NORTHERN ARIZONA UNIVERSITY
The W. A. Franke College of Business

Estimating Flagstaff Residents Willingness to Pay for Forest Restoration in the Lake Mary and Upper Rio de Flag Watersheds: A Pilot Study

Working Paper Series—12-06 | October 2012

Corresponding Author:

Julie Mueller
Assistant Professor

Northern Arizona University
The W. A. Franke College of Business
PO Box 15066
Flagstaff, AZ 86011.5066

Julie.Mueller@nau.edu

(928) 523-6612

Fax: (928) 523-7331

Acknowledgements

The author would like to thank the Ecological Restoration Institute, the Northern Arizona University Faculty Grants Program, The W.A. Franke College of Business, and the City of Flagstaff Utilities for support of this project. The author would also like to thank the Flagstaff Water Commission for valuable input during focus groups. Abe Springer provided research insight and facilitated focus groups. Sharon Masek-Lopez, Erik Nielsen, and Wes Swaffar provided valuable input. Reviewers for The W.A. Franke College of Business working paper series provided insightful comments. In addition, Ron Klawitter, Clint Basham, and Chanda Durnford provided excellent research assistance. All remaining errors are the sole responsibility of the author.

Estimating Flagstaff Residents Willingness to Pay for Forest Restoration in the Lake Mary and Upper Rio de Flag Watersheds: A Pilot Study

1. Introduction

Ecological restoration can play a pivotal role in restoring forest health and mitigating catastrophic wildfire potential [Allen et al. 2002]. The Four Forest Restoration Initiative [4FRI], seeks to restore over 970,000 hectares of Ponderosa pine forests across four National Forests in Arizona. Restored forests maintain a more resilient structure that encourages natural surface fire regimes, discourages tree seedling recruitment, overstocking and the consequent threat of stand-replacing wildfire [Mast 2003]. After treatment areas are initially thinned, maintaining this forest condition requires follow-up management such as frequent burning or restoration monitoring.

Without large-scale intervention, fire suppression and rehabilitation costs will continue to grow, impeding the ability to maintain forest conditions into the future [Covington 2000, Daugherty and Snider 2003]. Costs, however, remain a significant barrier to restoration. Despite high restoration costs and the scale of the challenge, numerous economic analyses confirm that it is more cost-effective to restore forests than to pay the costs associated with severe wildfire [Wu et al. 2011, Daugherty and Snider 2003, Berry 2010]. Funding exists for the intial treatment for 4FRI, however future funding for monitoring and maintenance is uncertain.

The purpose of the study is to estimate Willingness to Pay (WTP) for forest restoration in the Lake Mary and Upper Rio de Flag watersheds. The 4FRI landscape-scale restoration initiative plans to restore all of the ponderosa pine forests in the Lake Mary watershed and 11,500 acres in the Rio de Flag watershed. Both the Lake Mary and Upper Rio de Flag watersheds provide municipal water for residents of Flagstaff, Arizona. Thus, Flagstaff residents are key beneficiaries of the restoration both through reduced catastrophic wildfire and consequent flood risk, and potential increases in the quantity and quality of their municipal water supply. Our study contributes to the current body of research about the benefits of watershed services in several ways. First, while previous studies have estimated the WTP for various water-related ecosystem services, few studies have estimated the non-market value of additional water-related ecosystem services following a change in vegetation management, such as forest restoration. In addition, our study investigates residential water users' WTP in the arid Southwest.

2. Methods

The Contingent Valuation method [CV] is a stated preference method of non-market valuation where respondents are asked to state their preferences for an environmental good or service that is not bought and sold in traditional markets. Many CV studies, including the one presented here, apply the dichotomous-choice elicitation format as recommended by Carson et al. [2003]. The Dichotomous-Choice CV method involves sampling respondents and asking if they would vote in favor of a referenda and pay a particular randomly assigned dollar amount.

Similar studies using CV have estimated values of non-market water-related ecosystem services. Loomis [1996] used CV to find a WTP of $73 annually among Washington residents for dam removal and restoration of ecosystem services and the associated fishery on the Elwha River. Pattanayak and Kramer [2001] used CV to estimate drought mitigation services provided by tropical forested watersheds in Ruteng Park, Indonesia. Loomis et al. [2000] used CV to estimate the value of five water-related ecosystem services on the Platte River in Colorado and found a WTP of $252 annually per household.

a. Sample selection, Focus Group, and Survey Design

Addresses were obtained from the City of Flagstaff utility records. Addresses were chosen at random from the city records ensuring a spatially representative sample. A focus group was held with the Flagstaff Water Commission to test and validate the survey instrument. A draft of the survey was distributed at a monthly Water Commission meeting. Attendee's recommendations were used to guide the survey design.

Data were obtained from a Dichotomous-Choice Contingent Valuation survey of Flagstaff city residents. The survey was designed using the Dillman Tailored Design Method [Dillman 2007]. A random sample of single family residences were sent a signed cover letter, colored survey booklet, and a return envelope. A reminder postcard was sent, and non-respondents received a second mailing of the survey booklet.

Because obtaining accurate estimates requires detailed descriptions of the resources being valued and the contingencies in question [Loomis et al. 2000], the first section of the survey included a watershed map and diagrams of three different watershed condition scenarios [see Figures 1 and 2]. Diagrams displayed three watershed conditions: "Current watershed condition," "Restored Watershed Condition" and "Watershed Condition Following Wildfire" and the hydrologic responses associated with each watershed condition. Following these diagrams were attitudinal questions about forest restoration, water supply and the WTP question. The last section included demographic questions and solicited respondent's comments.

Figure 1: Map of Watershed

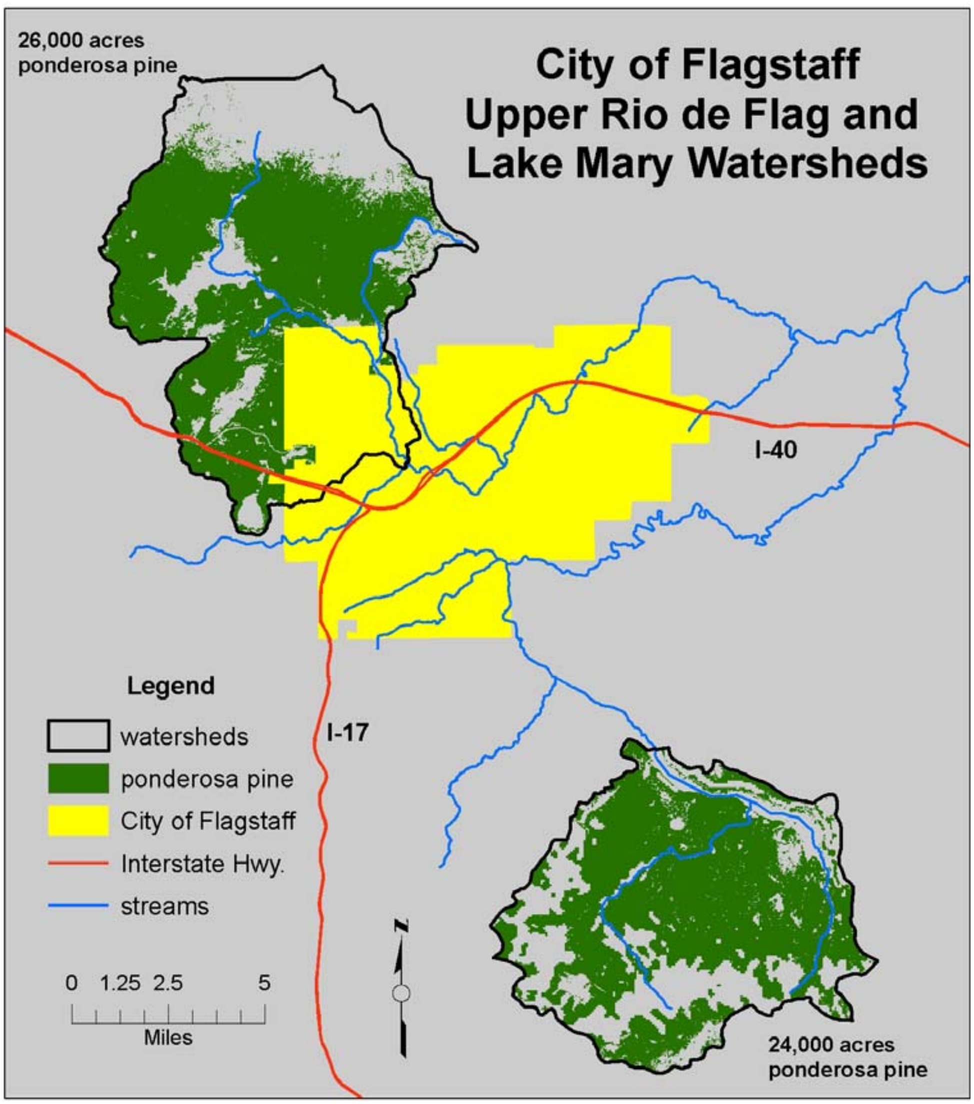
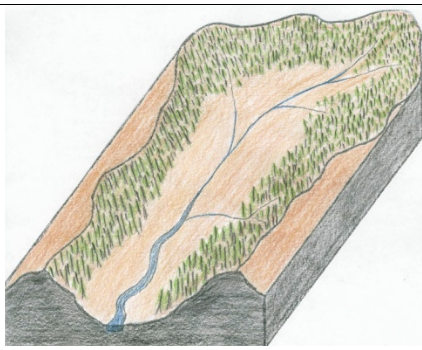
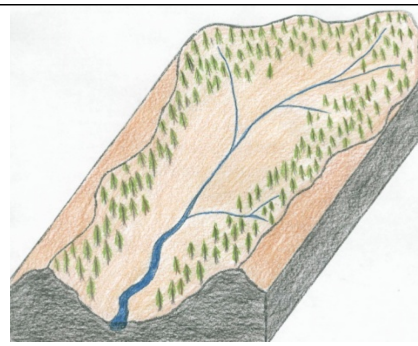
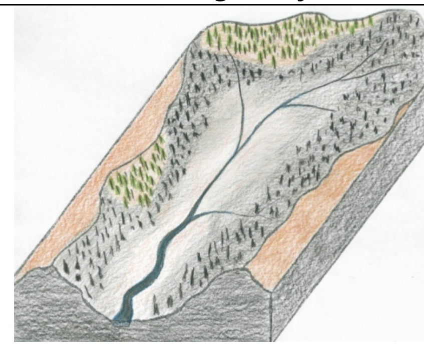


Figure 2: Watershed Conditions Diagram

Consider the following watershed conditions and how they impact water supply.

Current Watershed Condition	***Restored Watershed Condition***	***Watershed Condition Following Wildfire***
		
• Limited water yield • Reduced groundwater recharge • Reduced water quality • High risk of catastrophic wildfire • Present day flows • Low flood risk in unburned areas	• Enhanced water yield • Enhanced groundwater recharge • Enhanced water quality • Reduced risk of catastrophic wildfire • Improved spring snowmelt flows • Reduced flood risk	• Irregular water yield • Restricted groundwater recharge • Highly reduced water quality • Increased sedimentation • Potential loss of Lake Mary as a water source • Potential of unprecedented flood events in Flagstaff

The WTP question read as follows:

"Suppose the City of Flagstaff is to propose a referendum requiring residential water users to pay a monthly fee on their water bill. By law, all funds would go directly to monitoring and maintaining the forest health of the Lake Mary and Upper Rio de Flag watersheds.

If the water user contribution program were to cost you an additional X $ per month, would you vote in favor of the referenda?"

where "X" equals a random bid amount inserted into surveys. Bid amounts ranged from $1 to $20, weighted with higher frequencies from $1-$8 and lesser frequencies from $9-$20. Bid amounts were selected based on suggestions from the focus group session.

After the WTP question, respondents were asked to rank their certainty of their response on a scale of 1 to 10, where 1 is "Not at all certain" and 10 is "Completely certain." A large body of research exists on reducing hypothetical bias by using certainty responses [Champ and Bishop, 2000]. Hypothetical bias occurs when responses to hypothetical contingent valuation questions do not elicit true values. That is, hypothetical bias occurs when respondents answer a hypothetical question in a way that is inconsistent with their actual behavior. While respondent uncertainty results in hypothetical bias, little theoretical guidance exists in explaining why respondents are uncertain [Akter et. al., 1999]. To investigate hypothetical bias, Champ and Bishop [2000] performed a split sample experiment where some respondents were asked their WTP to invest in wind energy for one year, while others were offered a hypothetical opportunity. Champ and Bishop [2000] found evidence of hypothetical bias—the WTP of the respondents with the hypothetical opportunity was higher than those with the actual investment opportunity. However, when respondents who were less certain of their answer to the hypothetical WTP question were coded as voting "no," the hypothetical bias was eliminated. Therefore, we choose to follow the approach suggested in Champ and Bishop [2000], and applied by Li et al [2009].

b. Method of Estimation

We estimate the WTP function with a standard probit model. Following Cameron and James [1987] The standard probit model is based on the assumption of an underlying WTP function

[1]

$$WTP_i = x_i'\boldsymbol{\beta} + \mu_i$$

where x_i is a vector of explanatory variables, β is a vector of estimated coefficients, and μ_i is a random error term. The WTP function is not observable to the researcher, yet latent WTP is represented by the respondents' "vote" on the WTP question. Let y_i represent the respondent's vote, =1 if "yes" and 0 if "no." Assume μ_i are independent and normally distributed with a mean 0 and standard deviation σ, and Bid_i is the randomly assigned bid amount for each respondent *i*. The probability of a "yes" vote given the explanatory variables and random error is equal to the probability that the individual's unobserved WTP is greater than the bid amount. Therefore,

[2]

$$\Pr(y_i = 1|x_i) = \Pr[\mathrm{WTP_i} > \mathrm{Bid_i}]$$

$$= \Pr[x_i'\beta + \mu_i > \mathrm{Bid_i}]$$

$$= \Pr[\mu_i > \mathrm{Bid_i} - x_i'\boldsymbol{\beta}]$$

$$= \Pr(z_i > [\mathrm{Bid_i} - x_i'\boldsymbol{\beta}) / \sigma]$$

where z_i is the standard normal random variable and σ is a variance parameter. The standard probit model with *n* observations thus has the likelihood function:

[3]

$$\log\mathrm{L} = \sum_{\mathrm{i=1}}^{\mathrm{n}} \left\{\mathrm{WTP_i} \log\left[1 - \Phi\left(\frac{\mathrm{Bid_i} - x_i'\boldsymbol{\beta}}{\sigma}\right)\right] + [1 - \mathrm{WTP}]_\mathrm{i} \log\left[\Phi\left(\frac{\mathrm{Bid_i} - x_i'\boldsymbol{\beta}}{\sigma}\right)\right]\right\}.$$

We use Maximum Likelihood estimation to estimate the standard probit model.

3. Results

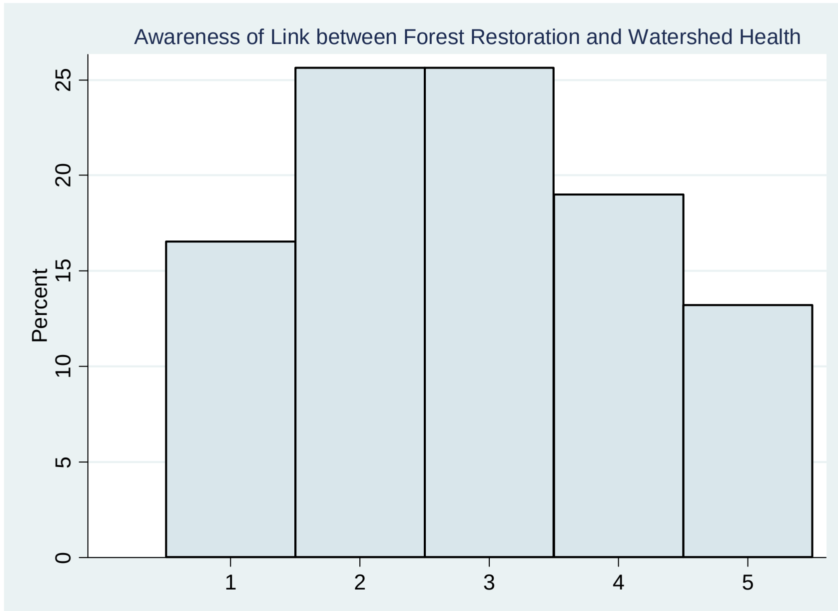
a. Response Rate

490 surveys were mailed with 120 responses and 48 undeliverables, resulting in a response rate of 24%.

b. Respondent Attitudes Toward Forest Restoration

Respondents were asked, "Prior to this survey, were you aware of the Four Forests Restoration Initiative?" 33.% of respondents were aware of the 4FRI initiative. We also asked respondents about their awareness of the link between forest restoration and watershed health. On a scale of 1 to 5, where 1 is "Not at All Aware" and 5 is "Very Aware," the mean value was 2.9. Figure 3 shows the distribution of respondent answers. Our results show that most of our respondents consider themselves at least "Somewhat Aware" of the link between forest restoration and watershed health.

Figure 3:



Respondents were asked, “Considering the full range of issues you face, how important is watershed health to you? On a scale of 1 to 5, where 1 indicates “Not Important” and 5 indicates “Extremely Important”, circle one.” The mean response was 3.97, indicating that watershed health is a high priority for our respondents. Figure 4 shows the distribution of responses.

Respondents were also asked, “Considering the full range of issues you face, how important is wildfire prevention to you? On a scale of 1 to 5, where 1 indicates “Not Important” and 5 indicates “Extremely Important”, circle one.” Responses are shown in Figure 5. The mean response was 4.52, indicating that wildfire prevention is a high priority for our sample.

Figure 4:

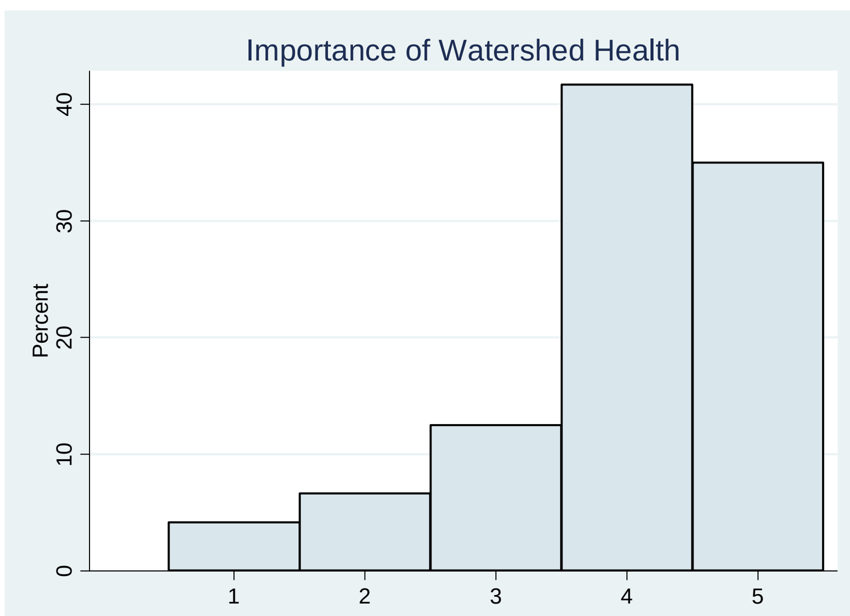
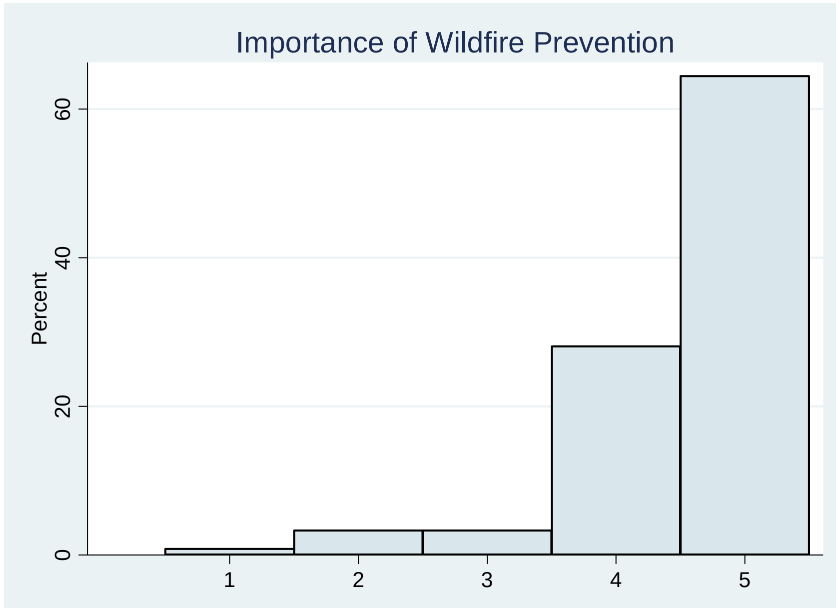


Figure 5:



Respondents were also asked to to indicate how concerned they are about threats to the Lake Mary and Upper Rio de Flag Watersheds including:

- Catastrohpic Wildfire
- Drought
- Flooding
- Global Climate Change

On a scale of 1 to 5, where 1 indicates "Not at All Concerned" and 5 indicates "Extremely Concerned," respondents are the most concerned about wildfire and drought. Table 1 shows the summary statistics for respondent concern about threats to the watersheds. 50% of our respondents consider themselves affiliated with the Democratic party. The average income is in the category $60,000-$79,999. Household income is shown in Figure 6.

Table 1: Summary Statistics for Attitudinal Variables

Variable	Mean	Std. Dev.	Min	Max
Wildfire	4.45	0.80	1	5
Drought	4.46	0.74	1	5
Flooding	3.23	1.16	1	5
Global Climate Change	3.55	1.34	1	5

c. Respondent Certainty

Respondents were asked, "On a scale of 1 to 10, with 1 being not at all certain and 10 being completely certain, how certain of you to your answer" to the WTP question. 70% of respondents chose a Certainty level of 8 or above on their answer to the WTP question. See Figure 7 for the distribution of respondent certainty on the WTP question. We follow the approach outlined in Champ and Bishop [2000] discussed above and re-code responses with a certainty level of 7 or less as "No" votes on the WTP question to reduce hypothetical bias.

Figure 6:

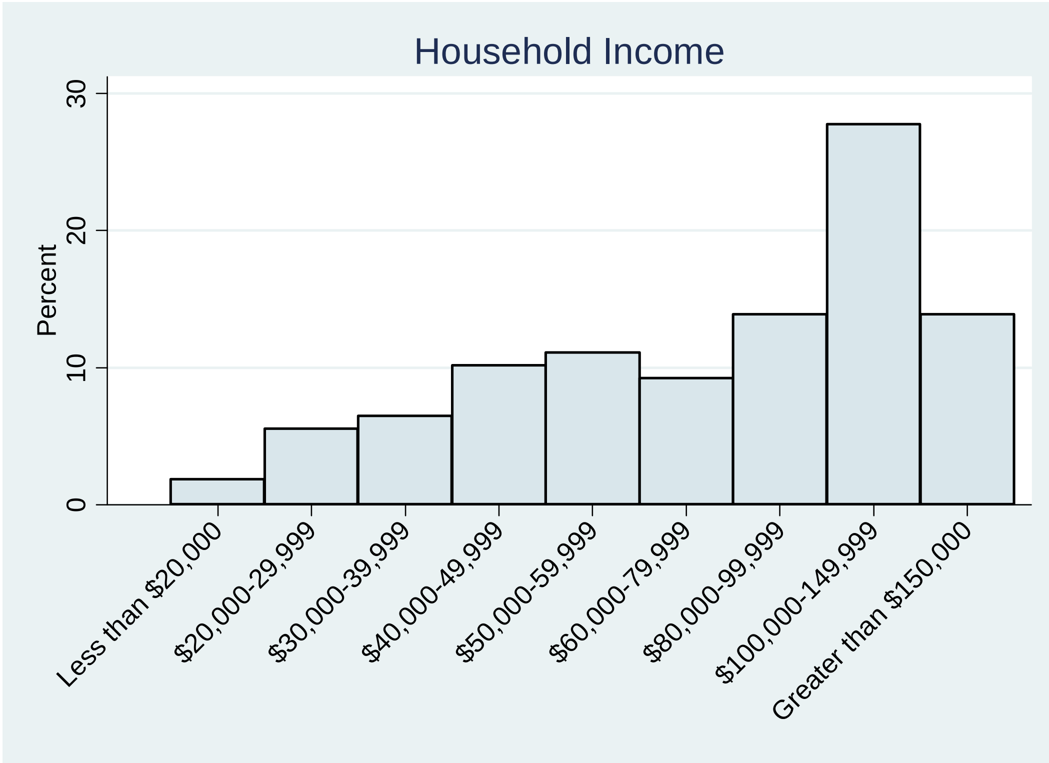
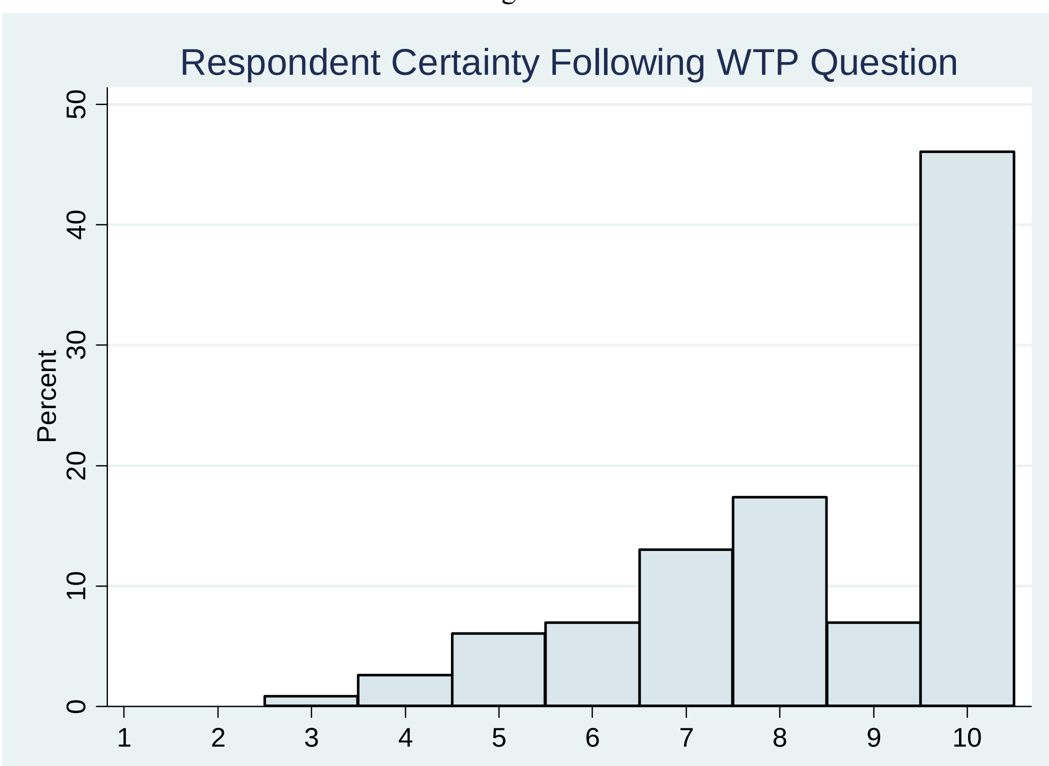


Figure 7:



d. WTP Estimates

WTP is obtained using the parameter estimates from the probit. Following Hanneman [1984], WTP from a standard probit is

$$\frac{-\alpha}{\hat{\beta}_{Bid}}$$

Where

$$\alpha = \hat{\beta}_0 + \left(\hat{\beta}_1 \times \bar{X}_1\right) + \left(\hat{\beta}_2 \times \bar{X}_2\right) + \cdots + \left(\hat{\beta}_{K-1} \times \bar{X}_{K-1}\right)$$

for all the explanatory variables except for $\hat{\beta}_{Bid}$. We predict WTP as a function of the following explanatory variables:

- *Awareness of 4FRI*: whether or not the respondent was previously aware of the 4FRI initiative (0 = "No", 1 = "Yes")
- *Importance of Fire Prevention:* the relative importance of wildfire prevention (5 point Likert Scale)
- *Concern for Watershed Health*: relative concern for watershed health (5 point Likert Scale)
- *Threat of Wildfire:* concern for threat of catastrophic wildfire (5 point Likert Scale)
- *Threat of Drought:* concern for threat of drought (5 point Likert Scale)
- *Democrat:* whether the respondent is a Democrat (0 = "Republican or Other", 1 = "Democrat")
- *Income:* a categorical measure of respondent's reported income (range from 1-9)

Several of the attitudinal variables are highly correlated. To avoid multicollinearity, we drop *Watershed Health, Wildfire,* and *Democrat* from our final model.[1] We obtain confidence intervals using the Krinsky Robb [1986] approach and the WTPCIKR command in STATA [Jeanty, 2007].

Regression results are reported in Table 2. The estimated coefficient on *Bid Amount* is negative and statistically significant, indicating that the higher the *Bid Amount*, the less likely the respondent is to vote "Yes" on the WTP question. The estimated coefficient on *Awareness of 4FRI* is positive and statistically significant, indicating that if a respondent was previously aware of 4FRI, they are more likely to vote "Yes" on the WTP question. The positive statistical significance of the Awareness of 4FRI variable could have significant policy implications. Our results show that respondents who are more aware are more likely to be WTP to provide financial support for the program.

The estimated coefficient on *Wildfire Prevention* is positive and statistically significant. This indicates that respondents with a high level of concern for wildfire prevention are more likely to vote "Yes" on the WTP question. The estimated coefficient on *Threat of Drought* is also positive and statistically significant, showing that respondents who are relatively more concerned with drought are more likely to vote "Yes" on the WTP question. Income also has a positive and statistically significant impact on WTP, which is consistent with economic theory. All else constant, respondents with higher income are more likely to vote "Yes" on the WTP question.

Based on our best statistical model, mean WTP is $4.76 per month with a 90% confidence interval of $1.38-$7.92. In other words, the average respondent would be willing to pay an additional $4.76 per month in their water bill to support monitoring and maintenance of the Lake Mary and Upper Rio de Flag watersheds. Flagstaff has approximately 20,000 households. Thus, the lower-bound estimate for net willingness to pay is approximately $26,700 per month for an annual benefit of $331,000 of 4FRI restoration. Based on the mean estimated WTP, the average benefit for Flagstaff residents is $95,200 per month for an annual benefit of $1.1M. The upper bound estimate is a value of $158,400 per month for an annual benefit of $1.9M.

[1] See Table A1 in the appendix for the full specification.

Table 2: Probit Regression Results: Independent variable: "Vote"

	Final Model
Bid Amount	-0.104**
	(0.0476)
Aware of 4FRI	0.572*
	(0.301)
Importance of Fire Prevention	0.455**
	(0.225)
Threat of Drought	0.549**
	(0.250)
Income	0.120*
	(0.0660)
Constant	-4.990***
	(1.363)
Observations	103
WTP	$4.76**
90% Confidence Interval	[$1.38, $7.92]

4. **Conclusions**

Ecological restoration of forested watersheds is necessary to prevent catastrophic wildfire and maintain watershed health. The City of Flagstaff obtains its drinking water from the Lake Mary and Upper Rio de Flag watersheds. The 4FRI plans to restore the Lake Mary and Upper Rio de Flag watersheds, however the funding source is uncertain. Forest maintenance provides benefits in terms of improved watershed health, and residents of Flagstaff are among the beneficiaries. We find that an average WTP from our sample of $4.76 per month to fund monitoring and maintenance of the 4FRI restoration. Our analysis shows a potential net annual benefit of approximately $1.1M to Flagstaff residents for the 4FRI restoration. Thus, our results provide evidence that a potentially sustainable source for funding is through charging Flagstaff residents for forest restoration.

Several areas of further research exist to solidify our initial results. Our study was a focused on single family residents in Flagstaff with a relatively small sample. An ideal sample would also include observations from all residents of Flagstaff and also include business owners. In addition, Flagstaff residents are only a small portion of the potential beneficiairies from forest restoration since the Northern Arizona forests offer recreational opportunities for people living outside of Arizona and the US. Nonetheless, our results provide statistical evidence that residents of Flagstaff have a positive value for improved watershed services through forest restoration.

References

Allen, C. D.; Savage, M.D.; Falk, K.F.; Swetnam, T.W.; Schulke, T.; Stacey, P.B.; Morgan, P.; Hoffman, M. and T.T. Klingel. 2002. Ecological restoration of southwestern ponderosa pine ecosystems: a broad perspective. Ecological applications 12 (5): 1418-1433.

Berry, A. 2010. Literature review: the economic value of water and watersheds on National Forest Lands in the United States. The Sonoran Institue. http://www.exloco.org/Headwaters_SLC/docs/Berry_Sonoran_FS_Water_Lit_Review.pdf

Brown, T. C. and R. M. Forest. Monetary Valuation of Timber, Forage, and Water Yields from Public Forest Lands. Rocky Mountain Forest and Range Experiment Station, Forest Service, US Dept. of Agriculture, 1982. Print.

Brown, T.C. and P. Froemke. 2009. Estimated mean annual contribution of water supply from units of the National Forest System (NFS) of the U.S. Forest Service. USDA Forest Service Rocky Mountain Research Station, Fort Collins, CO. Online: http://www.fs.fed.us/rm/value/docs/water_supply_national_forests.pdf.

Brown, T.C.; M.T. Hobbins and J.A. Ramirez. 2005. The source of water supply in the United States. RMRS-RWU-4851 Disc. Pap. US For. Serv. Rocky Mountain Res. Stn., Fort Collins, CO. 57 p.

Cameron, T.A. and James, M.D. 1987. Efficient Estimation for “Closed-Ended” Contingent Valuation Surveys. The Review of Economics and Statistics, 69, 2, 269-276.

Carson, R.; Mitchell, R.;Hanemann, M.,; Kopp, R.;Presser, S. and Rudd, P. 2003. Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill. *Environmental and Resource Economics* 25: 257-286.

Covington, W.W. 2000. Helping western forests heal. Nature 408:135–136.

Dillman, D. 2007. Mail and Internet Surveys: The tailored design method, second edition. John Wiley and Sons, Inc. New Jersey.

Furniss, M. J.; Staab, B. P.; Hazelhurst, S.; Clifton, C. F.; Roby, K.B.; Ilhadrt, B. L.; Larry, E. B.; Todd, A. H.; Reid, L. M.; Hines, S.J.; Bennett, K.A.; Luce, C. H.; Edwards, P.J. 2010. Water, climate change, and forests: watershed stewardship for a changing climate. Gen. Tech. Rep. PNW-GTR-812. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 75

Jeanty, P. Wilner. 2007. "wtpcikr: Constructing Krinsky and Robb Confidence Interval for Mean and Median Willingness to Pay (WTP) Using Stata." North American Stata Users' Group Meetings 2007, 8.

Kauffman, J.B. 2004. Death rides the forest: perceptions of fire, land use, and ecological restoration of western forests. Conservation Biology, Vol. 18, No. 4. Pp. 878-882.

Krinsky, I. and A.L. Robb. 1986. "On Approximating the Statistical Properties of Elasticities." *Review of Economic and Statistics* 68: 715-719.

Li et. al. (2009) Public support for reducing US reliance on fossil fuels: Investigating household willingness-to-pay for energy research and development. *Ecological Economics* 68: 731–742.

Loomis, J.B. 1996. Measuring the economic benefits of removing dams and restoring the Elwha River: results of a contingent valuation survey. Water Resources Research, vol. 32, no. 2: 441-447.

Loomis, J.; Kent, P.; Strange, L.; Fausch, K.; and A. Covich. 2000. Measuring the total economic value of restoring ecosystem services in an impaired river basin: results from a contingent valuation survey. Ecological Economics, 33: 103-117.

McKenzie, D.; Gedalof, Z.; Peterson, D.L.; and P. Mote. 2004. Climatic change, wildfire and conservation. Conservation Biology, Vol. 18, No. 4. Pp. 890-902.

Mast, J.N.. 2003. Tree Health and Forest Structure, in Ecological Restoration of Southwestern Ponderosa Pine Forests.

Pattanayak, S.K.; and R.A. Kramer. 2001. Pricing ecological services: willingness to pay for drought mitigation from watershed protection in eastern Indonesia. Water Resources Research, Vol. 37, No. 3: 771-778.

Snider, G.B.; Wood, D.B.; and P.J. Daugherty. 2003. Analysis of costs and benefits of restoration-based hazardous fuel reduction, treatments vs. no treatment. NAU School of Forestry Research Progress Reports, Progress Report #1. June 13, 2003.

Stanton, T. and S. Zwick. 2010. Why Denver spends money on trees. Ecosystem Marketplace. http://www.ecosystemmarketplace.com/pages/dynamic/article.page.php?page_id=7706&section=home.

United States Forest Service (USFS). 2007. The U.S. Forest Service-An Overview. http://www.fs.fed.us/documents/USFS_An_Overview_0106MJS.pdf

Westerling, A. L.; Hidalgo, H.G.; Cavan, D.R.; and T.W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science, vol. 18: 940-943.

Wu, T.; Kim, Y.S.; and M.D. Hurteau. 2011. Investing in natural capital: using economic incentives to overcome barriers to forest restoration. Restoration Ecology, vol. 18, issue 4: 441-445.

Appendix

Table A1: Alternative Specification

	(A)
Bid Amount	-0.113**
	(0.0482)
Aware of 4FRI	0.525*
	(0.315)
Importance of Fire Prevention	0.133
	(0.329)
Watershed Health	-0.0176
	(0.197)
Threat of Wildfire	0.588*
	(0.328)
Threat of Drought	0.384
	(0.292)
Democrat	0.150
	(0.298)
Income	0.120*
	(0.0723)
Constant	-5.325***
	(1.474)
Observations	98
WTP	**$5.03****
90% Confidence Interval	[$2.05,$8.16]