References

Belin, D.L., Kittredge, D.B., Stevens, T.H., Dennis, D.F., Schweik, C.M., Morzuch, B.J., 2005. Assessing NIPF owner attitudes toward forest management. Journal of Forestry 103 (1), 28–35.
Butler, B.J., 2008. Family Forest Owners of the United States, 2006. General Technical Report NRS-27, USDA Forest Service, Newtown Square, Pennsylvania, p. 72.
Catanzaro, P., Sweetser, W., Kittredge, D., Romano, L., 2010. Chapter 61B Open Space and Recreational Land: Current Tax Use Program. Retrieved April 4, 2010 from the Trustees of Reservations Website: http://www.thetrustees.org/hci/library/CH61B_final_1.pdf.
Dickinson, B., 2010. Massachusetts Landowner Participation in Forest Management Programs for Carbon Sequestration: An Ordered Logit Analysis of Ratings Data. M.Sc. thesis, University of Massachusetts Amherst.
Finley, A.O., Kittredge, D.B., 2006. Thoreau, Muir, and Jane Doe: different types of private forest owners need different kinds of forest management. Northern Journal of Applied Forestry 23 (1), 27–34.
Fletcher, L.S., Kittredge Jr., D., Stevens, T., 2009. Forest landowners' willingness to sell carbon credits: a pilot study. Northern Journal of Applied Forestry 26 (1), 35–37.
Greene, W.H., 2003. Econometric Analysis, 5th edition. Prentice Hall, Upper Saddle River, NJ.
Kittredge, D.B., 2004. Extension/outreach implications for America's family forest owners. Journal of Forestry 102 (7), 15–18.
Kittredge, D.B., D'Amato, A., Catanzaro, P., Fish, J., Butler, B., 2008. Estimating ownerships and parcels of non-industrial private forest in Massachusetts. Northern Journal of Applied Forestry 25 (2), 93–98.
LeVert, M., Stevens, T., Kittredge, D., 2009. Willingness to sell conservation easements: a case study of private forestland owners in Southern New England. Journal of Forest Economics 15, 261–275.
Mitchell, R.C., Carson, R., 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Resources for the Future, Washington, DC.
Nickerson, J., 2008. CCAR Forest Protocols (PowerPoint slides). Retrieved June 15, 2009 from Northern California Society of American Foresters Web site: http://www.norcalsaf.org/temparticles/Nickerson.pdf.
Nunery, J.S., Keeton, W.S., 2010. Forest carbon storage in the northeastern United States: net effects of harvesting frequency, post-harvest retention, and wood products. Forest Ecology and Management 259, 1363–1375.
Perschel, R.T., Evans, A.M., Summers, M.J., 2007. Climate Change, Carbon, and the Forests of the Northeast. Forest Guild. Retrieved June 30, 2009 from Forest Guild Web site: www.forestguild.org/publications/2007/ForestGuild_climate_carbon_forests.pdf.
Rickenbach, M.G., Kittredge, D.B., Dennis, D., Stevens, T., 1998. Ecosystem management: capturing the concept for woodland owners. Journal of Forestry 96 (4), 18–24.
Stevens, T.H., White, S., Kittredge, D.B., Dennis, D., 2002. Factors affecting NIPF landowner participation in management programs: a case study. Journal of Forest Economics 8, 169–184.
U.S. Climate Legislation & Forestry Offsets: Implications for Forest Landowners, Investors and Regulated Entities. Retrieved March 29, 2010 from the New Forests Website: http://www.newforests.com.au/news/pdf/articles/PolicyOctUS.php.

Please cite this article in press as: Dickinson, B.J., et al., Estimated participation in U.S. carbon sequestration programs: A study of NIPF landowners in Massachusetts. J. Forest Econ. (2011), doi:10.1016/j.jfe.2011.06.002

Michigan Working Forest Carbon Offset Program

Overview

The goal of the Michigan Forest Carbon Offset Program (MFCOP) is to provide landowners with financial incentives to engage in sustainable forest management, address climate change, support local natural resource economies and preserve family lands.

The Program allows landowners to generate revenue through the sale of carbon offset credits on the Chicago Climate Exchange.

The Chicago Climate Exchange (CCE) – a voluntary, member-based market comprised of large companies, municipalities and institutions – allows carbon sequestration benefits from conservation practices to be quantified, credited and sold. The credits are pooled from many different landowners and sold to CCE members who have made a commitment to reduce their greenhouse gas emissions. CCE members must reduce their emissions to meet legally binding targets or mitigate a portion of their emissions through the purchase of offset credits generated by eligible practices. The Delta Institute, a non-profit organization, pools and sells these credits on the CCE on behalf of the landowner. The revenue from the sale, minus pooling and trading fees, is returned to the landowner.

Landowners who sustainably manage forestlands provide a valuable public service through carbon sequestration. This rise of carbon credit trading has opened new financial markets for landowners. However, the complexities and costs to enter these markets are often a barrier to participation. The Michigan Working Forest Carbon Offset Program eliminates this barrier to entry, allowing landowners to earn revenue for providing a valuable ecosystem service.

Step 2: Please **rate** the options using the instructions below:

Please assume a similar forest carbon offset program will soon be developed in Massachusetts and complete the following. Please **rate each** of the following carbon offset programs on a scale of 1–10, with 10 being programs in which you would definitely enroll and 1 being programs in which you would definitely not enroll. Please look over all three of the alternatives before making your ratings. You may use any particular rating for more than one program if you feel equally about them.

	Carbon Credit Program 1	Carbon Credit Program 2
Eligibility	Requires management plan written by professional forester	Requires management plan written by professional forester
Time commitment	5 years	5 years
Verification	Baseline carbon inventory calculated by forester; changes in carbon capacity must be reported annually	Baseline carbon inventory calculated by forester; changes in carbon capacity must be reported annually
Expected payment	$5/acre/year	$30/acre/year
Early withdrawal penalty	$10/acre one time payment	None
	Rating (1–10 scale):_____	Rating (1–10 scale):_____

	Carbon Credit Program 3
Eligibility	Requires management plan written by professional forester
Time commitment	10 years
Verification	Baseline carbon inventory calculated by forester; changes in carbon capacity must be reported annually
Expected payment	$15/acre/year
Early withdrawal penalty	$10/acre one time payment
	Rating (1–10 scale):_____

Please cite this article in press as: Dickinson, B.J., et al., Estimated participation in U.S. carbon sequestration programs: A study of NIPF landowners in Massachusetts. J. Forest Econ. (2011), doi:10.1016/j.jfe.2011.06.002

traded on the CCX at $0.10 (http://www.chicagoclimatex.com/).[10] At approximate sequestration rates of 1–3 tonnes/acre year (Fletcher et al., 2009), this translates to a potential revenue of only between ten and thirty cents/acre/year. Value of carbon equivalents may change if policy evolves from a voluntary OTC marketplace to a mandatory cap-and-trade system. Our results at this point, however, imply that very few, if any, NIPF owners would participate at current expected payment rates.

Discussion and conclusion

Massachusetts owners of non-industrial private forests can help mitigate climate change by managing their land in a way that maximizes carbon sequestration. There are domestic markets for the trade of forest-related carbon offsets, including over the counter. Although at the moment there are few opportunities for Massachusetts NIPF landowners to participate in forest management offset markets, these programs are rapidly changing. This paper examines the willingness of Massachusetts landowners to participate in either private aggregation programs or in government-sponsored programs to induce carbon sequestration.

Results of the ordered logit analysis of the landowner survey indicate that respondents are less likely to participate in a program that requires a management plan, has a higher time commitment, and has an early withdrawal penalty. Landowners are more likely to give a 10 rating to a program with higher per acre annual revenue. Males are less concerned about higher time commitments than females, though the effect of a higher time commitment on probability of a 10 rating is negative for both. Lower educated and older respondents care less about the early withdrawal penalty and about revenue than other respondents.

The probability that respondents who gave 6–9 ratings would give a 10 rating to a OTC-like program is very low – around 7.5%. That appears to be the result of low expected payment ($8 annually per acre) and an aversion toward a required management plan, lengthy time commitment and early withdrawal penalty (see Table 5).

Although our results are based on a 48.6% response rate, they clearly suggest that to induce greater landowner enthusiasm towards forest management carbon offset programs in Massachusetts, a policy maker would have to change some or all of the policy attributes currently facing prospective program participants. The probability that respondents who gave ratings of 6–9 would participate in a landowner-friendly program is around 43%. Such a program would have no required management plan, only a five year time commitment, a $30 per acre annual revenue and no early withdrawal penalty. That only 43% would enroll in such a program suggests that with respect to carbon markets, many respondents may be motivated by non-monetary factors.

Carbon sequestration on NIPF lands faces an important policy paradox. Nationally, family-owned forests represent 35% of the U.S. woodland, and in all of the eastern United States including Massachusetts, this proportion is much higher (Butler, 2008). This means that if forests are to be managed or maintained as an important source of carbon sequestration, NIPF owners need to be involved. On the other hand, our results suggest that owners see meaningful obstacles to participating in programs designed to promote carbon sequestration on their lands, and indeed, it is likely that a large proportion of owners are disinterested in any program. If the policy maker's goal is to maximize carbon sequestration, the approach obviously needs to appeal to owners. Owner appeal needs to be balanced with a program that results in verifiable, permanent or additional carbon sequestration. The policy maker must balance likelihood of landowner participation with quality of the resulting carbon sequestration in forming a program.

Appendix A. Choice elicitation section of the survey

Step 1: Please **read** the following description of the Michigan Working Forest Carbon Offset Program:

[10] The CCX program existed from 2000 to 2010.

Please cite this article in press as: Dickinson, B.J., et al., Estimated participation in U.S. carbon sequestration programs: A study of NIPF landowners in Massachusetts. J. Forest Econ. (2011), doi:10.1016/j.jfe.2011.06.002

Table 5
Probabilities of 10 rating for modal respondents with 6–9 ratings at different program attribute levels.

Required plan?	Time commitment	Revenue	Penalty?	Probability
Yes	15	8	Yes	0.075
Yes	15	8	No	0.110
Yes	15	30	Yes	0.235
Yes	15	30	No	0.318
No	5	5	Yes	0.099
No	5	5	No	0.143
No	5	30	Yes	0.331
No	5	30	No	0.430

show, these characteristics conflict with the motivation of landowners. The most sound carbon sequestration program (for example, programs like P8) will be the least agreeable for the average family forest owner.

The policy maker should also consider whether the population of interest resembles the modal values of individual characteristics included in this study. The modal respondent is a male below the age of 66, with some college or a college degree and who owns 100 acres or more. For non-modal respondents, the probability of giving a 10 rating for a program with any combination of attributes considered here can be calculated using the ordered logit results (Table 3). If the population of interest consists of older males with only high school diplomas with less than 100 acres, the probability of a 10 rating is lower than what is provided in Table 4 results.

The policy maker may want to consider the type of population that gave 6–9 ratings in the survey; that type of respondent feels positively if not certain about participation. Modal 6–9 rating respondent are the same as general modal respondents except they have more than a college degree. Probabilities of giving a 10 rating by this group for alternative estimated programs are presented in Table 5 (i.e., programs not specifically given to respondents).

As shown in Table 5, these respondents have a 7.5% chance of giving a 10 rating to a straight over the counter, OTC, like program with an $8 per acre return[9] (see line 1, Table 5). Since the policy maker might consider some form of subsidy to encourage participation, it is interesting to note that the probability of giving a 10 rating for a OTC-like program in which a government agency has absorbed the early withdrawal penalty and subsidized $22 on top of the OTC-earned revenue is 31.8% (see Table 5). The probability of a 10 rating for a Chapter 61B-like program is 9.9% where there is a penalty for early withdrawal and only a $5 per acre annual revenue. The highest probability of a 10 rating corresponds to the Chapter 61B-like program that has no early withdrawal penalty and a $30 annual revenue; that probability is 43%. Interestingly, even a relatively simple program with no potentially onerous withdrawal penalty and a high rate of annual payment only attracts 43% of respondents.

This analysis provides an interesting opportunity to compare preliminary results from 17 participants in live focus group settings (i.e., Fletcher et al., 2009) with 910 respondents of a mail survey. The same programs and tradeoffs were used in both studies. Fletcher et al. (2009), using likelihood of participation based on a rating of 9 or 10 in a logit model, estimated that as few as 5% of participants would sell credits for a payment as low as $15/acre/year, and even when the price increased to $50/acre/year, only 33% would enroll. Interestingly, the Fletcher, et al. focus group respondents appeared to prefer the longer time commitment. Our results indicate that shorter time commitments are preferred but they also suggest that the probability of adopting most programs is quite low. As in the Fletcher et al. (2009) study, our results imply that payment is important, but even under the highest presented scenario of $30/acre/year and the most lenient requirements (i.e., no management plan, 5 year time commitment), 33.9% of respondents rated it at 9 or 10. Carbon markets have been very volatile and in May 2010, for example, carbon credits (metric tons of CO2) were

[9] An $8 per acre revenue is used here because that was a reasonable expected return for a OTC program (Dickinson, 2010) and because it is useful for comparison with the results of Fletcher et al. (2009).

Please cite this article in press as: Dickinson, B.J., et al., Estimated participation in U.S. carbon sequestration programs: A study of NIPF landowners in Massachusetts. J. Forest Econ. (2011), doi:10.1016/j.jfe.2011.06.002

Table 4
Probabilities of ratings by program.

	Ordered logit											
	Survey 1			Survey 2			Survey 3			Survey 4		
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
$P(R=1)$	0.190	0.396	0.181	0.299	0.126	0.353	0.225	0.553	0.152	0.446	0.105	0.403
$P(R=2)$	0.046	0.068	0.045	0.061	0.034	0.066	0.052	0.067	0.039	0.069	0.029	0.068
$P(R=3)$	0.045	0.059	0.044	0.056	0.034	0.058	0.049	0.054	0.039	0.058	0.030	0.059
$P(R=4)$	0.031	0.037	0.031	0.037	0.025	0.038	0.034	0.032	0.028	0.036	0.022	0.037
$P(R=5)$	0.190	0.179	0.188	0.195	0.165	0.188	0.196	0.136	0.178	0.167	0.151	0.177
$P(R=6)$	0.055	0.041	0.056	0.049	0.054	0.044	0.054	0.027	0.055	0.036	0.051	0.040
$P(R=7)$	0.079	0.052	0.080	0.065	0.082	0.057	0.075	0.033	0.082	0.045	0.081	0.051
$P(R=8)$	0.122	0.067	0.125	0.090	0.141	0.077	0.111	0.041	0.134	0.058	0.145	0.066
$P(R=9)$	0.053	0.026	0.055	0.036	0.067	0.030	0.047	0.015	0.061	0.021	0.072	0.025
$P(R=10)$	0.187	0.076	0.196	0.112	0.272	0.090	0.157	0.042	0.230	0.063	0.315	0.074

Marginal willingness to pay for a change in each program attribute is calculated as the ratio of the estimated attribute and revenue coefficients, β_A/β_R (see Table 3). The modal respondent, who is male, over age 65 and has more than a high school diploma, is willing to give up $3.56 per acre per year to avoid having a management plan, $0.44 per acre per year to avoid an extra year in the program, and $6.95 per acre per year to avoid an early withdrawal penalty. This suggests that programs designed without a withdrawal penalty would be particularly attractive to the average landowner.

In the following discussion, we focus primarily on the likelihood that various programs will be adopted by the landowners in our sample. For this purpose, we assume that a "10" rating corresponds to program adoption. First, we focus on the programs that were given to respondents in the survey (see Tables 1 and 2). Then we estimate a 10 rating for several programs not given to respondents.[6]

Starting with programs given to respondents, Table 4 shows predicted probabilities that the modal respondent will choose each rating, R, for each program they were asked to evaluate.[7] The probabilities in Table 4 are calculated with program attribute levels corresponding to the version and program number and individual characteristics corresponding to the sample modes (they are all indicator variables).

The least popular program – that is, the program with the lowest probability of a 10 rating – among modal respondents is program 8 (P8) in survey version 3. This program, which has a probability of adoption of only 4.2%, requires a management plan, has a 10 year time commitment, offers a $5 per acre annual revenue, and includes a penalty for early withdrawal. The most popular program is P11 in survey version 4 which has a probability of being given a 10 rating of 31.5%. That program requires a management plan, has a five year time commitment, offers a $30 per acre annual revenue, and has no penalty for early withdrawal.

By comparing P8 and P11, a policy maker interested in crafting a NIPF landowner-friendly carbon offset program faces a tradeoff between conflicting policy elements. There are two major issues a policy maker will likely consider in crafting such a program: what program characteristics would make a viable carbon sequestration policy and what determines the likelihood of forest owner participation in such a program. While not discussed here in detail, the usual characteristics of a viable carbon sequestration program include verifiability, additionality and permanence.[8] As our results

[6] For example, respondents were not given a program with no management plan, a 5 year time commitment, $30 per acre annual revenue and no withdrawal penalty because this would be a dominant program with the result that respondents would not be forced to make tradeoffs between program attributes.

[7] The modal respondent is the most common. Since all socioeconomic characteristics are 0, 1 variables (see Table 2) the modal respondent is more useful in this context than the average or median. The modal respondent is male, less than 66 years old with some college or a college degree and owns 100 acres or more.

[8] Verifiability means it can be proven that the offset programs increases carbon sequestration. For additionality, the offsets must be in addition to carbon that would be sequestered otherwise. Permanence refers to the notion that the offset is valid over a long period of time.

Please cite this article in press as: Dickinson, B.J., et al., Estimated participation in U.S. carbon sequestration programs: A study of NIPF landowners in Massachusetts. J. Forest Econ. (2011), doi:10.1016/j.jfe.2011.06.002

were significantly younger and more highly educated. At a 5% level of significance, fewer people over the age of 65 rated the three programs while more respondents with greater than a college degree rated the three programs compared to all survey respondents. The results must be viewed with this caveat in mind.

Results

The ordered logit regression results (see Table 3) show many statistically significant variables. All rating cutpoints (the μs in Eq. (2)), except cutpoint 4, are statistically significant at the 10% or better level. These cutpoints can be used to calculate the probability of each rating level, *R*. All attribute and socio-economic characteristic coefficients are statistically significant except for the age (66 or older) and education (high school diploma or less) indicators (see Table 2 for variable definitions).

For the independent variables (i.e., the *x*s in Eq. (1)), the odds ratios in Table 3 indicate the probability of moving to a higher or lower rating with a one unit change in each of the independent variables contained in *x* (Eq. (1)), all else held constant. For example, the probability of choosing a higher rating is decreased by a factor of 0.81 when a management plan is required, all else held constant. The odds of choosing a higher rating are decreased by a factor of 0.92 with a larger time commitment, and decreased by 0.66 when there is an early withdrawal penalty (see Table 3). The probability of a higher rating increases with higher per-acre revenue (by a factor of 1.06 for a $1 per acre per year increase) and when the respondent is from the higher education category versus other education categories (by a factor of 1.54) and when the respondent owns 100 acres or more (by a factor of 1.13). Odds of a higher rating decrease by a factor of 0.53 if the respondent is male. The odds decrease even more when a management plan is required for older respondents (by a factor of 0.71) and when a management plan is required for less educated respondents (by a factor of 0.68). For the cutpoints, the odds ratio indicates the log of the odds of being less than or equal to the cutpoint category. Because this is a cumulative calculation, the odds ratios increase with each subsequent cutpoint.

Table 3
Ordered logit results.[a]

Parameter	Estimate	Odds ratio	Chi-square	Pr > ChiSq
Cutpoint 1	−1.047***	0.35	19.688	<.0001
Cutpoint 2	−0.769***	0.46	10.673	0.001
Cutpoint 3	−0.534**	0.59	5.159	0.023
Cutpoint 4	−0.384	0.68	2.664	0.103
Cutpoint 5	0.416*	1.52	3.133	0.077
Cutpoint 6	0.639***	1.89	7.376	0.007
Cutpoint 7	0.970***	2.64	16.930	<.0001
Cutpoint 8	1.557***	4.74	43.045	<.0001
Cutpoint 9	1.875***	6.52	61.765	<.0001
Plan	−0.215***	0.81	6.790	0.009
Time	−0.086***	0.92	9.583	0.002
Rev	0.060***	1.06	214.468	<.0001
Pen	−0.419***	0.66	32.859	<.0001
Acre	0.121*	1.13	3.050	0.081
Older	−0.090	0.91	0.252	0.615
LowerEd	−0.122	0.89	0.316	0.574
HigherEd	0.431***	1.54	32.873	<.0001
Male	−0.636**	0.53	6.428	0.011
Plan*Older	−0.348**	0.71	4.451	0.035
Rev*Older	−0.025***	0.98	9.926	0.002
Plan*LowerEd	−0.384*	0.68	3.665	0.056
Rev*LowerEd	−0.018*	0.98	3.580	0.059
Time*Male	0.059*	1.06	3.507	0.061

* Statistically significant at 10% level.
** Statistically significant at 5% level.
*** Statistically significant at 1% level.
[a] Interaction terms are indicated by *.

Please cite this article in press as: Dickinson, B.J., et al., Estimated participation in U.S. carbon sequestration programs: A study of NIPF landowners in Massachusetts. J. Forest Econ. (2011), doi:10.1016/j.jfe.2011.06.002

to indicate how many acres they own and because of economies of scale associated with aggregation programs acres were converted to a dummy variable indicating 100 acres or more for the analysis.

The ordered logit model, also known as the cumulative or ordinal logistic model, was used to analyze landowners' decisions. This approach assumes that r^* (see Eq. (1)) is an unobservable continuous variable representing the degree of enthusiasm toward a program, given by a function:

$$r^* = x\beta + e \tag{1}$$

where x is a vector of program attributes and individual characteristics (e.g., age); β is a vector of regression coefficients to be estimated and e is stochastic (unobserved) variation distributed logistically. While we cannot observe r^*, we do observe categories of responses (ratings), R:

$$\begin{aligned} &R = 1 \quad \text{if} \quad r^* \le \mu_1 \\ &R = 2 \quad \text{if} \quad \mu_1 < r^* \le \mu_2 \\ &R = 3 \quad \text{if} \quad \mu_2 < r^* \le \mu_3 \\ &\vdots \\ &R = 9 \quad \text{if} \quad \mu_8 < r^* \le \mu_9 \\ &R = 10 \quad \text{if} \quad \mu_9 < r^* \end{aligned} \tag{2}$$

In this equation, the μs represent thresholds of r^* that delineate categories of R. The μs are called "cutpoints", restricted to be positive where each one is greater than the previous, and, as is typical practice, normalized to 0 (i.e., $\mu_1 = 0$). Eq. (2) provides the basis for the derivation of the logistic cumulative density function which is used to calculate the probability of choosing any particular rating or lower (i.e., the cumulative probabilities of the ratings). Precise rating probabilities are calculated from these cumulative probabilities.[5]

Sample description

Approximately 55% of survey respondents owned 100 acres or more, and 74% of all respondents were male. Seventeen percent had a high school diploma or less, while 36% had at least a college degree.

A brief telephone survey of 147 non-respondents (i.e., roughly 10% of respondents) used a subset of three questions from the original survey to probe for non-response bias. Respondents were not significantly different in terms of the size of ownership from non-respondents. Respondents were significantly more likely to be enrolled in a current use program with a management plan (i.e., 34% of respondents versus 22% of non-respondents). Finally, non-respondents were asked one Likert scale attitudinal question regarding expectation of their land: "Land must provide a return to cover the expenses associated with ownership", with response options ranging from 1 (strongly disagree) to 5 (strongly agree). A chi square test shows that the difference in proportions of those who gave 1 and 5 ratings is not significant at the 1% level for respondents versus non-respondents, implying no attitudinal differences on the expectation of a return. However, because a distinct response bias was detected with respect to current use program participation (such as enrollment in Chapter 61) and management plans, the results need to be interpreted carefully. The results cannot necessarily be construed to represent the overall population of private Massachusetts woodland owners.

As noted above, of the 1403 returned surveys, only 910 rated all three programs. There were no follow-up questions to assess whether these resulted from protest attitudes or difficulty in making complex choices (Dickinson, 2010). However, the potential for bias is estimated by comparing socio-economic characteristics of respondents who rated the three programs to all respondents. If the group that rated the three programs is significantly different from the group as a whole, then protest attitudes, choice task complexity, and/or sample selection bias is likely present.

The only statistically significant differences between the program raters ($n = 910$) and all respondents as a whole ($n = 1403$) are with respect to age and higher education. Carbon choice respondents

[5] Several references are available that describe the ordered logit model in more theoretical detail; for example, see Greene (2003).

Please cite this article in press as: Dickinson, B.J., et al., Estimated participation in U.S. carbon sequestration programs: A study of NIPF landowners in Massachusetts. J. Forest Econ. (2011), doi:10.1016/j.jfe.2011.06.002

Table 1
Attributes and levels for each of the 12 programs.

	Version 1			Version 2			Version 3			Version 4		
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Plan	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Time	5	10	10	5	5	10	5	10	10	5	5	10
Rev.	15	5	30	5	30	15	15	5	30	5	30	15
Pen.	No	No	Yes	No	Yes	Yes	No	Yes	No	Yes	No	Yes

P1. . .P12 are programs.
Plan: Management plan required.
Time: Time commitment, in years.
Rev.: Expected per-acre revenue, net of all costs ($).
Pen.: Penalty for early withdrawal.

Table 2
Explanation of variables used.

Plan: Management plan required is a 1; not required is a 0.
Time: Time commitment, in years. Takes on values of 5, 10, and 15 years.
Rev: Revenue net of costs, in dollars per acre per year. Takes on values of 5, 15, and 30 dollars per acre per year.
Pen: Penalty for early withdrawal is a 1; no penalty is a 0.
Acre: Respondent owns 100 acres or more is a 1; fewer than 100 acres is a 0.
Older: Respondent is 66 years or older in age takes a 1; younger than 66 takes a 0.
LowerEd: Respondent's education level is high school diploma or less takes a 1; some college or more takes a 0.
HigherEd: Respondent has more than a college degree is a 1;
a college degree or less is a 0.
Male: Respondent is male takes a 1; female takes a 0.
Plan*Older: 1 if management plan is required and respondent is 66 years or older; else 0.
Rev*Older: Revenue for respondents 66 and older.
Plan*LowerEd: 1 if management plan is required and respondent has a high school diploma or less; else 0.
Rev*LowerEd: Revenue for respondents with a high school diploma or less.
Time*Male: Time commitment for males.

tradeoffs and it allows respondent uncertainty to be directly incorporated into the analyses (see Stevens et al., 2002; LeVert et al., 2009).

The programs varied according to: whether or not a management plan is required of the landowner, length of time commitment, per-acre net revenue, and penalty for early withdrawal from the program. These four attributes were used because they represent key features of aggregation programs and the Chapter 61 programs described above.

In total there were 256 possible programs which were reduced to 12 programs using the standard fractional factorial design. Care was taken to avoid dominant or reverse-dominant programs that all respondents would likely rate 10 or 1, respectively. There were four versions of the survey, each with a distinct set of three programs.[4] Thus, the data included ratings for all 12 programs. The levels and attributes associated with each program are listed in Table 1.

The survey collected socio-economic characteristics of each respondent including acres owned, age, level of education and gender. The variables used in these analyses and their associated variable names are listed in Table 2.

The survey asked respondents to indicate their age by checking one of five age categories. Since 65 is a common retirement age which may often correspond with changes in decision making and because the average Massachusetts forestland owner is 60 years old, these age categories were condensed into just two for the analysis: those older than 65 years and those 65 years and younger. There were five categories of education in the survey which were condensed into three categories. These include a high school diploma or less, some college, and a college degree or more. The survey asked respondents

[4] Three programs per block were used to avoid cognitive overload that can occur when each respondent is asked to rate 6 or more complex programs.

Please cite this article in press as: Dickinson, B.J., et al., Estimated participation in U.S. carbon sequestration programs: A study of NIPF landowners in Massachusetts. J. Forest Econ. (2011), doi:10.1016/j.jfe.2011.06.002

carbon offset program was described to focus groups of Massachusetts landowners. Seventeen participants were asked to rate six programs each on a scale of 1–10, where a 10 represents absolute certainty that the landowner would participate in the program. Program attribute variables include: whether or not an official management plan must be filed, per acre annual net revenue from the carbon offsets ($5, $15 and $30), time commitment (five or ten years) and whether or not there is a penalty for early withdrawal from the program.

Fletcher et al.'s results indicated landowners have a preference for certain program attributes. Landowners gave higher ratings to programs that do not require a management plan, have a higher revenue stream, and do not have an early withdrawal penalty. Surprisingly, the pilot study showed that a longer time commitment also led to a higher rating. An analysis of landowners willingness to accept payment to participate in these carbon sequestration programs suggests that only 5% of landowners would participate at an annual per-acre payment of $15, with other attributes held constant at their means. Approximately 13% would take part in a program with a $30 per acre per year payment.[2]

Results like those of the Fletcher et al. study are important to policymakers and others invested in designing forest management carbon offset programs likely to appeal to the target audience of private forest owners. In Massachusetts, this can be especially important because private landowners own 70% of all forestland in the state and 77% of that land is owned by families (Butler, 2008).

To this end, the present study expands on the Fletcher et al. pilot investigation with a larger sample and a mail survey. This study estimates the probability that Massachusetts landowners will participate in various offset programs using landowner survey data collected by the Family Forest Research Center at UMass–Amherst. The data are analyzed with an ordered logit discrete choice model and marginal probabilities are estimated for individual socio-economic characteristics and program attributes.

Methods

The Family Forest Research Center (a joint venture of the USDA Forest Service and the University of Massachusetts Amherst, Department of Environmental Conservation) conducted a mail survey of a random sample of 3000 Massachusetts forestland owners in October 2009. Woodland owners of ten or more acres were randomly selected from property tax lists acquired from 54 different towns (i.e., roughly 15% of the total number of towns in the state). We followed a modification of the Dillman Tailored Design Method. We sent initial postcards to the entire sample, notifying them of the survey and asking for their participation. This was followed three days later by a copy of the survey, personalized cover letter, and postage paid return envelope. Ten days later, a reminder postcard was sent thanking the respondents for their participation and requesting it if they had not yet returned the survey. A second wave of survey, personalized cover letter, and postage paid envelope was sent to non-respondents 4 weeks later. Some names and addresses were apparently invalid and resulted in 105 surveys being returned as undeliverable. The participation rate of respondents was 48.6%. However, of the 1406 returned surveys, only 910 were complete (i.e., all questions on the surveys were completed). We conducted a telephone survey of a 10% sample of non-respondents to investigate the possibility of non-response bias.[3]

Respondents answered questions about themselves and their land and were then asked to rate, on a scale of 1–10, three different hypothetical carbon sequestration programs. The rating question was worded such that a 10 indicates that the landowner definitely would enroll in the program given the opportunity, while a 1 indicates that the landowner definitely would not enroll in the program (see Appendix A). Any rating in the middle indicates varying levels of likelihood of enrollment on the part of the landowner. Prior to the rating questions, respondents were asked to read one page of background information on aggregator programs.

It is important to note that this so called conjoint formulation has two major advantages compared to a standard contingent choice framework: It derives more information about each respondent's

[2] At a carbon price of $6 per ton, an average Massachusetts forest that sequesters one to three tons per year translates to an annual per acre revenue of $6 to $18.

[3] This response rate is about average for academic mail surveys involving complex questions about attitudes and tradeoffs (Mitchell and Carson, 1989).

Please cite this article in press as: Dickinson, B.J., et al., Estimated participation in U.S. carbon sequestration programs: A study of NIPF landowners in Massachusetts. J. Forest Econ. (2011), doi:10.1016/j.jfe.2011.06.002

emissions. However, very little is known about the extent to which forest landowners might participate in carbon sequestration programs.

This paper assesses the likelihood that non-industrial private forestland (NIPF) owners in Massachusetts would enroll in various forestland carbon sequestration programs. To that end, data from a 2009 landowner survey is used to build on the findings of a pilot study conducted by Fletcher et al. (2009) to estimate the response of Massachusetts NIPF landowners to alternative hypothetical carbon sequestration programs.

Background

At the national level, there are possibilities for the NIPF landowner to implement enhanced carbon storage and sell the resulting carbon offsets, through programs like the California Climate Action Reserve (see Nickerson, 2008), Western Climate Initiative (see Perschel et al., 2007), and the Regional Greenhouse Gas Initiative (Perschel et al., 2007). Over the counter (OTC) offset markets offer additional programs (Dickinson, 2010). Moreover, the U.S. Congress is debating a possible national cap and trade system that could involve NIPF landowners (U.S. Climate Legislation, 2010). Despite these possibilities, opportunities for Massachusetts NIPF owners to sell carbon offsets are limited.[1]

Massachusetts is located in the northeastern United States and its land use is dominated by forest. In spite of being the third most densely populated state in the United States, 60% of the land cover is forest. Seventy percent of this forest is owned by over 36,000 different individual non-industrial private families and individuals. The overall average ownership size is 17.9 acres and when ownerships smaller than 10 acres are excluded, the average rises to 42.5 acres (Kittredge et al., 2008). The goals and attitudes of these owners are diverse and well documented. In numerous studies, owners consistently express strong preferences for amenity and non-consumptive benefits (e.g., aesthetics, wildlife, privacy, recreation, nature protection) and negligible interest in traditional forestry and timber harvesting (Belin et al., 2005; Finley and Kittredge, 2006; Kittredge, 2004; Rickenbach et al., 1998). Owners tend to be older (average age of 60 years), well educated (a majority have college degrees), and relatively affluent, which is not unlike the profile of non-industrial private forest owners in many eastern states where their collective ownership dominates forested landscapes (Butler, 2008). Because of the small ownership size in Massachusetts, the costs of certification and meeting requirements of existing carbon programs are often too high at the individual NIPF scale. However, several offset aggregation programs designed to create the economies of scale necessary to sell on carbon markets by pooling the offsets of Massachusetts NIPF landowners are being formed (Dickinson, 2010). These aggregation programs are fairly new developments and the requirements for participating in them are quite consistent. A prospective participant must be willing to sign a 15 years contract and file a management plan, and the participant usually will be penalized for breaking the contract. For example, one such aggregator in the Northeast U.S. is CarbonTree, LLC. In Massachusetts, a program that bases property tax on forestland current use may provide another option for sequestering carbon. This current use Massachusetts program (Chapter 61) provides substantial tax incentives in return for providing wildlife habitat and local timber products. It requires a professionally prepared 10-year forest management plan and obligates the owner to manage for timber. A Chapter 61B program, which is a recent variant of Chapter 61, does not require participants to file a management plan, has a minimal time commitment, a more modest tax benefit, and a low penalty for early withdrawal (Dickinson, 2010; Catanzaro et al., 2010). While both programs can be considered to sequester carbon, whether or not they provide additional carbon sequestration depends on what the landowner would do without the program. For example, if the landowner would use his or her land in the same way without Chapter 61B, this program cannot be said to provide additional carbon sequestration.

There is very little information available about the likelihood that NIPF landowners will participate in carbon offset markets. To the authors' knowledge, there is only one published study that investigates the topic quantitatively. In a pilot study conducted by Fletcher et al. (2009), a forest management

[1] It should be noted that at this time, there are no such opportunities for European NIPF landowners (Dickinson, 2010). And, the U.S. voluntary Chicago Climate Exchange (CCX) Program was eliminated in 2010.

Please cite this article in press as: Dickinson, B.J., et al., Estimated participation in U.S. carbon sequestration programs: A study of NIPF landowners in Massachusetts. J. Forest Econ. (2011), doi:10.1016/j.jfe.2011.06.002

G Model
JFE-25138; No. of Pages 11 ARTICLE IN PRESS

Journal of Forest Economics xxx (2011) xxx–xxx

Contents lists available at ScienceDirect

Journal of Forest Economics

journal homepage: www.elsevier.de/jfe

Estimated participation in U.S. carbon sequestration programs: A study of NIPF landowners in Massachusetts

Brenton J. Dickinson[a], Thomas H. Stevens[a,*], Marla Markowski Lindsay[b], David B. Kittredge[b]

[a] Department of Resource Economics, University of Massachusetts, 216 Stockbridge Hall, Amherst, MA 01003, United States
[b] Department of Natural Resources Conservation, University of Massachusetts, Amherst, MA 01003, United States

ARTICLE INFO

Article history:
Received 19 July 2010
Accepted 17 June 2011

JEL classification:
Q23
Q54
Q57
Q58

Keywords:
Carbon sequestration
Ordered logit
Economic incentives
Carbon offsets

ABSTRACT

Although carbon sequestration programs for non-industrial forestland owners in Massachusetts are being developed, very little is known about the program attributes of importance to different types of landowners or the likelihood that landowners will participate in any given program. This study estimates the probability that Massachusetts landowners will participate in several carbon offset programs using data from a survey of 3000 Massachusetts forestland owners. Results from an ordered logit discrete choice model suggest that the likelihood of enrollment in most programs is quite low. Landowners are clearly motivated by economic factors, but other aspects of carbon sequestration may also be important in their decision making.

Introduction

Depending on species, stand structure and growth rates, some forms of forest management have been shown to provide meaningful potential for storing carbon above and beyond what would be stored without management (Nunery and Keeton, 2010). The extra sequestered carbon could be traded on offset markets creating additional revenue for forestland owners as well as reduced net carbon emissions. Ten percent of US carbon emissions is absorbed by U.S. forests each year (Dickinson, 2010), and enhanced carbon sequestration from forests could play an important role in offsetting carbon

* Corresponding author. Tel.: +1 413 545 5714; fax: +1 413 545 5853.
E-mail address: tstevens@resecon.umass.edu (T.H. Stevens).

1104-6899/$ – see front matter © 2011 Department of Forest Economics, SLU Umeå, Sweden. Published by Elsevier GmbH. All rights reserved.
doi:10.1016/j.jfe.2011.06.002