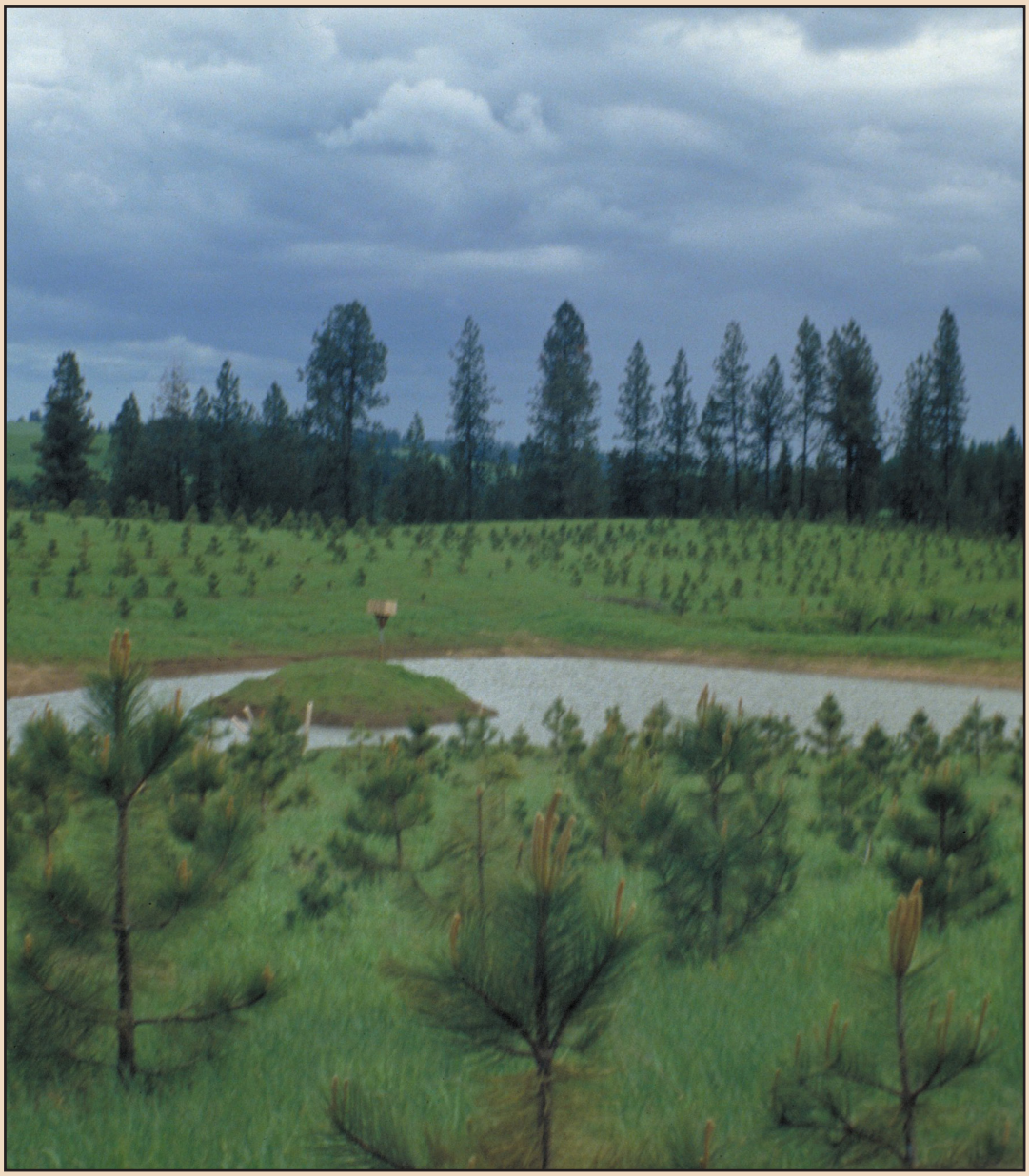
United States Department of Agriculture

Statistical Analysis on the Factors Affecting Agricultural Landowners' Willingness to Enroll in a Tree Planting Program

Taeyoung Kim and Christian Langpap



Forest Service | Pacific Northwest Research Station | Research Paper PNW-RP-604 | September 2015

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at http://www.ascr.usda.gov/complaint_filing_cust.html and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by: (1) mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Washington, D.C. 20250-9410; (2) fax: (202) 690-7442; or (3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.

Authors

Taeyoung Kim is an assistant professor, Department of Food and Resource Economics (Institute of Agriculture & Life Science), Gyeongsang National University, #452-321, 501, Jinju-daero, Jinju-si, Gyeongsangnam-do, 660-701, Republic of Korea ; and **Christian Langpap** is an associate professor, Department of Applied Economics, Oregon State University, 240E Ballard Extension Hall, Corvallis, OR 97331-3601. This work was performed under PNW agreement 10-JV-11261955-064.

Cover photograph: Pine plantation and pond, by Chris Schnepf, University of Idaho, Bugwood.org.

Abstract

Kim, Taeyoung; Langpap, Christian. 2015. Statistical analysis on the factors affecting agricultural landowners' willingness to enroll in a tree planting program. Res. Pap. PNW-RP-604. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 34 p.

This report provides a statistical analysis of the data collected from two survey regions of the United States, the Pacific Northwest and the Southeast. The survey asked about individual agricultural landowners' characteristics, characteristics of their land, and the landowners' willingness to enroll in a tree planting program under incentive payments for carbon sequestration. From this statistical analysis, we found both similar and contrasting features between the two survey regions. The Southeast is more responsive to incentive payment for carbon sequestration than the Pacific Northwest, and the variables that are highly correlated with the willingness to enroll in a tree planting program are somewhat different between the two regions.

Keywords: Agricultural landowner survey, afforestation, carbon sequestration, incentive payments, statistical analysis, tree planting.

Contents

1 **Introduction**

2 **Survey Description**

3 **Statistical Analysis of Survey Results**

3 Landowners' Demographic Characteristics and Attributes

11 Land Characteristics

18 Other Attributes Related to Land Use and Management

21 **Landowners' Response to Incentives for Planting Trees and Correlations With Other Factors**

21 Proposed Incentive Payment Scheme and Questionnaire Design

22 Landowners' Willingness to Plant Trees for Carbon Sequestration

29 **Conclusion**

29 **Acknowledgments**

30 **Literature Cited**

33 **Appendix: Description of Incentive Scheme**

Introduction

The forest sector plays an important role in mitigating greenhouse gas emissions by transferring carbon from the atmosphere through the process of photosynthesis of standing live trees and in other forest ecosystem components such as the understory and soil (USDA 2011). Afforestation—tree planting on lands previously not in forest—has often been suggested as a possible strategy to increase carbon sequestration (e.g., Adams et al. 1999, Moulton and Richards 1990), and has relatively larger potential for carbon sequestration than other land use choices (Gorte 2009). Afforestation of crop or pasture land can sequester 2.2 to 9.5 metric tons of carbon dioxide equivalent per acre per year (Mt CO_2eq. ac^{-1} y^{-1}) (US EPA 2005) and 2.7 to 7.7 Mt CO_2 eq. ac^{-1} y^{-1} (Lewandrowski et al. 2004), respectively.

Much of the literature that examines afforestation of agricultural land has focused on estimating the costs of carbon sequestration and has shown that afforestation is a relatively low-cost measure for mitigating CO_2 emissions. Sectoral model approaches such as the U.S. Regional Agricultural Sector Model (USMP) and The Forest and Agricultural Sector Optimization Model (FASOM) have explicitly modeled the links between agricultural land, forest land, and timber markets, and examined the potential for offsetting changes in land use (from forest to agriculture) resulting from price feedbacks (Adams et al. 1993, Alig et al. 1997, Lewandrowski 2004). Alternatively, Plantinga (1997), Plantinga et al. (1999), Stavins (1999), Newell and Stavins (2000), and Lubowski et al. (2006) used econometric models to calculate the opportunity costs of afforestation, which account for additional factors affecting land enrollment decisions such as the cost of acquiring skills and nonmarket benefits.

An individual landowner who is a utility maximizer might consider not only expected net returns, but also various additional factors when making land use decisions. However, most previous studies are not based on surveys of individual landowners. Hence, a lack of information about individual landowners' characteristics and land characteristics has been an important obstacle to understanding the key factors affecting individual landowners' land use decisions.

To overcome this obstacle, we conducted a survey to obtain individual landowners' characteristics (demographic characteristics and owner-specific attributes) and land characteristics, including spatial attributes. A stated-preference approach based on a survey allows us to examine the various factors affecting landowners' afforestation decisions as a complement to revealed preference studies.

The objectives of this report are to conduct a statistical analysis to understand the key factors affecting landowners' tree planting program participation, measure the potential extent of participation in a tree planting program for carbon

sequestration, and conduct a comparison study to identify differences in relevant characteristics between the two survey regions.

The rest of this report comprises a detailed survey description, a statistical analysis of survey results, landowners' response to incentives for planting trees, and correlations with factors affecting landowners' land use decisions, and conclusions.

Survey Description

The main purpose of the survey is to generate data to conduct an empirical analysis of landowners' responses to an afforestation incentives program. The survey gathered data on factors affecting landowners' decisions regarding use of their land, including program participation. Survey respondents were asked a series of questions about their demographic characteristics, the types and areas of lands they own, annual net returns and level of productivity of their lands, the spatial characteristics of agricultural lands they own, reasons for owning their agricultural lands, their understanding and attitudes about the importance of environmental services provided by their lands, and their willingness to enroll in response to incentives for tree planting to sequester carbon.

Two regions, the Pacific Northwest (PNW) and the Southeast (SE),[1] were selected to conduct the survey and conduct a comparative analysis, because it has been shown that the PNW is relatively less responsive to incentive payments for afforestation than the SE (Alig et al. 2010, Lewandrowski et al. 2004).

Agricultural landowners' mailing lists for both regions were provided by county tax assessor's offices, except for six counties in Georgia, for which data were purchased from qPublic.net, which manages counties' geographic information system (GIS), parcel, and tax data. One thousand landowners out of 20,443 and 14,104 candidate agricultural landowners for the PNW and SE, respectively, were randomly chosen to participate in the survey. A draft of the survey was reviewed by a group of experts (USDA Forest Service and Oregon State University Department of Statistics, Department of Applied Economics, and College of Forestry). An in-person pretest was conducted with a group of agricultural landowners to design the questionnaires and to establish an appropriate bid range of carbon prices. Based on the in-person discussions and expert reviews, a total of 42 questions were written, including an open-ended question asking recipients' willingness to participate in an

[1] The specific counties selected for the survey are (1) Pacific Northwest region: Benton, Jefferson, Columbia, Lane, Polk, Coos, Crook, Deschutes, Douglas, Josephine, Lake, Marion, Linn, and Clatsop in western Oregon, and Grays Harbor, Pierce, Whatcom, San Juan, Clallam, Jefferson, Skamania, and Kitsap in western Washington; (2) Southeast: Alleghany, Ashe, Buncombe, Swain, and Wilkes in western North Carolina, and Bartow, Gillmer, Harbersham, Stephens, Catoosa, Walker, Banks, Fannin, Lumpkin, Murray, Rabun, and Union in northern Georgia.

incentives program. We provided a flyer to help respondents understand the detailed incentive scheme.

The survey was designed and conducted following Dillman's (1978, 2007) survey design method. The final sets of survey questionnaires were mailed out on January 14, 2011, with a personalized cover letter, university letterhead, a flyer explaining the incentive program, and a $2 bill as a token of appreciation for survey participation.[2] A followup postcard reminder was mailed out a week after the first mailing, and a third reminder with a replacement survey questionnaire was mailed out a month after the first mailing. The final response rates for the survey are 47 percent for the PNW region and 27 percent for the SE region.

Finally, a followup phone survey of a sample of nonrespondents for the PNW region and a mail survey for both regions were conducted to assess and control for selection bias induced by nonresponses. Out of 100 nonrespondents (around 20 percent of nonrespondents) contacted in the PNW region, 27 answered the followup phone survey. Additionally, 26 out of 100 returned a followup mail survey in the PNW region, and 38 out of 150 returned a followup mail survey in the SE region.

Statistical Analysis of Survey Results

The survey questionnaire included questions on (1) general knowledge of climate change; (2) characteristics of agricultural lands owned or rented; (3) current activities, and past and future tree planting preferences; (4) response to incentives for tree planting to sequester carbon; and (5) demographic characteristics and other attributes that might affect landowners' willingness to accept tree planting. We start by providing a summary of landowners' demographic characteristics. We focus on describing implications based on the entire sample and provide detailed summary statistics tables (see tables 1 and 2).

Landowners' Demographic Characteristics and Attributes

This section provides a statistical description of survey respondents' demographic characteristics and attributes such as occupation and retirement status. Detailed summary statistics of respondents' demographic characteristics are provided in table 1 for the PNW and table 2 for the SE. Landowners' demographic characteristics were collected to ensure that we reached an adequate cross section of agricultural landowners with this survey. The information will be used to describe how landowners' demographic characteristics and their attributes affect landowners' willingness to participate in a tree planting program.

[2] Many studies have shown that prepaid monetary incentives can achieve higher response rates (e.g., Brennan 1992, Little and Hubbard 1988, James and Bollstein 1990, Salant and Dillman 1994).

Table 1—Summary statistics of surveyed data for the Pacific Northwest region

	Cropland		Grassland		Total	
Variables	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**
Demographic characteristics and owners' attributes:						
Age	60.246	12.296	60.728	12.831	60.520	12.590
Education (1 if elementary school)	0.011	0.103	0.016	0.127	0.014	0.117
Education (1 if middle school)	0.027	0.162	0.028	0.167	0.028	0.164
Education (1 if high school)	0.289	0.454	0.297	0.458	0.293	0.456
Education (1 if college)	0.107	0.310	0.110	0.313	0.109	0.311
Education (1 if university)	0.294	0.457	0.313	0.465	0.305	0.461
Education (1 if graduate school)	0.273	0.447	0.236	0.425	0.252	0.435
Household income (1 if less than $20 K)	0.059	0.236	0.045	0.207	0.051	0.220
Household income (1 if $20 to $40 K)	0.203	0.403	0.183	0.387	0.192	0.394
Household income (1 if $40 to $60 K)	0.171	0.378	0.175	0.381	0.173	0.379
Household income (1 if $60 to $80 K)	0.139	0.347	0.183	0.387	0.164	0.371
Household income (1 if $80 to $100 K)	0.123	0.329	0.183	0.387	0.157	0.364
Household income (1 if $100 K or more)	0.305	0.462	0.232	0.423	0.263	0.441
Gender (1 if male)	0.701	0.459	0.675	0.469	0.686	0.465
Occupation (1 if farmer)	0.246	0.432	0.130	0.337	0.180	0.385
Retired (1 if retired)	0.380	0.487	0.427	0.496	0.406	0.492
Member of NGO[a] (1 if member)	0.160	0.368	0.146	0.354	0.152	0.360
Member of agricultural organization (1 if member)	0.337	0.474	0.252	0.435	0.289	0.454
Refer neighbors decision (1 if it does)	0.813	0.391	0.793	0.406	0.801	0.399
Knowledge about climate change	0.973	0.162	0.972	0.167	0.972	0.164
Knowledge about carbon sequestration	0.877	0.329	0.907	0.292	0.894	0.308
Land characteristics:						
Total land owned (acres)	—	—	—	—	137.048	492.263
Total land owned in region (acres)	—	—	—	—	106.591	404.017
Total land rented in region (acres)	—	—	—	—	38.309	226.836
Total agricultural land owned (acres)	81.582	288.677	40.526	136.778	58.257	216.575
Total agricultural land rented (acres)	50.791	256.836	3.598	22.946	23.979	171.020
Number of unconnected parcels	2.037	3.861	1.642	2.311	1.813	3.080
Acquisition method (1 if bought)	0.455	0.499	0.346	0.477	0.393	0.489
Acquisition method (1 if inherited)	0.834	0.373	0.907	0.292	0.875	0.331
Owned year	23.197	15.799	22.227	14.988	22.646	15.333
Ownership (1 if individual owner)	0.679	0.468	0.744	0.437	0.716	0.451
Expect development (1 if does)	0.080	0.272	0.081	0.274	0.081	0.273
Annual farm profit/acre	285.042	432.792	149.397	243.958	213.539	352.215
Proportion of high-productivity land (%)	46.789	45.852	27.203	38.818	35.662	43.059
Proportion of low-productivity land (%)	14.415	31.009	33.224	43.070	25.101	39.408
Proportion of not-in-use land (%)	11.598	25.370	18.103	32.758	15.294	29.935

Table 1—Summary statistics of surveyed data for the Pacific Northwest region (continued)

	Cropland		Grassland		Total	
Variables	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**
Spatial and physical characteristics:						
Close to home–resident owner (1 if "yes")	0.893	0.310	0.907	0.292	0.901	0.299
Close to city (1 if "yes")	0.203	0.403	0.142	0.350	0.169	0.375
Close to highway (1 if "yes")	0.604	0.490	0.561	0.497	0.580	0.494
Adjacent to forest (1 if "yes")	0.348	0.477	0.431	0.496	0.395	0.489
Adjacent to agricultural land (1 if "yes")	0.840	0.368	0.809	0.394	0.822	0.383
Adjacent to river (1 if "yes")	0.257	0.438	0.215	0.412	0.233	0.423
Adjacent to conservation area (1 if "yes")	0.139	0.347	0.126	0.333	0.132	0.338
Close to fire hazard (1 if "yes")	0.160	0.368	0.191	0.394	0.178	0.383
Steep slope area (1 if "yes")	0.214	0.411	0.211	0.409	0.212	0.410
Reasons for owning properties (importance score from 1 to 5):						
For selling farm product	3.882	1.290	3.390	1.446	3.603	1.401
For investment	3.102	1.350	3.126	1.354	3.115	1.351
For heir	3.283	1.485	3.260	1.486	3.270	1.484
For protecting nature	3.519	1.228	3.654	1.191	3.596	1.208
For amenity	4.433	1.057	4.654	0.812	4.559	0.931
Environmental services (importance score from 1 to 5):						
For preventing soil erosion	4.246	1.156	4.163	1.146	4.199	1.150
For improving water quality	4.166	1.168	4.220	1.092	4.196	1.125
For providing wildlife habitat	4.032	1.177	4.093	1.169	4.067	1.172
For carbon sequestration	3.428	1.398	3.541	1.384	3.492	1.390
Other attributes:						
Conservation farming (1 if "yes")	0.326	0.470	0.224	0.417	0.268	0.443
Own forest (1 if "yes")	0.406	0.492	0.415	0.494	0.411	0.493
Past afforestation (1 if "yes")	0.321	0.468	0.325	0.469	0.323	0.468
Future afforestation plan (1 if "yes")	0.321	0.468	0.362	0.481	0.344	0.476
Administrative organization:						
NGO	0.446	0.500	0.417	0.495	0.430	0.496
Government agencies	0.283	0.453	0.287	0.454	0.285	0.453
Carbon market	0.054	0.228	0.104	0.307	0.082	0.275
Private company	0.228	0.422	0.191	0.395	0.208	0.407

— = not applicable.
Std. dev. = standard deviation.
[a] NGO = nongovernmental organization.

Table 2—Summary statistics of surveyed data for the Southeast region

	Cropland		Grassland		Total	
Variables	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**
Demographic characteristics and owners' attributes:						
Age	64.123	10.784	62.298	11.513	62.935	11.274
Education (1 if elementary school)	0.025	0.156	0.020	0.140	0.022	0.146
Education (1 if middle school)	0.012	0.111	0.020	0.140	0.017	0.130
Education (1 if high school)	0.333	0.474	0.311	0.465	0.319	0.467
Education (1 if college)	0.136	0.345	0.205	0.405	0.181	0.386
Education (1 if university)	0.247	0.434	0.238	0.428	0.241	0.429
Education (1 if graduate school)	0.247	0.434	0.205	0.405	0.220	0.415
Household income (1 if less than $20 K)	0.111	0.316	0.106	0.309	0.108	0.311
Household income (1 if $20 to $40 K)	0.148	0.357	0.185	0.390	0.172	0.379
Household income (1 if $40 to $60 K)	0.111	0.316	0.119	0.325	0.116	0.321
Household income (1 if $60 to $80 K)	0.160	0.369	0.152	0.361	0.155	0.363
Household income (1 if $80 to $100 K)	0.111	0.316	0.126	0.333	0.121	0.326
Household income (1 if $100 K or more)	0.358	0.482	0.311	0.465	0.328	0.470
Gender (1 if male)	0.815	0.391	0.795	0.405	0.802	0.400
Occupation (1 if farmer)	0.185	0.391	0.139	0.347	0.155	0.363
Retired (1 if retired)	0.494	0.503	0.497	0.540	0.496	0.526
Member of NGO[a] (1 if member)	0.247	0.434	0.219	0.415	0.228	0.421
Member of agricultural organization (1 if member)	0.370	0.486	0.305	0.462	0.328	0.470
Refer neighbors decision (1 if it does)	0.877	0.331	0.861	0.347	0.866	0.341
Knowledge about climate change	0.926	0.264	0.940	0.238	0.935	0.246
Knowledge about carbon sequestration	0.840	0.369	0.854	0.354	0.849	0.359
Land characteristics:						
Total land owned (acres)	—	—	—	—	115.767	155.984
Total land owned in region (acres)	—	—	—	—	109.580	152.531
Total land rented in region (acres)	—	—	—	—	15.328	50.177
Total agricultural land owned (acres)	34.667	42.237	43.187	68.109	40.213	60.387
Total agricultural land rented (acres)	10.123	36.311	7.113	26.711	8.164	30.365
Number of unconnected parcels	1.966	1.514	2.220	3.569	2.131	3.013
Acquisition method (1 if bought)	0.679	0.470	0.530	0.501	0.582	0.494
Acquisition method (1 if inherited)	0.457	0.501	0.298	0.459	0.353	0.479
Owned year	26.559	15.482	24.460	15.151	25.193	15.267
Ownership (1 if individual owner)	0.728	0.448	0.748	0.435	0.741	0.439
Expect development (1 if does)	0.123	0.331	0.086	0.281	0.099	0.299
Annual farm profit/acre (1 if it is)	205.050	318.508	112.247	153.362	144.648	228.848
Proportion of high-productivity land	36.906	45.435	25.819	40.955	29.690	42.803
Proportion of low-productivity land	11.200	27.897	10.497	27.306	10.743	27.455
Proportion of not-in-use land	12.433	31.382	23.221	38.365	19.454	36.379

Table 2—Summary statistics of surveyed data for the Southeast region (continued)

	Cropland		Grassland		Total	
Variables	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**
Spatial and physical characteristics:						
Close to home - resident owner (1 if "yes")	0.679	0.470	0.742	0.439	0.720	0.450
Close to city (1 if "yes")	0.111	0.316	0.113	0.317	0.112	0.316
Close to highway (1 if "yes")	0.815	0.391	0.748	0.435	0.772	0.421
Adjacent to forest (1 if "yes")	0.691	0.465	0.642	0.481	0.659	0.475
Adjacent to agricultural land (1"yes")	0.741	0.441	0.722	0.450	0.728	0.446
Adjacent to river (1 if 'yes')	0.284	0.454	0.152	0.361	0.198	0.400
Adjacent to conservation area (1 if "yes")	0.222	0.418	0.225	0.419	0.224	0.418
Close to fire hazard (1 if "yes")	0.086	0.283	0.119	0.325	0.108	0.311
Steep slope area (1 if '"yes")	0.469	0.502	0.483	0.501	0.478	0.501
Reasons for owning properties (importance score from 1 to 5):						
For selling farm product	3.753	1.462	3.490	1.595	3.582	1.552
For investment	3.062	1.426	3.079	1.468	3.073	1.450
For heir	4.296	0.993	4.159	1.120	4.207	1.077
For protecting nature	4.160	1.066	4.225	0.974	4.203	1.005
For amenity	4.370	1.167	4.530	0.944	4.474	1.027
Environmental services (importance score from 1 to 5):						
For preventing soil erosion	4.543	0.881	4.715	0.647	4.655	0.740
For improving water quality	4.531	1.038	4.603	0.857	4.578	0.923
For providing wildlife habitat	4.173	1.202	4.364	1.003	4.297	1.078
For carbon sequestration	3.605	1.385	3.887	1.186	3.789	1.263
Other attributes:						
Conservation farming (1 if "yes")	0.259	0.441	0.166	0.373	0.198	0.400
Own forest (1 if "yes")	0.778	0.418	0.728	0.446	0.746	0.436
Past afforestation (1 if "yes")	0.407	0.494	0.219	0.415	0.284	0.452
Future afforestation plan (1 if "yes')	0.235	0.426	0.185	0.390	0.203	0.403
Administrative organization:						
NGO	0.346	0.485	0.302	0.463	0.315	0.467
Government agencies	0.308	0.471	0.365	0.485	0.348	0.479
Carbon market	0.000	0.000	0.016	0.126	0.011	0.106
Private company	0.192	0.402	0.190	0.396	0.191	0.395

— = not applicable.
Std. dev. = standard deviation.
[a] NGO = nongovernmental organization.

Age, education, and household income—
Age has traditionally been considered one of the main variables that might affect landowners' land use decisions. Several studies have shown that age has a positive correlation with adoption of soil conservation practices (Ervin and Ervin 1982), while it has a negative correlation on harvesting and investment on silvicultural activities (Beach et al. 2005). However, some studies argue that age does not significantly affect timber harvest behavior and participation in a forestry cost-share program (Dennis 1989, Nagubadi et al. 1996). Figure 1 presents the distribution of respondents with respect to age group, which shows that 19.6 percent of agricultural landowners in the PNW region and 30.6 percent in the SE region are in the 65-year-or-older group. Survey participants' average age was 60.5 in the PNW region, compared to 62.9 in the SE region (see tables 1 and 2).

It is also argued that income is negatively correlated with timber harvest (Beach et al. 2005; Dennis 1989, 1990), and positively correlated with silvicultural management activities (Beach et al. 2005). However, several studies have found that both income and education do not significantly affect forest owners' management decisions (Dennis 1989, Langpap 2006). Farm- or forest-related occupations are positively and significantly correlated with timber harvest (Beach et al. 2005). The fraction of landowners in the sample whose highest education level is a bachelor's degree is 55.9 percent in the PNW region and 46.6 percent in the SE region (see fig. 2), which is high relative to 24 percent for the general population (Butler 2008).

The distribution of household income level in figure 3 shows that 27.5 and 32.3 percent of agricultural landowners in the PNW and SE region, respectively, have annual household income of at least $100,000. This proportion is considerably higher than that for the general population (12 percent) (Butler 2008).

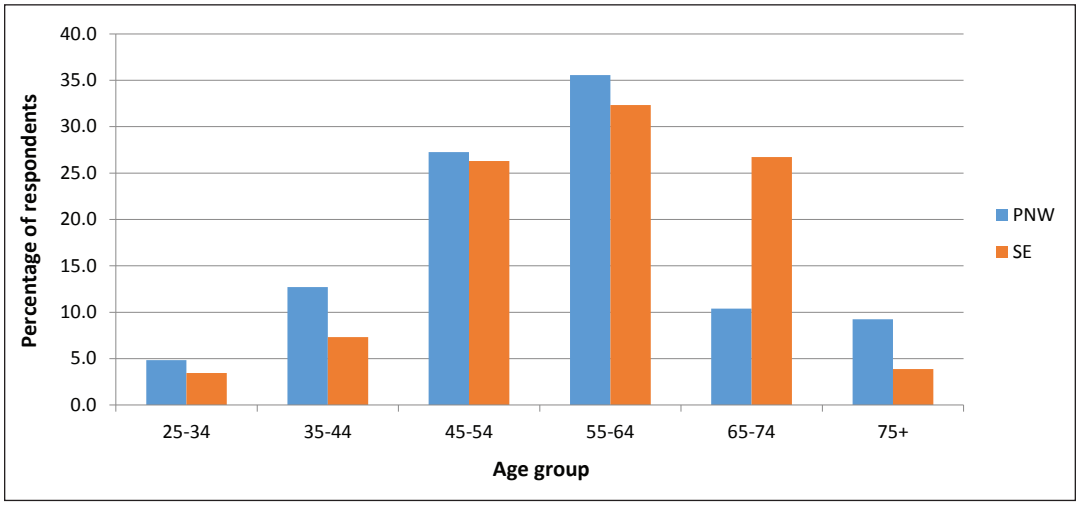


Figure 1—Distribution of age group in the Pacific Northwest (PNW) and Southeast (SE).

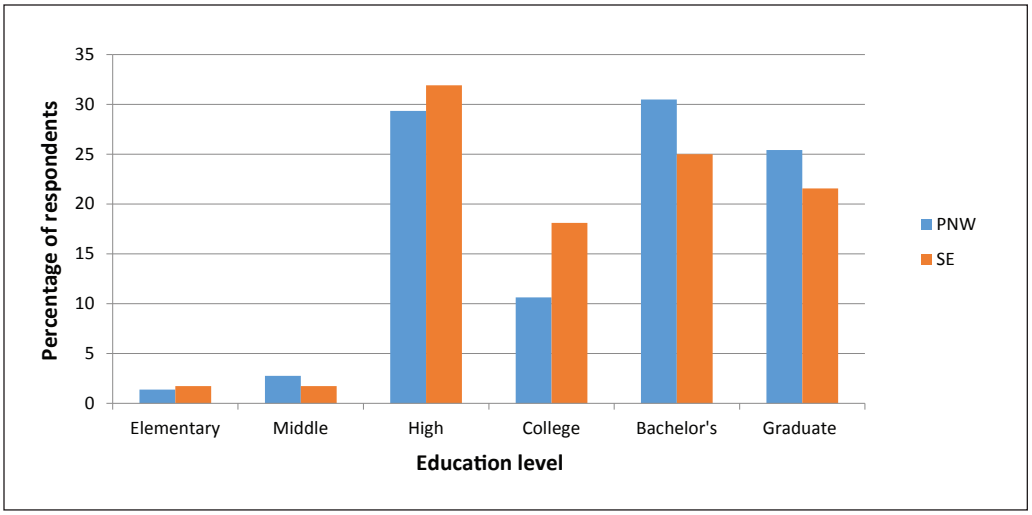


Figure 2—Distribution of education group in the Pacific Northwest (PNW) and Southeast (SE).

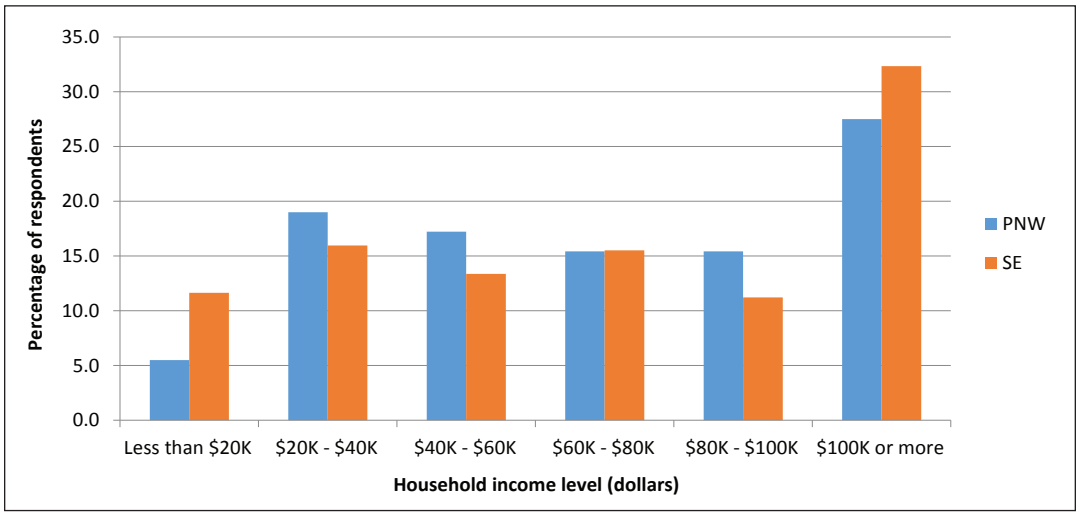


Figure 3—Distribution of household income level in the Pacific Northwest (PNW) and Southeast (SE).

Gender, occupation, retirement, and memberships—
The distribution by gender shows that 68.6 percent of survey respondents in the PNW and 80.2 percent in the SE region are male. Around 18 and 15 percent of agricultural landowners in the PNW and SE regions, respectively, have a farm-related occupation. Additionally, 40.6 percent of landowners in the PNW and 49.6 percent in the SE are retirees, compared to 49 percent of family forest owners (Butler 2008). The percentage of respondents that are members of a nongovernmental organization (NGO) is 15.2 and 22.8 percent in the PNW and SE, respectively, and 28.9 and 32.8 percent of them are members of an agricultural association (see tables 1 and 2). More than 80 percent of landowners (80.1 percent in the PNW and 86.6 percent in the SE) who completed the survey questionnaire refer to other neighbors' land use and management decisions for their own management and land use decisions.

Sources of information—
Figure 4 shows that receiving information from other landowners (70.9 percent) is the preferred source of information, followed by offline publications in the PNW and online media (Internet, TV, and radio) in the SE. Obtaining information from membership organizations is the least preferred method in both regions, possibly because not all landowners have a membership. These results are mostly consistent with Butler (2008).

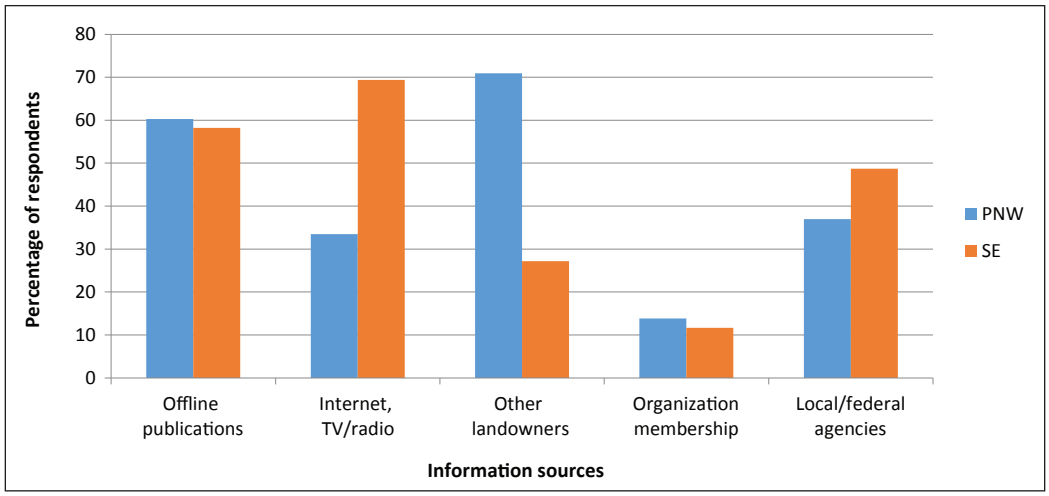


Figure 4—Proportion of information sources level in the Pacific Northwest (PNW) and Southeast (SE).

General knowledge of climate change—
At the beginning of the survey, we asked whether landowners have basic knowledge about climate change, global warming, and carbon sequestration. We expected that the landowners who do not have knowledge about climate change and carbon sequestration might have difficulty answering the questionnaire, which might affect their willingness to participate in a tree planting program for carbon sequestration. Through these questions, we also tried to remind the survey respondents that tree planting can contribute to carbon sequestration and climate change mitigation. As shown in figure 5, 97.2 and 93.5 percent of respondents in PNW and SE region, respectively, have knowledge about climate change and global warming, and 89.4 and 84.9 percent of respondents in PNW and SE, respectively, have knowledge about a positive relationship between carbon sequestration and tree planting. We note that a relatively smaller proportion of landowners have knowledge about carbon sequestration through tree planting compared to knowledge about climate change.

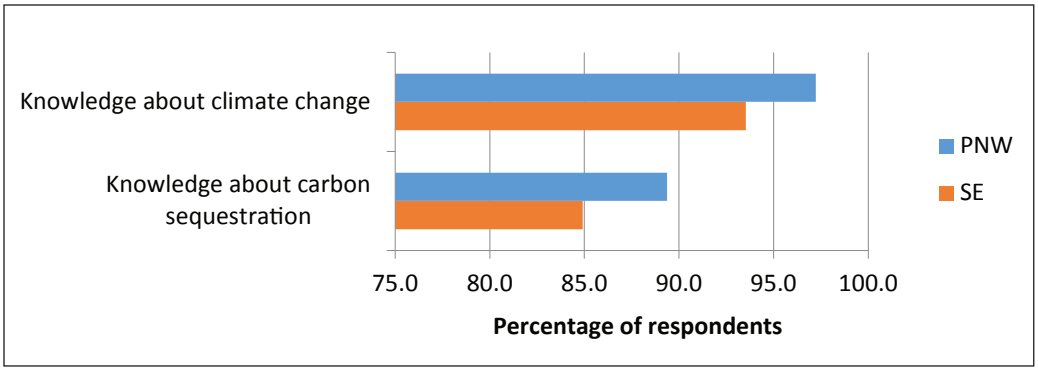


Figure 5—General knowledge about climate change and carbon sequestration in the Pacific Northwest (PNW) and Southeast (SE).

Land Characteristics

An important aspect of designing an incentives program for farm landowners is learning about their land and how it is used. Therefore, landowners were asked to answer questions about characteristics of their lands.

Size of lands owned and rented—
The size of lands managed by landowners can be a factor affecting their decision on participation in a tree planting program. Figure 6 presents average size of land (i.e., total land, agricultural land) owned/rented by survey respondents (see tables 1 and 2 for more details). The average size of total lands owned by survey respondents is 137 and 115.8 ac (55.4 and 46.9 ha) in the PNW and SE, respectively. The average size of agricultural land owned within the survey region is 58.3 and 40.2 ac (23.6 and 16.3 ha) in the PNW and SE, respectively. In the PNW, the average size of cropland is greater than that of grassland, while the reverse is true in the SE.

Figure 7 shows the distribution of agricultural land across size classes. In the PNW and SE, respectively, 54.1 and 46 percent of landowners owned less than 30 ac (12.1 ha), while 11.1 and 14.6 percent of them owned at least 100 ac (40.5 ha).

Number of unconnected parcels—
We asked respondents about the number of unconnected parcels they own, because we expect that more unconnected parcels would allow landowners to allocate parts of their land to a tree planting program more easily. Moreover, the number of unconnected parcels might be correlated with the size of agricultural lands. Figure 8 shows that most landowners (70.7 percent in the PNW and 57.3 percent in the SE) have one parcel, 15 percent (PNW) and 19.8 percent (SE) have two parcels, and 1.8 percent (PNW) and 3.9 percent (SE) of landowners have more than six parcels.

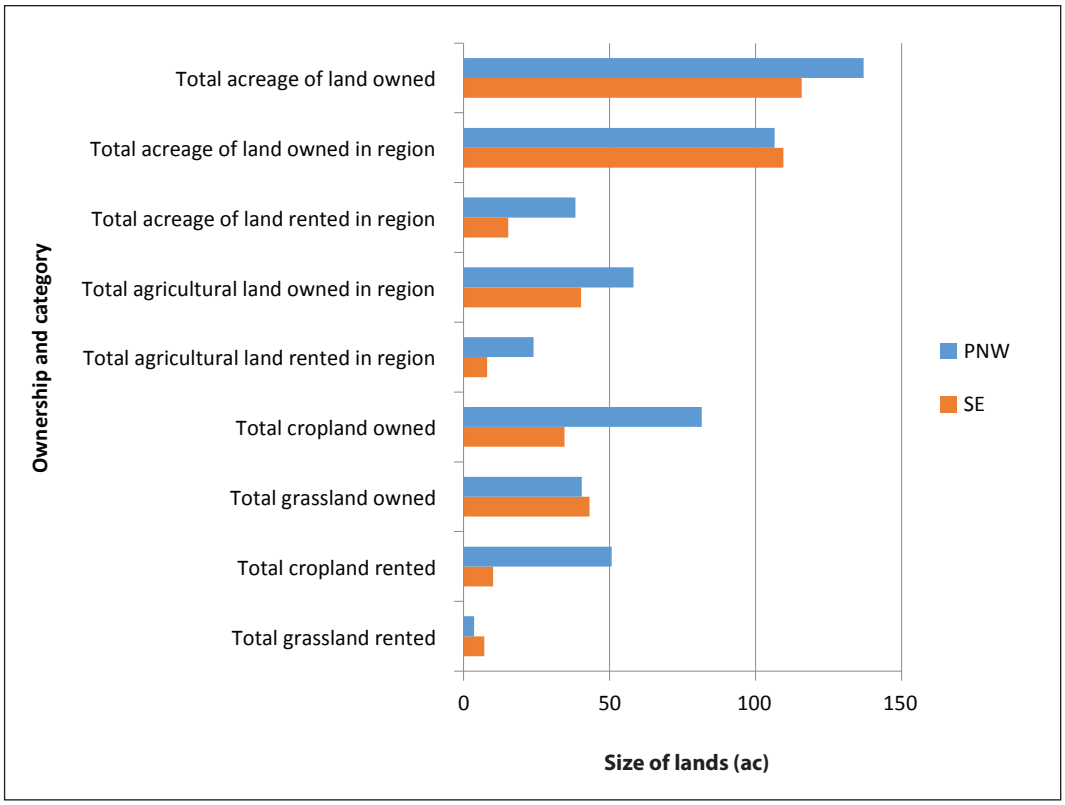


Figure 6—Size of lands owned and rented in the Pacific Northwest (PNW) and Southeast (SE).

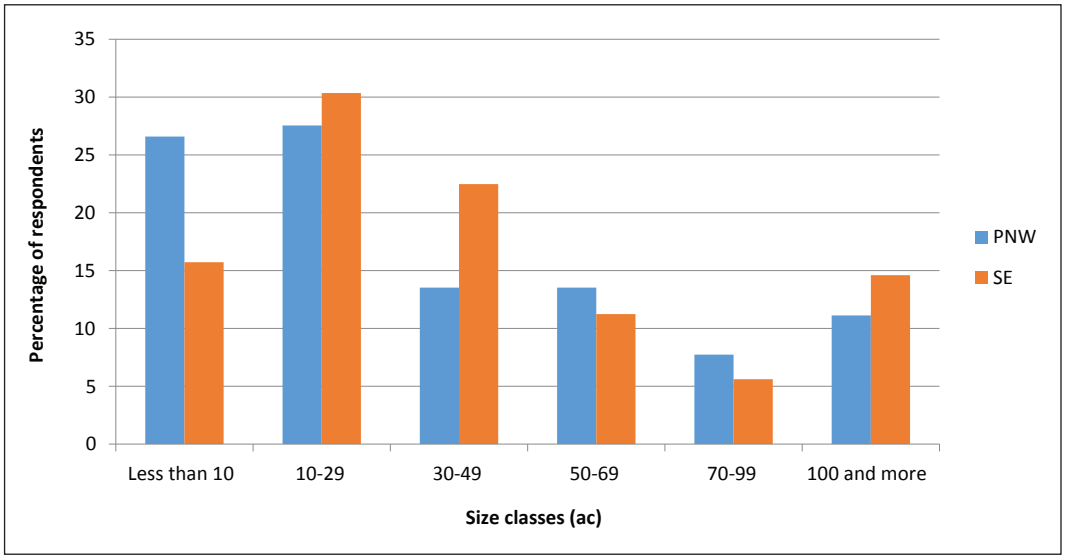


Figure 7—Distribution of agricultural land across size classes in the Pacific Northwest (PNW) and Southeast (SE).

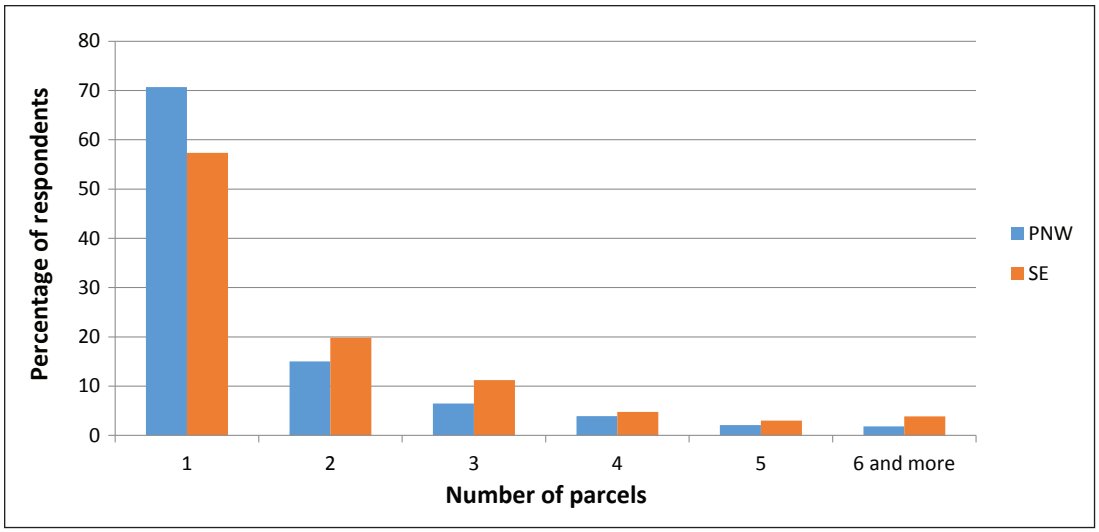


Figure 8—Distribution of number of unconnected parcels in the Pacific Northwest (PNW) and Southeast (SE).

Figure 9 shows average number of parcels across six different size classes. As we expected, as agricultural land size increases the number of parcels increases as well. The average number of parcels is 1.8 in the PNW and 2.1 in the SE (see tables 1 and 2).

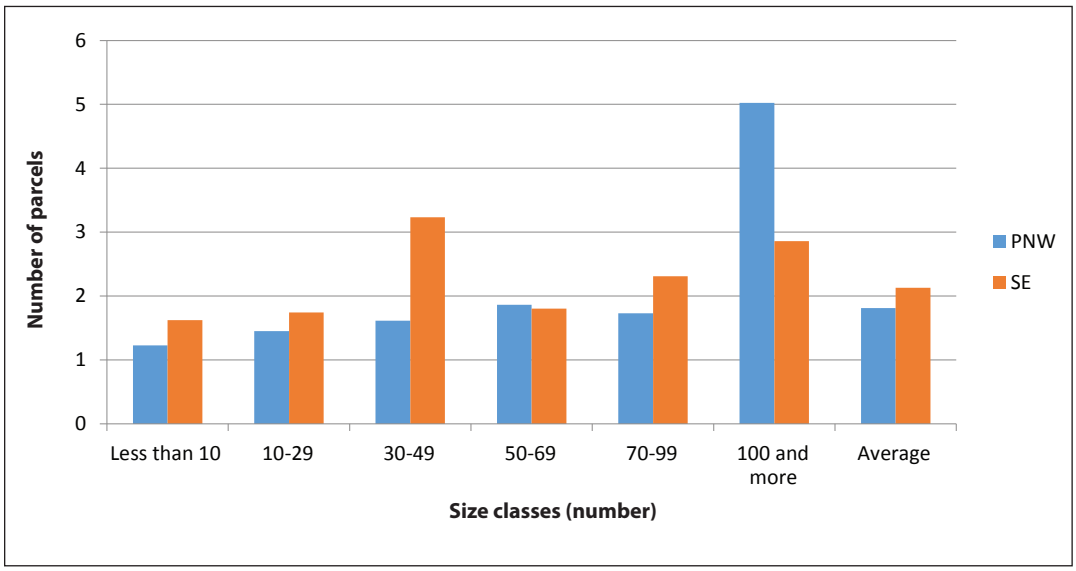


Figure 9—Average number of unconnected parcels across size classes in the Pacific Northwest (PNW) and Southeast (SE).

Acquisition methods—

How landowners acquired their lands might affect their land use decisions. Landowners were asked whether they bought or inherited their land. Figure 10 shows the proportion of respondents who bought or inherited. The figure shows that 87.5 percent of respondents in the PNW own inherited agricultural land, compared to 35.3 percent in the SE. The proportion of landowners who bought their land is smaller than the proportion who inherited their land in the PNW, but this is reversed in the SE.

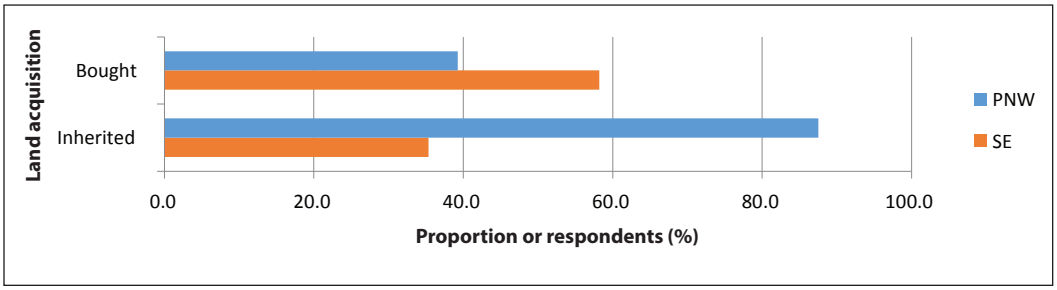


Figure 10—Proportion of agricultural land acquisition methods in the Pacific Northwest (PNW) and Southeast (SE).

Years of ownership—

Because a large proportion of land is inherited, and the average age of landowners in both regions is more than 60 years, we expected that agricultural lands have been owned for long periods of time. As shown in figure 11, 53.8 percent of respondents in the PNW region and 62.9 percent of respondents in the SE region have owned for more than 20 years. On average, survey respondents have owned their property for 22.6 years in the PNW region and 25.2 in the SE region (see tables 1 and 2).

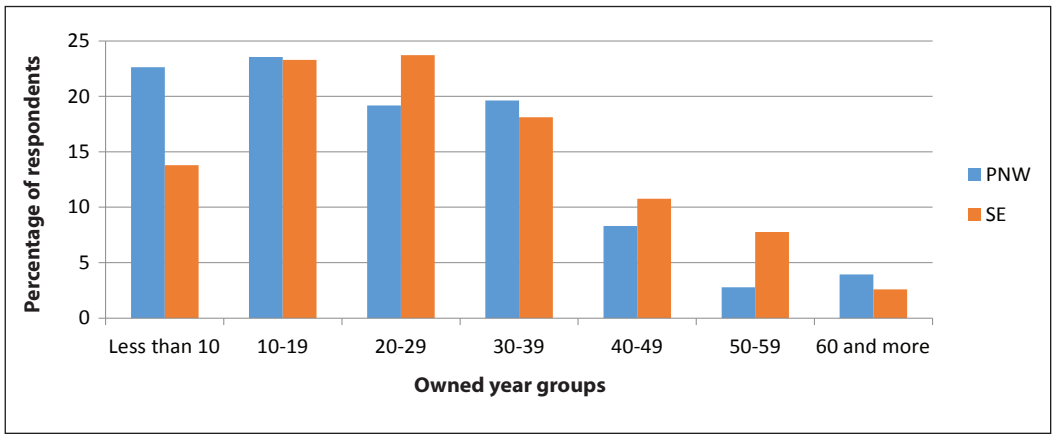


Figure 11—Distribution of owned years of agricultural lands in the Pacific Northwest (PNW) and Southeast (SE).

Ownership type—
Ownership type is also considered an important factor for land use decisions. We expect that land use change decisions can be made more easily under individual ownership than under joint ownership. Tables 1 and 2 show 71.6 and 74.1 percent of respondents in the PNW and SE, respectively, have individual ownership. However, the fact that individual ownership is the dominant ownership type does not guarantee responsiveness of land use decisions with respect to incentive payments for carbon sequestration.

Development pressure—
Development pressure is a well-known attribute affecting land use decisions. We asked landowners whether they have any expectation of development within the next 10 years. Tables 1 and 2 show 8.1 and 9.9 percent of respondents in the PNW and SE, respectively, expect to develop their land.

Average profits per acre—
We asked landowners to state their expected annual net returns from agricultural lands, because we expected that landowners who owned highly profitable lands might be reluctant to convert their lands to another use, and hence might require higher compensation than those who own less profitable lands. Figure 12 presents the distribution of landowners with respect to seven different ranges of annual profits. In the PNW, 46.5 percent and in the SE, 59.5 percent of landowners, own agricultural lands yielding less than $100 per acre. The stated average annual profit per acre is $213.5 in the PNW and $144.6 in the SE, and cropland profit is greater than grassland profit in both regions (see tables 1 and 2).

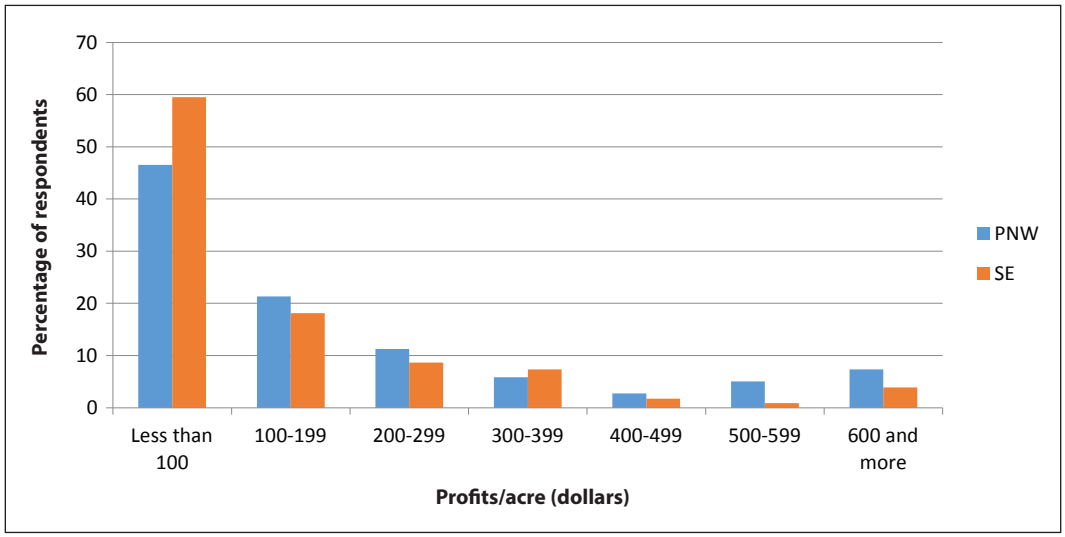


Figure 12—Distribution of landowners with respect to agricultural land profits per acre in the Pacific Northwest (PNW) and Southeast (SE).

Productivity of agriculture—
We also considered the productivity of agricultural lands as one possible factor affecting land use decisions. We expect that landowners who owned low-productivity lands might allocate those lands for tree planting at relatively lower compensation. Figure 13 shows the proportion of agricultural lands for three different levels of productivity. In both regions, a higher proportion of croplands than grasslands are highly productive. On average, low-productivity lands accounted for 25.1 and 10.7 percent of agricultural lands, and high-productivity lands accounted for 35.7 and 29.7 percent in the PNW and SE region, respectively.

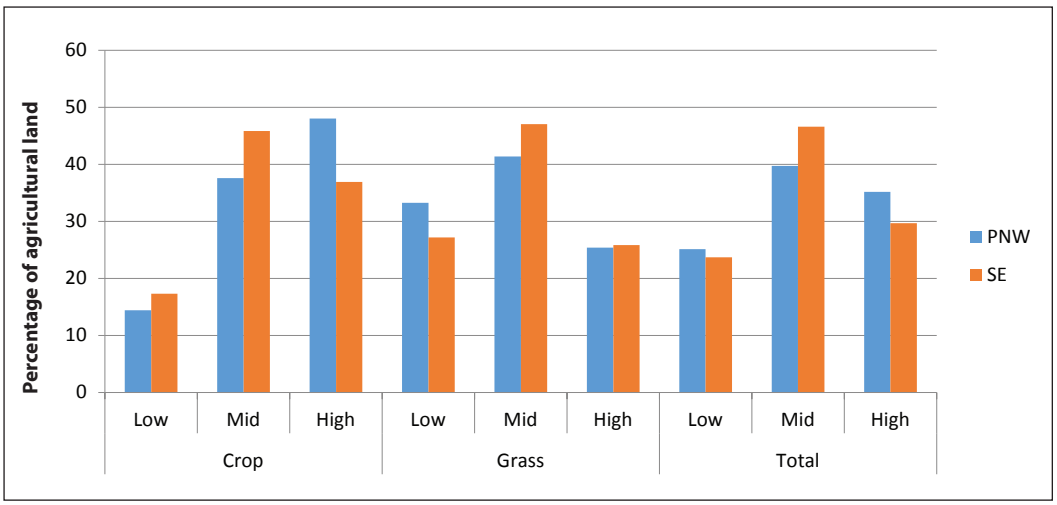


Figure 13—Proportion of agricultural lands with respect to different levels of productivities in the Pacific Northwest (PNW) and Southeast (SE).

Land not in use—
We also asked landowners how many acres of agricultural lands were not currently used for production, because agricultural lands not currently in use might have a lower opportunity cost for planting trees. As shown in tables 1 and 2, the average size of agricultural land not currently in use is 4.8 ac in the PNW region and 6.8 ac in the SE region.

Spatial and physical characteristics of agricultural land—
The spatial characteristics of agricultural land are important attributes affecting land use decisions. However, their effect is not examined in detail in existing studies about tree planting because of a lack of information on parcel location (Kim 2012). Zhou and Kockelmen (2008) recognized that variables such as central business district access and distance to the nearest highway, as well as each parcel's neighborhood attributes, can affect landowner's land use and management decisions. Development pressure, such as distance from major city, contiguity with urban growth boundary, and so on, can affect land use choice (Kristensen et al.

2001, Langpap and Wu 2008, Mansfield et al. 2000). Potential risk of fire can affect land use and management decisions as well (Amacher et al. 2005, Konoshima et al. 2008).

Because we do not know the exact location of each parcel, we directly asked landowners whether their agricultural lands are close or adjacent to certain areas or landmarks such as a home, city boundary, highway, forest land, other agricultural land, river, conservation areas, and fire hazards. We also asked whether their agricultural lands have steep slope (more than 15 degrees) areas or not.

Figure 14 shows the proportion of respondents who answered "yes" to each question. The results show that, for the PNW and SE, respectively, 90.1 and 72 percent of agricultural lands are located within a mile from home, 16.9 and 11.2 percent are located close to a major city boundary, 58 and 77.2 percent are adjacent to forest land, 82.2 and 72.8 percent are adjacent to other agricultural lands, 23.3 and 19.8 percent are adjacent to a river, 13.2 and 22.4 percent are adjacent to conservation areas, and 17.8 and 10.8 percent are adjacent to fire risk areas. Finally, 21.2 percent of landowners in the PNW compared to 47.8 percent of landowners in the SE own agricultural lands with steep slopes.

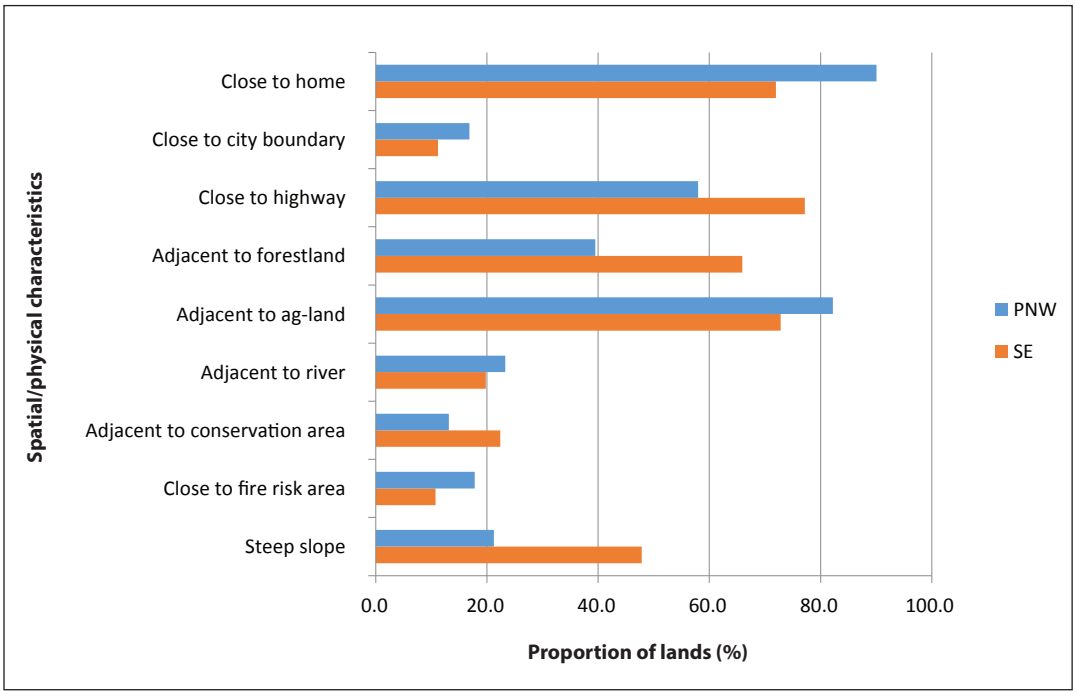


Figure 14—Proportion of lands revealed existence of listed spatial and physical characteristics in the Pacific Northwest (PNW) and Southeast (SE).

Other Attributes Related to Land Use and Management

Reasons for owning agricultural land—
Landowners may have multiple objectives for ownership of their agricultural land, and we believe that these various reasons for ownership may affect landowners' land use decisions. To examine how the reasons for owning agricultural land affect the landowners' willingness to plant trees for carbon sequestration, we asked landowners to rank the level of importance of their reasons for owning agricultural land with a 5-point scale ranging from "not important" to "very important." We categorized five reasons for owning agricultural lands: for selling agricultural products, investment, heirs, protecting nature, and amenities. We expect that land use decisions may differ across these reasons. Average scores for cropland, grassland, and total lands across regions are described in tables 1 and 2.

Figure 15 shows the distribution of the importance score for each reason. In the PNW region, 87.6 percent of agricultural landowners scored at least 4 "for amenity," 53.6 percent "for selling agricultural products," 50.6 percent "for protecting nature," 42.6 percent "for heirs," and 36.5 percent "for investment." In the SE region, 83.6 percent of agricultural landowners scored at least 4 "for amenity," 71.1 percent "for heirs," 71.1 percent "for protecting nature," 54.4 percent "for selling agricultural products," and 33.6 percent "for investment."

Additionally, figure 16 presents the average scores earned for each category of reason for owning (see tables 1 and 2 for more details). Among the five different reasons for owning agricultural lands, "For amenity" is scored the highest (4.6 for the PNW, 4.5 for the SE), and "For investment" is scored the lowest (3.1) in both regions. For the remaining three possible reasons, the PNW gives more weight to selling agricultural products, while the SE gives more weight to heirs and protecting nature.

Importance of providing environmental services for the public—
Landowners can contribute to providing environmental services by converting their current land use to another use, or adopting more environmentally friendly management practices. There are multiple environmental services that landowners can provide, such as preventing soil erosion, improving water quality, providing wildlife habitat, and increasing carbon sequestration. We asked landowners to rank the importance of providing these environmental services for the public with a 5-point scale ranging from "not important" to "very important."

As shown in figure 17, among the four different types of environmental services, preventing soil erosion and improving water quality earned the highest average score (4.2) in the PNW, and preventing soil erosion earned the highest (4.7) in the SE. In both regions, preventing soil erosion, improving water quality, and providing wildlife habitat earned at least a score of 4, while sequestering carbon

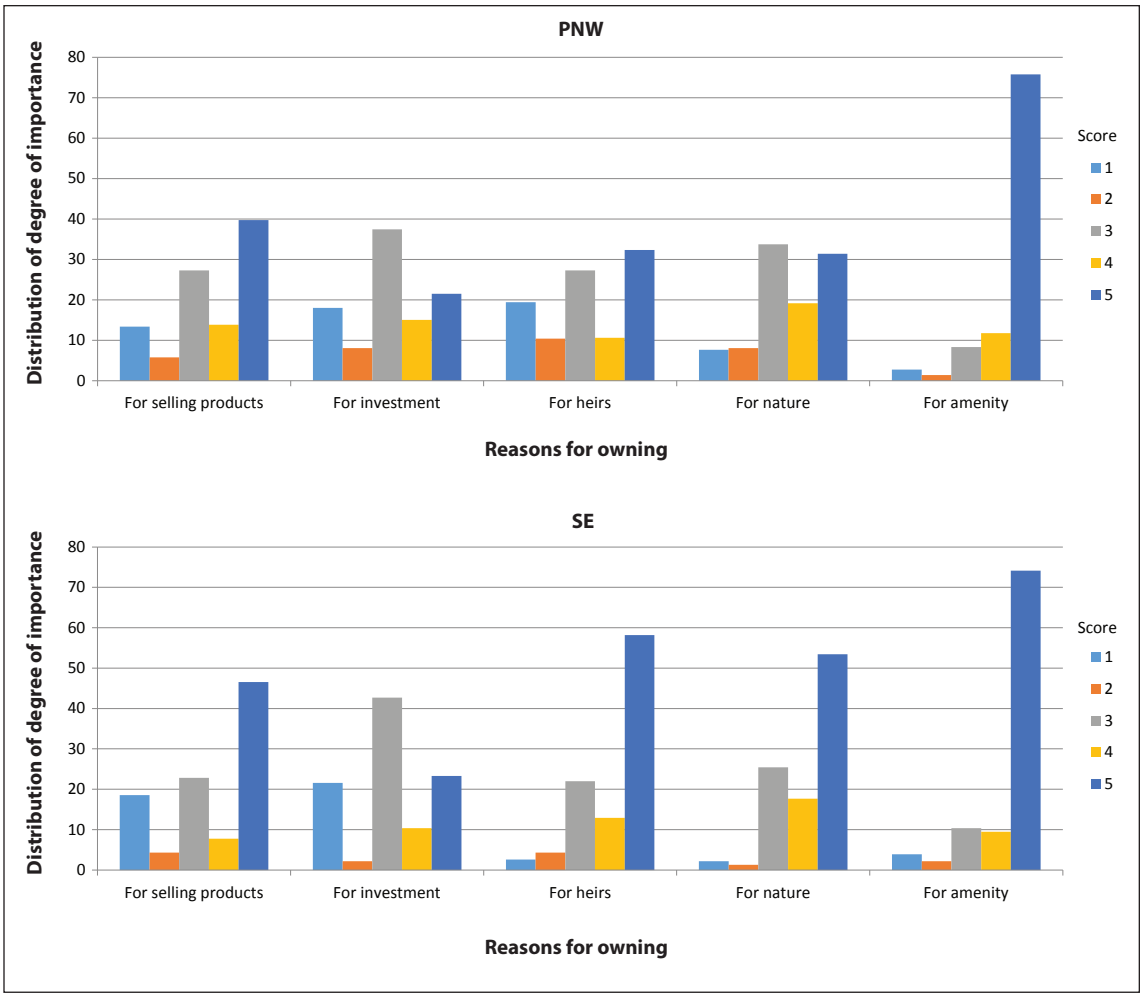


Figure 15—Distribution of degree of importance for reasons for owing agricultural lands in the Pacific Northwest (PNW) and Southeast (SE).

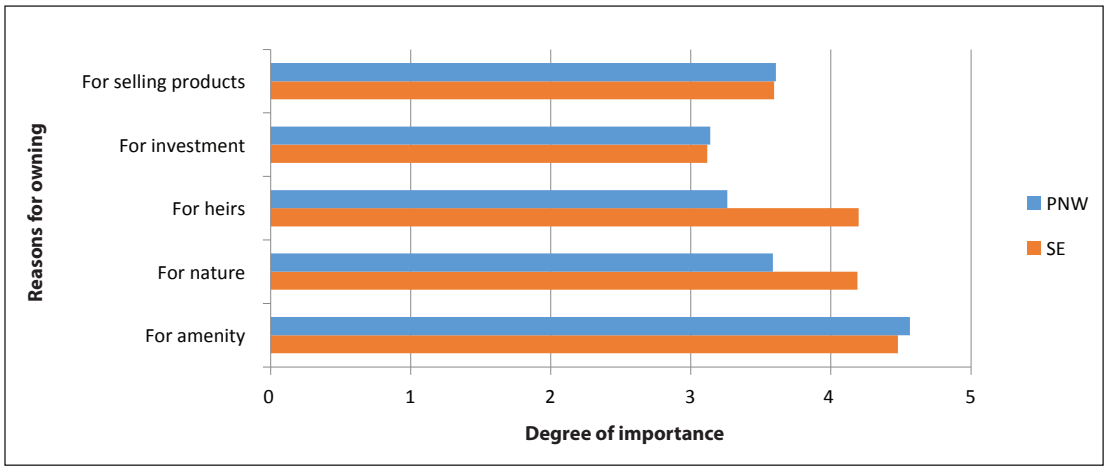


Figure 16—Proportion of reasons for owning properties across levels of importance in the Pacific Northwest (PNW) and Southeast (SE).

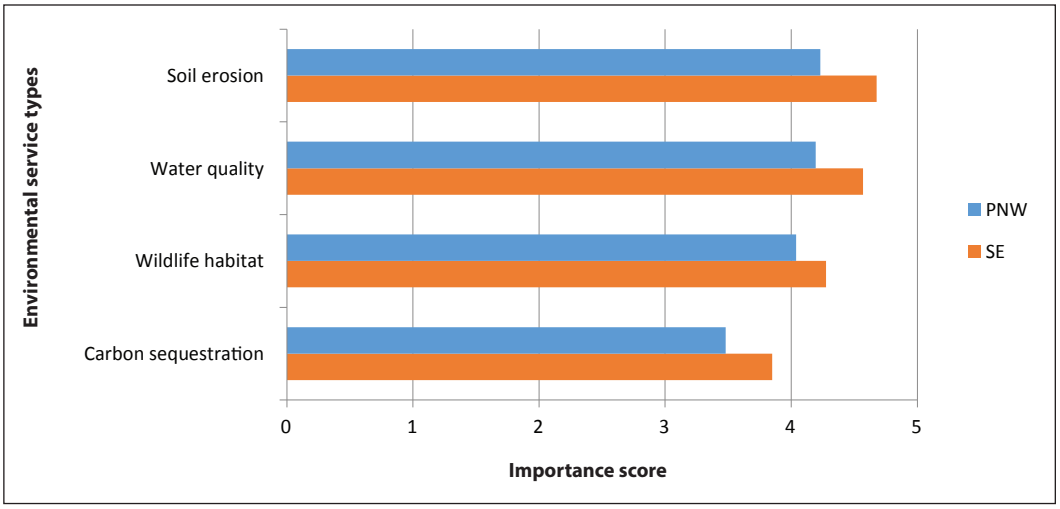


Figure 17—Average scores of importance of providing environmental services for the public in the Pacific Northwest (PNW) and Southeast (SE).

earned the lowest score (3.5 and 3.8 in the PNW and SE, respectively) suggesting that the respondents are relatively unsupportive of sequestering carbon compared to other services. This result also suggests that landowners' participation in a tree-planting program for carbon sequestration might be motivated by other environmental services.

Past experiences, current management, and future plans—
Past and current experiences with conservation farming practices, tree planting, and owning forest lands, as well as future plans for tree planting without any incentive payments can also be factors affecting land use decisions.

Figure 18 shows that the proportion of respondents who are conducting conservation farming practices is 26.8 percent in the PNW and 19.8 percent in the SE, whereas 6.0 percent and 6.5 percent of respondents in the PNW and SE, respectively, have received conservation payments. A large proportion of respondents (41.1 percent in the PNW and 74.6 percent in the SE) previously owned forest lands. Around 32 percent of respondents in the PNW and 28 percent of respondents in the SE have past experience with tree planting, and 34.4 percent of respondents in the PNW and 20.3 percent of respondents in the SE have future plans for tree planting.

Preferred administrative organization—
The survey respondents who were willing to participate in a tree planting program were asked about their preferred type of administrative organization to provide the program. As shown in figure 19, among four different types of candidate organizations, a nongovernmental organization (NGO) is most preferred, and a carbon market is least preferred in the PNW, while a carbon market is most preferred, and a private company that emits large amounts of CO_2 is the least preferred in the SE.

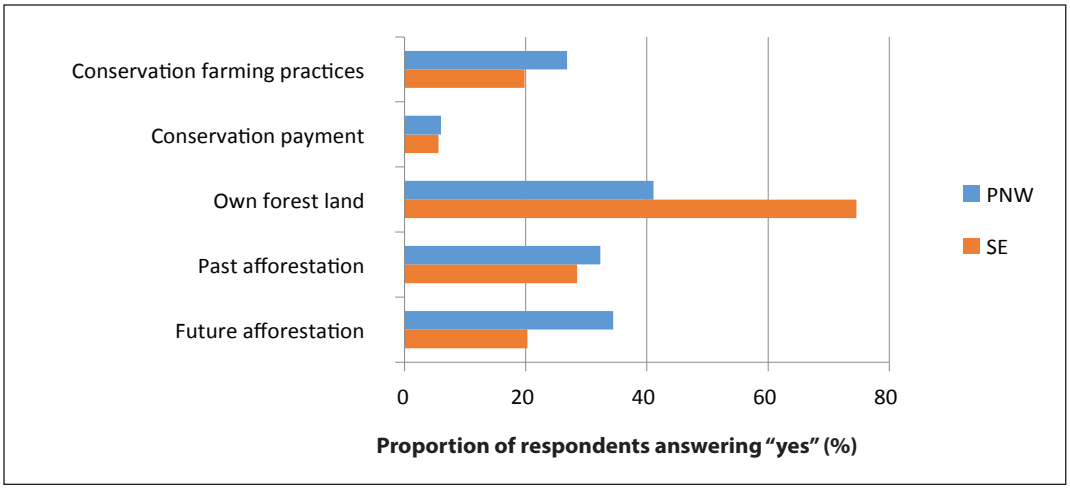


Figure 18—Proportion of respondents who answered "yes" to questions related to experience with conservation practices and programs in the Pacific Northwest (PNW) and Southeast (SE).

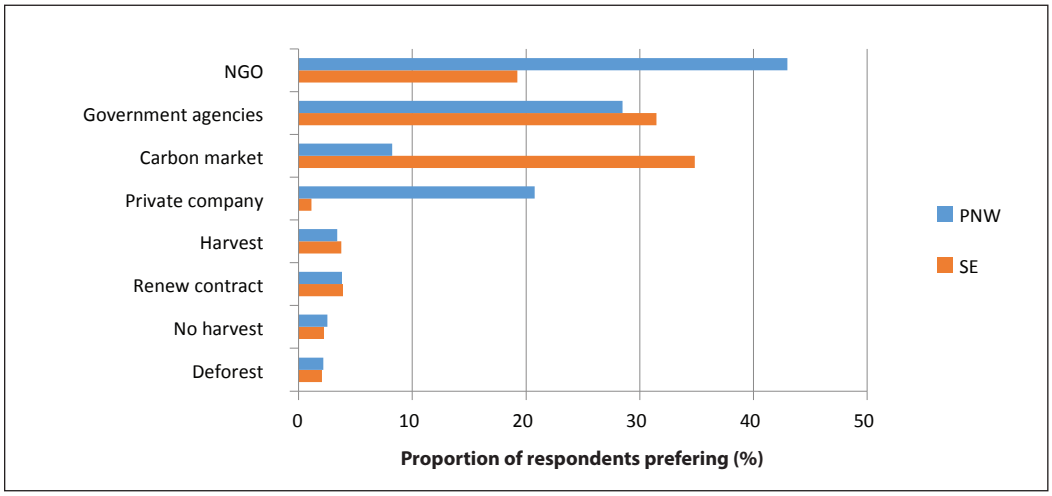


Figure 19—Proportion of preferred administrative organization for the Pacific Northwest (PNW) and Southeast (SE). NGO = nongovernmental organization.

Landowners' Response to Incentives for Planting Trees and Correlations With Other Factors

Proposed Incentive Payment Scheme and Questionnaire Design

To examine landowners' response to incentive payments for carbon sequestration, we proposed an incentive scheme that is consistent with components of the USDA Conservation Reserve Program (CRP), including a 50 percent cost-share subsidy for establishing trees and an annual rental payment for the 15- and 30-year duration of the contract. An additional flyer was provided to help respondents' understanding of how annual compensation would be calculated. The description of the incentive scheme, enrollment questions, and an additional flyer are provided in the appendix.

Through in-person pretest, expert review, and literature reviews, we chose a carbon price ranging from $1 to $150 per metric ton of carbon, with 12 breaks. This is consistent with the average of the maximum carbon price in US EPA (2005) and in the U.S. Agricultural Sector Model (Lewandrowski et al. 2004). The payment per metric ton of carbon is converted to a per-acre payment based on the annual carbon sequestration rate over the duration of the contract. Annual carbon accumulation rates over the duration of the contract were calculated by using the carbon accumulation table created by Smith et al. (2006).

We initially asked survey respondents whether they would be willing to participate in a tree planting program. Then, the respondents who stated they would be willing to participate were asked to reveal the amount or proportion of acreage they would be willing to enroll in the program, given three different levels of per-acre annual compensation.

Landowners' Willingness to Plant Trees for Carbon Sequestration

From the dichotomous choice question to identify the respondents who are willing to participate in a tree planting program, we found that 207 out of 433 (47.8 percent) valid respondents in the PNW and 89 out of 232 (38.4 percent) valid respondents in the SE responded affirmatively. Given the data collected from valid respondents in both regions, we conduct a statistical analysis to examine the correlation between landowners' willingness to allocate their agricultural lands for tree planting and various factors affecting land use conversion, as well as carbon incentive payments.

Effect of incentive payments on enrollment—
Figure 20 presents the acreage of agricultural land that landowners are willing to allocate for tree planting for different levels of annual compensation (standardized to carbon prices) and contract duration in each region. The linear trend line suggests that compensation and willingness to enroll are positively correlated for both regions and contract durations at 1 percent significance level. The slopes of the trend lines suggest that willingness to participate is more responsive to changes in carbon payment in the SE than in the PNW ($p = 0.081$). Between the two contract durations, respondents are more responsive to changes in carbon payments with a 30-year contract than with a 15-year contract ($p = 0.023$).

Figure 21 shows the relationship between acreage respondents would be willing to enroll and the size of the agricultural land they own. In every case, the linear trend line suggests that acreage enrolled increases as the size of agricultural land increases, while the slopes are different across the contract duration and regions.

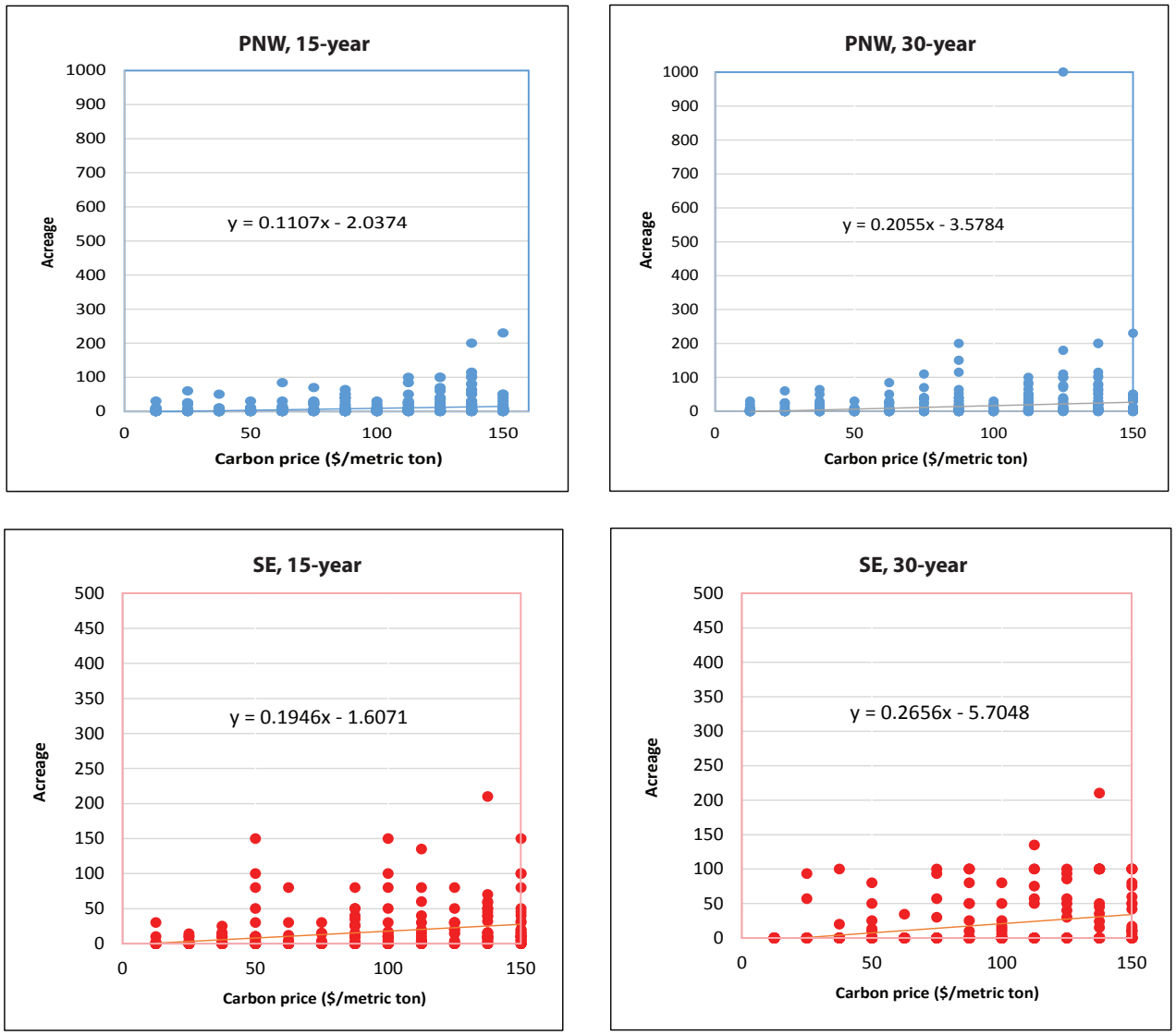


Figure 20—Acreage of enrollment with respect to incentive payment in the Pacific Northwest (PNW) and Southeast (SE).

However, we need to be careful when estimating landowners' willingness to allocate their land for tree planting when using size of land holdings as a dependent variable in an econometric analysis. Because property size ranges from 0 to 1,000 ac (0 to 404.7 ha) in the PNW and from 0 to 210 ac (84.9 ha) in the SE, inclusion of a few large properties may distort estimation results, and thus may overstate true willingness to plant trees under a carbon payment program. If this is an issue, the proportion of agricultural land enrolled might be a better option as a dependent variable, as it allows us to avoid the scale issue. Thus, figure 22 presents the

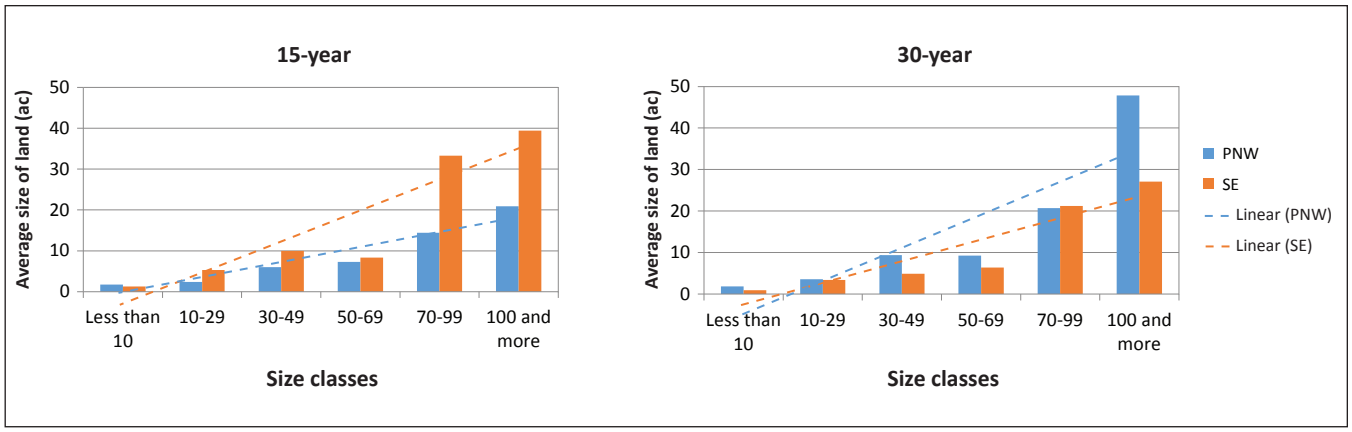


Figure 21—Average acreage of enrollment with respect to size of agricultural lands in the Pacific Northwest (PNW) and Southeast (SE).

proportion of land enrolled at different levels of incentive payment. While the linear trends in figure 22 are similar to those in figure 20, under a 15-year contract, respondents in the SE are more responsive than in the PNW, but under a 30-year contract, the opposite is true. This may be because the average timber harvest rotation period in the SE is shorter than in the PNW (Lewandrowski et al. 2004, Smith et al. 2006), and thus the respondents in the SE might prefer to have a shorter contract than in the PNW.

Correlations between proportion of land enrollment and related factors—Finally, we provide pairwise correlations between proportion of land enrolled and other factors presented in table 3.[3] The signs are mostly consistent between a 15-year contract and a 30-year contract in both regions. We describe and highlight the variables for which there are significant differences between the two possible contract durations.

Carbon payments are positively and significantly correlated with enrollment for both contract durations and in both regions. Additionally, in the PNW, we find a positive correlation between enrollment and a high school education, household

[3] The estimation results of empirical econometric analysis using surveyed data can be found in chapter 3 of Kim (2012). The primary goal of this analysis is to predict the landowners' willingness to enroll in a tree planting program in response to different levels of incentive payments by controlling various factors affecting the landowners' land use decision.

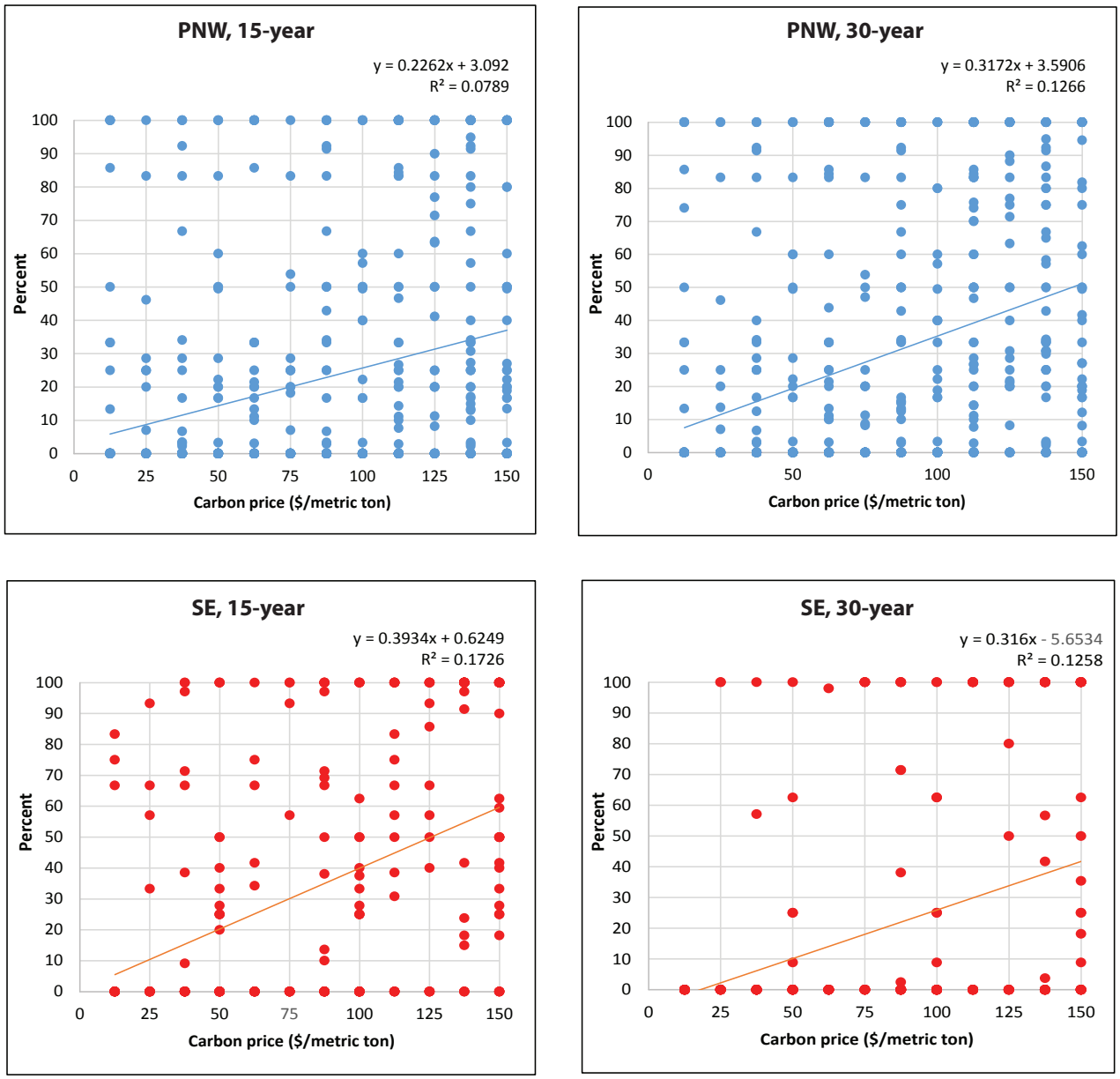


Figure 22—Proportion of enrollment with respect to incentive payment in the Pacific Northwest (PNW) and Southeast (SE).

income between $40,000 and $60,000, a male landowner, knowledge about climate change, inherited land, a higher proportion of unused land, owning land to protect nature or amenities, and placing importance on providing water quality and carbon sequestration. Furthermore, respondents who owned forest land, have experience with past afforestation, have a future afforestation plan prefer, NGOs as administrative organizations, or prefer government agencies as administrative organizations

Table 3—Correlations between proportion of land enrollment and other variables

	Pacific Northwest		Southeast	
Variables	**15 year**	**30 year**	**15 year**	**30 year**
Carbon payment	0.2545*	0.3617*	0.4101*	0.2682*
Demographic characteristics and owners' attributes:				
Age	0.0257	0.0267	0.0609	-0.0566
Education (1 if elementary school)	-0.0144	-0.0243	0.0801	0.1404*
Education (1 if middle school)	-0.0182	-0.0593*	0.0801	-0.0787
Education (1 if high school)	0.0945*	0.0781*	0.0252	-0.0525
Education (1 if college)	-0.0279	-0.0155	-0.1036*	-0.0808
Education (1 if university)	-0.0265	0.0074	0.0132	-0.0063
Education (1 if graduate school)	-0.0311	-0.0481	-0.0118	0.0983*
Household income (1 if less than $20 K)	-0.0787*	-0.0654	0.0825	-0.0178
Household income (1 if $20 to $40 K)	-0.0037	0.0103	-0.1337*	-0.0752
Household income (1 if $40 to $60 K)	0.0658*	0.0251	-0.0178	0.0013
Household income (1 if $60 to $80 K)	-0.0199	-0.0227	-0.0512	-0.0433
Household income (1 if $80 to $100 K)	0.0102	-0.0158	-0.0019	-0.0229
Household income (1 if $100 K or more)	-0.0076	0.0335	0.0981*	0.1114*
Gender (1 if male)	0.0643	0.1286*	0.0019	0.0647
Occupation (1 if farmer)	-0.0869*	-0.0707*	-0.0317	-0.1143*
Retired (1 if retired)	0.0308	0.0174	0.0804	0.0525
Member of NGO (1 if member)	0.0434	0.0207	0.0081	0.0002
Member of agricultural organization (1 if member)	-0.0710*	-0.0322	-0.0958*	-0.0561
Refer neighbors decision (1 if it does)	-0.0089	-0.0013	0.0254	0.0093
Knowledge about climate change	0.0838*	-0.0233	-0.0123	0.0342
Knowledge about carbon sequestration	-0.0318	-0.0278	0.0967*	0.0583
Land characteristics:				
Total land owned (acres)	-0.0559	0.0083	0.0079	0.0141
Total land owned in region (acres)	-0.0871*	-0.0541	-0.0058	0.0158
Total agricultural land owned (acres)	-0.0813*	-0.0696*	-0.0596	-0.0256
Number of unconnected parcels	-0.0538	-0.0390	0.0441	-0.0487
Acquisition method (1 if bought)	-0.1623*	-0.1433*	0.0729	0.0264
Acquisition method (1 if inherited)	0.0674*	0.1118*	-0.1750*	-0.0704
Owned year	0.0081	-0.0021	-0.0045	-0.0425
Ownership (1 if individual owner)	-0.0335	-0.0263	0.0715	0.0582
Expect development (1 if does)	-0.0274	-0.0107	0.1759*	0.0244
Annual farm profit/acre (%)	-0.1075*	-0.1282*	-0.0272	-0.0251
Proportion of high productivity land (%)	-0.1043*	-0.1134*	0.0105	-0.0182
Proportion of low productivity land (%)	0.0534	0.0311	0.0952*	0.0651
Proportion of not-in-use land (%)	0.0724*	0.0773*	0.1435*	-0.0007

Note: * indicates statistical significance at $\alpha = 5$ percent.

Table 3—Correlations between proportion of land enrollment and other variables (continued)

	Pacific Northwest		Southeast	
Variables	**15 year**	**30 year**	**15 year**	**30 year**
Spatial and physical characteristics:				
Close to home—resident owner (1 if "yes")	0.0452	0.0034	-0.0283	-0.0600
Close to city (1 if "yes")	0.0289	0.0112	0.0444	0.0391
Close to highway (1 if "yes")	-0.0053	-0.0033	-0.0501	-0.0561
Adjacent to forest (1 if "yes")	0.0520	0.0396	0.0345	0.0240
Adjacent to agricultural land (1 if "yes")	-0.0619*	-0.0039	-0.0577	-0.0251
Adjacent to river (1 if "yes")	0.0339	0.0618	-0.0509	0.0830
Adjacent to conservation area (1 if "yes")	-0.0547	-0.0307	-0.0276	-0.0114
Close to fire hazard (1 if "yes"	-0.0186	-0.0091	0.1928*	0.1356*
Steep slope area (1 if "yes")	-0.0269	-0.0485	-0.0016	-0.0066
Reasons for owning properties (importance score from 1 to 5):				
For selling farm product	-0.1133*	-0.1029*	-0.0862	-0.0488
For investment	0.0392	0.0247	0.0219	-0.0601
For heir	0.0211	0.0770*	-0.0907*	-0.0457
For protecting nature	0.1489*	0.0836*	0.0711	0.0480
For amenity	0.0828*	0.0500	0.0405	0.0224
Environmental services (importance score from 1 to 5):				
For preventing soil erosion	-0.0403	-0.0280	0.1087*	0.0253
For improving water quality	0.0134	0.0095	0.0515	0.0134
For providing wildlife habitat	0.0717*	0.0410	0.1070*	0.1445*
For carbon sequestration	0.1456*	0.0851*	0.1374*	0.0424
Other attributes:				
Conservation farming (1 if "yes")	-0.0901*	-0.1302*	0.0153	-0.0406
Own forest (1 if "yes")	0.0916*	0.0585	0.0692	-0.0022
Past afforestation (1 if "yes")	0.1232*	0.0735*	0.0467	0.0692
Future afforestation plan (1 if "yes")	0.1080*	0.0385	0.0522	0.0577
Administrative organization:				
NGO	0.0763*	0.0176	0.0382	-0.0093
Government agencies	0.0961*	0.0831*	-0.1190*	-0.0079
Carbon market	-0.0042	-0.0331	0.1234*	0.0217
Private company	-0.1398*	-0.0603	0.1173*	0.0778

Note: * indicates statistical significance at $\alpha = 5$ percent.
NGO = nongovernmental organization.

are more likely to enroll. Respondents with household income below $20,000, who are farmers and members of an agricultural organization, conduct conservation farming, and prefer a private company as an administrative organization are less likely to enroll. Enrollment is also negatively correlated with total size of land in the region, size of agricultural land owned, purchased land, higher levels of farm profit per acre and larger proportions of high-productivity land, and adjacency to other agricultural lands.

In the SE, respondents with household income at least $100,000, with knowledge about carbon sequestration, and who prefer either a carbon market or a private company as an administrative organization are more likely to enroll. Additionally, enrollment is positively correlated with the proportion of low-productivity and unused land, proximity to fire hazards, and interest in preventing soil erosion, providing wildlife habitat, and sequestering carbon. Respondents who are farmers, have a college education, household income between $20,000 and $40,000, are members of an agricultural organization, and prefer government agencies as administrative organization are less likely to enroll. Enrollment is also negatively correlated with inherited land and interest in bequeathing the land to heirs.

However, in both region, landowners' ages and retirement status, membership of NGO, number of unconnected parcels, owned years, spatial or physical characteristic variables (except adjacency with other agricultural land in the PNW, and except closeness to fire hazard) are not significantly correlated with the proportion of land enrollment. Additionally, in the SE, the variables representing the respondents who have been conducting conservation farming, who own forest, who experienced afforestation in the past, and who have a plan for future afforestation are not significantly correlated with proportion of land enrollment, while they are significantly correlated in the PNW.

Conclusion

It is important to know individual landowners' characteristics and land characteristics to estimate landowners' willingness to participate in a tree planting program given incentive payments for carbon sequestration. This statistical analysis of data collected through an agricultural landowner survey is motivated by recognizing that a lack of information about these characteristics is one of the main obstacles to eliciting willingness to participate in a tree planting program.

This report provides a statistical analysis of the data collected from the two survey regions, the Pacific Northwest and the Southeast. The survey asked about characteristics of individual agricultural landowners and their land, as well as their willingness to enroll in a tree planting program given different levels of incentive payments for carbon sequestration.

This statistical analysis revealed both similar and contrasting features between the two survey regions. One key insight is that landowners in the SE are generally more responsive to incentive payments for carbon sequestration than landowners in the PNW, and that the variables which are highly correlated with the willingness to enroll in a tree planting program are somewhat different between the two regions.

This report helps us understand the key factors affecting landowners' tree planting program participation, measure the potential extent of participation in a tree planting program for carbon sequestration, and conduct a comparison study to find different characteristics between the two survey regions.

Acknowledgments

We thank Ralph Alig for his valuable comments, advice, and funding through the Goods, Services, and Values Research Program in the USDA Forest Service Pacific Northwest Research Station.

Literature Cited

Adams, D.M.; Alig, R.J.; McCarl, B.A.; Callaway, J.M.; Winnett, S.M. 1999. Minimum cost strategies for sequestering carbon in forests. Land Economics. 75: 360–374.

Alig, R.J.; Adams, D.M.; McCarl, B.; Callaway, J.M.; Winnett, S. 1997. Assessing effects of mitigation strategies for global climate change with an intertemporal model of the U.S. Environmental and Resource Economics. 9: 259-274.

Alig, R.; Latta, G.; Adams, D.; McCarl, B. 2010. Mitigating greenhouse gases: the importance of land base interactions between forests, agriculture, and residential development in the face of changes in bioenergy and carbon prices. Forest Policy and Economics 12: 67–75.

Amacher, G.S.; Malik, A.S.; Haight, R.G. 2005. Not getting burned: the importance of fire prevention in forest management. Land Economics. 81(2): 284-302.

Beach, R.H.; Pattanayak, S.K.; Yang, J.C.; Murray, B.C.; Abt, R.C. 2005. Econometric studies of non-industrial private forest management: a review and synthesis. Forest Policy and Economics. 7(3): 261–281.

Brennan, M. 1992. The Effect of a Monetary Incentive on Mail Survey Response Rates: New Data. Journal of the Market Research Society 34(2): 173–177.

Butler, B.J. 2008. Family forest owners of the United States, 2006. Gen. Tech. Rep. NRS-27. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 72 p.

Dennis, D.F. 1989. An economic analysis of harvest behavior: integrating forest and ownership characteristics. Forest Science. 34(4): 1088–1104.

Dillman, D.A. 1978. Mail and telephone surveys: the total design method. New York: Wiley-Interscience.

Dillman, D.A. 2007. Mail and Internet surveys: the tailored design method. 2nd ed. Hoboken, NJ: John Wiley.

Ervin, C.A.; Ervin, D.E. 1982. Factors affecting the use of soil conservation practices: hypotheses, evidence, and policy implications. Land Economics. 58(3): 277–292.

Gorte, R.W. 2009. U.S. tree planting for carbon sequestration. CRS report for Congress. Washington, DC: Congressional Research Service.

Kim, T. 2012. Three essays on private landowners' response to incentives for carbon sequestration through forest management and afforestation. Corvallis, OR: Oregon State University. 163 p. Ph.D. dissertation.

Konoshima, M.; Montgomery, C.A.; Albers, H.J.; Arthur, J.L. 2008. Spatial-endogenous fire risk and efficient fuel management and timber harvest. Land Economics. 84(3): 449–468.

Kristensen S.; Thenail, C.; Kristensen, L. 2001. Farmer's involvement in landscape activities: an analysis of the relationship between farm location, farm characteristics and landscape changes in two study areas in Jutland, Denmark. Journal of Environmental Management. 61(4): 301–318.

Langpap, C. 2006. Conservation of endangered species: can incentives work for private landowners? Ecological Economics. 57(4): 558–572.

Langpap, C.; Wu, J. 2008. Predicting the effect of land-use policies on wildlife habitat abundance. Canadian Journal of Agricultural Economics. 56: 195–217.

Mansfield, C.; Pattanayak, S.; McDow, W. 2000. What drives voluntary preservation? Significant natural heritage areas in North Carolina. Working Paper 00_002, Research Triangle Park Institute, USA. http://www.rti.org/publications/abstract.cfm?pub

Moulton, R.J.; Richards, K.R. 1990. Costs of sequestering carbon through tree planting and forest management in the United States. Gen. Tech. Rep. WO-58. Washington, DC: U.S. Department of Agriculture, Forest Service.

Nagubadi, V.; McNamara, K.; Hoover, W.; Mills, W., Jr. 1996. Program participation behavior of nonindustrial forest landowners: a probit analysis. Journal of Agricultural Applied Economics. 28: 323–336.

Newell, R.G.; Stavins, R.N. 2000. Climate change and forest sinks: factors affecting the costs of carbon sequestration. Journal of Environmental Economics and Management. 40(3): 211–235.

Plantinga, A.J. 1997. The costs of carbon sequestration in forests: a positive analysis. Critical Reviews in Environmental Science and Technology. 27(Nov): 268–278.

Plantinga, A.J.; Mauldin, T.; Miller, D.J. 1999. An econometric analysis of the costs of sequestering carbon in forests. American Journal of Agricultural Economics. 81(Nov): 812-824.

Smith, J.E.; Heath, L.S.; Skog, K.E.; Birdsey, R.A. 2006. Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States. Gen. Tech. Rep. NE-343. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 216 p.

Stavins, R.N. 1999. The costs of carbon sequestration: a revealed-preference approach. American Economic Review. 89(4): 994–1009.

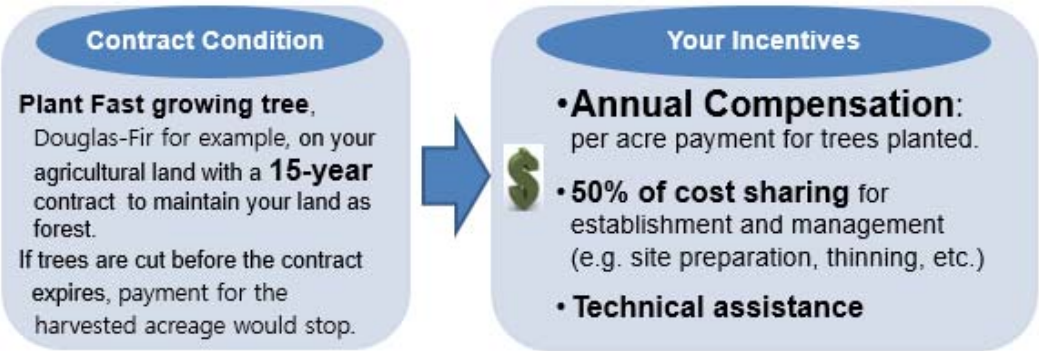
U.S. Department of Agriculture [USDA], Climate Change Program Office. 2011. U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990-2008. Technical Bulletin No. 1930. Washington, DC: Office of the Chief Economist. 159 p. http://www.usda.gov/oce/climate-change/greenhouse.htm.

U.S. Environmental Protection Agency [US EPA], Office of Atmospheric Programs. 2005. Greenhouse gas mitigation potential in U.S. forestry and agriculture, EPA 430-R-05-006. Washington, DC.

Zhou, B.; Kockelman, K.M. 2008. Neighborhood impacts on land use change: a multinomial logit model of spatial relationships. The Annals of Regional Science. 42: 321–340.

Appendix: Description of Incentive Scheme

Suppose you are offered incentives to plant **fast-growing trees** on your agricultural lands for carbon sequestration. If you agree, you would enter into a contract with a private or governmental organization. The contract would have the following conditions and incentive scheme:



Enrollment question

Step 1: Given the incentives described above, would you be willing to participate in a tree planting program for carbon sequestration?

☐ Yes, given the right incentives and conditions ⇒ If 'yes', please proceed to **next question.**

☐ No, not under any conditions ⇒ If 'no', please **go Question ___**.

Step 2: Question asking willingness to allocate agricultural land

Suppose you are offered a **<u>15 year contract</u>** for a tree planting program.

If the annual compensation level is **<u>$____</u>** per acre, on how many acres of your agricultural land are you willing to plant trees? If 'none', please answer '0 (zero)'.

Cropland: ( ) Acres, or ( ) %	Grassland: ( ) Acres, or ( ) %

↳ How about if annual compensation is **<u>$___</u>** per acre?

Cropland: ( ) Acres, or ( ) %	Grassland: ( ) Acres, or ( ) %

↳ How about if annual compensation is **<u>$___</u>** per acre?

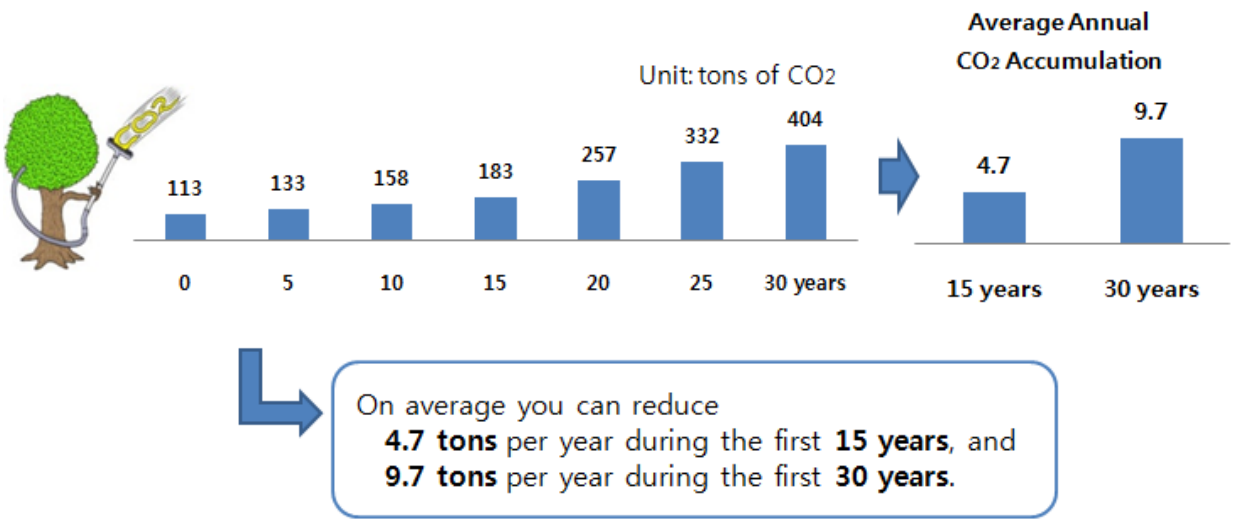
Cropland: ( ) Acres, or ( ) %	Grassland: ( ) Acres, or ( ) %

Example of Annual Compensation Calculation

If you plant Douglas-Fir in the Western Oregon and Western Washington, as the trees are growing, you can reduce CO_2 from the atmosphere.

* Global warming and climate change are being driven by the addition of carbon dioxide (CO_2) and other greenhouse gases. Carbon dioxide is the biggest culprit, producing 60percent of the human-enhanced greenhouse effect that leads to global warming (United Nations Environmental Program)

The following figure shows annual accumulation of CO_2 by planting Douglas-Fir



Source: Smith et al. 2006. USDA Forest Service.

How much can you get?

Suppose you plant Douglas-Fir on 100 acres of your agricultural land.

And suppose the contract payment for CO_2 is $10 per ton.

Then your <u>Annual</u> Compensation will be:

- **With a 15-year contract: 100 acres x 4.7 tons x $10 = $4,700**
- **With a 30-year contract: 100 acres x 9.7 tons x $10 = $9,700**

Pacific Northwest Research Station

Web site	http://www.fs.fed.us/pnw/
Telephone	(503) 808–2592
Publication requests	(503) 808–2138
FAX	(503) 808–2130
E-mail	pnw_pnwpubs@fs.fed.us
Mailing address	Publications Distribution Pacific Northwest Research Station P.O. Box 3890 Portland, OR 97208–3890

Federal Recycling Program
Printed on Recycled Paper

U.S. Department of Agriculture
Pacific Northwest Research Station
1220 SW 3rd Ave
P.O. Box 3890
Portland, OR 97208–3890

Official Business
Penalty for Private Use, $300