Private Landowners' Response to Incentives for Carbon Sequestration in Forest Management

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Introduction

- Forest sector plays an important role in carbon sequestration
- Potential role of NIPFs for carbon sequestration (NIPFs comprise around 59% of timberland in the U.S.)
- Paying incentive for carbon sequestration in forest is relatively low cost option. However, many studies have focused on landowners' response to incentives for afforestation and timber harvest decision
  - Afforestation (e.g. Adams et al. 1993, Alig et al. 1997, Plantinga et al. 1999, Stavins 1999, and Lubowski et al. 2006).
  - Extend rotation period (e.g. Sohngen and Brown 2008).
- Alternative source of carbon sequestration -- Intermediate forest management practices (MPs) to increase tree growth rate or enhance fire resistance, e.g. Fuel treatment, Fertilization
- Few studies elicits landowners' intermediate MP choices in response to incentive payment.
- Not well known how landowners' intermediate MPs choice response to incentive payments.
- ***Question**: Is paying incentives for carbon sequestration by changing intermediate forest management practice cost effective?*

Objectives

- to predict landowners' decision of intermediate MP and the factors affecting their decision
- to measure the carbon sequestration potential of MPs with different incentive payment strategies, and
- to compare the results with those from other carbon sequestration methods.

Model specification

- Assume utility maximizing owner
- The probability of adopting a certain MP K is given by a Multinomial Logit model (Maddala 1983).

$$P_{ik} = \frac{e^{Z'_{ik}\beta_k}}{\sum_{j=0}^{K} e^{Z'_{ij}\beta_j}},\ k = FFT, F, FT, NA.$$

$$Z_{ik} = [\pi_{ik}, x_i] = [AnnLTV_{ik}, OWN_i, LC_i, SC_i, OA_i]$$

Where $AnnLTVk_{ik}$ is a vector of average *annual net returns* of combination k, OWN_i is a vector of landowners' demographic characteristics, LC_i is a vector of forestland characteristics, SC_i is a vector of spatial characteristics of forestlands, and OA_{ki} is a vector of landowners' attributes.

Data

- MP choice set (K) and most of independent variables are from National Woodland Owner Survey (NWOS).
- Annual net return (AnnLTV) is the annualized Land and Timber Value (LTV) for each MP and individual.
- Stand volume to calculate LTV is calculated using Forest Vegetation Simulator based on location of each forest.

Selected MPs combinations from the survey

i) Choice 1: Fuel Treatment – Fertilization (FFT)
ii) Choice 2: Fertilization only (F)
iii) Choice 3: Fuel Treatment only (FT)
iv) Choice 4: No activities (NA)

Estimation results

Key findings from factors affecting landowners' choices

- Landowners' demographic characteristics are not significantly affect the choice of MPs
- Variables representing objectives of owning forests (for privacy, timber harvest, biodiversity), concerns about risk of fire or disease, spatial characteristics such as distance from road, slope are significantly affect the landowners' MP decision

Semi-elasticities of probabilities w.r.t Annual net return

	Choice 1: FFT (Fertilization & Fuel treatment)	Choice 2: F (Fertilization only)	Choice 3: FT (Fuel treatment only)	Choice 4: NA (No activity)
AnnLTV1	0.204 (0.063)***	-0.139 (0.071)*	-0.218 (0.09)**	0.154 (0.109)
AnnLTV2	-0.002 (0.049)	0.282 (0.101)***	-0.249 (0.14)	-0.032 (0.19)
AnnLTV3	-0.147 (0.051)*	-0.035 (0.069)	0.699 (0.096)***	-0.517 (0.105)***
AnnLTV4	-0.056 (0.071)	-0.111 (0.096)	-0.238 (0.163)	0.405 (0.229)*

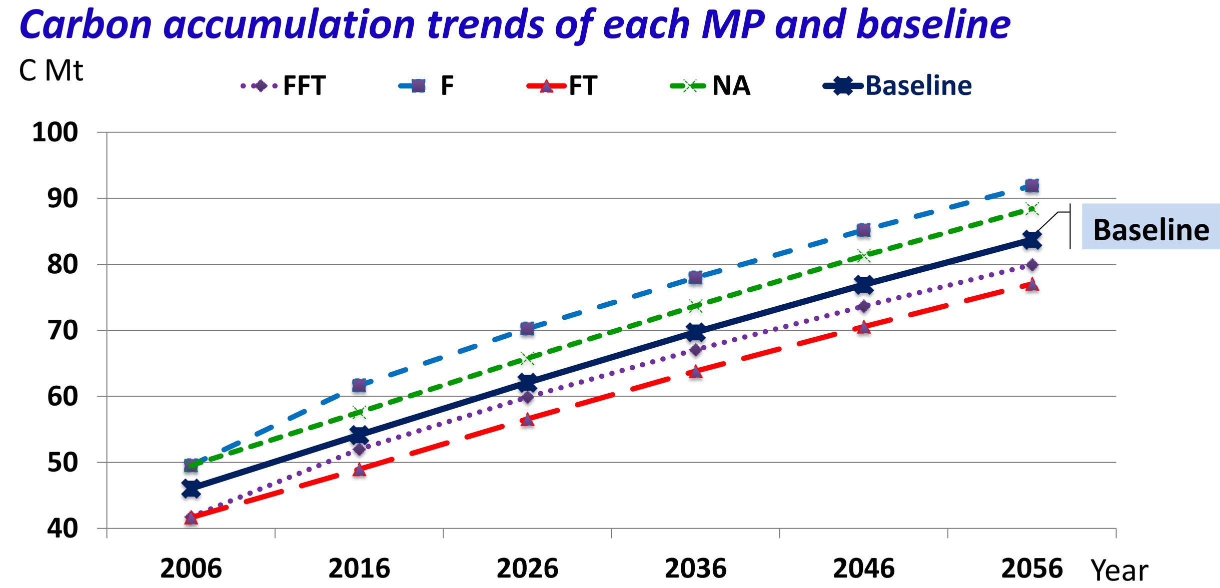
*, **, *** Statistical significance at α = 10, 5, and 1 %. Parentheses are z value.

- 1% increase in annual LTV of each MP choice increases the probability of adopting the MP choices 'FFT' by 0.2 percentage point (%p), 'F' by 0.28%p, 'FT' by 0.7%p, and 'NA' by 0.4%p.

Predicted probabilities of MP choices (Baseline behavior)

	Choice1: FFT	Choice2: F	Choice3: FT	Choice4: NA
Predicted	14.1	3.1	49.6	33.1
Actual	12.1	3.9	48.2	35.8

Carbon accumulation trends of each MP and baseline



Note: Forest Vegetation Simulator (FVS) is used to calculate carbon trend.

- Fertilization (F) is the highest, Fuel treatment (FT) is the lowest.
- Fuel treatment increases tree growth rate and fire resistance, but removes large portion of carbon when it's occurred.
- Baseline: the average of annual carbon accumulation of MPs weighted by the predicted probabilities of MP choices

Simulation of carbon sequestration

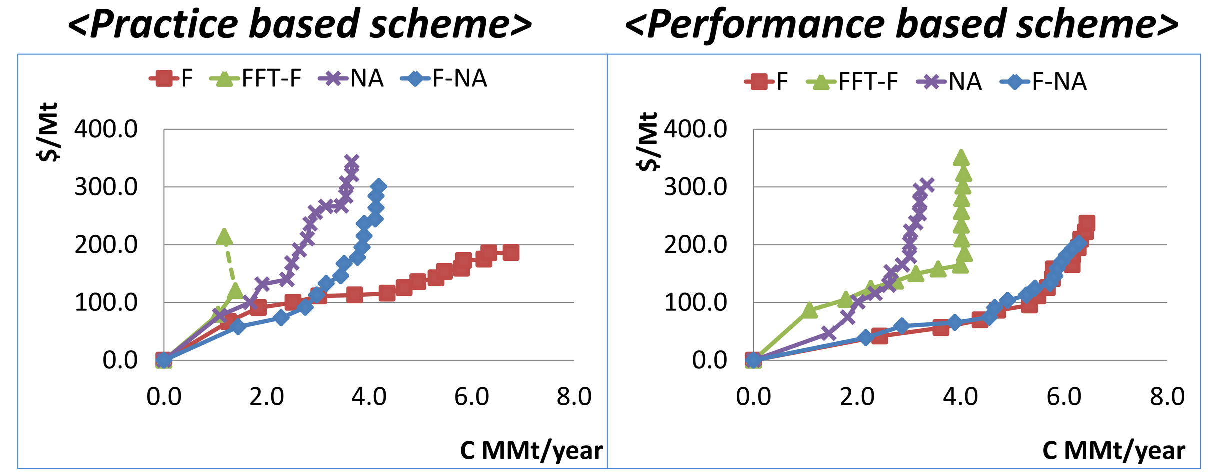
Incentive Design

- Payment Criteria: Practice based vs. Performance based
- Contract year: 10-year & Sensitivity Analysis with 5- and 15-year
- Possible incentive strategies to produce additional carbon are:

i) Pay incentives only for fertilization -> F
ii) Pay for fertilization with & without fuel treatment -> F-FFT
iii) Pay for only no activities -> NA
iv) Pay for fertilization and no activities -> F-NA

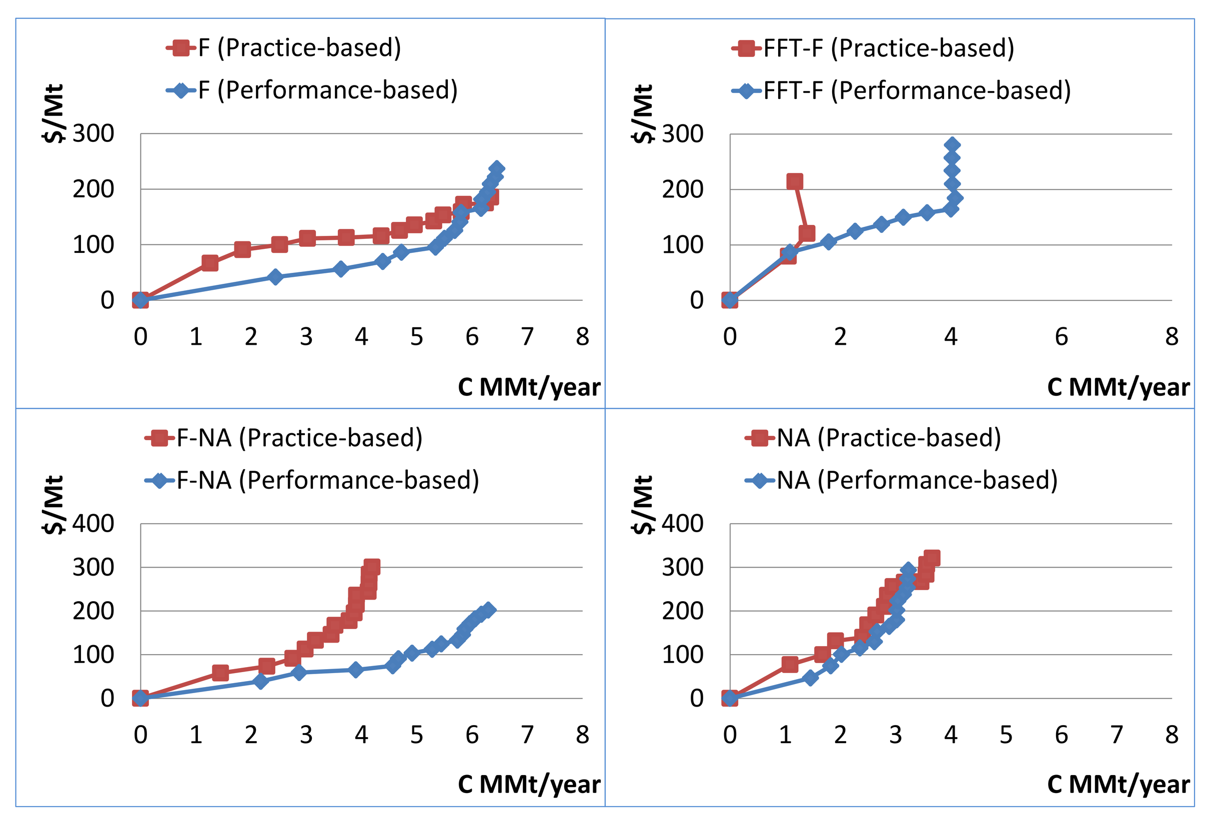
Carbon supply function by MPs (Western US)

<Practice based scheme> <Performance based scheme>



- Strategy 'F' & 'F-NA' perform better than others

Carbon supply function by payment criteria (Western US)

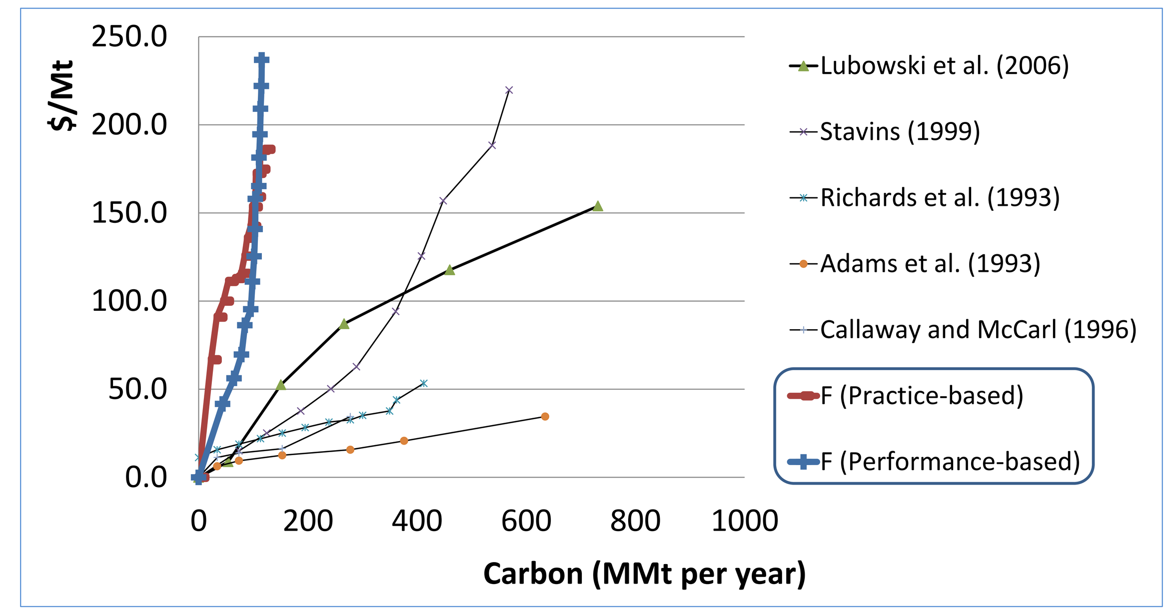


- Performance based payment always perform better with no consideration of implementation cost.

Sensitivity analysis: Carbon sequestration potential at $100/Mt with alternative duration of contract

Payment targets	Practice-based payment			Performance-based payment		
	5-year	10-year	15-year	5-year	10-year	15-year
F	1.86	2.52	1.78	3.49	5.39	5.45
FFT-F	1.11	1.23	1.29	1.14	1.59	1.44
NA	1.74	1.68	1.28	2.25	2.01	2.00
F-NA	2.73	2.85	2.80	3.68	4.85	4.65
Average	1.86	2.07	1.79	2.56	3.46	3.38

Comparison with other study results (National scale)



- Note: The top five represent carbon supply functions of afforestation borrowed from Lubowski et al (2006), and we added our supply functions based on paying 'Fertilization' by scaling up the regional scale to national scale.
- The carbon supply function of changing MPs is much steeper than that of afforestation.

Conclusions

- Landowners' management practice choice decision is not solely affected by its net returns, but also affected by others such as objectives of owning forests (for privacy, timber harvest, biodiversity), concerns about risk of fire or disease, and spatial characteristics.
- The MPs for timber growth enhancement are not always helpful to increase carbon sequestration. Doing nothing can be better option.
- Paying incentives only to change intermediate forest MP without extending rotation period cannot produce additional carbon sequestration as much as afforestation
  - Because physical carbon sequestration potential per acre is lower than that with afforestation
  - Because of property of reveal preference approach: tend to have higher marginal cost than other approach such as optimization model or bottom-up engineering approach.

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