WILL LANDOWNERS ADOPT REFORESTATION PRACTICES? ANSWERS FROM THE MISSOURI RIVER FLOOD PLAIN

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ABSTRACT.—Reforestation of ecologically sensitive flood plain lands will depend greatly on private landowners. This paper develops several competing models that can help public agencies to predict landowner adoption of reforestation cost-share programs. Akaike's Information Criteria (AIC) is used to rank the models, based on data from a mail survey of flood plain landowners along the Missouri River. Results show that landowners who already have forested land, have already interacted with forestry agencies and are of middle age and/or family tenure status are the most likely to adopt. Such landowners may enroll up to 13 percent of Missouri River flood plain land. The challenge for forestry agencies will be to make that first contact with or plant that first tree on the land of the other, less likely landowners.

The bottomland forests in the Missouri River valley, along with its tributaries, are some of the richest and most diverse ecosystems in the world. These flood plains provide a treasure of economic and ecological values. Some of these values include mitigating the erosive nature of stream channel dynamics, improving water quality, protecting levees and other structural improvements, production of forest products, moderation of storm flow events, travel lanes for wildlife, and aquatic habitat [Malanson, 1995].

Since settlement by Europeans and pioneering Midwesterners, the extent of bottomland forests has been greatly reduced. The riparian forest corridor with its network of tributaries was severely fragmented as these forests were cleared for agricultural production and impacted by large flood control projects [Brinson et al., 1981; Turner et al., 1981; Malanson, 1995].

One problem in these flood plain forests is the recurring one of sustaining mature oaks or securing adequate regeneration in the understory. In both the public and private sectors, there is a growing interest in improving the understanding of riparian forest ecosystems and in developing management techniques that ensure the sustainability of this important resource. The U.S. Department of Agriculture's continuous Conservation Reserve Enhanced Program [Missouri Conservation Reserve Enhancement Program, 2000] focuses on riparian buffers. Riparian buffers have substantial economic value in reducing agricultural non-point source pollution in a Missouri Watershed [Qiu and Prato, 1998].

One key to reforestation of the flood plain is the private landowner who owns and farms the lands adjacent to the rivers and riparian areas. This land is particularly suited to an agroforestry system or practice. In Missouri private landowners own over 90 percent of the flood plain along the Missouri River [Missouri Resource Assessment Partnership, 2001]. At this time, there is much we do not know about their goals for ownership of this land, nor do we know whether they would be interested in adopting land management practices that incorporate trees in flood plain areas. Recent research has shown that farmers will elect to plant a buffer unless the net crop price is high or the land rental rate is low. The choice of buffer type, trees or grass, is affected by crop price, farm size, relative incentive payments, relative cost share rates, and amount of deer damage [Lynch and Brown, 2000]. The economics of restoring private lands to forests can only continue to gain in importance. Landowners can derive periodic income from timber production. In addition, annual income from hunting leases or carbon credits may also be available to some landowners [Stanturf et al., 2000].

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To improve our understanding of the factors that will influence landowners and managers to adopt reforestation practices in flood plain areas and to better understand landowners' knowledge, motivation and behavior, we developed a survey directed to flood plain landowners. Our goal was to develop and evaluate models that can help public land management agencies and others to predict which landowners will adopt reforestation practices and at what cost-share levels. This information will help these agencies to develop and target programs and determine what these programs will cost and how much land they will influence.

Methods

A "Behavior Survey" was designed, tested and administered to a group of Missouri River flood plain landowners. This survey included questions about how respondents currently manage their land, what forest management practices (if any) they employ, whether they have a management plan and, if so who helped them develop it, and whether at various cost-share levels they would enroll in a flood plain reforestation program. In addition there were questions about long- and short-term goals and opinions of the forestry services received from different government agencies. There were also a set of demographic questions on age, gender and income. This set also included questions on land tenancy and land characteristics [Treiman and Dwyer, 2002].

Flood plain land outside the levee in thirteen counties bordering the Missouri River was chosen as the study area, representing 49 percent of the Missouri River's flood plain in Missouri [Missouri Department of Conservation, 2001]. Using available GIS coverages [Missouri Resource Assessment Partnership, 2001] we estimated the overall ratio of flood plain land to land owned. A complete list of flood plain landowners, private, corporate and public, in these 13 counties was developed from courthouse records and from aerial photographs. The list included the names of six-hundred and thirty-three names of private landowners. Of these, five-hundred twenty qualified as current landowners with land outside the levee. About one-half of these, 260, received the "Behavior Survey" and the other half received a separate "Knowledge Survey", designed to address other issues not addressed in this paper [Treiman and Dwyer, 2002]. The survey was administered using techniques and methods described by Dillman [2000]. In this paper, we shall consider the results of the "Behavior Survey".

We developed a set of *a priori* logistic models that might explain a landowner's decision to enroll in a hypothetical flood plain reforestation cost-share program. These models include demographic, knowledge and current behavior variables. (See Table 1.) The *a priori* models were developed to help design a future cost-share program and to predict who would enroll and how many acres would be enrolled. The resource management agency can also use the results to help target the program either towards the most likely enrollees or to try to help turn unlikely landowners into likely ones.

The variables of interest were those that might be easily identifiable by, or particularly useful to, program managers and planners. These included knowledge of forestry/land management and behavior: such as having a forest management plan, managing for wildlife or timber, or having trees on their land. Also included were a set of demographic variables: age, gender, income, tenancy and size of ownership that may help program managers target their work. Program managers and planners, as well as county-level state forestry agents have access to much of this data in Missouri, whether from county courthouse land ownership records and maps, lists of state forestry agency landowner contacts, records of other cost-share programs and so on.

We began with a demographic model, which included only age, gender and income, and then developed further *a priori* models to test whether the more forestry-specific parameters could help decision-makers design a better reforestation program. Age and gender might affect long-term commitment to the land [Olmstead and McCurdy, 1989]. Both Ervin and Ervin [1982] and Cooper and Keim [1996] have found that "orientation to farming" and experience affect policy adoption. Income, or the size of their ownership, might affect the landowner's ability to meet the landowner's part of the cost-share [Ervin and Ervin, 1982; Olmstead and McCurdy, 1989]. Length of tenancy and

Table 1.—A priori models with their underlying hypotheses and notation. These models were developed to explain and predict landowners' adoption of the proposed reforestation cost-share programs. The models were designed to provide potentially useful input to decision makers considering and designing such programs.

Hypothesis	Model Structure
1. Demographic Model: Age, Gender, and Income	$(x) = \beta_0 + \beta_1 A + \beta_2 G + \beta_3 I$
2. Forest Plan and Demographic	$\gamma(x) = \beta_0 + \beta_1 F + \beta_2 A + \beta_3 G + \beta_4 I$
3. Having Trees and Demographic	$\gamma(x) = \beta_0 + \beta_1 H + \beta_2 A + \beta_3 G + \beta_4 I$
4. Current Management and Demographic	$\gamma(x) = \beta_0 + \beta_1 C_t + \beta_2 C_w + \beta_3 A + \beta_4 G + \beta_5 I$
5. Length of Tenancy, Having Trees and Demographic	$\gamma(x) = \beta_0 + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3 + \beta_4 T_4 + \beta_5 H + \beta_6 A + \beta_7 G + \beta_8 I$
6. Length of Tenancy, Having Trees, Forest Plan and Demographic	$\gamma(x) = \beta_0 + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3 + \beta_4 T_4 + \beta_5 H + \beta_6 F + \beta_7 A + \beta_8 G + \beta_9 I$
7. Length of Tenancy, Having Trees, Forest Plan, Size of Ownership and Demographic	$\gamma(x) = \beta_0 + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3 + \beta_4 T_4 + \beta_5 H + \beta_6 F + \beta_7 S + \beta_8 A + \beta_9 G + \beta_{10} I$
8. Size of Ownership and Demographic	$\gamma(x) = \beta_0 + \beta_1 S + \beta_2 A + \beta_3 G + \beta_4 I$
9. Having Trees and Income	$\gamma(x) = \beta_0 + \beta_1 H + \beta_2 I$
10. Having Trees and Age	$\gamma(x) = \beta_0 + \beta_1 H + \beta_2 A$
11. Having Trees	$\gamma(x) = \beta_0 + \beta_1 H$
12. Having Trees, Forest Plan and Age	$\gamma(x) = \beta_0 + \beta_1 F + \beta_2 H + \beta_3 A$
13. Having Trees, (Future) Tenancy and Age	$\gamma(x) = \beta_0 + \beta_1 H + \beta_2 T_4 + \beta_3 A$
14. Having Trees and Forest Plan	$\gamma(x) = \beta_0 + \beta_1 H + \beta_2 F$

Where the cumulative probability of enrollment at cost level *j*, is:

$$P(Y \le j \mid \mathbf{x}) = e^{\gamma(x)} / (1 - e^{\gamma(x)}),$$

and Y, the observed response (yes/no) to the hypothetical program at cost *j*, depends on the vector **x**, which contains a subset of the variables:

A	=	Age, ordinal variable (1 to 5)
G	=	Gender, categorical variable (1, 0) where 1 = "Male"
I	=	Income, ordinal variable (1 to 4)
F	=	Has Forest management plan, categorical variable (1, 0), where 1 = "Yes"
H	=	Having trees on land now, categorical variable from the landowners response (1, 0), where 1 = "Yes"
C_t	=	Managing for timber, categorical variable (1, 0) where 1 = "Yes"
C_w	=	Managing for wildlife, categorical variable (1, 0) where 1 = "Yes"
T_1	=	Tenancy of current owner, ordinal variable (1 to 4) where 1 = <5 years, 2 = 5 to 15, 3 = 15 to 25 and 4 = >25 years
T_2	=	Tenancy of family, ordinal variable (1 to 5) where 1 = <5 years, 2 = 5 to 15, 3 = 15 to 25, 4 = 25 to 50, and 5 = >50 years
T_3	=	Live on this land, categorical variable (1, 0) where 1 = "Yes"
T_4	=	Likelihood of future tenancy of family, ordinal variable (1 to 4) where 1 = "Very unlikely", 2 = "Unlikely", 3 = "Likely", and 4 = "Very likely"
S	=	Size of ownership, ordinal variable (1 to 4) where 1 = <520 acres, 2 = 20 to 80, 3 = 80 to 160, 4 = 160 to 320, and 5 = >320 acres

and β_0 is a vector of intercepts for each of the four cost-share levels, coded as ordinal variables (1 to 4) where 1=$50/acre cost *to* the landowner, 2=$125, 3=$175 and 4=$250.

residence (whether absentee or resident) might also affect commitment to a cost-share program [Lynch et al., 2002]. If a landowner already has a forest management plan, or already manages the land for timber or wildlife, this may indicate a greater willingness to commit to a long-term reforestation program [Marty et al., 1988]. Finally, models were evaluated to determine which combinations of parameters would provide the best predictions. We limited our analysis to the 14 models we judged most useful and for which we had a sufficiently large dataset to allow comparison across models using Akaike's Information Criteria (AIC).

The inferences that we wish to make from our survey depend on having a meaningful model. An information-theoretic approach consists of the science and objective based development of *a priori* models. This set of candidate models allows researchers to avoid data dredging, over-fitting and the rush to hypothesis testing [Burnham and Anderson, 1998]. AIC has developed into a tool to estimate the best approximating model (from the candidate set) and allows the researcher to explicitly look at model selection uncertainty [Akaike, 1973; Burnham and Anderson, 1998].

Following Anderson et al. [2000] and Burnham and Anderson [1998], we proceed from multiple working hypotheses, through multiple testing to seek the hypothesis that loses "as little information as possible about the truth" [Anderson et al. 2000]. To achieve this we used Akaike's Information Criteria [Akaike, 1973], adjusted for small sample sizes (AIC_c) as the basis for ranking models. The response variable in these models is the cost-share level (cost/acre *to* the landowner) coded as a polychotomous ordered variable. Several of the independent variables are also coded as ordinal categorical variables [McCullagh and Nelder, 2001].

Each respondent was asked, in addition to all the other items, whether they would enroll in a cost share program at each of four different levels (i.e. four questions per respondent), using the following language:

> "Hardwood bottomland forest restoration involves the planting of specially selected and grown trees such as black walnut, swamp white oak, bur oak and others. These species have potential for **high commercial timber value** on a 60-80 year rotation and also provide **annual value** as the source of other forest products, such as nuts. These trees also provide food and habitat for wildlife and help soil conservation. The trees are planted on raised beds if necessary, fertilized and use fiber-based mats to control weeds. There is also the opportunity to interplant other annual **revenue** producing crops, such as red top clover, with the trees.
>
> To encourage this forest restoration, the State of Missouri is considering developing different programs to encourage bottomland owners to participate. These potential programs all plant the same trees. They differ only in the cost share between you and the state.
>
> Please read the four <u>potential</u> programs and indicate whether or not you would enroll in each one, and, if so, how many acres you would enroll."
>
> A) Professional advice, planning and trees are provided free of charge. Tree planting and maintenance are paid on a cost share of 10% (you)/90% (state).Your estimated cost: $50 per acre. Would you enroll? Yes....• No...•
>
> B) Professional advice, planning and trees are provided free of charge. Tree planting and maintenance are paid on a cost share of 25% (you)/75% (state).Your estimated cost: $125 per acre. Would you enroll? Yes....• No...•
>
> C) Professional advice, planning and trees are provided free of charge. Tree planting and maintenance are paid on a cost share of 35% (you)/65% (state).Your estimated cost: $175 per acre. Would you enroll? Yes....• No...•
>
> D) Professional advice, planning and trees are provided free of charge. Tree planting and maintenance are paid on a cost share of 50% (you)/50% (state).Your estimated cost: $250 per acre. Would you enroll? Yes....• No...•

The four levels were $50, $125, $175 and $250 cost /acre to the landowner (i.e. at the $50 level the landowner pays less per acre than at the $125 level) with the remainder of the cost being born by the program. The cost levels were based on costs observed at a flood plain reforestation trial along the Missouri River using root propagation method seedlings, mounding and weed control [Dey et al, 2001; Treiman personal communication]. We would expect more landowners to enroll at successively

Table 3.—The maximum likelihood parameter estimates of Model #10: $\gamma(x) = \beta_0 + \beta_1 H + \beta_2 A$, where H=Have Trees and A=Age.

Parameter[1,2]	Estimate	Standard Error	Wald Chi-Square	Pr>ChiSq
$\beta_{0\ \text{Cost-share=\$250}}$	-3.96	0.75	27.83	<.0001
$\beta_{0\ \text{Cost-share=\$125}}$	-2.97	0.67	19.64	<.0001
$\beta_{0\ \text{Cost-share=\$50}}$	-1.77	0.61	8.39	0.003
$\beta_{1\ \text{Have trees}}$	1.45	0.63	5.25	0.021
$\beta_{2\ \text{Age 20-35}}$	-0.57	0.80	0.50	0.479
$\beta_{2\ \text{Age 36-50}}$	1.11	0.51	4.77	0.028
$\beta_{2\ \text{Age 51-65}}$	0.28	0.40	0.48	0.485

[1]No estimate was produced for cost-share level $175. All respondents who would adopt at that level also reported that they would adopt at $250.
[2]The parameter for Age 65 and over is a linear combination of the parameters for the other age variables (dummies). No responses were observed for Age less than 20 (i.e. no responding landowners in our mailing were younger than 20).

higher levels of cost-share assistance. Analysis was based on a logit function, using these four levels. This produces four separate "intercepts" or constants, one for each cost-share level. Parameter estimates and AIC values were thus calculated by using PROC LOGISTIC [SAS Institute, 2001].

Results

The response rate for the "Behavior" surveys was 51.2 percent after two mailings [Treiman and Dwyer, 2002], for a total N=133. Model ranking methods, however, required that only those surveys in which the respondents chose to answer *all* the questions which were involved in all 14 of the competing models be included in the analysis, yielding N=81. A smaller AIC_c statistic is more indicative of a parsimonious model. The results of the AIC_c ranking are listed below in Table 2. This table also reports the distance between the AIC_c and the minimum AIC_c (ΔAICc) and the Akaike weights (T) of the AIC_c statistics, representing the predictive likelihood between models. In our model construct, models with AIC_c that are more than four units lower than other models are preferred [Burnham and Anderson, 1998].

In Table 2, the five highest ranked models (models #10, 13, 11, 12 and 14) were within <4 ΔAIC_c units of the each other [see Burnham and Anderson, 1998, page 123; Buckland et al., 1997]. These models must also be considered competing models because of the uncertainty in estimates of model precision (that is, the small differences in AIC_c are not enough to say with certainty that one model outperforms another). All five of these models rely on whether the land already has trees. Age is contained in three of the models. Two models include the presence of a management plan. The reported likelihood of continued (future) tenancy appears in one model.

The highest ranked model (model #10) relies only on whether the land already has trees (defined as answering "Yes" to having forest, timber or wood lots on flood plain land) and the landowner's age, described by an ordinal categorical variable. Coding age in this way allowed for the exploration of non-linear effects of age upon adoption. The parameter estimates for this model are found in Table 3.

Table 3 shows the differing intercepts ($\beta_{0\ \text{cost-level}}$) for each of the cost-share levels. These intercepts decrease from the lowest cost-share level, $50/acre cost to the landowner, to the highest, $250/acre. This matches our expectation that lower cost to the landowner will result in acres enrolled. Note that all landowners who responded that they would enroll at a cost of $175/acre to themselves would also enroll at $250/acre.

The parameter estimate for "Having trees" ($\beta_{1\ \text{have trees}}$) is positive. Landowners who already have some forested land, wood lots, interplantings, or other trees on their flood plain land are more likely to

Table 2—Model selection results and ranking, using the Akaike Information Criteria adjusted for small sample sizes (AIC_c). K is the number of parameters in each model (including the constant for each of the 4 cost levels). ΔAICc represents the difference of each model from the model with the lowest AICc and T is the Akaike weight, calculated as $\exp(-\frac{1}{2}\Delta_i)/\sum_{r=1}^{14}\exp(-\frac{1}{2}\Delta_r)$ for each model i in the set of 14 models. These weights represent the likelihood that a model is the best model in the set of models. The model number refers to the more complete description of the model found in Table 1.

Hypothesis	Model #	K	AICc	ΔAICc	T
Having Trees and Age	10	4	167.393	-	0.326
Having Trees, (Future) Tenancy and Age	13	5	167.555	0.16	0.300
Having Trees	11	1	168.803	1.41	0.161
Having Trees, Forest Plan and Age	12	5	169.461	2.07	0.116
Having Trees and Forest Plan	14	4	170.619	3.23	0.065
Having Trees and Income	9	4	173.869	6.48	0.014
Having Trees and Demographic	3	8	175.981	8.59	0.013
Demographic Model: Age, Gender, and Income	1	7	179.838	12.44	0.004
Current Management and Demographic	4	9	181.574	14.18	0.001
Forest Plan and Demographic	2	8	182.062	14.67	0.000
Length of Tenancy, Having Trees and Demographic	5	19	187.223	19.83	0.000
Length of Tenancy, Having Trees, Forest Plan and Demographic	6	20	187.835	20.44	0.000
Length of Tenancy, Having Trees, Forest Plan, Size of Ownership and Demographic	7	24	198.081	30.69	0.000
Size of Ownership and Demographic	8	22	198.498	31.10	0.000

enroll. The parameter estimates for the effects of age ($\beta_{2\ \text{age range}}$) show that "middle-aged" landowners (ages 36-50) are the most likely to enroll. Being younger than 35 actually has a negative effect.

Discussion

Elsewhere, Treiman and Dwyer [2002] used data from both the "Knowledge" and "Behavior" surveys to predict that at the lowest cost-share level ($50/acre to the landowner), up to 13 percent of Missouri River flood plain land would be enrolled in a reforestation cost-share program. A total enrollment of 8,600 acres, at cost of $1.7 million to the sponsoring agency, was predicted. But this ranking of competing models allows decision makers to see just who those potential enrollees are, and, more importantly, who they are not.

The only variable to appear in all five competing models (models #10, 11, 12, 13 and 14) is whether or not the landowner's flood plain land already has forest, timber or wood lots on flood plain land. These owners have trees on *some* of their land but may be interested in enrolling in the hypothetical cost-share program in order to reforest other land. Having trees on the land is important for two reasons. First, it may indicate that the landowner already has an interest in forestry, even if this interest is only passive. Second, it may indicate that the landowner is not solely interested in row crops.

In Treiman and Dwyer's separate "Knowledge" survey, row crops were identified by the average survey respondent as both their most important short-term and long-term goal, with an average ranking of 4.1 on a scale of 1 (Not Important) to 5 (Very Important). However, landowners with trees ranked row crops lower (3.9), than those without trees on their flood plain land (4.4), although this result is not significant at the 95% level [Treiman and Dwyer, 2002].

Whether or not the landowner has developed a forest management plan was the only variable related to current management practices included in any of the competing models. Having a forest management plan increased the likelihood of adoption across all cost-share levels. However, only 9 percent of Missouri River flood plain landowners report having such a plan [Treiman and Dwyer, 2002]. These landowners hold about 4,570 acres of the 71,400 private Missouri River flood plain acres outside the levee. For the most part these landowners have, when developing their plan, worked with State, Federal or University-Extension foresters, with over 63 percent reporting such contact. In the "Knowledge" survey, those landowners also reported a favorable experience when working with those foresters, ranking the quality of forestry service received at an average of 3.5 on a scale of 1 (Poor) to 5 (Excellent) [Treiman and Dwyer, 2002].

Age is the only variable from the original demographic model to remain in the set of competing models. Neither income nor gender proved to be particularly useful as a predictor of adoption. The landowner's age affects the likelihood of adoption of reforestation practices in a non-linear manner, with landowners between 36 and 50 being more likely to adopt than either younger or older landowners. Another demographic variable, the reported likelihood that the land would remain in the respondent's family into the future, also appears in one of the competing models. The more likely the respondent thought that the land would remain in the family, the more likely they were to say that they would adopt the cost-share program.

Data on all of these predictive variables are available to program managers and planners, as well as county-level state forestry agents. County-level foresters know which land in their counties is already in trees. Program managers know who already has a management plan (in Missouri these plans are co-signed by the state forestry agency). Landowner age is, of course, confidential but could be "eye-balled" by the forester.

None of the other variables included in the original 14 models proved to be of much predictive value. It did not seem to matter how landowners were currently managing their land. Neither did the size of their ownership nor the length of their tenancy enter into any of the final five competing models.

Conclusions

The landowner most likely to enroll his/her land in even the most generous flood plain reforestation cost-share program is the landowner who already has trees and who has already worked closely enough with forestry agencies to have developed a forest management plan. The likeliest landowner is also middle-aged, perhaps with enough time to have settled down but also with enough of his/her lifetime remaining to commit to the long-term nature of forestry. This landowner also believes that his/her land will stay in his/her family into the future, so that his/her family will be there to enjoy the long-term benefits of reforestation as a bequest.

The hypothetical cost-share programs we have described to the survey respondents turn out to be most attractive to those who are or should already be the best clients of state, federal or university-extension forestry agencies. With the passage of the 2002 Farm Bill, significant new funding will be forthcoming to provide technical and financial assistance to landowners [United States Department of Agriculture, 2002]. This new funding would be most effective if directed towards these most likely adopters.

The only variable in the five competing models that is in any way under the control of state, federal or university-extension forestry agencies is the forest management plan. This is the opening by which these agencies can get people involved in making forest management decisions about their property. The challenge for forestry agencies interested in sustaining mature flood plain forests and securing adequate regeneration (natural or artificial) in the flood plain will be to go beyond the 13 percent of land that we predict would be enrolled in these hypothetical cost-share programs. The results of this survey show that state agencies must make that first, positive contact with the "unlikely" landowners, transforming them into "likely" landowners. The can lead to the development of a forest management plan and enrollment in a cost-share program. If that first tree is planted (or preserved) on row crop land, it can help turn that unlikely adopter into a likely adopter. Dedicating agency staff and resources to these contacts is vital, as is training staff to make that first contact a success. The questions remains, however; if unlikely landowners are converted into likely ones, where will state agencies find the funding and personnel to expand their cost-share programs?

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