be distributed logistically (Hanemann and Kanninen, 1996; Kline et al., 2000). This study chose to estimate the random utility model using a logistic function, or logit, estimation approach, which implies the use of the standard logistic cumulative density function.

Factors that may influence a landowner's observed utility (Δv, see equation 7), and therefore influence the decision to participate, include the incentive payment offered and a vector of forest management and land ownership objectives, land and forest characteristics, and a landowner's socio-demographic characteristics. Each of the independent variables, with the exception of the offer variable, is condensed into a single term $\boldsymbol{s}$ for model simplification purposes. Given the uncertain functional form of the payment offer variable included in the model, this study chose to estimate the model with two separate functional forms depicting underlying utility, one assuming a linear form of the offer variable (i.e. utility of income is constant over the range of payments) and the other assuming a logged version offer variable (corresponding to the log linear utility function). These models will henceforth be referred to, respectively, as the linear utility function and the log utility function. The algebraic specification of the utility difference function Δv (see equation 7) can be modeled using the following logit estimation (Hanemann and Kanninen, 1996),

(8) $\Delta v = \alpha(s) + \beta(offer) + \varepsilon_i$ for the linear utility function

(9) $\Delta v = \alpha(s) + \beta ln(offer) + \varepsilon_i$ for the log utility function

Given the logit estimation of the random utility function the probability of participation can be modeled assuming a logistic distribution of the error term,

(11) $P_i = E(Y = 1]X_i) = \frac{1}{1+e^{-(\alpha(s)+\beta(offer)+\varepsilon)}}$

where Δv can be represented as a dichotomous variable (1 characterizing participants and 0 characterizing non-participants), while ***s*** represents a vector of property, management, and landowner characteristics**.** In addition, α and β represent the parameter vector of coefficients to be estimated. Specific explanatory variables included in the vector of property, management and landowner characteristics are discussed in the following section.

4.2 Explanatory Variables

The dependent variable in the logit estimation indicates whether or not a landowner is willing to accept the incentive payment offer, enroll in the improved forest management program, and agree to the associated management requirements and restrictions. The variable is coded as a dichotomous variable, where 1 represents participation in the IFM program and 0 represents nonparticipation. Therefore, the explanatory variables discussed below are predictors of the participation decision of the forest landowner.

For each explanatory variable included in the model there is a discussion below about the reasons it was included, how the variable was measured, findings from similar studies, and the expected relationship with program participation estimated in this study. Table 6 provides a list of variables included in the estimation and the expected sign of the coefficients prior to the estimation.

Table 6: Expected Sign of Explanatory Variable Coefficients

Variable	Description	Exp. Coeff.
Payment offer (p)		
Offer	Payment offered for participation	+
LnOffer	Log of Offer	+
Land and Property Characteristics (l)		
Acre	Number of acres owned	+
Forest Management Characteristics (m)		
Plan	Has a written management plan	+
Advice	Received forestry advice from a professional	+
Ownership Objectives (o)		
Nature	Own land for scenery and nature	+
Timber	Own land to harvest wood products	-
Recreation	Own land for recreational purposes	+
Invest	Own land for investment	+
Privacy	Own land for privacy	-
Landowner Attitudes and Beliefs (a)		
Climate	Climate attitude score (low score = skeptic)	+
Political	Political beliefs score (low score = liberal)	-
Social and Demographic Characteristics (d)		
Absentee	Primary residence is not on property	-
Age	Age of landowner (years)	-
Income 2	$25,000 - $49,999	+
Income 3	$50,000 - $74,999	+
Income 4	$75,000 - $99,000	+
Income 5	$100,000 - $150,000	+
Income 6	Greater than $150,000	+

4.2.1 Payment Offer (p)

Perhaps the most important determinant of landowner participation in the hypothetical forest carbon sequestration program is expected to be the amount of the incentive payment offered (OFFER). In this study, incentive payments ranged from \$5 to \$200 per acre and included payment values of \$10, \$25, \$50, \$75, \$100, and \$150. It is likely that as incentive payments increase, the probability that a landowner will participate in the proposed program will also increase. As a result, the estimated coefficient of the offer variable is expected to be positive. As seen in previous literature, for example, Kline et al. (2000), Fletcher et al. (2009), and LeVert et al. (2009), the amount of incentive payment offered is often a significant and strong predictor of program participation. For a complete discussion regarding the selection of specific payment offers, please see the relevant discussion in Chapter 3.

Although economic theory justifies the inclusion of the payment offer in the logit model, theory alone provides little guidance on the functional form of the offer variable. A logged incentive payment offer assumes that in the absence of a financial incentive mechanism, participation in the program would be zero. When the same model is estimated with a linear functional form of the incentive payment, it is assumed that some participation in the program would occur even in the absence of a monetary incentive.

In reality, there is reason to support both of these assumptions. Some landowners, recognizing potential overlapping objectives with the proposed management plan and their personal management style, may agree to enroll in the program without an incentive payment. Further, a strong environmental ethic and desire to help alleviate climate change problems may be enough of a moral and social incentive to result in some degree of participation. Conversely, given the low levels of forest management currently taking place in the region, low levels of participation in other management programs and limited knowledge of climate change issues, there is reason to believe that without an incentive payment there might be participation. It is likely that the true rate of participation lies somewhere between these two alternatives. As a result, this study provides estimation models that include both linear and logistic functional forms of the offer variable.

Along with the payment offer variable, which is the primary variable of concern for the WTA analysis, several explanatory variables are also included in the econometric analysis. By including the variables discussed below, policymakers will have the ability to target landowners effectively if a program similar to the one outlined in this study were to be implemented in the future. In addition, the variables are included in the analysis to increase construct validity. According to Perman et al. (2003), "Construct validity concerns the degree to which the estimated contingent valuation method measure agrees with other measures as predicted by theory." If the additional variables included in the econometric model follow economic theory, then it is more likely that the offer variable is being estimated appropriately. In this case the additional variables increase the theoretical validity of the contingent valuation method applied in this study.

4.2.2 Forest Management Characteristics (m)

Other forest management variables are included in the logistic regression equation because they are potential determinants of program participation. Although many variables were included in the survey instrument regarding past forest management and future plans, the questions were often difficult to convert into variables for use in the econometric models. From the responses collected, it became clear that landowners consider active management very differently from one another. For example, some landowners considered minor cosmetic tree trimming as timber harvests and active management while others only considered active management to be significant harvests for financial return. As a result, proxy variables are used in the econometric analysis to measure active management in an effort to segregate *professional* forest management from amateur management. It was determined that whether or not a landowner received advice from a professional forester (ADVICE) and whether or not he or she had a written management plan on the property (PLAN), are variables that could be used as proxies for active management because they require input from a professional in the forestry industry. It is likely that landowners who are more involved or interested in forest management will have increased exposure to forestry professionals and written management plans.

Whether or not a landowner has received information or advice (ADVICE) from a professional forester will also likely affect program participation. Due to the complex nature of an improved forest management program for carbon sequestration, professional advice is important for enrollment. Therefore, landowners were asked whether they received any information about forestry management topics from DEC foresters, extension foresters, private consultants, logging contractors, non-profit organizations, or other forest landowners. The advice variable was coded as a 1 if a landowner received information from a professional (DEC foresters, extension foresters, private consultants, logging contractors, or non-profit organization), and 0 otherwise. It is likely that landowners who used professionals as sources of information in the past would be more likely to participate in the forest management program proposed in this study. This is because landowners who receive information from these sources have already indicated an interest in and knowledge of forest management and forestry related issues, whether it is for timber harvests or environmental purposes.

Not surprisingly, Nagubadi et al. (1996) found that a landowner who received advice was more likely to join forestry assistance program and Langpap (2004) found that landowners who were a member of a forestry organization were more likely to participate in an endangered species conservation program. As a result, the same can be expected in this study and a positive coefficient is expected in the model's estimation.

Sometimes a landowner already has a written management plan that guides how their land should be managed. Written management plans are created by a professional forester and provide important guidance about forest management, health, and productivity. Oftentimes written management plans are voluntary, but are sometimes required by law if the land is part of an incentive program, tax relief program, or conservation easement. The management plan variable (PLAN) in this study is a dichotomous variable, coded as a 1 if a landowner has a written management plan, and 0 otherwise. Although the number of landowners with written forest management plans is likely to be relatively low (Birch and Butler, 2001; Butler and Leatherberry 2004; Kay and Bills, 2007), this can be expected to have a positive relationship with program participation because landowners who already have a written forest management plan are more likely to engage in management practices similar to the requirements of the forest carbon storage program. It is unlikely that the existing management plans have conditions that would not permit the landowner from participating. Therefore a landowner could most likely engage in the incentive program proposed in the survey while still implementing his/her existing forest management plan.

4.2.3 Land and Property Characteristics (l)

The logit regression equation also includes a variable that measures the total acreage of the property (ACRE). It is likely that landowners with larger plots will be more likely to participate in a potential forest carbon sequestration program because of the economies of scale necessary to profit from such a program. As stated previously, only landowners with more than 25 acres of forested land are included in the sample. However, even among this subset of forest landowners, it is likely that owners with larger properties have more land available to use for a variety of different purposes. These landowners will thus have a greater potential to enroll only a portion of their land in a program, while retaining a full suite of land management options on the remaining unenrolled acreage. As a result, it is likely that, holding all else constant, landowners with larger acreage will exhibit an increased probability of participating in a forest carbon management program. Ideally the econometric model would also include other plot characteristics such as the age of the forest stand, the forest's tree species composition, logging road access, and other site-specific variables. However, this type of information is difficult to measure accurately through a mail survey. Therefore, additional land and property characteristics could not be included in the analysis despite their potential importance in the enrollment decision.

4.2.4 Ownership Objectives (o)

There are a variety of different variables that can be used to measure a landowner's forest ownership objectives. The previous literature indicates that landowners own forests for a variety of different reasons. Many times these objectives overlap with one another and are not mutually exclusive. As a result, a landowner's reasons for owning his or her forested property are likely to influence potential participation. This is especially important in the utility maximization framework outlined above rather than for more traditional profit maximization objectives.

A variety of questions included in the survey attempted to capture and categorize the primary objectives of owning forested land. Respondents were asked to rank each reason on a four-point scale. Rather than create a separate variable for each of the reasons listed, exploratory factor analysis, EFA, was used to reduce the number of variables. The purpose of EFA is to identify several distinct variables that may be measuring the same latent factor. By combining these variables into a single factor, the number of variables in the logit model can be reduced while still accounting for the majority of the variance captured by the individual variables themselves. This also allows the researcher to measure the unique underlying characteristics that may be difficult to capture with a single question. Although not widely used in the field of economics, EFA is common in other social sciences and is often applied to forest landowner surveys (Kline et al., 2000; LeVert et al., 2009; Rasamoelina et al., 2010).

Results of the EFA identified three latent factors that individual variables loaded onto with a large degree of communality. Communality refers to the amount of variance in an observed variable that is accounted for by the limited number of factors. Retaining these three factors was determined based on the Kaiser criterion, also known as the eigenvalue-one criterion, which suggests retaining any factor with an eigenvalue greater than one (Kaiser, 1960). For a table of eigenvalue values associated with each factor, see Table 7. Eigenvalues greater than one are retained because the component is accounting for more than the variance of any single variable included in isolation. Although potentially simplistic in approach, three factors were also incorporated due to the clear and logical clustering of the individual variables (Mulaik, 1972).

Table 7: Exploratory Factor Analysis Eigenvalues

Factor	Eigenvalue	Percent of Variance	Cumulative Percent
1	2.42	26.91	26.91
2	1.77	19.71	46.62
3	1.10	12.19	58.81
4	0.90	9.96	68.77
5	0.74	8.20	76.97
6	0.70	7.74	84.71
7	0.57	6.28	90.99
8	0.43	4.78	95.76
9	0.38	4.24	100.00

The next step in the EFA is to determine the underlying latent factor causing the individual variables to group together and to interpret the meaning of the retained factors. The pattern matrix provided in Table 8 can be used to determine which variables load onto each factor. In this study, the pattern matrix was extracted using maximum likelihood estimation and rotated to provide uncorrelated factors using a varimax rotation with Kaiser normalization. This method calculates factor loadings that maximize the probability of sampling the observed correlation matrix from a population (Mulaik, 1972). The rotation was conducted to make the pattern matrix solution easier to interpret. The varimax rotation is an orthogonal rotation that maximizes the variance of loadings and results in separate, uncorrelated factors. From this table, it can be seen that owning forested land to enjoy beauty or scenery and to protect nature and biological diversity both load strongly on the first factor. On the other hand, owning forested land to harvest firewood or biofuels or for production of sawlogs, pulpwood or other timber products both load heavily on factor two. Finally, owning forested land for hunting and fishing, for other recreation, and to pass land onto children or heirs all load heavily on factor three.

Table 8: Exploratory Factor Analysis Pattern Matrix

Reasons for Owning Forested Land	Factor 1	Factor 2	Factor 3
Harvest Firewood	-0.008	***0.583***	0.263
Hunting or Fishing	-0.029	0.326	***0.435***
Pass to Children	0.088	0.130	***0.564***
Investment	0.100	0.238	0.082
Protect Nature	***0.491***	0.045	0.110
Enjoy Privacy	0.393	0.079	0.389
Recreation	0.348	0.058	***0.446***
Enjoy Scenery	***0.984***	-0.037	0.018
Harvest Timber Products	-0.068	***0.966***	0.002

As a result, it is evident that factor one represents owning forested land "to enjoy beauty or scenery" and "to protect nature and biological diversity" (NATURE). Factor two represents owning land "production of sawlogs, pulpwood, or other timber products" and "for production of firewood or biofuels" (TIMBER). Factor three represents owning land "for hunting and fishing," "for recreation, other than hunting or fishing," and "to pass land on to my children or other heirs" (RECREATION). At first glace owning forested land to pass on to children or other heirs may not appear to overlap with the other recreational variables. However, on closer review it is evident that many respondents who place high importance on this ownership objective do so because they use their land to spend time with family while participating in recreational activities. For instance, many of these respondents claim to use their land as part of a "family camp" or a place to vacation with their families. Many of these landowners desire to pass their land on to their children and family in order to maintain family traditions. Therefore, the variable is appropriately assigned to the recreation factor.

On the other hand, owning "for land investment" purposes (INVEST) does not load heavily on any factor and owning land "for privacy" (PRIVACY) has evenly distributed loadings. Therefore it can be concluded that these latter variables are isolated factors and their effects should be estimated independently of the other factors and variables. Given the large number of multi-objective landowners in the region, landowners were not categorized and divided into groups for owning land exclusively due to one of the objectives investigated in the EFA. Instead, each landowner was given a score measuring the importance of owning forested land for each of the five objectives. Each factor's score was created by taking a simple average of the relevant variables in each factor (determined from the pattern matrix in Table 8) and were therefore measured on a scale from one to four. High scores indicate a high level of importance whereas a low score indicates a relatively low level of importance.

A Cronbach's' alpha reliability test was performed on this scale to confirm that the test score was accurate, internally consistent and reliable. According to Cronbach (1951), "a reliability coefficient demonstrates whether the test designer was correct in expecting a certain collection of items to yield interpretable statements about individual differences." This quantifies the magnitude of error in the measurement of the scale when summing individual variables together. It provides yet another confirmation that the exploratory factor analysis is properly grouping variables according to their latent factor and internal correlation (Cronbach, 1951). The resulting alpha values of 0.63 for the NATURE factor, 0.72 for the TIMBER factor, and 0.55 for the RECREATION factor are considered adequate measures of reliability for the variables created by the factor analysis.

It is likely that landowners with timber harvesting objectives (TIMBER) will be less likely to participate in the forest management program suggested in this study due to restrictions placed on harvest size and the opportunity costs of foregoing land for uses other than productive purposes. However, the forest management plan proposed in the survey still allows for timber harvests and the requirements for land management will increase future timber productivity on the land. Therefore, the estimated relationship between the timber variable (TIMBER) and participation is somewhat uncertain, but likely to be negative. This is likely to also be true for landowners who are more interested in the investment opportunities associated with the forested property (INVEST). Although participation may allow the landowner to achieve a given rate of return while leaving long-term objectives (20+ years) relatively open, the restrictions placed on the land during the enrollment period will infringe on most investment opportunities. The landowner would also be forgoing potentially lucrative large-scale harvests. As a result, it is likely that the investment variable will have a negative coefficient in the regression equation.

Landowners placing a high importance on nature and scenic objectives (NATURE) also have an uncertain relationship with participation. On the one hand, these landowners will be less involved with timber harvests in general and therefore may not highly value the opportunity costs associated with the program's restrictions. Also, these landowners are likely to see the environmental and climate benefits associated with participation and therefore may be more inclined to participate. This supports the hypothesis that participation may be more likely amongst the environmentally concerned landowner population. This finding would warrant specific program design for carbon offsets and climate mitigation and could be a significant departure from more traditional management programs. However, these landowners may also be less interested in forest management in general and may not want to be bothered with the active management required by the program, regardless of the end goals.

Similarly, it is unclear whether landowners placing high importance on recreational objectives (RECREATION) will be more or less likely to participate. Participation in a carbon sequestration program would allow the property to still function for many types of recreation such as hiking, nature observation, and snowmobiling, but might cause enough habitat transformation to decrease hunting opportunities. The underlying uncertain expected coefficient is also due to the potential for decreased interest in forest management for reasons similar to those landowners who place a high importance on nature and scenic objectives.

Finally, landowners who place relatively high importance on privacy (PRIVACY) are expected to be less likely to participate. This inverse relationship is likely due to the desire for autonomy and seclusion, which is prevalent among many forest landowners. Whether the land is owned for a vacation home or primary residence, these landowners typically do not want to be bothered by management programs, non-profit groups, or government agencies regardless of their motives. Therefore, it is likely that the privacy variable will have a negative coefficient in the logit regression equation.

4.2.5 Landowner Attitudes and Beliefs

Two of the most important variables estimated measure a landowner's attitudes towards climate change and political orientation. The previous chapter provided an overview of the survey questions that asked respondents to rate how strongly they agreed or disagreed with several comments related to climate change and general political issues. Responses to each of these statements were then coded into an aggregate variable by summing the 1-to-5 score for each of the five statements included in both variables. The resulting two variables were coded as scales ranging from 5 to 25; one for climate change attitudes (CLIMATE) and another for political beliefs (POLITICAL).[6]

Half of the statements were transformed by "flipping" the 1-to-5 point response scale so that the responses could be accurately aggregated. For example, the statements "Climate change

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[6] For more information on the questions forming this variable, see Tables 4 and 5 in the previous chapter as well as the survey instrument provided in Appendix B.

is a serious problem that requires immediate action" and "Concern about climate change is overblown" are obviously incompatible if the scores are simply added. Therefore, the variables representing negative or skeptical views towards climate change were recoded so that "strong agreement" became a 1 instead of a 5, "strong disagreement" became a 5 instead of a 1, and 2 and 4 were also swapped accordingly. As a result, higher scores on the climate variable represent people who generally agree with mainstream climate science and are concerned about potential impacts. A relatively low score, closer to five, represents skepticism of climate science and little concern over potential impacts. A similar transformation method was performed on the political values variable. As a result, high scores on the political variable represent relatively conservative, "right wing" values, whereas a low score represent more liberal, "left wing" values. A Cronbach's' alpha reliability test was also performed on both of these scales to confirm that the test scores are internally consistent and reliable. The resulting alpha scores of 0.91 for the climate scale and 0.74 for the political scale confirm that the scales are internally consistent and that the included items measure the same latent factor.

Although some respondents may be motivated purely by monetary incentives, it is likely that a landowner's personal beliefs will also strongly impact program participation. Research has suggested that social and moral incentives are strong drivers in program participation and economic decision-making (Smith and Shogren, 2002; Langpap, 2004; Belin et al., 2005; Fischer and Charnley, 2010). This is especially true when environmental issues are involved. Therefore, landowners who generally agree with climate change science, that their actions can help solve climate change problems, and that climate change is a threat, will also be more likely to enroll in a program addressing the issue (CLIMATE). Skeptical landowners, however, may well have a lower likelihood of participation because they may not believe climate change is a problem, they may not believe forest carbon sequestration is an effective solution even if climate change is deemed a problem, they may distrust the program that is proposed, and/or they may protest participation due to the politicized nature of the issue rather than economic fundamentals. Yet, it is also important to mention that it is plausible that skeptical landowners may indeed respond to economic incentives *even if* they do not believe in the issue or its solutions, as long as they are being paid to participate. As a result, although some uncertainty surrounds this variable, the hypothesis of this study is that climate attitudes will have a direct relationship with participation.

The variable measuring political beliefs (POLITICAL) is likely to impact a landowner's decision-making process for similar reasons. Landowners with a relatively conservative orientation (higher scores on the variable's scale) are more likely to place significant importance on political autonomy and controlling all management decisions on their land. Deep-rooted skepticism in government programs and any form of public intervention on private land has long been prevalent in the forest landowner community, in general (Fischer and Charnley, 2010). This predisposition is likely to be even more prevalent among politically conservative landowners. Further, those who believe in smaller government may disagree with having any type of forest management program, even if it is not directly sponsored or administered by a federal, state or local government agency. As a result, the coefficient of the political variable is likely to be negative in the logistic regression equation, due to a desire for limited government and a distrust of government programs.

4.2.5 Social and Demographic Characteristics (d)

The last vector of variables in the model includes a variety of measures of landowner demographic characteristics that are likely to influence participation in an improved forest management program designed for carbon benefits. The age of the landowner, measured in years as a continuous variable (AGE), is likely to affect potential participation, but the direction is unclear. One possibility is that older landowners tend to be more experienced land managers and therefore more likely to engage in active and informed management of their land. The other possibility is that older landowners may not value the benefits in participating in a program that spans twenty years, and may not want to join due to potential resale or inheritance issues. Joshi and Arano (2009) found a negative relationship between age and timber harvests as well as management for wildlife or recreation purposes. Langpap (2004) found similar results, wherein older landowners were less likely to participate in an endangered species conservation program and were hesitant to set land aside for a significant amount of time or to actively manage their land.

However, Kline et al. (2000) found that older landowners were more likely to actively manage their land for environmental benefits, and Nagubadi et al. (1996) found similar results for participation in forestry assistance programs. As a result, the previous literature is unclear about the influence that age is likely to have on participation in a carbon offset program. In this particular case, however, it is likely that the long program length of 20 years will likely deter many older landowners. As a result, it is expected that younger landowners will be more likely to participate and therefore age is expected to have a negative coefficient in the estimated models.

Oftentimes, forest landowners do not reside on their forested property and are therefore considered absentee landowners (ABSENTEE). The number of absentee landowners is likely to be even greater than normal in the Catskills region given the popularity of the region for vacation homes due to the proximity of New York City. It is likely that absentee landowners will be less likely to engage in a carbon offset program because they may not manage their land as intensively as resident landowners and may only spend a few weeks, or less, on the property each year. However, if the management is conducted by a third party, perhaps in return for a portion of the payment offer, the absentee landowner might prefer to participate if the management could be accomplished while not residing or visiting the property. Previous research (Fletcher et al., 2009) indicates that absentee landowners are less likely to sell carbon credits with their land. Therefore the absentee variable is likely to have a negative coefficient in the empirical analysis.

Finally, a landowner's income was also included in the logit model estimation. The income variable is measured as a set of six dichotomous variables representing income groups ranging from less than $25,000 to over $150,000 (INCOME2, INCOME3, INCOME4, INCOME5, INCOME6). The lowest income category was removed from the model to avoid the "dummy variable trap" and served as the base case for the estimation. In the model estimation, income has an uncertain *a priori* relationship with program participation. Wealthier landowners likely own their land for purposes that are more compatible with a carbon sequestration program such as recreation, aesthetics, or as part of a vacation home. Another reason for this relationship is because one of the most significant restrictions on land management under the program is the inability to engage in large harvests to maximize economic returns. As a result, the opportunity costs of foregone harvesting are likely to be less of a problem with wealthier landowners. Additionally, Grossman and Krueger (1995) demonstrated that the environment could be considered a luxury good. Therefore, managing land for carbon and environmental benefits is likely to increase with income. These reasons would all make participation among wealthier landowners more likely (Kline et al., 2000). However, landowners with lower incomes may be more likely to participate under some circumstances because they have increased needs for new economic opportunities. Despite this possibility, it is expected that income will have a positive coefficient in the estimation results.

CHAPTER 5

ECONOMETRIC RESULTS

In an effort to determine a landowner's willingness to accept an incentive payment to participate in a carbon management program, the random utility model outlined in Chapter Four was estimated using logit regression. This process also identified key variables that are important in a landowner's enrollment decision. These explanatory variables are outlined extensively in the previous chapter and are included in the model estimation below. The results of the logit estimation can also be used to compute median willingness-to-accept values and an estimated supply curve for acreage enrollment and carbon sequestration under a hypothetical carbon forest management program in the Catskills.

5.1 Logit Model Estimation

Prior to estimation, the landowner sample was divided into two groups – participants and nonparticipants – based on the answers to the contingent valuation question. The dichotomous answer to this question became the dependent variable in the logit estimation. The results of the contingent valuation question, found in Table 9 and Figure 7, provide the frequency of "yes" and "no" responses for each payment offer. Of the 439 respondents who appropriately answered the CV question, 253 (57.6 percent) responded as participants, and 186 (42.4 percent) responded as nonparticipants. As expected, lower payment offers elicited lower levels of participation and higher payment offers elicited higher levels of participation. For example, payment offers of $5 and $10 per acre, per year, resulted in an average participation rate of 34 and 31 percent, respectively, whereas at $150 and $200 offers, 86 and 76 percent, respectively, of respondents chose to participate. At incentive payments near $50, approximately half of all respondents indicated a preference to enroll in the improved forest management program.

According to Kanninen (1995) the lowest biases in contingent valuation occur when bids are located within the 30th and 70th percentiles for a known distribution. As a rule of thumb, bids should not be placed outside of the 15th and 85th percentile (Kanninen, 1995). In this study it is encouraging that none of the lowest and highest offers fall outside of this range. In addition, the results indicate that most of the bids fall in the middle range of the distribution, thus limiting overall bias (Alberini, 1995; Kanninen, 1995; Boyle et al., 1998) Rather than use lower payment offers that may result in parameter values located below the 15th percentile and that might bias the results, participation below the lower bound of $5 was predicted by comparing the linear and log utility functional forms. The results of these two models provide a range of expected participation rates at offers within the lower tail of the distribution. For example, participation rates are likely to fall between the linear and log functional forms in the area surrounding the lower end of the distribution. These results suggest that a proper range of offer payments was provided to the survey respondents and, thus, that the CV question was appropriately framed.

Table 9: Contingent Valuation Participation Results

Offer	Nonparticipants	Participants	Total	Percent Participation
$5	40	21	61	34%
$10	37	17	54	31%
$25	30	23	53	43%
$50	26	28	54	52%
$75	15	37	52	71%
$100	17	32	49	65%
$150	9	57	66	86%
$200	12	38	50	76%
Total	186	253	439	58%

Figure 7: Contingent Valuation Participation Results

The random utility model (equation 5) is estimated using logistic econometric techniques, for both the linear utility function (equation 8) and the log utility function (equation 9).[7] In this estimation, selected management characteristics, property characteristics, ownership objectives, and landowner demographics are used as explanatory variables and regressed on the participation variable. As stated previously, the participation variable is a dichotomous variable representing whether or not the landowner would be willing to participate in a forest management program for carbon sequestration given a specified payment amount. The list of variables included in the estimation is provided again in Table 10 along with the corresponding number of observations, mean, standard deviation, minimum and maximum values. As stated previously in Chapter 3, due to list-wise deletion of missing observations during the logit estimation, the sample used in the estimation is smaller (n = 303) than the complete survey results provided in the previous chapter and only complete surveys were used. As a result, summary statistics of the limited

[7] See Chapter 4 for original model equations and further discussion.

sample may not match the full results indicated previously, but rather reflect only the observations used in the final estimation.

Empirical results are provided for two final models, one estimating the log utility function and the other estimating the linear utility function. Tables 11 and 12 provide the estimated coefficient, standard error, t-ratio and odds ratio associated with each independent variable included in the model. The results indicate that the offer amount, property acreage, and climate attitudes all have a positive and significant impact on prospective program participation and enrollment. Landowners who are offered larger incentive payments (OFFER), who have larger properties (ACRE), and who have higher scores on the climate change acceptance and belief score (CLIMATE), will be more inclined to participate in the proposed IFM program. At the same time, political attitudes (POLITICAL) and the ownership objectives of land investment (INVEST) and privacy (PRIVACY) are significant and negative predictors of program participation and enrollment. The estimated coefficients indicate that if a landowner places more importance on investment and privacy, the predicted rate of participation will decrease. These relationships hold regardless of the functional form of the payment offer variable.

Interestingly, the only management objective variables that were significant predictors in the model were ones with negative coefficients. This implies there may not be ownership objectives that drive participation, but there are ones that act as barriers to participation. In addition, other ownership variables may not be significant predictors due to a lack of program specifics detailed in the survey. Because carbon management is site specific, the program overview in the survey was necessarily somewhat vague. As a result, it was intentionally not clear whether or not the program would be more conducive to landowners already involved with timber harvesting or with more landowners with nature and scenic objectives.

Table 10: Summary Statistics

Variable	Description	Mean	Std. Dev.	Min	Max
Payment offer (p)					
Offer	Payment offered for participation	78.76	66.01	5	200
LnOffer	Log of Offer	3.79	1.26	1.61	5.30
Land and Property Characteristics (l)					
Acre	Number of acres owned	115.21	137.91	25	1200
Forest Management Characteristics (m)					
Plan	Has a written management plan	0.18	0.39	0	1
Advice	Received forestry advice from a professional	0.45	0.50	0	1
Ownership Objectives (o)					
Nature	Own land for scenery and nature	3.35	0.67	1	4
Timber	Own land to harvest wood products	1.92	0.90	1	4
Recreation	Own land for recreational purposes	2.83	0.80	1	4
Invest	Own land for investment	2.36	1.00	1	4
Privacy	Own land for privacy	3.14	0.96	1	4
Landowner Attitudes and Beliefs (a)					
Climate	Climate attitude score (low score = skeptic)	16.68	5.89	5	25
Political	Political beliefs score (low score = liberal)	14.57	4.19	5	25
Social and Demographic Characteristics (d)					
Absentee	Primary residence is not on property	0.51	0.50	0	1
Age	Age of landowner (years)	62.10	11.60	31	97
Income 2	$25,000 - $49,999	0.17	0.37	0	1
Income 3	$50,000 – $74,999	0.15	0.36	0	1
Income 4	$75,000 - $99,999	0.13	0.33	0	1
Income 5	$100,000 - $150,000	0.19	0.40	0	1
Income 6	Greater than $150,000	0.33	0.47	0	1
Sample size	303				

Table 11: Logistic Regression Results, Log Utility Function

Variable	Coefficient	Std. Err.	t-Ratio	Odds Ratio
Constant	-0.033	2.07	-0.02	0.967
Payment offer (p)				
LNOFFER	0.714 ***	0.12	5.91	2.042
Land and Property Characteristics (l)				
ACRE	0.003 **	0.00	2.00	1.003
Forest Management Characteristics (m)				
PLAN	0.109	0.45	0.24	1.115
ADVICE	0.102	0.34	0.30	1.107
Ownership Objectives (o)				
NATURE	-0.014	0.26	-0.05	0.986
TIMBER	-0.135	0.19	-0.72	0.873
RECREATION	0.193	0.22	0.89	1.212
INVEST	-0.342 **	0.15	-2.28	0.710
PRIVACY	-0.411 **	0.19	-2.11	0.663
Landowner Attitudes and Beliefs (a)				
CLIMATE	0.079 **	0.03	2.37	1.082
POLITICAL	-0.122 **	0.05	-2.40	0.886
Social and Demographic Characteristics (d)				
ABSENTEE	-0.016	0.32	-0.05	0.984
AGE	0.006	0.01	0.39	1.006
INCOME 2	-0.399	0.83	-0.48	0.671
INCOME 3	-0.103	0.84	-0.12	0.902
INCOME 4	-0.338	0.88	-0.39	0.713
INCOME 5	-0.115	0.84	-0.14	0.892
INCOME 6	-0.339	0.82	-0.41	0.713
Sample Size	303			
Likelihood Ratio Test	98.48 ***			
Pseudo R^2	0.25			

*Significant at α= 0.10

**Significant at α = 0.05

***Significant at α = 0.01

Table 12: Logistic Regression Results, Linear Utility Function

Variable	Coefficient		Std. Err.	t-Ratio	Odds Ratio
Constant	1.440		2.03	0.71	4.220
Payment offer (p)					
OFFER	0.014	***	0.00	5.60	1.014
Land and Property Characteristics (l)					
ACRE	0.003	*	0.00	1.93	1.003
Forest Management Characteristics (m)					
PLAN	0.199		0.45	0.44	1.221
ADVICE	0.106		0.34	0.31	1.112
Ownership Objectives (o)					
NATURE	0.056		0.26	0.22	1.058
TIMBER	-0.115		0.19	-0.61	0.891
RECREATION	0.217		0.22	1.01	1.243
INVEST	-0.378	**	0.15	-2.50	0.686
PRIVACY	-0.477	**	0.20	-2.44	0.621
Landowner Attitudes and Beliefs (a)					
CLIMATE	0.075	**	0.03	2.25	1.077
POLITICAL	-0.125	**	0.05	-2.50	0.883
Social and Demographic Characteristics (d)					
ABSENTEE	0.033		0.32	0.10	1.033
AGE	0.007		0.01	0.46	1.007
INCOME 2	-0.323		0.81	-0.40	0.724
INCOME 3	0.042		0.82	0.05	1.043
INCOME 4	-0.037		0.86	-0.04	0.964
INCOME 5	-0.027		0.83	-0.03	0.973
INCOME 6	-0.209		0.80	-0.26	0.811
Sample Size	303				
Likelihood Ratio Test	96.34	***			
Pseudo R^2	0.24				

*Significant at $\alpha = 0.10$

**Significant at $\alpha = 0.05$

***Significant at $\alpha = 0.01$

To better interpret the coefficients, Tables 11 and 12 also provide the computed odds ratio for each variable. These were computed by raising the coefficient to the base of the natural log (*e*) (Griffiths et al., 1993; Greene, 2008). The odds ratio provides an estimate of how much more (or less) likely participation is if the value of a predictor variable changes by one unit. Although the odds ratios are provided for both functional forms of the model, they are only interpreted for the log utility function. For instance, the odds ratio of 1.082 for the climate variable indicates that a respondent who scored 1 point higher on the climate variable's 25-point scale will be 8.2 percent more likely to participate in the forest management program. Therefore, a landowner who indicated an acceptance and belief in climate change and mainstream science (a score of 25) is more than twice as likely to participate in the program as a climate skeptic (a score of 5). Opposite results can be interpreted from the odds ratio of the political variable. Here, a 1-point higher score on the political variable, indicating a more conservative political preference, is predicted to have nearly twice as much impact on participation, but in the opposite direction. A one-point increase in the political variable is predicted to decrease participation by 11.4 percent. Therefore, more conservative landowners (with higher scores of the political variable) are much less likely to participate. Similar results are found for the variable measuring the importance that a landowner places on investment and privacy ownership objectives. The respective odds ratios of 0.710 and 0.663 indicate that a one-unit increase in the investment and privacy variables (on a four-point scale) is estimated to decrease participation by 29 and 33.7 percent, respectively.

Some of the odds ratios must be interpreted with caution. For example, the property size variable (ACRE) at first glance appears to have a very small effect on participation due to the low odds ratio of 1.003. A one-acre increase in property size makes a landowner 0.3 percent more likely to participate. Although a 0.3 percent increase does not seem large, when property sizes range from a few dozen acres to several hundred acres, the impact can be substantial. For example, holding everything else constant, a landowner with 500 acres is more than twice as likely to participate than a landowner with only 100 acres. The odds ratio for the offer variable is also difficult to interpret because to the model's logged functional form. An odds ratio of 2.042 indicates that a 1-unit increase in the natural log of the payment offer will increase the odds more than twofold. However, it is difficult to interpret a 2.042 increase in the natural log of the payment offer. For instance, the payment offer range of \$5 to \$200 changes to a range of 1.61 to 5.30 on a logarithmic scale. Additionally, the logarithmic scale no longer exhibits constant elasticity because a one-unit change from 1.5 to 2.5 (\$7.70) is much smaller than a one-unit change from 4.5 to 5.5 (\$154.67).

The predicted probability of participation is also provided for both the log utility model and linear utility model. Using the estimated coefficients from Tables 7 and 8, predicted probabilities were determined for all potential payment offers ranging from \$0 to \$200. To do this, predicted probabilities were calculated using the following equations:

(12) $\hat{y} = \alpha + \beta(offer)$ for the linear utility function

(13) $\hat{y} = \alpha + \beta ln(offer)$ for the log utility function

In these equations, the other explanatory variables are held constant and the probabilities are calculated at the mean values. In order to be properly interpreted, the predicted values from equations (10) and (11) were transformed for each dollar value using the following equation from Hanemann (1984) and Hanemann and Kanninen (1996).

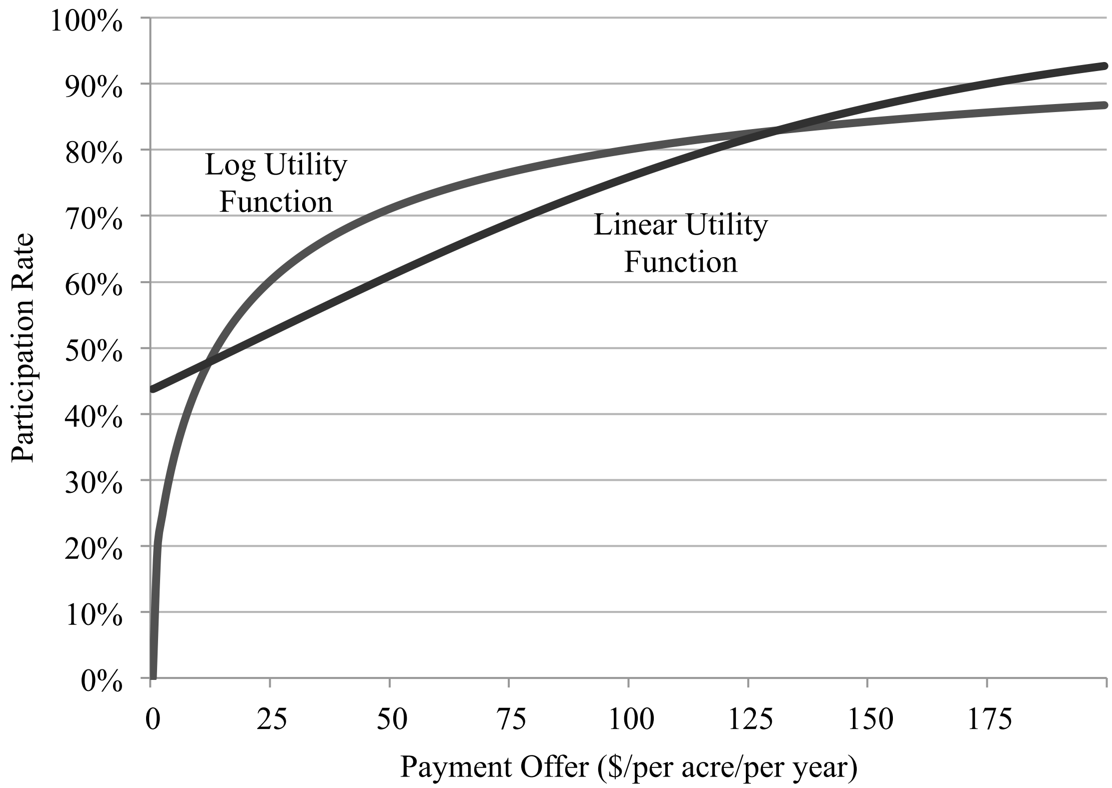
(14) $\Pr = \dfrac{e^{\hat{y}}}{1 - e^{\hat{y}}}$

This transformation is necessary to properly interpret the results and allow a graphical representation of the offer variable.

The results of this exercise yield a predicted value for every potential payment offer ranging from $0 to $200 for both the log utility model and the linear utility model. When displayed graphically (Figure 8), the results clearly demonstrate the probability of participation at each dollar amount offered. This graphical representation also clearly indicates the difference between the results given the two functional forms and the assumptions that each of these force at the bottom end of the offer variable. For example, the linear functional form allows the best fit line to intersect the y-axis whereas the log functional form forces the best fit line though the intercept. The lowest bound provided in the contingent valuation question is $5, but the results of these models allow the reader to interpret values below this bound. The actual participation at these lower values likely falls between these two estimates. Therefore the space beneath the linear curve and above the log curve, to the left of the first intersection represents the likely area of participation at the lower bound.

The resulting best fit lines also allows the reader to estimate participation levels at payment offers outside of the ones selected for the survey sample. For example, a $33 payment offer would be expected to result in a 64 percent rate of participation assuming the log utility function and 60 percent participation assuming the linear utility function. On the other hand, a higher payment offer of $133 would be expected to result in an 83 percent participation rate under both functional forms. This exercise will prove valuable for policy makers attempting to decide the appropriate incentive payments for a given policy or program.

Figure 8: Predicted Participation at Each Payment Offer



Additional models were estimated for both functional forms that removed statistically insignificant groups of variables in an effort to create a more parsimonious model. For complete results of model sensitivities, see Appendix A. According to Hanemann and Kanninen (1996), "the relevant income variable could be supernumerary income rather than full income." This implies that estimation can be conducted using only the payment offer (the supernumerary income) and without a landowner's full income. Accordingly, the second set of models is nearly identical to the original models discussed above, but estimates the utility function without the inclusion of income (e.g. variables INCOME2, INCOME3, INCOME4, INCOME5, INCOME6). Variables measuring whether or not a landowner has a written forest management plan (PLAN) and whether or not a landowner has received advice from a professional (ADVICE) are removed from the model in the next iteration due to their low corresponding p-values. The remaining iterations follow the same procedure and remove the remaining landowner characteristic variables. The excluded variables include whether or not a landowner lives more than 30 miles away from his or her largest forested property (ABSENTEE), the landowner's age (AGE), as well as the insignificant EFA variables measuring the importance of owning land to enjoy nature or scenery and to protect nature and biological diversity (NATURE), for the production of firewood or timber products for commercial sale (TIMBER), and for hunting and fishing, other recreation, or to pass land onto children or other heirs (RECREATION). As the results in Tables A-1 and A-2 (See Appendix A) indicate, each subsequent iteration does not change which variables are significant predictors, and importantly, each iteration has only a very modest impact on the coefficients of the included variables. This demonstrates the stability and robustness of the underlying models being estimated (e.g. those reported in Tables 7 and 8).

Table 13 also provides the frequency of participation at each certainty level. Certainty levels were determined from the participation follow-up question that asked respondents who said yes to the participation question how certain they were of their response. Certainty was measured on a 10-point scale where 1 indicated "very uncertain" and 10 indicated "very certain." The participation variable was then recoded for each participant based on his or her stated level of certainty on the follow-up question. If a participant's stated certainty was below the given threshold, then the respondent's decision was recoded as a nonparticipant. For example, at a certainty cutoff of 1, all "yes" responses were considered as participants, whereas at a certainty level of 7, only those who stated a certainty level of 7 or higher were considered as participants. In these cases, all respondents with certainty levels below the threshold (e.g., level 1-6) were recoded as nonparticipants. As expected, the frequency of participation dropped as the certainty threshold increased from 1 to 10. When compared to the responses without the certainty question filter, the percentage of participant responses dropped 41 percent between the lowest certainty level and the highest. Previous research – including Champ et al. (1997), Welsh and Poe (1998), Champ and Bishop (2001), Ready et al. (2001) – provides some guidance on using the certainty question to appropriately scale CV responses. However, this literature has exclusively examined this process with willingness-to-pay questions rather than willingness-to-accept questions. As a result, this study refrained from using the certainty levels to recode the participation variable for final estimation. Instead, only a parsimonious model was estimated, which included only the offer variable as an independent variable. In this case, the remaining independent variables are incorporated indirectly through the constant term. The results of this process can be found in Tables A-3 and A-4 of Appendix A. As the corresponding graphs indicate (Figures A-1 and A-2), the predicted participation falls considerably and median participation values increase substantially as the required certainty threshold increases to 10. Further research is needed to determine whether or not the certainty level follow up question can be utilized to adjust responses in a WTA context.

Table 13: Participation Rates at Different Certainty Levels

Offer	Certainty Level									
	1	2	3	4	5	6	7	8	9	10
$5	32%	32%	30%	30%	28%	21%	18%	9%	7%	5%
$10	29%	29%	29%	29%	29%	27%	25%	15%	10%	6%
$25	43%	43%	43%	41%	41%	35%	31%	31%	20%	14%
$50	53%	51%	51%	51%	49%	43%	39%	33%	16%	4%
$75	71%	69%	67%	65%	65%	63%	57%	49%	27%	16%
$100	67%	65%	65%	65%	63%	58%	58%	54%	40%	31%
$150	87%	85%	84%	84%	81%	76%	69%	63%	47%	31%
$200	76%	72%	72%	70%	68%	56%	50%	44%	34%	24%
Total	57%	56%	55%	55%	53%	48%	44%	37%	25%	16%

5.2 Regression Diagnostics

A series of regression diagnostics were performed to ensure that no econometric assumptions were violated and to assure robust estimation of the logit models. First, the model was checked for influential data points that may have exerted a significant impact on the model. To do this, residuals were computed that measured the difference between the predicted and observed values. The residuals were then plotted graphically using a stem-and-leaf diagram to visually inspect for outliers in the data. This process confirmed that no outliers exist and therefore there is not likely a significant problem of influential data in the model estimation.

Second, the data were observed for multicollinearity problems that might arise when two or more independent variables in the model are highly correlated or approximately determined by a linear combination of other independent variables (Griffiths et al., 1993; Greene, 2008). In this case, the individual effects of independent variables cannot be isolated because the group of variables can move together in a systematic way. To check for this, a correlation matrix was estimated that confirmed low levels of correlation between the individual variables included in the model. Variance inflation factors (VIF) were also calculated to measure the degree to which a coefficient's variance is increased due to multicollinearity. The resulting VIF computed for each variable range from 1.13 to 2.11, with a mean value of 1.43. Given that problems of multicollinearity do not arise until an order of magnitude or so higher than these VIF values, the results of this test suggests that multicollinearity is not a problem in the model's data (Greene, 2008).

In order to maximize the likelihood that the model was specified correctly, a link test was used to identify potential specification errors. If the model is specified correctly, then additional statistically significant predictors should not be found except by chance. To test this, the linear predicted values ($\hat{y}$) and the square of the linear predicted values ($\hat{y}^2$) were used as the predictors in another logit model. If the model is properly specified, $\hat{y}$ should be a significant predictor, whereas $\hat{y}^2$ should be insignificant. If this is not the case, there is most likely a problem of omitted variables because $\hat{y}^2$ should not have predictive power except by chance (Stata Topics: Logistic Regression, 2010). In the logit model estimated above, the results suggest that model specification is not a problem and that there is not likely a significant problem of omitted relevant variables.

Finally, a goodness-of-fit test was performed to appraise how well the model fits the data. To measure goodness-of-fit, the Hosmer-Lemeshow test statistic[8] was calculated to measure the relative similarities between the observed data obtained from the survey instrument and the predicted values resulting from the model estimation. The computed Hosmer-Lemeshow statistic was 5.32 with a corresponding p-value of 0.72. Given the large p-value and subsequent insignificance of the Hosmer-Lemeshow statistic, it can be assumed that the model fits the data adequately (Hosmer and Lemeshow, 2000).

Although numerous regression diagnostic tests may be used to test the logit estimation results, the several tests that were conducted in this section confirm that the results of the logit estimation performed in this study do not violate the assumptions of the logit model. It is likely that the results provided above are robust estimates of the variable coefficients. As a result, the results drawn from the predicted model can be used without fear of violated assumptions or invalid statistical inference.

[8] The chi-squared test statistic for the Hosmer-Lemeshow test was 5.36 with a corresponding p-value of 0.7181.

5.3 Median Willingness to Accept and Estimated Supply Curve

The first portion of this chapter focused detailed attention on specific variables and characteristics that appear to influence a landowner's decision to participate or enroll in an IFM program for carbon sequestration. These results are important from a policy perspective, especially when considering the early prospective implementation of a program and considering which landowners to target. However, the main goal of this study, and the purpose of this section, is to calculate the median willingness-to-accept values of program participation and to develop an aggregate supply curve of potentially enrolled forested land and carbon sequestration. This process will allow for a more detailed analysis of the economic efficiency of forest carbon sequestration programs when comparing to other climate mitigation policies.

The econometric model's estimated coefficients discussed earlier in this chapter can be used to estimate the corresponding willingness-to-accept values. The WTA values can be used to compare models to one another and to estimate potential program participation. Although WTA can be estimated by either mean or median values, this study chooses to estimate WTA using median values. Use of median values was used because, according Hanemann (1984), "Greater emphasis should be placed on the welfare measure which corresponds to the median because it is likely to be more robust with respect to errors and outliers in the experimental responses." In addition, median WTA estimates are less sensitive to outliers than mean values.

To calculate median WTA estimates, the utility indifference function (equations 8 and 9) is set equal to zero and solved, resulting in the following equation (Hanemann, 1984; Hanemann and Kanninen, 1996; Kline et al., 2000),

(15) $WTA = -(\alpha/\beta)$ for the linear utility function

(16) $WTA = e^{-(\alpha/\beta)s}$ for the log utility function

where α represents the coefficients of the explanatory variables (excluding the offer variable), s represents the mean values of the explanatory variables, and β represents the coefficient of the offer variable. Explanatory variables were solved using their mean values.

The results of this analysis provide median WTA values for both of the model's functional forms. The median WTA value for the log utility model is $14.36, whereas the linear utility model predicts a median WTA value of $18.97. These results suggest that the eight payment offers to landowners were adequately chosen because some of the payment offers fall below the median WTA and some are above. It is not surprising that the median WTA value for linear offer variable is higher than the logged offer variable. This is a result of the fundamental assumption that with a logged offer variable there will be no participation given zero dollar payment offers. As a result, this assumption "pulls" the lower end of the payment offer down below the results for the linear offer. The median WTA values were also estimated at each certainty level using the model with only the offer variable as an explanatory variable and these results are provided in Appendix A.

Another important use of the model coefficients is to use the estimated probabilities to create a supply curve for potentially enrolled forested land in the Catskills region. To do this, the estimated probabilities at each dollar amount are multiplied by the total acreage of privately owned forests in the region. In this example, only the results from the original log functional form estimation are used to create the supply curve, but other iterations could be used in a similar manner. This analysis assumes that landowners with less than 25 acres of land will respond in similar ways to the landowners included in this sample. Unfortunately, little data or information are available providing the amount of forested land over the 25-acre threshold in the region. As a result, this analysis was applied to all of the private timberland in the region, even to properties smaller than 25 acres in size. This assumption will likely overestimate the total amount of acreage enrollment because it is likely that smaller landowners, not surveyed in this study, will be unable or unwilling to participate. Also, it must be assumed that the sample included in this study is representative of the entire region and that no selection bias occurred in the estimation process. These assumptions are most likely inaccurate at some level, but due to the lack of better information and the high degree of aggregation involved, this potential error is considered acceptable for this calculation as long as the caution is taken when interpreting the results. Due to these assumptions and limitations, this exercise is for illustrative purposes only and not intended to predict actual levels of carbon sequestration likely to occur.

According to Birch and Butler (2001) and the New York State Department of Environmental Conservation (2010), there are approximately 1.7 million acres of private timberland in the region of this study. The 1.7 million acres only includes existing forested land where private management is applicable and does not include any publicly owned land or land in the Catskills Forest Preserve. Table 14 provides the estimated participation rate, acreage enrollment and level of carbon sequestration at $10 increments for payment offers from $0 to $200. The estimated supply curve, in Figure 9, allows the reader to choose a payment level and see the estimated number of acres potentially enrolled in the program statewide. If it is assumed that each acre of forested land enrolled in an improved forest management will sequester an additional one to three tons of carbon[9], then supply curves can also be generated for the carbon being sequestered at different enrollment levels. The curves provide policymakers an idea of how much enrollment and carbon sequestration can be expected given a particular payment offer. For example, assuming a sequestration rate of 1.5 tons per acre, a carbon sequestration management

[9] For a more in depth discussion on the amount of carbon sequestration achieved through improved forest management, see relevant discussion in Chapters 1 and 2.

program in the Catskills region could be expected to sequester between 1 to 2.5 million tons of CO2 depending on the payment offer provided to forest landowners. Although this is not much in comparison to the State's total emissions (over 200 million tons per year), it still represents an efficient method of carbon emission reductions and could generate more climate benefits if the program were conducted throughout the state.

Figure 9: Supply Curves for Acreage Enrollment and Carbon Sequestration

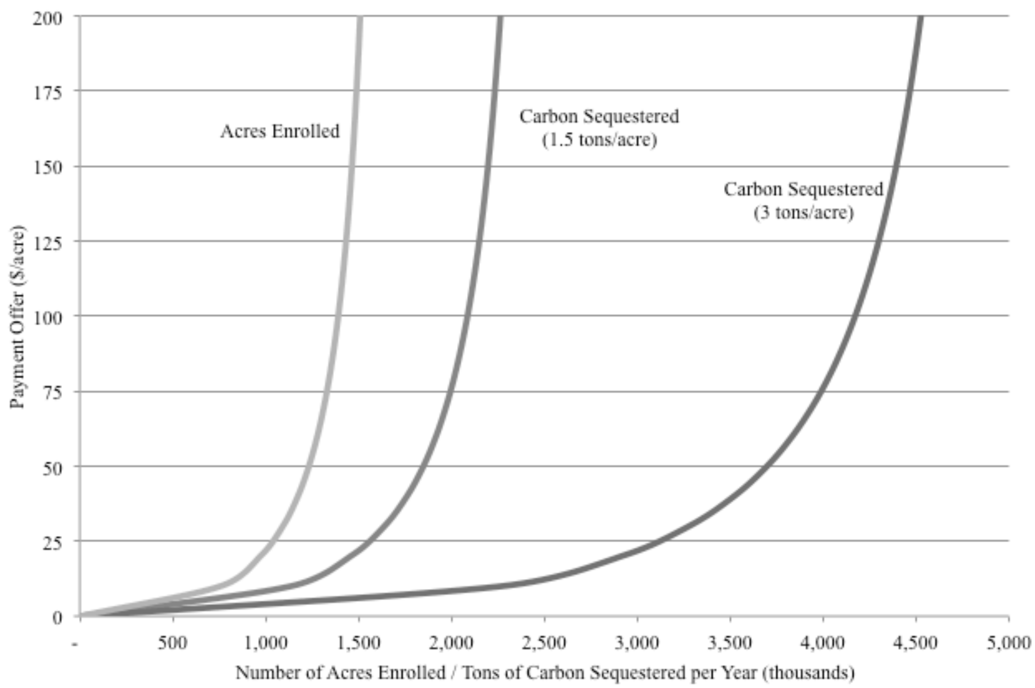


Table 14: Estimated Carbon Sequestration of a Catskills Forest Carbon Program

Payment Offer ($)	Participation Rate	Acreage Enrolled	CO2 Sequestered		Marginal Cost ($/ton)	
			~1.5 tons/acre	~3 tons/acre	~1.5 tons/acre	~3 tons/acre
0	0%	-	-	-	-	-
10	44%	757,792	1,136,687	2,273,375	$6.67	$3.33
20	56%	971,790	1,457,686	2,915,371	$13.33	$6.67
30	63%	1,092,964	1,639,446	3,278,893	$20.00	$10.00
40	68%	1,173,920	1,760,880	3,521,760	$26.67	$13.33
50	71%	1,232,908	1,849,362	3,698,724	$33.33	$16.67
60	74%	1,278,304	1,917,456	3,834,911	$40.00	$20.00
70	76%	1,314,590	1,971,885	3,943,771	$46.67	$23.33
80	77%	1,344,419	2,016,629	4,033,257	$53.33	$26.67
90	79%	1,369,475	2,054,213	4,108,425	$60.00	$30.00
100	80%	1,390,887	2,086,330	4,172,660	$66.67	$33.33
110	81%	1,409,443	2,114,164	4,228,328	$73.33	$36.67
120	82%	1,425,713	2,138,569	4,277,139	$80.00	$40.00
130	83%	1,440,120	2,160,180	4,320,360	$86.67	$43.33
140	84%	1,452,986	2,179,480	4,358,959	$93.33	$46.67
150	84%	1,464,561	2,196,842	4,393,684	$100.00	$50.00
160	85%	1,475,042	2,212,562	4,425,125	$106.67	$53.33
170	85%	1,484,585	2,226,877	4,453,754	$113.33	$56.67
180	86%	1,493,319	2,239,978	4,479,956	$120.00	$60.00
190	86%	1,501,348	2,252,023	4,504,045	$126.67	$63.33
200	87%	1,508,761	2,263,141	4,526,283	$133.33	$66.67

CHAPTER 6

DISCUSSION

Fischer and Charnley (2010) state that, “Nonindustrial private forests hold great potential for sequestering carbon and have received much attention in discussion about forestry-based climate change mitigation. However, little is known about social and cultural influences on owner’s willingness to manage for carbon and respond to policies designed to encourage carbon oriented management.” The survey results and econometric findings throughout this thesis shed considerable light on Fischer and Charnely’s (2010) observations about the lack of information about private forest landowners and their potential willingness to participate in carbon management programs. Given the empirical results reported here, there are several key findings to this study.

6.1 Key Findings

The results of this study clearly indicate that there is strong interest among a broad spectrum of nonindustrial private forest landowners in forest management programs, including those that address climate change and carbon sequestration. This interest is especially high when large incentive payments – those exceeding \$100 per acre (\$33 - \$100 per ton of carbon sequestered) – are offered for enrollment and participation. More interesting, however, is the surprisingly high level of interest and willingness to participate even at the lowest payments offered. Even with only \$5 - \$10 per acre of incentive payments, over 30 percent of surveyed landowners stated a willingness to participate in the carbon management program outlined in the study.

Based on comments from a large portion of respondents, this willingness to participate may be driven, at least in part, by a desire to lower the property tax liability for landowners across the region. Many of the landowners stated a need for payments to help offset the burden of high taxes and would be willing to accept management restrictions in return for a lower tax burden. Although Section 480-A of New York State's property tax code allows this type of tradeoff to occur, the low current levels of participation – less than 15 percent of eligible landowners in this study – highlights significant barriers limiting enrollment. It is important to understand these barriers because they are likely to also occur in a future carbon management program similar to the one outlined in this study.

Second, although financial returns are a strong determinant of program participation, this is not the only consideration when landowners choose to enroll in a program such as those one proposed in this study. When asked "How important are the following factors in your decision to participate in a program similar to the one outlined," the surveyed landowners, on average, ranked the following factors (in descending order): knowledge of management details, the costs of participation, management restrictions, availability of technical help from foresters and other landowners, and time commitment higher than the payment offer. This finding is consistent across each group of payment offers from $5 to $200. This reinforces the assumption that financial returns and profit maximization are not the only drivers influencing nonindustrial private forest landowners.

Third, landowners' attitudes and beliefs toward climate change as well as their political opinions also influence the participation decision. Although there remains a strong contingent of climate change skeptics within the forest landowner community, the majority of landowners agree with mainstream climate science and are at least somewhat concerned about the future climate impacts in the region. As a result, these landowners are shown to likely participate in a forest carbon management program at higher rates than those who disagree with the prevailing science. This suggests at least some degree of social and moral incentives play a role in potential participation.

Landowners' political preferences are one of the most significant factors associated with potential participation in a carbon sequestration program and this is likely one of the most important barriers to overcome. In general, many landowners are skeptical of outside influences over their land and management decisions, whether by government or other organizations. One of the most consistent and most widely shared views that was elicited in the survey was the desire of landowners to control what happens on their land and the maintenance of private property rights. Autonomy is critical for many private forest landowners and is likely to be a large stumbling block for future program participation. When nonrespondents were asked why they would not enroll in the forest management program, 75 percent claimed, "I want to control what happens on my land." This answer was substantially higher than any of the other options.

Other interesting conclusions can be drawn from the results regarding the variables that were not found to be significant predictors of participation. For instance, a landowner's ownership objectives for nature and scenery, timber and wood harvests, and recreation were not found to be significantly different between participants and nonparticipants. This suggests that management for carbon sequestration on forested lands is compatible with different types of management styles and various reasons for forest ownership. The insignificant relationship is also likely due to the lack of details provided to survey respondents outlining the exact forest management required. Without these details, the program may have appeared to be compatible with each type of forest management. In the future, with a more specific program outlined to potential participants, a cleaner relationship may arise between participation and the ownership objectives involving timber harvesting versus enjoying nature and scenery. This reinforces the fact that carbon management goals are not mutually exclusive from other forestry goals and can be applied across a wide spectrum of management objectives.

In addition, there appears to be no significant difference in the probability of program participation between absentee and resident landowners, landowners who have and who have not received advice from a forestry professional, or those with and without written management plans. Even more interesting, there is no significant difference between landowners of different ages or income levels. However, it is not certain whether or not these null findings would occur in a different or larger sample.

Overall, the results of the study suggest that there is a broad interest among forest landowners in the Catskills pertaining to forest management, in general, and carbon management, in specific. There are several identifiable and significant factors that influence a landowner's potential participation and enrollment decisions. Although the payment offered to individuals has a very important influence, it is not the only factor. The utility-maximizing preferences among the forest landowners include other variables as well.

6.2 Policy Recommendations

This study assumes that a comprehensive climate and energy policy is required in order to lessen the impacts of global climate change. In addition, it assumes that each ton of carbon emission causes damage to the global environment and economic system. This negative environmental externality occurs because the damages caused by an individual entity are imposed on others without their permission and without compensation. As such, an efficient policy would require emitters of carbon to pay for the marginal damage caused by each ton of carbon emissions. Forests, on the other hand, provide valuable ecosystem services, one of them being carbon sequestration and storage. These services represent a positive environmental externality because forest landowners are providing benefits to society as a whole, without compensation. An efficient policy therefore would compensate landowners for the benefits their forests provide. In order to achieve efficiency, landowners would be compensated for the marginal benefit provided by each ton of carbon sequestered and stored. The marginal benefit per ton of carbon sequestered would be equivalent in magnitude to the marginal damage caused by carbon emissions. Although the marginal damages of carbon emissions are not known and are surrounded by debate and uncertainty, it is certain that they are greater than zero. The same is true for the marginal benefits associated with forest management, carbon sequestration, and carbon storage. Therefore, in the absence of an incentive program, there will be suboptimal levels of forest management activities specifically targeting carbon sequestration and storage.

Additionally, managing forestland for maximum carbon benefits requires significant costs to the landowner. However, the benefits of such a program accrue to society as a whole. Although some altruistic landowners might participate voluntarily, without proper incentives most landowners are not likely to incur the private costs to provide these social benefits. The greatest costs incurred by landowners involved in such a program would be the opportunity costs of managing their land and losing the ability to achieve considerable financial gains through timber harvesting. As a result, without a proper incentive program carbon sequestration on forested land is likely to be far below the socially efficient level. If improved forest management and carbon sequestration are to be viable climate mitigation options, then payment mechanisms for forest landowners are necessary to provide land management at a social rather than a private optimum.

There is a clear need for a forest management policy established around carbon and climate goals. This includes incentivizing the sequestration of additional carbon above natural levels, but also the protection of existing carbon stocks as well as promoting forest adaptation and forest ecosystem resilience. The policy outlined in this study and proposed to a sample of forest landowners illustrates a potential future policy alternative similar to the ones discussed by policymakers nationwide (and discussed in Chapter 2).

Although market mechanisms are available to policymakers, in the short-term, a government program would likely be necessary rather than reliance on carbon markets. It is likely that actions taken now, during early program development, will greatly impact results and participation later on. While actual funding mechanisms and functioning carbon markets may be years off, the ability of small non-industrial forest landowners to access this future opportunity depends on these early actions. A program promoting improved forest management through incentive payments rather than relying on carbon markets would allow the industry to gain the expertise and knowledge necessary for a viable and accurate offset market in the future. In addition, a public funding program could help promote a national climate policy and would also be able to support land use with secondary and tertiary benefits associated with forests, ecosystem services, and rural development.

Perhaps the most significant reason for a government program in place of carbon markets is to promote short-term capacity-building among a diverse group of landowners. Carbon markets are likely to attract mainly industrial landowners and the largest private forest landowners due to economies of scale and high transaction costs. However, the majority of forested land in New York and the rest of the United States are owned by NIPFLs. If forest carbon sequestration is to become a significant mitigation strategy, government programs will need to specifically reach out to smaller private landowners. In the future, aggregators will likely be able to achieve economies of scale, but programs must include education and management advice specific to carbon sequestration. Currently, carbon markets are not developed or lucrative enough to attract extensive participation by private landowners. Rather than wait for a comprehensive national climate policy, a short-term government program could be established to increase the capacity for future involvement by this ownership class.

While carbon markets and forest carbon sequestration are in their infancy, there is a lot of uncertainty and risk involved in participation. Although it is possible that early entrants will capture first-mover benefits, there is also increased risk. A government program rather than a carbon market would help bring risk to manageable levels and bring more certainty into future programs. Providing a guaranteed payment per year rather than a fluctuating carbon price could help provide this stability. NIPFLs may also be more likely to participate in a government program because they are more comfortable applying for specific programs rather than entering into uncertain carbon markets with unstable carbon prices.

As described in Chapter 2, adaptation strategies are equally important as mitigation efforts. In order to make forests less susceptible to a changing climate and other disturbances, forest managers may have to sacrifice maximum levels of carbon sequestration. In the context of a carbon offset market, little incentive exists to make these necessary sacrifices. As a result, a government program, in lieu of carbon markets, would allow for both mitigation and adaptation efforts simultaneously. In addition to increasing adaptive capacity and resiliency, there are other ecosystem benefits that could be achieved in the context of a program rather than carbon markets. This includes forest management for air and water quality, wildlife diversity, recreation and many others. The management of forests to generate joint ecosystem benefits simultaneously rather than just carbon benefits would help achieve a socially optimal level of forest conservation. Most importantly, a cost-benefit analysis associated with improved forest management should not be calculated solely on carbon benefits, but should also include other ecosystem services.

A final reason for a government program rather than private carbon markets is the stated preference among respondents surveyed in this study. Although 50 percent of respondents stated that they did not prefer one type of program to the other, the remaining respondents indicated a clear preference towards a government program. In total, 72 percent of respondents who indicated a preference between the two options preferred a government program to private carbon markets. Reasons for this included an increased trust in government programs, long-term stability, and a prevalent "Wall Street skepticism" among landowners who feared being taken advantage of by market traders. The potential for increased participation is a strong motivator for a government program rather than carbon markets.

The results of this study indicate that such a program has the potential to be cost-effective and efficient. When compared to other mitigation strategies, an improved forest management program competes well with other options. For instance, assuming a $20 tax were placed on a ton of carbon emissions and that improved forest management sequestered an additional one to three tons of carbon annually per acre, then potential incentive payments would be $20 to $60 per acre. At these payment levels, this study estimates that participation in the Catskill forest landowner community would be between 50 and 74 percent. Although this predicted probability may be lower or higher when considering enrollment in an actual program, the relatively high participation rate suggests that a program would likely be well received among the forest landowner community and has the potential to be successful, effective, and efficient. This finding suggests that it may not be the cost of incentive payments and level of participation that will be most critical for program efficiency. Instead the efficiency of carbon management programs may rely more on the uncertainty and lack of permanence associated with forest carbon storage and sequestration. Given that carbon reductions cannot be absolutely assured to be permanent, future carbon benefits may have to be discounted appropriately.

This study also highlighted several important factors beyond the incentive payment in a landowner's utility-maximizing decision of whether or not to participate and enroll in a potential carbon management program. These factors are equally important to policy makers and should be used when designing and implementing future programs. For example, the results indicate that larger landowners are more inclined to participate. This suggests that a program would be more effective targeting larger landowners due to increased enrollment in terms of total acreage. This also highlights the importance for programs to establish the possibility of cooperative enrollment and the aggregation of the forested land of many small acreage landowners.

Another finding that is important when designing effective management programs is the predicted increase in enrollment among landowners with favorable attitudes and beliefs towards climate science and policy. This finding suggests that increased outreach on climate science, issues, and awareness may be a necessary precursor for an effective forest carbon management program. Increased outreach to the forest landowner community specifically regarding climate change will likely have large payoffs of increased enrollment later on. This outreach could start now, even before a program is in place and would be relatively inexpensive. Unfortunately, opinions on climate change tend to be based more on fundamental ideology rather than education on the subject matter. Therefore, the potential success of education and outreach may be limited. It is also evident that a program should stress the climate-related benefits associated with program enrollment. As we have seen here, many landowners are at least partially motivated by altruistic, social, and moral incentives in addition to monetary incentive payments. By taking advantage of these motivations, program costs could be reduced and participation likely increased.

It is important to recognize early on the critical barriers to participation. According to the results of this study, these barriers include the desire for landowners' privacy and autonomy in managing their land. When reaching out to potential participants, the program could be implemented in a way that stresses the importance of landowner autonomy and privacy. If a program is not sensitive to these issues, there can be expected to be significant resistance among many in the forest landowner community. Although there was not a significant difference in the probability of participation between landowners with different ownership objectives, these objectives are still important when implementing a program. The results indicate that the program could be structured differently according to landowner preferences while still allowing for similar carbon benefits. For example, a program for landowners with timber harvesting objectives could be structured around improved harvest techniques and lengthening rotations, whereas a program for landowners with nature or scenery objectives could be structured around increasing forest stand diversity.

Also, the large number of comments on the need for property tax reform should be taken into account. Without reforming the tax code and corresponding forestry programs, a high property tax burden in the region will place increasing pressure on landowners to sell some or all of their land. If this were to occur, the region's forested properties are at risk of parcelization and fragmentation, a precursor to development and subsequent carbon loss. Additionally, given the high income levels and correspondingly high income taxes paid by many forest landowners in the region, tax incentives, including property tax reductions, may lead to greater participation and more effective implementation than straight payment offers. This approach may also enhance the political feasibility of such a program.

When evaluating future improved forest management programs for carbon sequestration and storage, it is important to consider non-carbon benefits as well. The co-benefits associated with forest management – such as increased air and water quality, forest health, and increased aesthetics and recreational benefits – are all potential outcomes of an IFM program for carbon storage and sequestration. It is therefore important not to look at an IFM program solely in terms of climate change and carbon sequestration potential. The efficiency of any IFM program should not be evaluated in isolation, but based on the totality of the benefits it provides.

Finally, although the results of this research suggest that a program would be an efficient mitigation strategy in the region, it is likely to be even more efficient if conducted in other countries. Given that CO_2 is a uniformly mixing pollutant, a decrease in carbon emissions in one region has the same social benefits as those in any other region. Therefore, a program may be more appropriate if implemented in developing countries (or elsewhere in the U.S.) due to lower opportunity costs of land and the increased threat of deforestation and development. A truly efficient program would be implemented in many countries and enrollment would be conducted in the cheapest properties first. However, such an approach appears to have little political feasibility at this time, and there would be increased problems associated with permanence, verification and leakage. Thus, even within an international framework, domestic forestry offsets will remain important.

6.3 Suggestions for Future Research

This study represents a preliminary attempt to measure landowner attitudes and preferences towards forest management for carbon storage and sequestration. Research involving this type of land management is quickly developing and this study hopes to stimulate further research in the field. As such, several areas were identified where future research will help develop a more in-depth understanding of the role of private forest landowners in carbon offset markets and related government programs. The future of carbon markets is yet to be determined, but it is likely that forest landowners will play an integral role in climate and energy policy throughout the country and international community. Therefore, building upon this study and other recent research will be crucial to the implementation of efficient policies and effective programs.

One obvious recommendation is to broaden the geographic scope of the survey to understand the differences between forest landowners in different regions across the state as well as the country. As discussed in Chapter 3, the Catskills region of focus in this study was chosen to exploit several unique attributes of the region. As a result, it is very likely that landowner demographics, attitudes and preferences will vary across different regions of New York State, the Northeast, and beyond. For example, landowners in the South and West tend to be larger and more inclined to harvest timber for financial return. In addition, the different types of tree species across regions will also impact the dynamics of carbon sequestration and storage. With a longer growing season and increased number of softwoods, the Southern U.S. will be more conducive of carbon sequestration. However the increased threat of forest fire and urbanization makes the region less conducive to carbon storage. These factors will, in all likelihood, influence potential program participation in various unpredictable ways. Understanding these differences is crucial, especially in the context of a national climate and energy policy that would apply across states. In addition, expanding the scope of such an approach across different countries, especially in the developing world, would also be important for policy linkages to the international community.

While increasing the geographic scope may allow for important observations, there is also a need to broaden the scope of this study to include different types of landowners. As stated previously, although nonindustrial private forest landowners own nearly three-quarters of forested land in New York State, another 3 million acres of forested land is owned publicly and another 700,000 acres of forested land is owned by industrial landowners. Given the high amount of land owned by a small number of stakeholders, it is likely that forest management on these lands would vary drastically from NIPFLs. Although these types of forest may not be the majority of forested land in the state, they will still play an important role in forest carbon management policies. Further, in different regions the bias towards small private forest landholdings will be less evident, requiring a more thorough review of other land ownership types. For example, regions in the Southern U.S. would be characterized by a larger number of industrial landowners whereas regions in the West would be characterized by a larger number of public land holdings.

When analyzing these types of land ownerships a broad mail survey to landowners may not be the most appropriate methodology. For instance, when considering researching carbon forest management on public lands it may be more appropriate to survey the broad population to understand the opinions of the citizen population. It will be equally as important to understand the capacity of the government organizations involved in forestry and forest policy at both the federal, state and local level. In addition, understanding industrial landowners would require significantly more attention on how the net present value of timber income would be altered under forest management. This approach would focus more on this profit-maximizing decision versus a utility-maximizing decision used in this analysis.

Third, this study could be replicated using additional incentive offers at the lower bound to see how landowners would respond to payments below the $5 used in this study. The lower bound was examined in this study only by estimating different functional forms of the offer variable. A future contingent valuation analysis could ask respondents whether or not they would participate at one or two dollars, or even if no payment were offered at all. Due to the relatively high level of willingness-to-accept even at the lowest bound used in this analysis, there is a need for a better understanding of landowner behavior at lower payment levels.

Yet another research recommendation is to use a choice experiment rather than the dichotomous choice contingent valuation methodology implemented in this study. Instead of offering respondents one program with different incentive payments, a choice experiment would offer respondents multiple programs and ask which one he/she would prefer. This methodology would allow the researcher to identify important program characteristics that would be the most important for inducing participation. This is especially important for policymakers in the program design phase, whereas the methodology used in this study was important to determine the potential economic efficiency of carbon management programs, in general.

Most importantly, a better understanding of the physical limitations and requirements of integrated forest management is necessary. This suggests the need for collaboration among several different disciplinary fields and a convergence between the social and physical sciences. One of the more important limitations of this study was the lack of clear recommended management techniques necessary for carbon storage and sequestration. Without this knowledge, the program proposed to landowners had to be less detailed than desired. As a result, some landowners responding to the survey stated that more information was required to adequately decide whether or not they would participate. This biological and scientific understanding will ultimately be the cornerstone of effective policy and climate change mitigation efforts.

Finally, as new programs are implemented across the country (and world), it will be important to research *actual* participation rather than stated willingness-to-accept. Contingent valuation studies are always limited by the hypothetical nature of their design. Although this is a fundamental limitation of this study, using a contingent valuation approach was the only applicable methodology given the lack of consistent and widespread carbon offset programs available for analysis. As forest carbon management programs become more common and widespread, researchers will have the ability to compare the findings of this study and others like it to actual programs with associated real incentive payments.

APPENDIX A

Table A-1: Model Sensitivity Comparison, Log Utility Function

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Sample size	303	336	336	344	352	355	357	360
Pseudo R^2	0.248	0.249	0.249	0.256	0.258	0.258	0.258	0.257
LNOFFER	0.714 ***	0.735 ***	0.735 ***	0.754 ***	0.739 ***	0.731 ***	0.738 ***	0.749 ***
ACRE	0.003 **	0.002 **	0.002 **	0.002 **	0.003 **	0.002 **	0.002 **	0.002 **
PLAN	0.109	0.026	REMOVED					
ADVICE	0.102	0.133	0.142	REMOVED				
NATURE	-0.014	0.122	0.123	0.130	0.144	0.140	0.154	REMOVED
TIMBER	-0.135	-0.094	-0.092	-0.062	-0.061	-0.053	REMOVED	
RECREATION	0.193	0.121	0.121	0.114	0.111	0.142	0.134	REMOVED
INVEST	-0.342 **	-0.350 **	-0.351 **	-0.369 ***	-0.358 ***	-0.387 ***	-0.400 ***	-0.370 ***
PRIVACY	-0.411 **	-0.355 **	-0.355 **	-0.350 **	-0.371 **	-0.390 **	-0.378 **	-0.270 *
CLIMATE	0.079 **	0.069 **	0.069 **	0.067 **	0.067 **	0.072 **	0.072 **	0.072 **
POLITICAL	-0.122 **	-0.121 **	-0.121 **	-0.124 ***	-0.130 ***	-0.127 ***	-0.128 ***	-0.133 ***
ABSENTEE	-0.016	-0.057	-0.056	-0.004	-0.029	REMOVED		
AGE	0.006	0.005	0.005	0.005	REMOVED			
INCOME2	-0.399	REMOVED						
INCOME3	-0.103	REMOVED						
INCOME4	-0.338	REMOVED						
INCOME5	-0.115	REMOVED						
INCOME6	-0.339	REMOVED						
Constant	-0.033	-0.682	-0.690	-0.684	-0.261	-0.325	-0.456	0.054

Table A-2: Model Sensitivity Comparison, Linear Utility Function

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Sample size	303	336	336	344	352	355	357	360
Pseudo R^2	0.243	0.241	0.249	0.256	0.249	0.249	0.250	0.247
OFFER	0.014 ***	0.014 ***	0.015 ***	0.015 ***	0.015 ***	0.014 ***	0.014 ***	0.015 ***
ACRE	0.003 **	0.002 *	0.002 **	0.002 **	0.003 **	0.002 **	0.002 **	0.002 **
PLAN	0.199	0.181	REMOVED					
ADVICE	0.106	0.062	0.122	REMOVED				
NATURE	0.056	0.159	0.164	0.172	0.176	0.179	0.195	REMOVED
TIMBER	-0.115	-0.072	-0.059	-0.028	-0.037	-0.025	REMOVED	
RECREATION	0.217	0.150	0.148	0.137	0.131	0.171	0.176	REMOVED
INVEST	-0.378 **	-0.362 **	-0.367 ***	-0.384 ***	-0.368 ***	-0.400 ***	-0.411 ***	-0.375 ***
PRIVACY	-0.477 **	-0.400 **	-0.405 **	-0.404 **	-0.423 **	-0.448 ***	-0.434 **	-0.304 **
CLIMATE	0.075 **	0.068 **	0.069 **	0.067 **	0.066 **	0.070 **	0.070 **	0.071 **
POLITICAL	-0.125 **	-0.124 ***	-0.122 ***	-0.126 ***	-0.134 ***	-0.132 ***	-0.133 ***	-0.135 ***
ABSENTEE	0.033	-0.035	-0.033	0.012	-0.028	REMOVED		
AGE	0.007	0.007	0.007	0.007	REMOVED			
INCOME2	-0.323	REMOVED						
INCOME3	0.042	REMOVED						
INCOME4	-0.037	REMOVED						
INCOME5	-0.027	REMOVED						
INCOME6	-0.209	REMOVED						
Constant	1.440	0.853	0.806	0.897	1.493	1.410	1.275	1.929

Table A-3: Estimated Coefficients of a Parsimonious Model at Each Certainty Level, Log Utility Function

Variable	Certainty Level									
	1	2	3	4	5	6	7	8	9	10
Constant	-2.216	-2.103	-2.146	-2.208	-2.192	-2.371	-2.485	-3.160	-3.677	-4.132
LNOFFER	0.677	0.628	0.630	0.635	0.613	0.600	0.581	0.677	0.643	0.615
Median	26.45	28.49	30.10	32.38	35.72	52.12	71.81	106.77	304.13	824.15

Table A-4: Estimated Coefficients of a Parsimonious Model at Each Certainty Level, Linear Utility Function

Variable	Certainty Level									
	1	2	3	4	5	6	7	8	9	10
Constant	-0.652	-0.635	-0.662	-0.699	-0.713	-0.839	-0.960	-1.281	-1.917	-2.452
OFFER	0.013	0.012	0.012	0.012	0.011	0.010	0.009	0.010	0.009	0.009
Median	48.33	52.13	54.77	58.34	63.50	85.14	105.75	134.29	202.27	269.38

Figure A-1: Estimated Participation at Different Certainty Levels, Log Utility Function

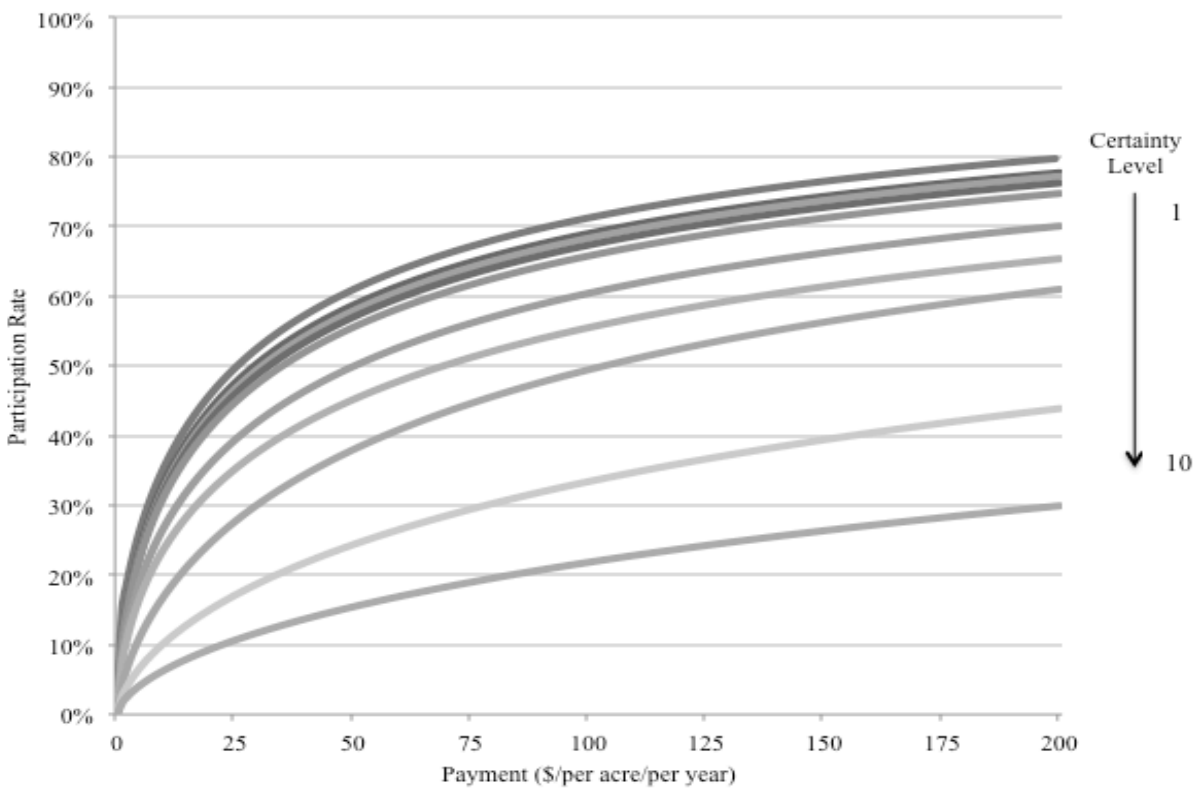
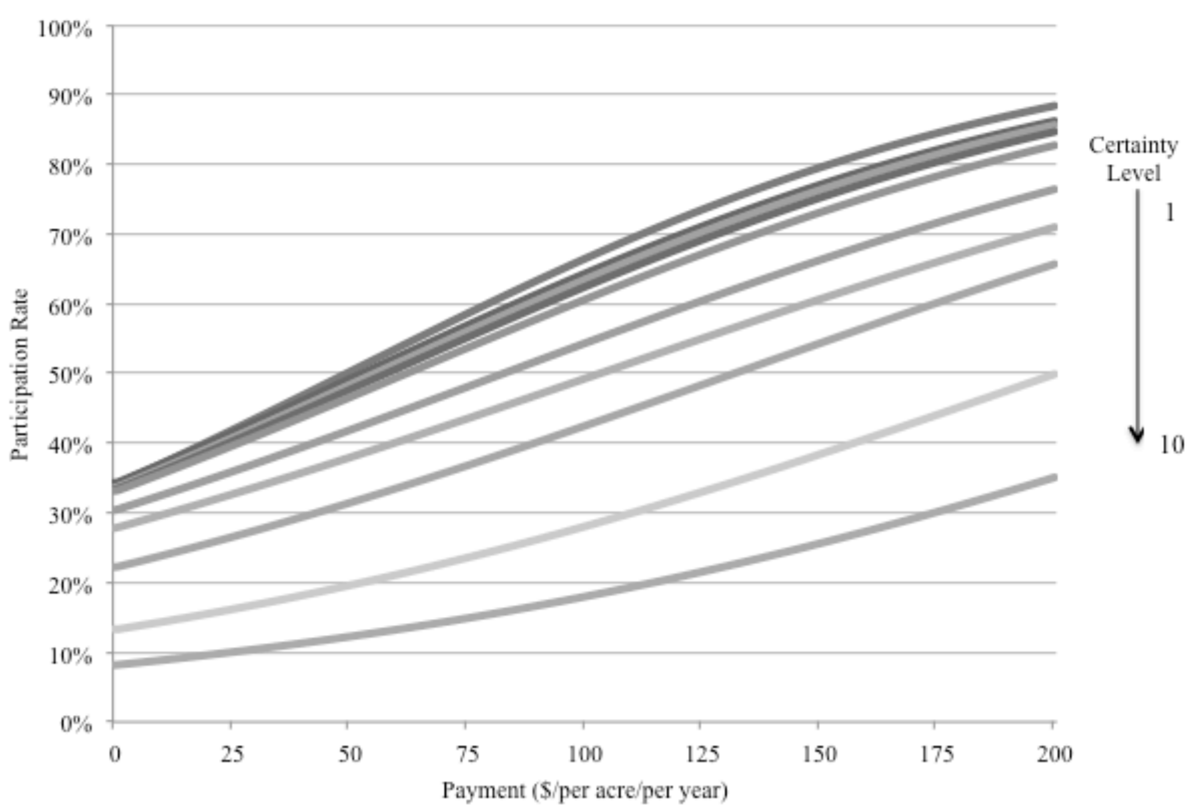


Figure A-2: Estimated Participation at Different Certainty Levels, Linear Utility Function



APPENDIX B

A Survey of New York State's Private Forest Landowners And their Interest in Carbon Storage

Research Conducted By
Cornell University
Charles H. Dyson School of
Applied Economics and Management
441 Warren Hall, Cornell University, Ithaca, NY 14853

Thank you for helping us with this survey. Your responses will provide policy makers with a better understanding of how forests across the state can help address climate change, while providing a unique economic opportunity to NY forest landowners like you. For more information on this survey please see the additional materials enclosed.

INSTRUCTIONS

- Please have the owner who makes most of the property decisions regarding your forestland answer this questionnaire at his/her earliest convenience.
- Provide answers for **only the LARGEST plot of forested land** that you own in Delaware, Greene, Ulster or Sullivan counties.
- If you do not own any forested land in Delaware, Greene, Ulster or Sullivan counties, please answer only the first question and return the survey to us so we do not send you unnecessary reminder letters.
- If you are not sure of an exact answer, such as the number of acres of forested land or future plans for your forest, please give us your best estimate.
- When you finish the questionnaire, please return it using the postage-paid envelope provided. **All responses are confidential.** Thank you for your time.

Q-1. Do you own 25 or more acres of forested land in Delaware, Greene, Sullivan or Ulster counties? *(Check one)*

____ No → Thank you for your time. Please return this questionnaire using the envelope provided, so we don't send you unnecessary reminder letters.

____ Yes → Please continue with Question 2.

Q-2. A. How many acres of land do you own in the counties listed above and about how many of those acres are forested? Please provide a total of any and all land that you own in those counties.

__________ approximate total acres owned (forested and nonforested)

__________ approximate total acres of forested land

B. About how many acres of forest are on your largest property?

__________ approximate acres of forested land on largest property only
(please refer to this property when answering the rest of the questions)

<u>If you own multiple properties, please refer to your LARGEST forested property when answering the questionnaire.</u>

Q-3. How long have you or your family owned this property?

__________ number of years

Q-4. How did you acquire this property? *(Check one)*

____ Bought it
____ Inherited it
____ Received it as a gift
____ Other (please specify) ____

Q-5. A. Is your home (primary residence) located on this property? *(Check one)*

____ Yes ____ No

B. If no, how far do you live from this property?

__________ miles from forest property

Q-6. Is this property enrolled in Section 480-a of the New York State Real Property Tax Law? (480-a refers to the New York State property tax relief program for forest landowners involved in approved forest management). *(Check one)*

____ Yes ____ No ____ I don't know

Q-7. Is this property part of a conservation easement? *(Check one)*

____ Yes ____ No ____ I don't know

Q-8. Do you have a written management plan for this forested property? *(Check one)*

____ Yes ____ No ____ I don't know

Q-9. People own forested land for many reasons. How important are the following as reasons for why you own this particular forested property? (*Please check one box for each reason listed*)

	Not Important	Somewhat Important	Important	Very Important
To enjoy beauty or scenery	☐	☐	☐	☐
To protect nature and biologic diversity	☐	☐	☐	☐
For land investment	☐	☐	☐	☐
To participate in carbon storage or offset markets	☐	☐	☐	☐
Part of my home or vacation home	☐	☐	☐	☐
Part of my farm	☐	☐	☐	☐
For privacy	☐	☐	☐	☐
To pass land on to my children or other heirs	☐	☐	☐	☐
For production of firewood or biofuels	☐	☐	☐	☐
For production of sawlogs, pulpwood or other timber products for commercial sale	☐	☐	☐	☐
For hunting or fishing	☐	☐	☐	☐
For recreation, other than hunting or fishing	☐	☐	☐	☐
Other (please specify)	☐	☐	☐	☐

Q-10. On the table above, what is the **most important** reason for owning your forestland? (*Please circle ONLY ONE of the reasons listed above*)

Q-11. Do you feel that your largest forested property **should be actively managed** in some way by you or others? *(Check one) (By actively manage we mean take deliberate actions to influence the value of the land. Some examples include harvesting firewood, marking a trail, improving habitat for wildlife, etc.)*

☐ Strongly Disagree ☐ Slightly Disagree ☐ Neutral ☐ Slightly Agree ☐ Strongly Agree

Q-12. Do you feel that you or others **do actively manage** this property? *(Check one)*

____ Yes ____ No

Q-13. On how many acres of this property do you conduct some type of management activity in an average year (exclusive of timber sales)? *(Answer only one)*

__________ acres -or- ____ All of my largest forested property

Q-14. Have trees been harvested or removed from this property in the past 5 years?

____ Yes → if yes, please continue to Question 15 (Q-15)
____ No → if no, proceed to Question 16 (Q-16)

Q-15. Why were the trees harvested or removed from this forested property? *(Check all that apply)*

____ To achieve objectives in my management plan
____ Trees were mature
____ To clear land for conversion to another use
____ Money and financial return
____ To help pay property taxes
____ Needed wood for own use (ex: firewood)
____ To improve scenic and recreational opportunities
____ To improve quality of remaining trees
____ Other (please specify): ______________________________________

Q-16. In the past 5 years, have you received advice or information regarding any forestry topic from any of the following sources? *(Check all that apply)*

____ I have not received information from any sources
____ New York State DEC forester
____ Extension forester or other university employee
____ Private consultant (ex. forester or wildlife biologist)
____ Logging contractor
____ Employee of a non-profit group
____ Other forest landowner, neighbor, or friend
____ Other (please specify): ______________________________________

Q-17. The following are activities some landowners do on their forested land. Please indicate if you (or someone else) have done any of the following on this particular forested property in the past 5 years, or plan to do any in the next 5 years? *(Check all boxes that apply)*

	Have done in the PAST 5 years	Plan to do in the NEXT 5 years
Leave forest as is, no activity	☐	☐
Harvest firewood for my own use	☐	☐
Harvest firewood for commercial sale	☐	☐
Harvest wood for sawlogs, veneer, or pulpwood	☐	☐
Improve timber quality by thinning or pruning	☐	☐
Plant trees	☐	☐
Improve wildlife habitat	☐	☐
Improve scenic views	☐	☐
Mark property boundaries	☐	☐
Reduce fire hazard	☐	☐
Build or maintain roads or trails	☐	☐
Sell some or all of my forested land	☐	☐
Give some or all of my forested land to my children	☐	☐
Buy more forested land	☐	☐

FOREST MANAGEMENT AND CLIMATE CHANGE

Recently there has been a lot of discussion regarding climate change and potential solutions to address it. One of the solutions often proposed is "storing carbon" in forests and wood (sometimes called "carbon sequestration"). This is a natural process that can be further enhanced through forest management techniques.

Recognizing these and other services that your forest provides, policymakers are considering providing payments and incentives to forest owners to increase carbon storage on their land with forest management techniques. This represents a **unique potential economic opportunity** for forest landowners across the state. By maintaining a healthy, sustainable forest, you could be eligible for compensation for the carbon your forest stores.

Q-18. How familiar are you with the following terms and concepts often used in discussions involving climate change? (*Check one box for each term listed)*

	Not Familiar	Somewhat Familiar	Familiar	Very Familiar
Climate Change or Global Warming	☐	☐	☐	☐
Forest Carbon Storage or Sequestration	☐	☐	☐	☐
Carbon Offsets	☐	☐	☐	☐
Cap-and-Trade	☐	☐	☐	☐

Q-19. To what extent do you agree or disagree with the following comments about climate change? *(Circle one number for each comment listed)*

	Strongly Disagree		Neutral		Strongly Agree
Climate change is a serious problem that requires immediate action	1	2	3	4	5
Concern about climate change is overblown	1	2	3	4	5
Climate change is a threat to my forest and local community	1	2	3	4	5
Generally, the science of climate change is inconclusive	1	2	3	4	5
My personal actions can have an influence on climate change	1	2	3	4	5

Q-20. To what extent do you agree or disagree with the following comments? *(Circle one number for each comment listed)*

	Strongly Disagree		Neutral		Strongly Agree
A first consideration of any good political system is the protection of private property rights.	1	2	3	4	5
Government provides valuable and necessary services to society.	1	2	3	4	5
The best government is the one that governs the least.	1	2	3	4	5
Government has a basic responsibility to protect our natural environment.	1	2	3	4	5
Decisions about development are best left to the economic market.	1	2	3	4	5

This section outlines a potential forest management program to increase carbon storage on forested land across New York State. This program would offset upfront management costs, provide necessary technical assistance, and pay forest landowners for the increased carbon their forests store.

CARBON STORAGE FOREST MANAGEMENT PROGRAM

- ◊ Establish and follow a written forest management plan with the help and monitoring of a certified forester,
- ◊ Reduce size and regularity of timber harvests,
- ◊ Thin and remove diseased, deformed, or dying trees to increase size, quality and species diversity of the remaining trees.
- ◊ No high-grade clear cutting or developing land for uses other than forest,
- ◊ Participation in the program for a minimum of 20 years.

Q-21. Would you enroll in the carbon storage forest management program detailed above if you were paid ***$____ per acre***, every year for the extent of the 20-year program? *(Check one)*

____ Yes → continue to Question 22 below.
____ No → skip to Question 24 on the next page.

Q-22. Based on your answer above, you believe that you would participate in the program. We would like to know how sure you are of that. On a scale from 1 to 10, where 1 means "Very Uncertain" and 10 means "Very Certain," how certain are you that you would participate in the program if you were paid $____ per acre every year for 20 years if the program was actually offered? *(Circle one number)*

1 2 3 4 5 6 7 8 9 10

very uncertain very certain

Q-23. If you answered YES to the Question 21 above, how many acres of your largest forested property would you enroll into the program? *(Answer only one)*

________ acres -or- ____ all of my forestland

STOP ***If you answered YES to Question 21 and would enroll in the program detailed above, please continue to Question 26 on the following page, skipping Questions 24 and 25.***

Answer Questions 24 and 25 only if you answered NO to the program proposed in Question 21.

Q-24. If you would NOT be willing to enroll in the program detailed in Question 21, why would you NOT enroll in the program? *(Check all that apply)*

____ Payment isn't large enough
____ I would not participate no matter how much I was paid
____ I do not believe climate change is a problem that requires action
____ I don't believe the program would work to solve climate change
____ I don't support government intervention on private land
____ I want to control what happens on my land
____ I don't want to place unnecessary restrictions on my forest management
____ I don't have enough time available

____ Other (please specify): ______________________________________

Q-25. If you would not be willing to enroll in the program detailed on Question 21, would you enroll if a higher price were paid? *(Check one)*

____ Yes
____ No

Regardless of how you answered Question 21, please continue with the rest of the questionnaire.

Q-26. A. The proposed carbon storage forest management program could be put into practice either as a New York State government sponsored program or through private carbon markets. Regardless of how you answered Questions 21-25, which type of program would you be more likely to enroll in? *(Check one)*

____ New York State sponsored program
____ Private carbon markets
____ Doesn't matter

B. We would like to better understand why you chose the type of program in the question above. Please briefly explain your reason below. *(Please specify)*

____

Q-27. There are several factors that may affect a landowner's willingness to participate in a carbon storage forest management program. How important are the following factors in your decision to participate in a program similar to the one outlined previously? *(Check one box for each factor)*

	Not Important	Somewhat Important	Important	Very Important
Amount of payment offered ($)	☐	☐	☐	☐
Amount of time and effort required	☐	☐	☐	☐
Exact details of management required	☐	☐	☐	☐
Availability of help from others putting the management plan into practice	☐	☐	☐	☐
Preference to let the forest grow naturally	☐	☐	☐	☐
Possible restrictions placed on my forest management or timber harvest options	☐	☐	☐	☐
Lack of personal knowledge about forest management for carbon storage	☐	☐	☐	☐
The length of time commitment required	☐	☐	☐	☐
The potential upfront or ongoing costs involved while participating	☐	☐	☐	☐
Requirement that a forester monitor my forest management activities	☐	☐	☐	☐
Other (please specify):	☐	☐	☐	☐

Q-28. In the table above please circle the **<u>most important</u>** factor influencing your decision. *(Circle only ONE)*

Q-29. Are you male or female? *(Check one)*

____ Male ____ Female

Q-30. In what year were you born?

19_____

Q-31. A. What is your main occupation? (If retired, what was your main occupation?)

____

B. Are you retired? *(Check one)*

____ Yes ____ No

Q-32. What is the highest level of formal education you have completed? *(Check one)*

____ Less than high school
____ High school diploma / G.E.D.
____ Some college or technical school
____ Associate's Degree
____ College undergraduate degree (e.g., B.A., B.S.)
____ Graduate or professional degree (MS, PhD, PE, JD, MD, etc)

Q-33. What is your best estimate of your household's combined annual income? *(Check one)*

____ Less than $25,000
____ $25,000 to 49,999
____ $50,000 to 74,999
____ $75,000 to 99,999
____ $100,000 to $149,000
____ $150,000 or more

Thank you for your time

Is there anything we overlooked? Please use the space provided on the back page for any additional comments that you would like to make.

APPENDIX C

Frequently Asked Questions

What is the purpose of this research?

The goal of this research is to learn more about why New York forest landowners own their land, how they manage that land, and to understand their interest, if any, in potential economic programs to compensate landowners for the benefits associated with forest carbon storage.

Who is conducting this research?

This study is being conducted by independent researchers at Cornell University's Charles H. Dyson School of Applied Economics and Management and is not affiliated with any government, private or nonprofit organizations. However, results of this research will be shared with policymakers at the New York State Department of Environmental Conservation, forest industry associations, and elsewhere.

Why should I fill out this questionnaire?

As a randomly selected participant, your opinions and concerns represent thousands of other landowners throughout New York State. Your responses will help shape policy that promotes issues relevant to forest landowners. This is an opportunity to voice your opinions and concerns on a variety of significant issues. You may be assured of complete confidentiality in your responses.

What is carbon storage?

Carbon dioxide (CO_2) is a greenhouse gas emitted from fossil fuel use and other activities that can prove harmful when levels in the atmosphere rise too high. Trees and forests naturally remove some of this CO_2 from the atmosphere and store it in forests and wood. This carbon storage, also commonly referred to as carbon sequestration, can be enhanced with improved forest management techniques. As a result, maintaining a healthy, sustainable forest has the potential to lessen the effects of climate change.

What is a carbon offset?

A carbon offset is a tradable commodity created by forest management actions that avoid or reduce the emission of one metric ton of CO_2 gas into the earth's atmosphere. Because every ton of CO_2 in the atmosphere affects the planet equally, solutions to climate change include both reducing CO_2 emissions from fossil fuels and other activities, and increasing carbon storage on forested land. Under this approach, companies and power plants have the option to reduce their own CO_2 emissions, or they may purchase an "offset" from a forest landowner. As a result, forest carbon storage is not only being discussed as a solution to climate change, but also as a potential economic opportunity for forest landowners.

How can forest management increase carbon storage?

Improved forest management includes techniques that increase the rate of carbon storage on forested land. Although exact management practices depend on individual forests, techniques often include decreasing harvest size and regularity, and thinning diseased or deformed trees in order to promote further growth and regeneration of healthier trees and increase species diversity. Often, techniques to improve forest health and prevent disturbances such as pests and fires also increase rates of carbon storage. Therefore, participating in a carbon storage program is also likely to increase forest productivity and the value of your land.

How can forest landowners participate?

The benefits from carbon storage programs -- and carbon offsets in the private market -- only result when forest landowners are willing to make, and continue to implement, a long-term commitment to sustainable forest management. Qualified foresters work with landowners to develop an improved forest management plan to increase carbon storage on their land. In return, landowners may be eligible for financial compensation for this service. Currently there are voluntary markets, such as the Climate Action Reserve, and regional government cap-and-trade programs such as the Regional Greenhouse Gas Initiative (RGGI) that allow forest landowners to sell carbon offsets. There is also discussion of a national climate policy that could expand these opportunities further through national, state, and local programs.

REMINDER POSTCARD

A Survey of New York State's

Private Forest Landowners

And Their Interest in Carbon Storage

Last week a questionnaire seeking your opinion about forest management and carbon storage programs was mailed to you. If you have already completed and returned it to us, please accept our sincere thanks.

If you have not returned the questionnaire, please do so today. Because it has only been sent to a small, but representative, sample of New York landowners it is extremely important that your response also be included in the study.

If by some chance you did not receive the questionnaire, or it got misplaced, please call me as soon as possible at (607) 301-0842 or e-mail me at dps236@cornell.edu, and I will get another one in the mail to you today.

Sincerely,

David R. Lee
Professor

Derek P. Stenclik
Graduate Research Assistant

APPENDIX D

Response Rate	
Total Sample Size	1,200
Responses Forested	451 *
Responses Unforested	57
Responses Protest	5
Total Responses	513
Total Undeliverable	68
Response Rate	42%

**Summary statistics provided in this appendix are for the complete database whereas statistics used in the econometric modeling sections of this paper only include surveys with complete responses.*

Q - 1	**Do you own 25 acres or more of forested land?**		
	Yes	422	82%
	No	57	11%
	Blank	34	7%

Q - 2	**Total Acres of Owned**				
	Mean	Median	Max	Min	Stdev
	121	80	1200	25	143

Total Acres Forested

Mean	Median	Max	Min	Stdev
85	55	810	25	100

Total Acres Forested (largest property)

Mean	Median	Max	Min	Stdev
76	50	800	25	85

Q - 3	**How long have you or your family lived on this property?**				
	Mean	Median	Max	Min	Stdev
	39	29	200	0	36

Q - 4	How did you acquire this property?			
	Bought it	Inherited it	Rec. as gift	Other
	345	84	11	2
	78%	19%	2%	0%

Q - 5	Is your primary residence located on this property?		
	Yes	175	39%
	No	271	60%
	Blank	5	1%

If no, how many miles away do you live?

Mean	Median	Max	Min	Stdev
127	12	3500	0	364

Q - 6	Is this property enrolled in Section 480-A of the NYS Real Property Tax Law?		
	Yes	41	9%
	No	321	71%
	Don't Know	78	17%
	Blank	11	3%

Q - 7	Is this property part of a conservation easement		
	Yes	21	5%
	No	371	82%
	Don't Know	50	11%
	Blank	9	2%

Q - 8	Do you have a written management plan for this forested property?		
	Yes	76	17%
	No	351	78%
	Don't Know	15	3%
	Blank	9	2%

Q - 9	**Why do you own your forested land?**

	Not	*Somewhat*	*Important*	*Very*	*Most*	*Average*
Scenery	2%	8%	27%	59%	18%	3.50
Nature	4%	14%	34%	42%	7%	3.20
Investment	20%	28%	29%	16%	5%	2.44
Offsets	35%	30%	15%	8%	1%	1.94
Home	10%	8%	22%	52%	17%	3.26
Farm	45%	10%	14%	22%	5%	2.13
Privacy	8%	12%	31%	43%	6%	3.15
Inherit	16%	17%	26%	37%	8%	2.87
Firewood	38%	25%	17%	14%	2%	2.06
Timber	47%	22%	17%	9%	0%	1.87
Hunting	27%	14%	19%	36%	13%	2.66
Recreation	11%	14%	33%	37%	3%	3.01

*For exact wording of response options, see survey instrument in Appendix B

Q - 11	**Do you think your property SHOULD be actively managed?**

Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree
30	9	83	122	182
7%	2%	18%	27%	40%

Q - 12	**Do you feel that you DO actively manage your proeprty?**

Yes	261	58%
No	171	38%
Blank	19	4%

Q -13	**On how many acres do you conduct some type of management activity?**

Mean	Median	Max	Min	Stdev
19	3	300	0	39

Q - 14	Have trees been harvested or removed in past 5 years?		
	Yes	206	46%
	No	227	50%
	Blank	18	4%

Q - 15	Why were trees harvested?*	
69	33%	Achieve objectives of management plan
70	34%	Trees were mature
24	12%	To clear land for conversion to another use
58	28%	Money and financial return
50	24%	Help pay property taxes
114	55%	Needed wood for personal use (firewood)
45	22%	To improve scenic and recreational opportunities
131	64%	To improve quality of remaining trees

*Percent of people who had harvested (said yes to Q-14), not all respondents

Q - 16	In the past 5 years, have you received information from the following?	
234	52%	No information from any sources
65	14%	NYS DEC Forester
22	5%	Extension forester or university employee
82	18%	Private consultant
81	18%	Logging contractor
17	4%	Employee of non-profit group
43	10%	Other forest landowner, neighbor or friend

Q - 17A	What management activities have you done on your land in the past 5-years?	
189	42%	Leave forest as is, no activity
252	56%	Harvest firewood for personal use
35	8%	Harvest firewood for commercial sale
79	18%	Harvest wood for sawlogs, veneer, or pulpwood
155	34%	Improve timber quality by thinning or pruning
123	27%	Plant trees
154	34%	Improve wildlife habitat
91	20%	Improve scenic views
193	43%	Mark property boundaries
41	9%	Reduce fire hazard
196	43%	Build or maintain roads or trails
12	3%	Sell some or all of my forestland
22	5%	Give some or all of my land to my heirs
20	4%	Buy more forestland

Q - 17B	What management activities do you plan to do in the next 5-years?	
85	19%	Leave forest as is, no activity
183	41%	Harvest firewood for personal use
34	8%	Harvest firewood for commercial sale
100	22%	Harvest wood for sawlogs, veneer, or pulpwood
156	35%	Improve timber quality by thinning or pruning
120	27%	Plant trees
137	30%	Improve wildlife habitat
68	15%	Improve scenic views
136	30%	Mark property boundaries
38	8%	Reduce fire hazard
141	31%	Build or maintain roads or trails
33	7%	Sell some or all of my forestland
51	11%	Give some or all of my land to my heirs
56	12%	Buy more forestland

Q - 18	**How familiar are you with the following terms regarding climate change?**

	Not	*Somewhat*	*Familiar*	*Very*	*Average*
Climate Change, Global Warm.	5%	19%	34%	42%	3.13
Carbon Storage / Sequest.	43%	22%	19%	15%	2.05
Carbon Offsets	42%	23%	19%	13%	2.03
Cap-and-Trade	47%	18%	18%	15%	2.01

Q - 19	**To what extent do you agree or disagree w/ the following statements regarding climate change?**

	Strongly Disagree		*Neutral*		*Strongly Agree*	*Average*
Serious	12%	9%	22%	20%	35%	3.57
Overblown	32%	13%	20%	16%	17%	2.73
Local Threat	14%	13%	32%	19%	20%	3.19
Inconclusive	25%	15%	24%	16%	18%	2.86
Personal Action	11%	8%	30%	25%	23%	3.42

serious = "climate change is a serious problem that requires immediate action", **overblown** = "concern about climate change is overblown", **local threat** = "climate change is a threat to my forest and local community", **inconclusive** = "generally, the sciency of climate change is inconclusive", **personal action** = "my personal actions can have an influence onf climate change"

Q - 20	**To what extent do you agree or disagree with the following comments?**

	Strongly Disagree		*Neutral*		*Strongly Agree*	*Average*
Private Property	3%	4%	13%	19%	60%	4.30
Valuable Serv.	8%	11%	26%	26%	28%	3.57
Governs Least	10%	13%	26%	18%	31%	3.48
Protect Envr.	4%	5%	18%	32%	39%	3.98
Free Market	28%	24%	27%	10%	8%	2.45

private property = "a first consideration of any good political system is the protection of private property rights", **valuable serv.** = "government provides valuable services to society", **governs least** = "the best government is the one that governs the least", **protect envr.** = "government has a basic responsibility to protect our natural environment", **free market** = "decisions about development are best left to the economic market"

Extensive results of the contingent valuation question (Q-21 through Q-23) are provided in the main text of the paper and are not provided in this Appendix.

The following questions apply only to respondents who said they would NOT participate in the carbon sequestration forest management program.

Q - 24	**If you would not be willing to participate, why not?**	
94	51%	Payment isn't large enough
23	12%	I would not participate no matter what
35	19%	Don't believe CC is a problem that requires action
49	26%	I don't belive the program would work to solve CC
97	52%	I don't support gov't intervention on private land
140	75%	I want control of what happens on my land
107	58%	I don't want to place unnecessary restrictions
38	20%	I don't have enough time available

Q - 25	**If you would not participate, would you at a higher price?**		
	Yes	94	50%
	No	94	50%

Q - 26	**Would you prefer a state sponsored program or private carbon markets?**	
131	29%	New York State sponsored program
51	11%	Private carbon markets
225	50%	Doesn't matter

Q - 27	How important are the following factors in your decision to participate in a program similar to the one outlined previously?

	Not	*Somewhat*	*Important*	*Very*	*Most*	*Average*
Payment	14%	23%	29%	30%	11%	2.79
Time & Effort	9%	16%	40%	31%	6%	2.97
Exact Details	4%	5%	33%	55%	12%	3.43
Help	10%	10%	36%	39%	4%	3.09
Grow Naturally	16%	30%	30%	20%	3%	2.57
Restrictions	10%	16%	23%	48%	3%	3.13
Knowledge	16%	22%	33%	23%	4%	2.66
Time Commit.	12%	19%	31%	34%	3%	2.90
Partic. Costs	6%	9%	29%	51%	4%	3.31
Monitoring	16%	23%	31%	26%	2%	2.70

Q - 29	Are you male or female?

Male	360	80%
Female	82	18%
Blank	9	2%

Q - 30	Age

Mean	Median	Max	Min	Stdev
63	63	97	26	12.05

Q - 31	Are you retired

Yes	202	45%
No	239	53%
Blank	10	2%

Q - 32	What is the highest level of formal education you have completed?
2%	Less than high school
14%	High school diploma (GED)
24%	Some college or technical school
8%	Associate's degree
24%	College or undergraduate degree
26%	Graduate or professional degree

Q - 33	What is your household's combined annual income?
4%	< 25,000
16%	25,000 - 49,999
17%	50,000 - 74,999
11%	75,000 - 99,999
21%	100,000 - 149,000
30%	150,000 +

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