



# Estimating the Supply of Forest Carbon Offsets

## A comparison of best-worst and discrete choice valuation methods

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### Summary

A recent national survey revealed that 75% of U.S. voters favor regulating carbon dioxide as a greenhouse-gas (GHG) pollutant.<sup>1</sup> One way to mitigate climate change is to create a market that pays land owners to sequester GHG, for example by planting pine trees, increase efficiency of nitrogen and other fertilizer inputs, or improving forest management techniques. Pine flatwood forests are common throughout Florida, but the state has yet to take advantage of vast public and private forestlands (over 16 million acres of forest, representing nearly half of the state's land area) to participate in carbon markets. The same may be true of other Southeastern states.

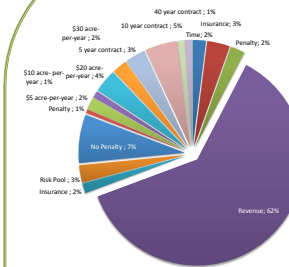
This study conducted an electronic survey of the one of the most comprehensive lists<sup>2</sup> of non-industrial private landowners in Florida to explore their attitudes towards offsets, and estimate the supply of carbon. Preliminary results indicate that non-industrial private forest landowners in our study would need between \$20 and \$30 acre-per-year to participate in a representative carbon offsets program. These results will be used to estimate a supply curve for carbon offsets in the Southeast as part of the PINEMAP project.

### Attributes and Attribute Levels in BWS, Binary, and DCE Questions

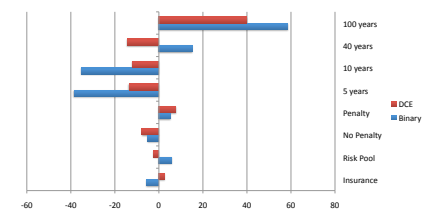
Attribute	Definition	Levels
Risk Tool	Options for risk reduction in forest project	Insurance Risk Pool
Penalty	Fines for leaving the program early	No Penalty Penalty
Contract Length	Commitment period	5-years 10-years 40-years 100-years
Revenue	Carbon-credit payments of acre-per-year, after costs	\$5 \$10 \$20 \$30

### Results

#### BWS Relative Desirability of Attributes



#### Estimates of Marginal Willingness to Accept (\$/attribute level)



### Example of Best-Worst Scaling Question

Non-Government Carbon-Credit Program  
 (Check one option as the most important and one option, as the least important)

Most Important		Least Important
<input type="checkbox"/>	Risk Pool	<input type="checkbox"/>
<input type="checkbox"/>	No Penalty for Withdrawal	<input type="checkbox"/>
<input type="checkbox"/>	\$5 acre-per-year	<input type="checkbox"/>
<input type="checkbox"/>	40 year contract	<input type="checkbox"/>

Would you enroll in this program?  Yes  No

### Example of Discrete-Choice Experimentation Question

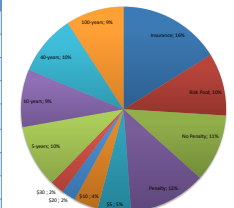
Of the Non-Government Carbon-Credit Programs below, which would you choose to participate in?  
 (Please check only one of the four options below)

Risk Pool	Insurance	Risk Pool	
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	None of these <input type="checkbox"/>
No Penalty for Withdrawal	Penalty for Withdrawal	Penalty for Withdrawal	
\$5 acre-per-year	\$10 acre-per-year	\$20 acre-per-year	
40 year contract	100 year contract	5 year contract	

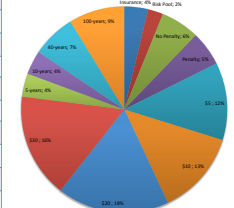
### Results from BWS, DCE, and Binary Questions

Variable	C-logit BWS	BWS Share of Preference	C-logit DCE	Logit Binary
Attribute "impact"				
Duration	0 (reference)	2.00%		
Insurance preference	0.55** (0.05) <sup>b</sup>	3.45%		
Penalty for withdrawal	0.09*** (0.05)	2.18%		
Revenue	3.43* (0.05)	61.71%		
Level "scale" values				
Insurance	-0.28* (0.04)	1.50%	0.03 (0.03)	0.02 (0.06)
Risk Pool	0.28*	2.63%	-0.02*	-0.02*
No Penalty	1.31* (0.04)	7.35%	0.31* (0.04)	0.29* (0.06)
Penalty	-1.31*	0.54%	-0.31*	-0.29*
\$5 acre-per-year	-0.06** (0.08)	1.86%	-0.69** (0.08)	-0.18** (0.09)
\$10 acre-per-year	-0.62** (0.09)	1.06%	-0.17* (0.06)	-0.51* (0.10)
\$20 acre-per-year	0.57* (0.08)	3.53%	0.25* (0.05)	0.46* (0.09)
\$30 acre-per-year	0.12*	2.24%	0.61*	0.23*
5 year contract	0.44 (0.07)	3.08%	0.80* (0.05)	0.89* (0.10)
10 year contract	0.88* (0.07)	4.79%	0.55* (0.05)	0.36* (0.09)
40 year contract	-0.72* (0.07)	0.97%	-0.46* (0.07)	-0.45* (0.10)
100 year contract	-0.60*	1.09%	-0.90*	-0.81*
Number of Respondents	88		94	93
Number of Choices	16896		6104	1478
Log Likelihood	-14126.23		-1764.15	-920.26
Chi-Square Statistic <sup>c</sup>	108775.11		702.66	204.71

#### Frequencies of Worst<sup>a</sup>



#### Frequencies of Best<sup>a</sup>



<sup>a</sup> Frequencies of "Best" and "Worst" attribute choices, divided by the number of times they were available.

<sup>b</sup> One (\*), two (\*\*), and (\*\*\*) asterisk represent 0.01, 0.05, 0.10 level of statistical significance, respectively.  
<sup>c</sup> Number in parentheses are standard errors.  
<sup>d</sup> Chi-square statistic associated with a test of the hypothesis that all model parameters are zero.  
<sup>e</sup> Effects coding; negative sum of the above level scale values corresponding to this attribute.

### Characteristics of Survey Respondents (BWS/Binary n=88; DCE n=83)

Category	NWOS <sup>7</sup>	Unweighted BWS/Binary Sample	Unweighted DCE Sample
Under 35 years	1.65% <sup>a</sup>	0.00%	1.11%
35 to 44 years	7.10%	3.37%	6.67%
45 to 54 years	18.04%	31.46%	21.11%
55 to 64 years	28.69%	31.46%	40.00%
65 to 74 years	21.14%	20.22%	24.44%
75+ years	19.29%	8.99%	5.56%
Less than 12th grade	7.76%	0.00%	2.22%
High school graduated or GED	16.08%	2.25%	6.67%
Some College	16.61%	10.11%	6.67%
Associate or technical degree	9.76%	12.36%	13.33%
Bachelor's degree	19.96%	35.96%	40.00%
Graduate degree	23.18%	35.96%	30.00%
Female	14.47%	17.98%	15.91%
Annual HH income less than \$25,000	10.90%	2.25%	2.22%
Annual HH income \$25,000 to \$49,999	17.84%	11.24%	10.00%
Annual HH income \$50,000 to \$99,999	22.84%	31.46%	31.11%
Annual HH income \$100,000 to \$199,999	14.45%	20.22%	24.44%
Annual HH income \$200,000 or more	18.71%	7.87%	7.78%

<sup>a</sup> Percent of respondents falling in the respective category.

### Methods

- 375 Florida Stewardship Program participants were surveyed (23% completed the full survey)
- All participants were fully randomized into two surveys, Best-Worst Choice<sup>3</sup> (BWC) and Discrete Choice Experimentation (DCE). These only varied on choice task.
- Orthogonal Main Effects Plan was used for both experimental designs.<sup>4</sup>
- BWC yielded two types of analysis, Best-Worst Scaling (BWS) and Binary question<sup>5</sup>.
- DCE and BWS<sup>5</sup> were analyzed using Conditional Logit, and the Binary question using a logistical regression (all in STATA).
- Frequency weights were used to balance the BWS survey question design<sup>5</sup>.

### Discussion

The significance and expected signs of all three models were very robust, namely, compensation and time had the most influence, while penalty was generally less desirable. The two risk management tools, "insurance" and "risk pool," considered in this study were insignificant (DCE and Binary), and placed lower amongst BWS preferences. All levels of compensation where significant, but the lower amounts, \$5 and \$10 acre per year, had a negative (less preferred in the case of BWS) impact on participation, while \$20 and \$30 had a positive association. Participants also indicated higher preferences for lower levels of contract duration, namely 5 & 10 years were preferred over 40 & 100 years.

Most of the marginal willingness to accept (WTA) estimates for Binary and DCE estimates correlated in sign, but differed in magnitude. Both models indicated that participants need to be compensated the most for a "100 year contract" (\$58 and \$39, respectively) over any other attribute level. These results also indicated a compensation of \$5.08 (Binary) or \$7.68 (DCE) of acre-per-year would be needed for "penalty." The authors are currently collecting more data, analyzing the influence of individual characteristics, attribute interactions, and total willingness-to-accept.

These preliminary results indicate that PINEMAP and policy makers would find more interest in carbon sequestration markets in Florida, with a program that would offer compensation between \$20 to \$30 acre-per-year, and commitment periods of 5 to 10 years. This type of program would require less compensation if no penalty for withdrawal is included.

### References:

- <sup>1</sup>Zabanko, Deborah (2012) U. voters favor regulating carbon dioxide: survey. Chicago Tribune, April 26, 2012. ([http://articles.chicagotribune.com/2012-04-26/business/ins-r-us-climate-energy-usa09e3902-01120426\\_1\\_tax-swap-independent-favor-carbon-dioxide](http://articles.chicagotribune.com/2012-04-26/business/ins-r-us-climate-energy-usa09e3902-01120426_1_tax-swap-independent-favor-carbon-dioxide)) accessed 14May2012.
- <sup>2</sup>More information on this program (Florida Stewardship Program) can be found at [http://www.sfr.ufl.edu/Pages/Florida\\_forestry\\_information/additional\\_pages/forest\\_stewardship\\_program.html](http://www.sfr.ufl.edu/Pages/Florida_forestry_information/additional_pages/forest_stewardship_program.html)
- <sup>3</sup>Marley, D.A., J.N., Flynn, and J.J. Louviere (2008) "Probabilistic Models of set-dependent and attribute-level best-worst choice," *Journal of Mathematical Psychology* 52, pp. 281-296.
- <sup>4</sup>Street, D.J., Burgess, L., and J.J. Louviere (2005) "Quick and easy choice sets: constructing optimal and nearly optimal stated choice experiments," *Int. J. Res. Marketing*, 22 (2005), pp. 459-470
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- <sup>6</sup>Lusk, Jason L., and N. Parker. Consumer Preferences for Fat in Ground Beef. *Journal of Agricultural and Applied Economics*, 41.1(April 2009): 75-90
- <sup>7</sup>National Woodland Owners Survey. (<http://www.fia.fs.fed.us/nwos/qwest/>) accessed 3March2012