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An assessment of forest landowner interest in selling forest carbon credits in the Lake States, USA

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ABSTRACT

The nation's family forest lands can be an important contributor to carbon sequestration efforts. Yet very little is known about how family forest landowners view programs that enable them to sell carbon credits generated from the growth of their forest and the compensation that would be required to encourage a meaningful level of participation. To address this information gap, we conducted a study to identify and quantify family forest landowner interest in participating in a voluntary carbon market trading program in the Lake States, USA. A mail survey was administered to 2,200 randomly selected family forest owners in Michigan, Wisconsin, and Minnesota. The questionnaire assessed landowner interest in participating in a hypothetical carbon credit trading program and sought information on landowner objectives and practices, perspectives on carbon credit programs and forest land characteristics. A total of 850 usable responses were received. A logistic regression model was developed to examine the factors affecting participation in a forest carbon offset project by family forest owners and estimate landowner participation probability. Results show that carbon program characteristics alongside landowner and parcel characteristics are associated with the decision to participate in a carbon credit program. Specifically, carbon credit payment amount, contract length, gender, value placed on other non-market forest amenities, need for additional income, attitude towards climate change, absentee status, land tenure and total acres owned were found to be significant determinants. Our findings indicate that carbon sequestration management may align with the ownership goals of many family forest owners in the Lake States.

1. Introduction

Forests have the potential to be one of the largest-volume and lowest-cost means of storing additional carbon (Galik et al., 2009; Gorte and Ramseur, 2010). Currently, the 731 million forested acres contained within the United States are able to sequester 10% of U.S. annual CO_2 emissions (USDA, 2011). While a variety of forestry activities[1] can increase carbon stores, forest management is the primary method for increasing carbon stocks on established forest lands (Hoover et al., 2000; Perschel et al., 2007; Markowski-Lindsay et al., 2011). By enhancing current forest management practices, the amount of carbon sequestered within US forests can be increased (Sedjo and Solomon, 1989; Nunery and Keeton, 2010). Additional stored carbon can be quantified and sold in the market place as carbon credits[2] to offset carbon emissions made elsewhere.

Individual and family forest landowners own 42% of the timberland in the United States (Butler and Leatherberry, 2004; Kilgore et al., 2008a). Given their numbers, family forests are a potentially large source of carbon offset credits, but only if their owners are willing to participate in markets that trade carbon credits. At present, few studies have investigated the views and opinions of family forest landowners towards carbon offset projects, their willingness to participate, and the types of incentives or compensation they would require in order to participate. This study addresses this information gap.

Family forest ownership objectives and attitudes have been found to affect management decisions (Karppinnen, 1998; Finley and Kittredge, 2006; Kilgore et al., 2008a). Consequently, understanding the objectives, goals, and intentions of this audience towards forest carbon offsetting efforts will provide direction to agencies seeking to increase forest carbon sequestration. This study estimates the potential supply of

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[1] Afforestation, reforestation, avoided deforestation

[2] Carbon credits are the commodity unit created for trading within a carbon market. One carbon credit equals 1 metric ton of additional carbon sequestered.

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domestic forest carbon offsets by family forest landowners in the Lake States region of the US (Michigan, Minnesota, and Wisconsin). It also assesses whether implementing a forest carbon offset project fits with the objectives of family forest owners and, if so, the incentives and compensation required for their participation.

2. Background

2.1. Demand for forest carbon offsets

The U.S. does not have a comprehensive climate policy framework. Nonetheless, several states and regions have moved forward with carbon reduction initiatives of their own (Perschel et al., 2007). The Regional Greenhouse Gas Initiative (RGGI) is one regional compliance initiative that has been agreed to by nine states (RGGI, 2012). The Western Climate Initiative, including four Canadian provinces and California, has also set regional reduction targets (WCI, 2012). The Midwestern Greenhouse Gas Reduction Accord is a currently latent initiative that included six Midwestern states and one Canadian Province (MGO, 2007; C2ES, 2012). Most significantly, California's Air Resources Board (CARB) adopted cap-and-trade regulation in December of 2011. The program will begin January 1, 2013 and run through 2020 (CARB, 2011). Forest carbon offsets are included in the plan, and allowable forest projects can be located anywhere within the contiguous United States (CARB, 2011). Altogether, within the US, 16 states have developed carbon reduction initiatives.

Concurrent with compliance measures, many carbon emitting entities are voluntarily deciding to curb their emissions and purchasing carbon credits on a voluntary carbon market. Forestry projects may be particularly desirable in the voluntary market because some companies appreciate the additional benefits (improved water quality, wildlife habitat, and esthetics) that forests provide (Lovell et al., 2009). Previously, voluntary market purchases were transacted primarily through the Chicago Climate Exchange, which is now closed (CCX, 2009). Currently there are a wide variety of voluntary market participants (COPC, 2012), and transactions are occurring with little government involvement. It is expected that demand for forest carbon offsets from the voluntary sector will continue to increase in at least the near term (Peters-Stanley et al., 2011).

2.2. Previous research on family forest owner interest in forest carbon markets

Very little information exists on family forest owner attitudes towards forest carbon credit programs. To our knowledge, only three such studies in the U.S. have been conducted to date – all in Massachusetts. An initial pilot study was conducted with 17 landowners using a focus group format (Fletcher et al., 2009). Researchers asked landowners to reveal their preference for carbon credit program attributes by rating potential programs. The attributes included whether or not a management plan was required, whether withdrawal penalties were enforced, contract length, and compensation amount. Results of this study found that landowners favored having no management plan requirement, higher carbon credit payments and no early withdrawal penalty. Somewhat surprising, the study found that landowners favored longer contract lengths. However, the 10-year commitment considered in the study as a long commitment period is at the short end of many carbon credit programs in operation today.

An extension of the Fletcher et al. (2009) study was carried out in Massachusetts (October 2009) with a much larger sample using a mail survey format (Dickenson et al., 2012). This study also asked family forest owners to reveal their preference for certain forest carbon credit program attributes by rating different hypothetical programs. The attributes varied were the same as those varied in the earlier Fletcher et al. (2009) study. Each landowner was asked to rate (on a scale of 1–10) three different "bundled" programs with a total of 12 program variations being included in the study. Results were analyzed using an ordered logit discrete choice model. Consistent with the Fletcher et al. study, this study found that landowners favored those programs that did not require a management plan, had higher carbon credit payments and did not have early withdrawal penalties. Contrary to the Fletcher et al. study, landowners in the larger study did not favor longer contract periods. Overall, the Dickenson et al. (2012) study found that landowner interest in enrolling in carbon programs is quite low in the state of Massachusetts.

In an effort to expand on the findings of Dickenson (2010), another study was conducted in the state of Massachusetts and was aimed at understanding the motivations of family forest owners toward participation in carbon sequestration efforts (Markowski-Lindsay et al., 2011). A random effects, ordered probit model was used to analyze data obtained from a mail survey. The study found that landowners are motivated to participate by factors other than price, and very few would be interested in voluntary market scenarios similar to current schemes.

In comparison, our study investigates the attitudes of landowners towards carbon credit programs with a different and much larger geographic audience (family forest owners in the Lake States) and incorporates more payment and contract length options as well as additional variables.

2.3. Forest carbon credit project requirements

Forest landowners who choose to participate in carbon offset markets are subject to several requirements. An extensive review of various forest carbon protocols was conducted in order to compile a listing of the most common requirements.[3] In general, participation in a forest management carbon offset project requires a landowner to:

- *Sign a contract and commit to participating for a specific period of time*. Current contract length requirements vary from 15 to 100 years.
- *Obtain an initial forest inventory by a professional forester*. This would include a detailed list of the types, size, and quality of trees on the land.
- *Obtain and follow a forest management plan*. This requirement ensures that increased carbon storage will occur on forest land above and beyond standard practice.
- *Certify their forest*.
- *Manage land consistent with carbon storage principles*. For example, delay harvest to allow more carbon to be stored in trees, carry out certain forest management practices, and reduce removal of dead biomass.
- *Keep a written record of the land management activities undertaken*.
- *Allow verification and periodic monitoring by an independent third party*. These would be conducted generally every 2–5 years.
- *Convey a conservation easement*. The landowner may be required to record a covenant with the property deed. This is a legal transfer of the land's development rights to a third party.

3. Data and methods

A mail-back questionnaire was used to obtain information from Lake States family forest landowners regarding their knowledge of and interest in selling carbon credits. The sampling frame consisted of private forest landowners owning 20 acres or more in the most heavily forested counties in a three state area (Michigan, Minnesota, and Wisconsin). This cluster of states shares many similar characteristics (e.g. markets, tree species, landowner demographics) allowing them to be included in a single analysis (Smith et al., 1997; Stearns, 1997). The 10 counties in each state containing the largest area of

[3] VCS, 2008a, 2008b; CCX, 2009*, CARB, 2011; RGGI, 2012, EPA 2008*;US EIA, 2006 1605(b)* (*suspended).

family-owned forest land formed the basis for selecting our survey sample (Miles et al., 1995, Leatherberry and Spencer, 1996, Schmidt, 1997).

County assessor offices in each state were consulted to determine which property tax classifications should be used to sample private forest landowners. Minnesota and Wisconsin each have several property tax classifications that contain only private forest land. In Michigan, only two property tax classes, Timber-Cutover and Commercial Forest, contain exclusively private forest land.[4] County assessors in all three states were asked to provide the name, mailing and parcel address, and legal description of each parcel in these forest land property tax classes that met the study criteria (e.g., >20 acres).[5] From this pool of candidate family forest lands, 2,208 landowners were randomly selected, with the sample weighted by the amount of family forest acreage in each state relative to the aggregate family forest acreage in the Lake States area.

Two separate screenings of our sample were conducted to ensure, to the best of our ability, that only family forest owners were included. Each screening process entailed a manual review of each record in our sample for owner titles suggesting non-family forest ownership arrangements such as "Inc" or "LLC." If a parcel was not a family forest owner, it was removed from our sample and replaced with a randomly selected family forest owner record. Parcels whose owners appeared to be hunt clubs were not removed from the database as they fit within the study sample population parameters desired (i.e. including recreationally focused family forest owners).

3.1. Questionnaire development

In addition to the review of current carbon protocols, questionnaire construction was guided by a literature review of family forest landowners. The questionnaire requested information aimed at understanding the attitudes and opinions of family forest owners towards forest carbon offset projects and their willingness to sell forest carbon credits. Following the work of Arrow et al. (1993) and Hanemann (1994), we utilized a closed-ended, dichotomous choice question for estimating the minimum compensation landowners require to sell forest carbon credits in which landowners were offered a per acre bid price for selling carbon credits for a specified contract period. The survey also posed questions regarding ownership objectives and practices (e.g. reasons for forest land ownership, past and anticipated future land management activities), forest land characteristics (e.g. parcel size, forest cover characteristics), and owner demographics (e.g. age, income, education, distance from forest land).

3.2. Questionnaire pilot test

A questionnaire pilot test was conducted using 400 randomly selected Lakes States family forest owners. The pretest questionnaires used both closed-ended, dichotomous choice and open-ended payment questions in an attempt to determine the appropriate range of carbon payments to be offered. Recipients of the questionnaire pilot test received either a closed- or an open-ended payment question. The close-ended payments ranged from $3 to $30/acre/year.

Using the tailored design method (Dillman, 2000), five mailings were sent including a pre-notice postcard, survey, reminder postcard, second survey, and final reminder postcard. The pilot test overall response rate was 51%. The median payment amount requested by pilot test respondents on the open-ended payment question was $100. As a result, we increased the highest bid payment amount from $30 to $60 /acre/year to reflect a higher landowner bid price yet still align with potential market prices.[6] Many participants noted in the open-ended comment section of the pilot-test survey that they would like more information regarding carbon credits. Consequently, an informational brochure on forest carbon markets and carbon credits was developed for use in the survey. No problems regarding general survey design (i.e. font size used, types of questions asked, method of delivery/response, overall length) were detected with the pilot-test questionnaire.

3.3. Survey deployment

Thirty-two versions of the survey were created; one for each of the combinations of different annual per acre carbon credit payments ($3, $5, $10, $20, $30, $40, $50, $60) and time commitment requirements (15, 25, 40, 50 years). The smallest payment offered, $3/acre/year, approximated the payment amounts seen in early carbon market exchange markets. The payment range of $5–$20 approximated the amount carbon credits were trading for on the voluntary markets at that time (Delta Carbon, 2010). The literature provides little guidance on the largest payment amount to offer and therefore the pilot test was used to give direction to the upper-end value. The contract lengths chosen (15, 25, 40, 50 years) corresponded with the shortest time frames currently in existence and extended toward the longest lengths considered.[7] To ensure that all landowners responding to the survey were contemplating the same benefit at a given payment level, landowners were told to disregard potential project costs (i.e. assume net payment/acre amounts would not be less than the amount listed).

The final survey was administered in September 2010 according to the mail survey protocol described by Dillman (2000). Each landowner received a packet containing a personally addressed cover letter, a copy of the revised survey (1 of the 32 versions), an informational brochure on carbon markets, and a pre-paid business reply envelope. The survey version initially sent to each landowner was recorded so that if additional survey mailings were necessary, the landowner would again be contemplating the same payment/time commitment combination. This was done to avoid confusion and maintain survey integrity (i.e. landowners wondering about a survey where the valuation question changed).

Of the 2,208 questionnaires distributed to family forest owners in the Lake States, 105 were returned as undeliverable. We received 1,107 responses (53%) with 850 (40%) surveys returned as usable for this analysis (i.e. all questions answered with the exception of those containing certain demographic information (see Section 3.6.)). The 40% usable response rate is in line with response rates for studies of family forest owners, which typically range from 32% to 63% (Potter-Witter, 2005; Butler, 2005; Kendra and Hull, 2005; Kilgore et al., 2008a; Rasamoelina et al., 2010).

3.4. Checking for non-response and respondent bias

Several analyses were conducted to identify potential bias in our survey data. First, the participant response rate for each state was

[4] Michigan Tax Classifications available to family forest owners in selected counties: ***Timber-Cutover*** primarily identifies land as vacant forest land - owners receive a tax break (no other requirements). ***Commercial Forest Program*** participants receive a low/acre tax rate in exchange for permitting walk-in traffic. For Commercial Forest, landowners must have a forest management plan, vacant land and a minimum of 40 acres.

[5] Forest landowner lists from ten counties in Minnesota and Wisconsin (each) were obtained. Mailing lists from only eight Michigan counties were obtained, as landowner tax records were either cost prohibitive to obtain or did not contain a sufficient number of landowners within the above classifications in two counties.

[6] The range of bid prices ultimately offered ($3 - $60) is similar to the price range EPA analysts used to project supply of forest carbon credits ($1- $50) (US EPA, 2005).

[7] Climate Action Reserve's Forest Project Protocol requires landowners to commit to allowing monitoring and verifying of a project for a period of 100 years following the issuance of credits for GHG reductions or removals (EPA, 2008).

compared to the proportion of questionnaires sent to each state (34% Michigan, 25% Minnesota, 41% Wisconsin). The percent of usable surveys returned from forest landowners in each state (Michigan 35%, Minnesota 24%, Wisconsin 41%) aligned very well with the percent of questionnaires mailed to landowners in each state. A second test for non-response bias compared the average parcel acreage owned by non-responders to the parcel size of those who responded to the surveys. Average owned acres for non-responders was 63.09 as compared to 62.57 acres for responders, indicating very similar parcel descriptions.

Additional testing was performed to assess how representative our data is of our target population (e.g., Lake State family forest owners). To do so, several variables from our Lake States survey respondents were compared against the results of a comprehensive, nationwide family forest study, the National Woodland Owner Study (NWOS) (Butler, 2008). Survey respondents were organized by state and compared to the descriptive statistics for NWOS respondents (owning ≥ 20 acres) for that state. The variables that were compared were parcel size, land tenure, age distribution, past harvest, residential status, and forest management plan status. Results showed that our Lake States respondents were very similar to profiles of family forest owners from the NWOS study with respect to parcel size, land tenure and age distribution. However, our sample population modestly undersampled owners who have conducted a previous timber harvest, substantially undersampled owners who reside on their land (the latter due primarily to the Michigan tax classification that required forest land be vacant), and substantially oversampled landowners that have a forest management plan (also likely due to those property tax classifications whose eligibility requires a forest management plan). In light of these tests, our study findings may be biased toward family forest owners who have not harvested timber, are absentee owners, and/or have a forest management plan.

3.5. Data inspection

Prior to building the logistic regression model, an extensive pre-analysis inspection was conducted to provide quality assurance regarding the accuracy of the data and the suitability of the analysis method chosen. The data base was checked for coding errors. All surveys containing missing values were deleted from analysis unless the missing value only involved a demographic variable (age, distance from land, education level, tenure, or income). It appeared that some respondents did not, understandably, want to answer certain demographic questions and it was felt that these values could reasonably be replaced by a mean score without obscuring the respondents' intent. Summaries, plots and tables of all variables were inspected. Binning of the database into workable subsets (by survey version) was undertaken so that the initial linearity assumption necessary to logistic regression modeling (requiring that all independent variables do indeed express a linear relationship to the response variable) could be adequately checked.

3.6. Model development

A random utility model (Hanemann, 1984) was used to estimate a family forest owner's interest in selling forest carbon credits using a dichotomous choice format (Loomis, 1987; Kilgore et al., 2008b). Landowners were asked whether they would sell carbon credits at the stated price for the contract term specified. The dependent variable PARTICIPATE had two responses: "1" if a landowner indicated that they would sell forest carbon credits at the price offered and "0" if a landowner indicated that they would not participate at the payment amount offered. Logistic regression analysis was used to relate probable participation in a forest carbon offset project to landowner and carbon credit program characteristics that were used as independent variables in the regression model. In logistic regression, the log odds of the outcome are modeled as a linear combination of the predictor variables (X's):

$$\text{Log odds} = \text{Log } p/1-p = \beta^0 X + \beta^1 X + \beta^2 X + \ldots\ldots .. \beta^k X \quad (1)$$

Where:

P	probability a landowner will sell forest carbon credits
β^o	intercept
β'	vector of regression coefficients
Xi	vector of predictor variables (e.g., landowner, land and program characteristics such as age, parcel size and contract length)

Logistic regression is based on the cumulative logistic probability function and can be used to estimate the probability of a certain event occurring given a set of categorical characteristics (Pindyck and Rubinfeld, 1981). Eq. (1) can be written so as to enable one to estimate the probability of occurrence of a specified outcome (Peng et al., 2002; Hanemann and Kanninen, 1998).

$$P\{\text{participation is "yes"}\} = \frac{1}{1 + e^{-[\beta^0 + \beta' Xi]}} \quad (2)$$

Estimates for the parameters were obtained using maximum likelihood estimation (MLE) procedures. The statistical modeling program used was R version 2.9.2.

3.7. Predictor variables

Guided by the literature on family forest landowners and other factors we hypothesized would influence a landowner's decision to participate in a carbon credit program, 21 predictor variables were initially identified. These independent variables were organized in three major categories: carbon program characteristics, owner characteristics and parcel characteristics. The carbon program characteristic variables initially considered included payment and contract length; the owner characteristic variables included age, gender, education, income, length of ownership, familiarity with carbon credits, value placed on other non-market forest amenities, attitude towards carbon, need for additional income, importance of timber, absentee status, attitude towards management changes, past participation in a forest assistance program, past participation in a tax program and estimation of program barriers; and the parcel characteristic variables included: total parcel size, past harvest status, previous forest certification, and the presence of a written management plan.

Several potential variables thought to be important predictors of a family forest owner's interest in selling forest carbon credits were found to be highly correlated and therefore removed from the list of potential predictors to be included in the logistic regression model. Guidelines used to determine the cut-off value of correlations followed guidelines specified by Cohen (1988). For those pairs of potential predictor variables containing correlation coefficients of 0.4 or greater, only one variable was retained (the one with the greatest expected influence on a landowner's decision to sell forest carbon credits). The number of initial predictors (21) was subsequently reduced to 15, with the highest correlation among predictor variables being 0.354 (landowner value on non-market forest amenities and attitudes regarding climate change). Eighty percent of the pair-wise correlations are less than 0.1 in absolute value. The 15 variables included in the model are shown in Table 1.

Two variables denoting carbon credit program characteristics were used in the model (Table 1). Previous studies have demonstrated a positive relationship between a landowner's decision to participate in a forestry activity and the compensation the owner receives for doing so. The amount of the carbon credit payment (PAYMENT)

Table 1
Variables hypothesized to have an influence on family forest owner participation in carbon credit markets.

Variable	Description	Hypothesized effect on selling carbon credits interest
Carbon offset program characteristics		
PAYMENT	A categorical variable indicating the payment amount offered ($/ac/year).	Positive
YEAR	A categorical variable indicating the contract length required	Negative
Landowner characteristics		
GENDER	A binary variable indicating the gender of the participant (male = 1)	Uncertain
EDUC	A categorical variable indicating level of education (proxy for income)	Negative
TENURE	A continuous variable indicating the length of ownership	Negative
RESIDE	A binary variable indicating whether the owner lives on their land	Uncertain
CO2.COMP	A continuous variable (composite score) indicating landowner attitude towards carbon reduction	Positive
FAMILIARITY	A categorical variable indicating the owner's familiarity with carbon credits	Positive
NON.MARKET	A continuous variable (composite score) indicating the importance of other non-market forest amenities (aside from carbon reduction)	Positive
MGMT.CHGS	A categorical variable indicating the importance placed on requiring management changes	Negative
ADD.INCOME	A continuous variable (composite score) indicating the importance of other forest Income	Positive
ASSIST.PROG	A binary variable indicating past participation in an educational or forest assistance program	Positive
BARRIERS	A continuous variable (composite score) indicating the rating of barriers posed by participation	Negative
Forest parcel characteristics		
TOT.ACRES	A continuous variable indicating the size of the parcel	Positive
PAST.HAR	A binary variable indicating whether or not the owner has harvested in the past	Positive

was included in the model and hypothesized to be positively related to participation (Sullivan et al., 2005; Engel et al., 2008; Fletcher et al., 2009; Dickenson et al., 2012). Contract length (YEAR) was expected to be an important determinant with longer contract lengths having a negative effect on the decision to participate (Layton and Siikamaki, 2009; Lin, 2010; Dickenson et al., 2012).

Several variables were found in the literature to affect a landowner's decision to participate in activities similar to selling forest carbon credits. Previous research has shown that gender can affect the decision to participate; however, the role of gender is mixed. Males were shown to be more interested in participating in certain forest management activities (e.g., Sullivan et al., 2005), yet other research has shown that women are more likely to participate in activities similar to carbon offsetting (e.g., Bliss et al., 1997). Therefore, gender (GENDER) was included in the model with the expected effect uncertain (Table 1).

Education (EDUC) was included in the model as a categorical variable ranging from "some high school or less" to "graduate degree" and hypothesized to be negatively related to participation (Table 1). Previous studies have shown that higher-educated individuals (and higher-income households) are less likely to engage in management activities (Kendra and Hull, 2005; Rasamoelina et al., 2010). Information regarding landowner annual income was also obtained from the questionnaire. However, because respondents are often reluctant to share such information and our income data was highly correlated with the level of educational attainment, education level was used as a proxy for income.

The length of parcel ownership (TENURE), measured in years, was included and hypothesized to have a negative relationship with participation as previous research found that the longer forest landowners owned their land, the less likely they were to place conservation easements on their property, which can be a condition of selling forest carbon credits (Lin, 2010) (Table 1).

It was expected that a landowner's residential status (i.e. whether or not the landowner resides on their forest parcel) would affect participation. Previous studies have conflicting findings whether residency status impacts program participation (Kendra and Hull, 2005; Kilgore et al., 2008b). Therefore, residential status (RESIDE) was included in the model, but the hypothesized effect was uncertain (Table 1).

It was intuitively felt that landowners who agree that climate change is an issue of concern would be more apt to participate in a carbon offset project. A composite score from the survey representing a landowner's attitude towards climate change (CO2 COMP) was included in the model and hypothesized to have a positive effect on participation (Table 1). Responses to four questions designed to gauge the level of landowner agreement with the existence of climate change and whether or not forests can mitigate it were used to compile the composite score (sum). Composite scores were low for those strongly disagreeing with certain statements (as indicated by a Likert rating) and high for those strongly agreeing.

A similar effect was hypothesized for those landowners who highly value other non-market forest amenities (e.g., soil, water, wildlife) which could potentially be enhanced by carbon management activities. A composite score for non-market forest amenities (NON MARKET) was included in the model and expected to be positively related to the desire to participate (Table 1).

Previous studies have shown that the more familiar a landowner is with a particular program, the more likely they are to participate (Kilgore et al., 2008a). The level of familiarity with carbon credits (FAMILIARITY) was included in the model and was expected to be positively related to participation (Table 1).

If landowners are actively involved in the local forestry assistance network through past participation with other landowner educational, technical, or financial assistance programs, we hypothesized they would be more likely to sell carbon credits. Therefore, a variable to indicate past participation in an assistance program (ASSIST.PROG) was included in the model (Butler and Leatherberry, 2004; Salmon et al., 2006; Roper, 2007; Rasamoelina et al., 2010) (Table 1).

Landowners who are very concerned about making necessary changes in the way they manage their forest (MGMT CHANGES) were expected to have negative attitudes toward participation based on an expectation that those most resistant to management changes will be less likely to agree to make changes and participate (Table 1). A composite score was created to represent a landowner's cumulative assessment of the barriers presented by certain potentially required actions. If landowners had already performed an action (e.g. developed a forest inventory, obtained a forest management plan) it presented no barrier (score of 0). If the landowner had not performed a certain action, they were asked to rate the extent to which it would affect participation (Likert score ratings: 1 "Not a Barrier" to 5 "Considerable Barrier"). The compiling of a composite score for barriers allowed the comparison of landowners who had already completed many requirements (scoring of 0–5) to those landowners without any requirements fulfilled and a high estimation of the barriers presented by requirements (score of

30–35). Landowners with high composite scores were hypothesized to be less likely to participate. In contrast, those landowners with very low composite scores were expected to be more likely to participate (Rasamoelina et al., 2010).

Also hypothesized to be a determinant of future participation in a forest carbon market is the importance landowners place on obtaining additional income other than timber (i.e. hunting leases) from their forest. Family forest owners have been shown to be a very diverse group whose initial forest purchase is not particularly motivated by expected financial returns (Baughman et al., 1998; Rickenbach et al., 2005; Butler et al., 2007). Therefore, those landowners who indicated that they purchased their forest expecting to receive some financial return were expected to be more likely to participate. The variable (ADD INCOME) was used to identify the importance landowners place on generating income from their forest land (Table 1).

Variables related to the forest parcel hypothesized to have an effect on participation are listed in Table 1. The variable (TOT ACRES), representing the total amount of contiguous forested acres owned, was included in the model and expected to be positively related to a landowner's desire to participate. Other studies have shown that landowners with larger parcels are more likely to participate in similar programs (Butler, 2008; Kilgore et al., 2008b).

A variable indicating land that has been previously harvested (PAST HARV) was included in the model (Table 1). A landowner's history of timber harvesting was hypothesized to be positively related to participation as it tends to indicate more active forest ownership (Butler et al., 2007).

4. Results

4.1. Profile of Lake States family forest landowners

Similar to studies of other forest owners across the nation (Butler and Leatherberry, 2004; Sullivan et al., 2005; Butler, 2008), the typical Lake States family forest owner who responded to our survey is nearing retirement age (59 years old, on average), owns a modest amount of forest land (an average of 63 acres), has completed some post-secondary schooling, and has an average household income ($75,000) (Table 2). Family forest owners in the Lake States indicate that their primary motivation for owning forest land is to enjoy nature, followed by a place to hunt. Average land tenure is 22 years. Forty-five percent of respondents have previously harvested trees, while 21% have enrolled in a forest property tax program (Table 2).

Table 2
Descriptive statistics of Lake States survey respondents (units of the variable are shown in parentheses).

Variable	Mean	S.D.
Respondent characteristics		
Age (years):	59.2	11.97
Gender (% male)	89	
Education level (years)	14	1.73
Average income: (dollars per household)	75,000	
Reside on land—overall (%)	24	
State analysis (% of each state's respondents)		
Michigan	8	
Minnesota	34	
Wisconsin	32	
Miles from land (absentee owners)	207	452.74
Dwell in rural area/small rural town (%)	64	
Land characteristics/tenure		
Average acreage	62.57	68.36
Years owned	22	16.26
Percentage of land forested (%)	79	
Previously harvested trees (%)	45	
Enrolled in tax program (%)	21	
Have a written management plan (%)	23	

Our sample contains a higher percentage of absentee forest landowners (76% overall) when compared to the Lake States family forest owner population as estimated by the NWOS which found 40% of Lake States forest landowners (owning ≥20 acres) were absentee owners (Table 2). Also, our sample contained a higher percentage of owners with forest management plans in two of the Lake States. Overall, 23% of our respondents had a written management plan (32% in MI; 17% in MN; 22% in WI) as compared to 14% in the NWOS study (7% in MI; 11% in MN; 23% in WI) (NWOS, 2008). Consequently, our study may preferentially describe the potential supply of carbon credits and attitudes toward carbon program characteristics that are associated with absentee owners and those with a forest management plan, and those who do not have a history of harvesting.

4.2. Familiarity with forest carbon credits

Lake States family forest owners are very unfamiliar with forest carbon credits. Respondents were asked to indicate how familiar they are with forest carbon credits by choosing from the following: never heard of them, minimal familiarity, some familiarity, extensive familiarity. Forty-two percent of our respondents indicated that they had not heard of forest carbon credits prior to our survey, with only 2% indicating they had extensive familiarity with the forest carbon market (37% indicated minimal familiarity, 19% some familiarity).

4.3. Potential actions needed to sell carbon credits

Survey participants were asked to indicate whether or not they had already carried out certain actions on their forest land commonly associated with selling forest carbon credits (e.g. inventoried forest, obtained a written management plan, certified forest). If a participant had not already completed the action, he/she was asked to indicate the extent to which doing so would be a deterrent from participating in a forest carbon offset project using a five-point Likert scale (1 = no barrier, 5 = considerable barrier). Carbon credit projects that would require a conservation easement posed the greatest barrier to landowner participation, with 53% of our respondents indicating such a requirement would be a significant barrier (11% stated the requirement would not be a barrier). Among all respondents, the mean response to this question is 4.0. Respondents expressed the least resistance towards the requirement to have a detailed inventory of their forest land.

4.4. Certainty of response

Several other researchers have explored the concept of level of certainty about responses to payment questions contained in contingent valuation surveys (Ready et al., 1995; Welsh and Poe, 1998; Champ et al., 1997; Samnaliev et al., 2006). In several studies, it was found that contingent valuation studies underestimate actual willingness to accept (WTA) compensation. In other words, while certain respondents may indicate they would be willing to accept a payment amount, in reality they are unsure or may not. To address this, some studies have found that by directly asking respondents how certain they are of their response, estimation of actual behavior is improved (Champ et al., 1997; Champ and Bishop, 2001; Ready et al., 2001; Poe et al., 2002; Vossler et al., 2003). In the Poe et al. (2002) and Vossler et al. (2003) studies, a certainty level of ≥7 most closely corresponded to actual participation rates. Guided by this research, following the forest carbon credit valuation question in our survey, respondents were asked to rate how certain they were of their response to the payment question using a 10-point scale (1 = completely uncertain, 10 = completely certain). Following the work of Poe et al. (2002) and Vossler et al. (2003), we also used ≥7 as a cutoff point to create a new binary variable of participate or not.

Table 2 summarizes the results of two binary logistic regression models developed to estimate a Lake State family forest owner's interest in selling forest carbon credits. Model 1 includes all usable survey responses ($n=773$). Model 2 includes only those respondents who indicated a high degree of certainty (Certainty Rating ≥ 7) in their response to selling forest carbon credits under the conditions offered ($n=494$).

4.5. Significant predictors of carbon market participation

Eight of the 15 variables are significant predictors of a landowner's interest in enrolling in a carbon credit program ($p<0.05$), as shown in Model 1 (Table 3). Both the carbon program characteristics of payment amount and contract length are significant. As expected, the carbon credit payment amount ($ per acre per year) is positively related to the response and contract length is negatively related to participation.

Alongside carbon program attributes, several landowner characteristics are important predictors of program participation using both models (Table 3). Those landowner characteristics found to have a significant positive effect on participation in a forest carbon market in both models are: gender (male), value placed on non-market forest amenities, the need for additional income, and attitude towards climate change. Landowner characteristics found to have a significant negative effect on participation include residing on land and the extent to which the program requirements pose significant barriers to participation. When only those landowners expressing a high certainty about their response to the annual per acre carbon credit payment amount offered are considered (Model 2), an additional landowner characteristic, land tenure, is found to have a significant negative effect on participation. Those landowners who have owned their land for a longer period of time are less likely to participate.

One land characteristic becomes significant when only considering the responses of those landowners who are highly certain of their response (Model 2). The amount of forest land owned (TOTAL ACRES) was found to be positively related to participation – those landowners with larger parcels are more likely to indicate a willingness to participate.

4.6. Overall interest in selling carbon credits

The survey asked respondents to characterize their overall interest in selling forest carbon credits. The average response of 5.5 suggests family forest owners are not sure whether they are interested in participating (scale of 1–10 where 1 = not interested, 10 = very interested). However, when only those landowners who expressed a high level of certainty in their response to the forest carbon credit valuation question are considered, the mean interest in selling carbon credits increases to 7.31. Ten percent of respondents who were not willing to sell forest carbon credits at the payment amount and contract length offered still expressed a high interest in selling carbon credits (score ≥ 7). This suggests that had the carbon credit bid price been higher and/or contract period shorter (on the survey version received), additional respondents might have indicated a willingness to sell forest carbon credits.

5. Discussion

5.1. Carbon credit program characteristics

Of the program characteristics examined, family forest owners in the Lake States are most responsive to a higher price for carbon credits. As the price offered for carbon credits increases, so does the willingness to participate in an offset program. We found payment amount to be a very significant ($p\leq 0.001$) predictor of participation when modeling all respondents (Model 1) and only those who were "very certain" of their answer to the question of whether or not to participate (Model 2). Participation is also tied to contract length. Family forest landowners in the Lake States are averse to long contract lengths—the longer the contract required, the less landowners want to participate. Contract

Table 3
Logistic regression analysis of factors affecting Lake States family forest owners' willingness to sell carbon credits by the statistical program R version 2.9.2.

Predictor	Model 1						Model 2					
	All respondents included						Only high certainty respondents					
	($n=773$)						($n=494$)					
	Coef. β	S.E.	Wald's X^2	P value	Marginal effects	e^{β} (odds ratio)	Coef. β	S.E.	Wald's X^2	P value	Marginal effects	e^{β} (odds ratio)
Program characteristics												
Payment	0.0329	0.005	6.712	0.0000***	0.00802	1.034	0.0484	0.007	6.507	0.0000***	0.0119	1.050
Year	−0.0267	0.007	−4.059	0.0005***	−0.0065	0.974	−0.0388	0.010	−3.963	0.0001***	−0.0095	0.962
Owner characteristics												
Gender (1 = male/0 = female)	0.8380	0.245	3.426	0.0006***	0.2042	2.312	0.9879	0.378	2.613	0.0090**	0.2421	2.686
Familiarity	−0.0949	0.114	−0.832	0.4055	−0.0231	0.909	−0.0660	0.165	−0.400	0.6892	−0.0162	0.936
Non-market composite	0.1255	0.037	3.431	0.0006***	0.0306	1.134	0.1284	0.051	2.500	0.0109*	0.0315	1.137
CO_2 attitude composite	0.0664	0.027	2.453	0.0142*	0.0162	1.069	0.1418	0.041	3.495	0.0005***	0.0347	1.152
Additional income	0.4581	0.075	6.135	0.0000***	0.1117	1.581	0.7431	0.118	6.309	0.0000***	0.1821	2.103
Education	−0.0886	0.053	−1.686	0.0919	−0.0216	0.915	−0.0549	0.077	−0.710	0.4778	−0.0134	0.947
Mgmt. Changes	−0.0183	0.082	−0.225	0.8223	−0.0045	0.982	−0.0926	0.120	−0.777	0.4375	−0.0227	0.912
Assist.Program	0.1757	0.268	0.655	0.5122	0.0428	1.192	0.5430	0.396	1.371	0.1704	0.1330	1.721
Reside	−0.5405	0.207	−2.617	0.0089**	−0.1258	0.582	−0.7795	0.315	−2.477	0.0132*	−0.1938	0.459
Tenure	−0.0046	0.006	−0.802	0.4228	−0.0011	0.995	−0.0250	0.009	−2.862	0.0042**	−0.0061	0.975
Barriers	−0.0650	0.011	−5.871	0.0000***	−0.015	0.937	−0.0941	0.017	−5.580	0.0000***	−0.0234	0.910
Land characteristics												
Total acres	0.0934	0.053	1.760	0.0785	0.0228	1.0978	0.1244	0.051	2.430	0.0151*	0.0305	1.132
Past harvest	−0.0034	0.194	−0.017	0.9861	−0.0011	0.9966	−0.0037	0.293	−0.013	0.9899	−0.0010	0.996

Goodness of fit tests (Model 1)	Goodness of fit tests (Model 2)
AIC: 811.16	AIC: 404.82
Cox and Snell: 0.40	Cox and Snell: 0.53
Nagelgerke R2: 0.51	Nagelgerke R2: 0.68
Hosmer Lemeshow: 0.284	Hosmer Lemeshow: 0.804

Significance codes: ***significant at $\alpha=0.001$ level, ** significant at $\alpha=0.01$ level, * significant at $\alpha=0.05$ level.

length was found to be a very significant ($p<0.001$) negative predictor of participation. The dampening effect an increasing contract length has on participation at the various payment amounts is demonstrated in Fig. 1. Using Model 1, the estimated participation when all contract lengths are considered is shown (middle line) as compared to participation at 15 years (top line) and at 50 year contract length requirements (bottom line) when all other variables are held at their mean values.

5.2. Owner characteristics

Several characteristics of the landowner are significant predictors of participation. Landowner attitudes towards both non-market forest amenities and climate change are positively related to the willingness to sell forest carbon credits. Family forest owners in the Lake States who place a high value on forest-based amenities that may result from the sale of carbon credits (e.g., improved water and soil quality, forest esthetics, wildlife habitat) are significantly more likely to participate in an offset project than those who do not value them. Not surprisingly, landowners who feel that climate change is a real environmental concern are much more likely to participate than those who do not feel that climate change is a problem. The importance landowners place on receiving additional income (aside from timber) from their forest land is also a significant predictor of participation—the more landowners value additional income, the more likely they agree to the program terms offered. Our results show that males are significantly more interested in participating in a carbon offset project than female respondents. This could indicate that, similar to the findings by Bliss et al. (1997) and Sullivan et al. (2005), males are more interested in engaging in certain types of forest management activities.

Those landowners who reside on their land are significantly less likely than absentee owners to participate in carbon offset programs.[8] This could indicate that absentee owners may be more willing than resident owners to comply with certain requirements such as allowing third-party inspections and the conveyance of conservation easements. Of the 18 respondents who already had a conservation easement on their land, all but one was an absentee owner. Also, landowners who do not live on their land may have a greater desire to reduce ownership costs given their presumed less frequent use of the land. For those that do reside on their land, the importance that they place on the necessity for additional income appears to be a key factor in their decision to participate.

The composite score for barriers (the extent a potential requirement would prevent participation) is very significant ($p<0.001$) with a negative coefficient—the higher the composite score, the less likely the respondent was to sell carbon credits. Those landowners who already had completed several requirements needed to sell carbon credits (e.g., forest inventory, written management plan, forest certification) were much more willing to participate in a carbon trading program. Although our sample contains a large portion of landowners with forest management plans, the preparation of a management plans alone does not significantly influence a landowner's decision to sell forest carbon credits.

5.3. Land characteristics

The one land characteristic positively related to carbon market participation is the total acreage owned. While not a significant predictor in Model 1, total parcel size becomes an important predictor of participation with landowners who indicate they are very certain of their decision whether or not to sell forest carbon credits for the terms offered. Those landowners having large parcels of forest land (200 acres, shown in Fig. 2) are more likely to sell carbon credits than those owning smaller parcels (40 acres).

[8] This finding held even when removing from the database those landowners from tax classifications that required absentee ownership.

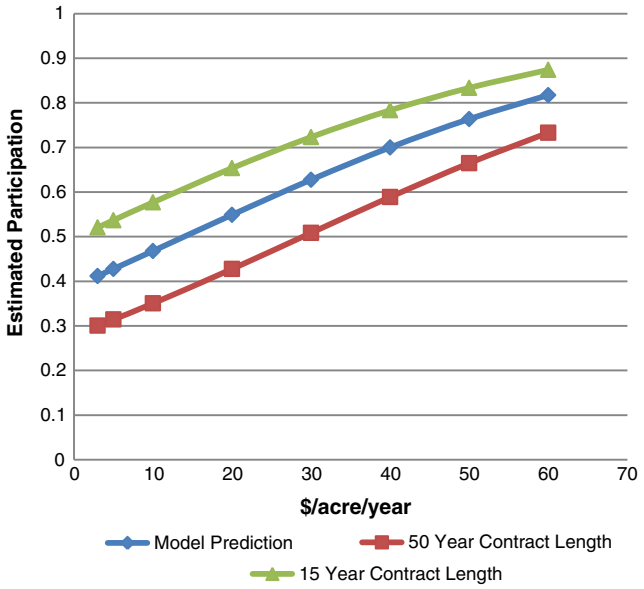

Fig. 1. Estimated participation by contract length required.

5.4. Unexpected findings

Familiarity with carbon offset programs was not shown to affect the decision to participate. Those family forest owners who were not familiar with the concept of selling carbon credits prior to receiving our survey were no less likely to consider participating than those who were extensively familiar with carbon credit programs. This finding is counter to other studies that found that interest in enrolling in similar type programs is influenced by familiarity with the program (Kilgore et al., 2008a).

6. Policy implications

According to analysis using Model 1, a payment of approximately $18/acre/year would be required to generate a 50% participation rate. The payment amount required to generate a 50% participation rate rises to $28/acre/year when estimated using only those respondents who express a high certainty in their response to the valuation question (Model 2). To our knowledge, these amounts are higher than is currently being offered for carbon credits through voluntary markets operating within the region. However, both model estimates reveal that some portion of landowners would participate for payments within the range of payments currently offered. If regression lines are extended towards the y axis, both models estimate that a portion of Lake States family forest owners would be willing to commit to managing for carbon for a specified period of time without receiving compensation. This finding agrees with other research on incentive payments to family forest owners for similar programs (Kline et al., 2000; Kilgore et al., 2007).

Comments provided by survey respondents to an open-ended question are consistent with our model results, namely that some landowners would require very little or no compensation for their efforts:

> "We use our property for deer and grouse hunting. Our son-in-law has a Forestry Degree- UW Stevens Point. He advises me on when to harvest trees, etc. It really makes no difference if carbon credits or not. I like trees. Every year we plant more and different kinds like oaks for wildlife."

> "I know forests help the carbon problem and voluntarily would keep my forest property in good environmentally favorable condition."

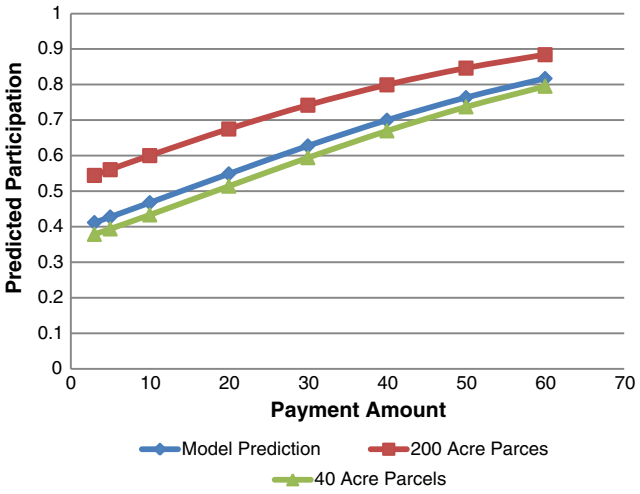

Fig. 2. Predicted participation by parcel size.

> "I am not interested in carbon credits but would want as much forest land to remain forest land because that is the most environmentally necessary – not because there is financial gain. Do the right thing for the environment."

It is possible that for a certain segment of family forest landowners, the value derived from making a positive contribution to an issue they are concerned about (climate change) alongside the ability to improve other valued forest amenities (e.g. wildlife habitat) may provide enough incentive to practice sequestration management, whether or not they ultimately sell carbon credits (Gottfried et al., 1996). Methods of identifying and assisting this group of landowners should be further investigated.

The majority of forest landowners who participated in this study indicated that requiring a conservation easement before selling carbon credits is a major deterrent. It is likely that if carbon offset standards contained this requirement, the participation rate would be much lower than that estimated through our models. Also, the Lake States landowners who responded to our survey are very resistant to long contract periods. Rather than developing projects that extend for 50–100 years (beyond the lifespan of many participants), carbon offset projects that can be completed within a 15–25 year time span, yet ensure permanence, would have a greater chance of success with family forest owners in the Lake States. In light of this finding, the current CARB forest offset protocol (requiring a 100 year contract length) may have low appeal to family forest owners in the Lake States (CARB, 2011).

7. Conclusion

Certain family forest landowners in the Lake States region may be well positioned to participate in carbon offset projects. A majority of the forest landowners who responded to our survey feel climate change is an issue of concern. While results showed Lake States family forest owners are not familiar with forest carbon credits (42% indicated they had never heard of them prior to our survey), a considerable number indicated that they would be willing to participate in an offset project under certain financial and contractual conditions. This high degree of interest may be a function of our sample, which contained a relatively high number of absentee landowners and those with a forest management plan. One interpretation of our study findings is that the management actions associated with carbon sequestration projects may provide benefits (both monetary and nonmonetary) that select forest owners in the Lake States value.

Our results indicate that large parcel, absentee owners who previously have completed several requirements (e.g. inventoried forest, obtained management plans, certified forest) and desire additional income from their forest investment are likely to be good candidates for carbon market participation. However, our results also indicate that the long contract lengths required for participation in current compliance markets (i.e. CARB) may greatly lessen carbon market interest even by these select family forest owners in the Lake States. Nevertheless, while increased carbon market participation amongst family forest owners may be desirable to some, it cannot be at the expense of meaningful sequestration. Forest offset protocols need to balance the need for increased participation with requirements that can assure substantial and permanent carbon reductions are made.

Carbon market participation requirements that severely dampen landowner interest in compliance measures may be necessary to assure offset quality. Still, our study findings show that carbon sequestration management appears to align with the ownership goals of certain family forest owners in the Lake States. Many of these landowners may simply view such actions as helping to mitigate a problem they are concerned about. It is possible that family forest owners may be most interested in forest carbon sequestration projects that are not geared toward the market (allowing less stringent requirements) yet able to provide benefits they value. For these landowners, programs that provide recognition (or tax relief) for contributions toward forest sequestration efforts, or enable them to achieve other forest land objectives through carbon management, may prove the most successful.

Our study only looked at one geographic area of the United States. It would be important to replicate this study with family forest owners in other regions of the United States. Such comparative studies would facilitate a more complete understanding of the potential supply of carbon credits provided by the nation's family forest owners. Having such information will assist in determining whether family forest lands will be a major contributor to strategies for reducing atmospheric carbon.

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