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The Western Economics Forum

A peer-reviewed publication from the Western Agricultural Economics Association

Purpose

One of the consequences of regional associations nationalizing their journals is that professional agricultural economists in each region have lost one of their best forums for exchanging ideas unique to their area of the country. The purpose of this publication is to provide a forum for western issues.

Audience

The target audience is professional agricultural economists with a Masters degree, Ph.D. or equivalent understanding of the field that are working on agricultural and resource economic, business or policy issues in the West.

Subject

This publication is specifically targeted at informing professionals in the West about issues, methods, data, or other content addressing the following objectives:

- Summarize knowledge about issues of interest to western professionals
- To convey ideas and analysis techniques to non-academic, professional economists working on agricultural or resource issues
- To demonstrate methods and applications that can be adapted across fields in economics
- To facilitate open debate on western issues

Structure and Distribution

The *Western Economics Forum* is a peer reviewed publication. It usually contains three to five articles per issue, with approximately 2,500 words each (maximum 3,000), and as much diversity as possible across the following areas:

- Farm/ranch management and production
- Marketing and agribusiness
- Natural resources and the environment
- Institutions and policy
- Regional and community development

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Willingness to Pay for Programs for the Human Papillomavirus Vaccine on a Rocky Mountain West College Campus

Chian Jones Ritten and Ian M. Breunig[1]

Introduction

Genital human papillomavirus (HPV) is the most prevalent sexually transmitted virus disease in the United States with more than 20 million Americans currently infected and another 6.2 million becoming infected each year (Weinstock et al., 2000). The lifetime likelihood of contracting HPV ranges between 80-85% (Fey et al., 2004). The highest rate of contraction is among adults ages 18-28, making college-age adults the most susceptible to infection (Koutsky, 1997). Although a majority of HPV infections resolve on their own with no health consequences, some strains cause genital warts and others are the cause of virtually all cervical cancers in women. Nearly all cervical cancer victims, 99.7%, are HPV-positive (Walboomers et al., 1999). Cervical cancer can be deadly, accounting for over 274,000 deaths a year worldwide (World Health Organization, 2007).

Although techniques such as cryosurgery of warty lesions and Imiquimod cream are used to treat genital warts, there is no cure for HPV. This makes prevention the key factor in the prevention of cervical cancer and genital warts. On June 8, 2006, the U.S. Food and Drug Administration (FDA) approved the use of a vaccine in women ages 10 to 26 to prevent infection (Bosch, 2003). Currently, two vaccines, quadrivalent and bivalent, are available for HPV prevention (each consist of three separate injections), with only quadrivalent approved for use in men (approved by the FDA in October 2009). The vaccines are nearly 100% effective in the prevention of the targeted HPV strains that may cause genital warts and precancerous cervical cell change (The Kaiser Family Foundation, 2011; Herrero, 2009).

Previous research pertaining to HPV vaccination focuses on general assessments of vaccine acceptability (Liau et al., 2012; Fazekas et al., 2008; Brewer et al., 2007), knowledge and awareness of the disease (Bynum et al., 2011; McCree et al., 2006; Dell et at., 2000; Denny-Smith et al., 2006; Yacobi et al., 1999; Dillard and Spear, 2010), and attitudes towards vaccine uptake (Friedman and Shepard, 2007). These studies suggest that general knowledge and awareness of HPV and its tie to genital warts and cervical cancer in women has drastically increased over the last couple of decades. General acceptability of the vaccine has also increased, although studies show that high costs of vaccination may prevent many that are at risk from receiving the vaccine (Liau et al., 2012; Dillard and Spear, 2010; Patel at al., 2012). The vast majority of these studies either focus on general trends for the entire U.S. or on regional aspects, specifically in the South, with little focus on the Rocky Mountain West. Regional differences are found in HPV vaccine uptake and cervical cancer rates (Jemal et al., 2013), limiting the effective extrapolation of these studies to this region.

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Research suggests that vaccination of adolescents and the college-age community is critical to reducing the number and spread of HPV infections, which represents a community public health goal (Allen et al., 2009). Many college-age individuals may not have traditional health insurance. Paying out of pocket for the vaccine, which can total $390 (CDC, 2011), may reduce the likelihood of successfully vaccinating this high risk group (Liau et al., 2012; Allen et al., 2009; Hoover et al., 2000). The effect of the passage of the Affordable Care Act (August 2012) on vaccine uptake has yet to be determined. The act mandates all insurance providers to provide coverage for the HPV vaccine with no cost sharing. However, deductibles and copays for the doctor visits themselves can still make HPV vaccination prohibitively expensive (Gudeman, 2007). On the other hand, insurance coverage will increase service availability only if clinicians are willing to provide the service. For instance, some clinics choose not to stock or administer expensive vaccines, such as for HPV, due to high upfront costs of service.

Recent studies suggest that only a small minority of college age women have initiated the vaccine series (estimates between 10-30%) (Jain et al., 2009; Price et al., 2011; Dempsey et al., 2001; Marchland et al., 2012), leaving the vast majority of target populations unvaccinated. Providing HPV vaccination programs for college students may be a significant approach to reduce the overwhelming prevalence of HPV.

This study uses a survey on the Colorado State University (CSU) campus to address how likely college-age students in the Rocky Mountain West are to pay for vaccination programs Student's willingness to pay (WTP) or vote for a campus HPV vaccination program is elicited using the contingent valuation method. Contingent valuation is a survey-based methodology for eliciting values of services that ordinary markets may not be able to measure (Champ et al., 2003). This technique has been frequently used to measure values associated with vaccines (Prosser et al., 2004; Lee et al., 2002; Medlock and Galvani, 2009).

Because of the financial burden that can deter many college students from receiving the vaccine, this study introduced three different HPV vaccine programs in which the method of payment varied. Students were asked about WTP out-of-pocket for self-vaccination, WTP for an increase in student fees to fund the vaccine free of charge for all students, and WTP for a reallocation of existing student fees away from other funded university programs in order for all students to have access to the vaccine free of charge.

Methods

Survey sample

Survey instruments were developed and information was collected on a sample of 426 students enrolled in introductory level undergraduate economics courses[2] at CSU in March 2011. These courses are required for many majors across disciplines and fulfill general studies requirements. The courses are also open to all majors at CSU, with only a small fraction of those enrolled being declared Economics majors. Students were approached within a classroom setting, given information about the survey, and completed the survey on a voluntary basis. Prior to collecting the data for this study, two focus groups of 4-5 volunteers were conducted, from which the survey instruments were altered to ensure understanding amongst respondents. Pretests were then performed and the data were analyzed. The results supported the validity of the survey

[2] The courses included Principles of Microeconomics, Principles of Macroeconomics, and Gender in the Economy. Students enrolled in these courses are found to be highly representative of the CSU student body based on 2011 enrollment statistics with respect to demographic aspects.

instruments. They were then approved by Human Subjects at CSU and the implementation of the surveys was permitted.

After eliminating 4 surveys with missing information on gender or age, the effective population size was 422, of which 198 (47%) were female. In total, 362 (86%) respondents identified as White, 9 (2%) identified as Black or African American, 17 (4%) as Asian, 19 (5%) as Hispanic or Latino, 11(3%) as another race or ethnicity, and 2 not responding. The average age of the respondent was 20. Most have very low incomes with only 69 (16%) reporting an annual income of $10,000 or greater. Nearly half of the respondents (46%) resided in a campus dormitory and only 32 (8%) respondents reported as having a spouse of live-in partner.

A majority of the sample indicated that they were previously familiar with HPV and its link to cervical cancer. A majority of females (62%) and 10% of males reported prior vaccination for HPV, suggesting that CSU students have higher rates of vaccination than previous studies have found. One male and one female reported having been previously diagnosed with HPV[3], and 43 (10%) respondents reported knowing a friend or family member diagnosed.

Measures for contingent valuation

Three hypothetical programs were proposed to capture the effect of the different payment vehicles on valuation. Two dichotomous choice WTP treatment arms were established that were randomly assigned to respondents[4]. The first treatment arm (Treatment 1) pertained to Program 1 and the second arm (Treatment 2) pertained to Programs 2 and 3.

Treatment 1 respondents were asked whether they were willing to pay a random but preselected amount ranging from $10 to $400 to be vaccinated (Program 1). This range was based on a survey of actual costs of vaccination (given the actual cost of $390 without insurance). Respondents were directed that the cost would be a one-time out-of-pocket cost in order to assure that they assumed the proper opportunity cost. Since vaccination was only recently approved for males and it may not be commonly known to be available, only female respondents were asked to respond to this question.

Treatment 2 respondents (both male and female) were asked whether they were willing to vote for two proposed vaccination programs (Programs 2 and 3) that would make available a vaccination for all *willing* CSU students. Program 2 had an associated cost of increased student fees equal to a random but preselected amount, ranging between $10 and $400, for all CSU students. The associated cost of Program 3 was equal to that of Program 2, however the source of funding would be a reallocation of existing fees. Table I provides the exact questions posed to the students with the randomized value of the vaccination indicated as *X*.

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[3] To determine if these observations should be dropped from the analysis, an indicator to control for these students was used, and no significant impact was seen. Therefore, these observations were retained in order to take advantage of their information regarding WTP for the vaccination programs.

[4] The treatment arm and the amount that respondents were asked if they would be willing to pay (ranging from $10 to $400) were randomized across (and within) the courses in which the survey was conducted.

Table I. Questions about willingness to pay posed to Treatment 1 (Program 1) and Treatment 2 respondents (Programs 2 and 3).

• Currently, CSU has 13,526 female students, making up 51.3% of all enrolled students. • The vaccine reduces the risk of being infected with HPV by 70% if previously uninfected. • If either proposal passes, the risk of cervical cancer will be reduced by 70% in women vaccinated.
Program 1: Would you pay an out-of-pocket price of $X to receive the vaccine yourself? (yes/no)
Program 2: An increase in all students' semester fees by $X to have the vaccine available for all female students. • The program will be funded by a new special student fee. • The costs of the program would have to be paid by you and other Colorado State University students. • Because you would be paying $X in additional student fees for the program, it would reduce the amount of available money for spending on your personal consumption. Would you vote for the proposed increase in your semester students fees of $X to have the vaccine available for all Colorado State University students? (yes/no)
Program 3: A reallocation of existing student fees, amounting to $X per student, away from other student services (rec center, classroom services, etc.) to fund availability of the vaccine free for all female Colorado State University students. • The program will not increase your student fees. • Payments for the program will be in the form of a reallocation of your student fees from other student services (for example, reallocation of fees from the Lory Student Center, Campus Recreation Center, University Facility Fee, Student Legal Services, Conflict and Resolution, Athletics, etc.). • Thus, paying for the program would reduce the amount of other student services that are currently available. Would you vote for this reallocation of student fees that would provide vaccinations for all students at the cost of other student services? (yes/no)

To ensure that respondents were aware of the opportunity cost for Treatment 2, the survey used the technique outlined by Bergstrom, Boyle and Yabe (2004). Prior to introducing the policy change, respondents were given a list of the programs that could have funding decreased if Proposal 2 (Program 3) were to pass. This was in order to have the respondent understand the true opportunity cost of a reallocation of resources. Although this assessment was not vital to the valuation for Treatment 1, respondents were asked to rank these programs in order to keep the treatments similar.

Preferences, especially social preferences, are important in individual decision-making (Jones Ritten, 2011). Researchers have shown that people deviate from assumptions of the self-interest (Henrich, et al., 2004). "Many behaviors are better explained by social preferences; in choosing to act, individuals commonly take account not only of the consequences of their actions for themselves but for others as well" (Bowles, 2006 p. 96). To measure their effect on valuation of vaccinations, respondents were asked the influence of self-interest and social preferences, or "Attitudes," on their WTP decisions. Each preference motivation was given in a statement in which respondents were asked to rank their level of agreement to each statement from 1 (strongly disagree) to 5 (strongly agree). All statements are listed in Table II. Self-interest has been the primary motivation assumed within economics, and therefore was included in this study. Unlike pure self-interest, those acting out of altruistic motives, "take costly actions to increase the payoff of another actor, irrespective of the other actor's previous action" (Camerer and Fehr, 2002). Altruism has been indicated as another potential motivation in responses to WTP questions (e.g. Loomis et al., 2009). The specific altruism statement was chosen since it associates altruism with providing the vaccine for others, but makes the decision of vaccination up to the other individuals.

Table II: Variables measuring preferences, perceptions, and protests for HPV vaccination programs*

Preferences • I want to protect myself from HPV ('*Self-Interest'*) • I want others to be able to be protected against HPV ('*Altruism*') • It seems fair to me to contribute a fair share to help others be vaccinated ('*Fairness*')
Perceptions • Do you believe that the majority of Colorado State University students would be willing to vote in favor of [the proposal]'(yes/no*) ('Others' intentions')* • I believe that I am susceptible to contracting HPV *('Risk')* • I believe it is important for the CSU community to be vaccinated for HPV *('Community')*
Protest • I generally believe that vaccines are safe *('Safety')* • I believe the spread of HPV is primarily due to socially unacceptable sexual behavior *('Sex')*

*For each statement, respondents ranked their level of agreement from 1 (strongly disagree) to 5 (strongly agree) unless indicated otherwise.

Experimental economics shows the relevance of other types of social preferences into decision-making: specifically fairness and the motivation of others (Jones Ritten, 2011; Andreoni, 1998; Bowles and Gintis, 2000; Camerer and Fehr, 2002). In this context, fairness is associated with the respondent providing vaccinations for others in order to be fair to all. The belief of other's motivations and actions are also found to influence behavior. Only Programs 2 and 3 involve university-wide decisions. For these respondents, after the WTP questions, the belief of the motivations of others was captured by asking the respondents about their beliefs of how others would vote ('Others' intentions')[5].

To capture whether unwillingness to pay/vote for either program might be due to "protest", students were asked to rank their agreement with statements that vaccinations are unsafe ('Safety') or that socially unacceptable sexual behavior was the root cause of the spread of the disease ('Sex'). To assess whether WTP might be due to respondents' perception of their own HPV risk, they were asked to rank their level of susceptibility ('Risk'). Similarly, they were also asked to rank how important it is for the CSU community to be vaccinated ('Community').

[5] For greater discussion and more explicit models for the relationship between social preferences and WTP, the reader is referred to Jones Ritten (2011).

Lastly, knowing that many college students either rely on their parents, scholarships, or on other external sources of funding, respondents were asked about their parents' income and whether they pay for tuition, fees, and living expenses out of their own pockets (strongly disagree=0 / strongly agree=5)[6].

Logistic Model of WTP

The basic choice problem of respondents is to obtain the highest utility possible; either by paying/voting for a HPV vaccination program or not. An individual will accept to pay (vote in favor of) a fee for a program when the utility associated with a program is higher than that with no program (Hanemann, 1984), i.e.:

$$v(y, I-A; S)+\varepsilon_y \geq v(n, I; S)+\varepsilon_n \quad (1)$$

Where *v(.)* is the indirect utility function, *y* indicates the presence of a vaccination program, while *n* indicates no program, *I* is income, *A* is the stated price of the program, *S* is a vector of other socioeconomic variables affecting program preference, and ε_y and ε_n are identically, independently distributed random variables with means of zero. Therefore, an individual will pay/vote for a program (*y*) if the utility of doing so is greater than the utility of no program (*n*).

The utility difference (Δv) between with and without a program is:

$$\Delta v = v(y, I-A; S) - v(n, I; s) + (\varepsilon_y - \varepsilon_n) \quad (2)$$

The probability that an individual will be willing to pay/vote is:

$$P(y) = 1 - P(n) = \frac{1}{1+e^{-\Delta v}} \quad (3)$$

$$= \frac{1}{1+e^{-(\alpha+\beta \cdot A+\gamma \cdot I+\theta \cdot S)}} \quad (4)$$

where α, β, γ, and θ are estimated using a logit model by maximum likelihood estimation.

Statistical analysis

The analysis described below addressed two objectives. The first objective was to evaluate the unconditional probability that the sample will be willing to pay/vote for Programs 1, 2, and 3, as well as the probability adjusted for the beliefs and other personal characteristics of the respondents. The second objective was to explore the factors which contributed to the respondents' choices. First, descriptive statistics with respect to the WTP/vote for Program 1, 2, and 3, respectively are presented. The median value of all ranked responses are provided[7].

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[6] During focus groups, participants indicated that a dichotomous, yes/no format for these questions was inadequate since in many cases students share, with varying degrees, these expenses with parents or scholarships.

[7] The Kruskal-Wallis equality of populations rank test was used to assess differences between respondents willing to pay/vote and unwilling to pay/vote for the respective programs. One-sided or two-sided Fisher's exact test was also used for all other categorical variables and a Wilcoxon-Mann-Whitney test was used for mean ages.

Multivariate logistic regression analysis was used to explore which factors significantly contributed to the respondents' choices to pay or vote for the respective programs, adjusting for other factors. Several ranked variables were operationalized by converting them to dichotomous or trichotomous variables due to infrequent responses among some extremes. These variables are noted in the tables with results. The average marginal effects of significant factors in the probability of WTP/vote were calculated. The overall (average) probabilities were then estimated to evaluate the popularity of the programs among the sampled students adjusted for significant factors.

Results

Sample characteristics

Table III presents the descriptive statistics for all of the questions on the surveys for Programs 1, 2, and 3. Just over half (52%) of women responding to Program 1 stated that they were willing to pay out of pocket for the HPV vaccine, unconditional on the stated price. Only 34% of students stated they were willing to vote for Program 2 – increasing total school fees paid by all students – but 45% stated they were willing to vote for Program 3 – reallocating the use of current fees in order to accommodate such a program.

The law of demand appears to hold among respondents to Program 1. Fewer proportions of women were willing to pay for the HPV vaccine as the stated price increased. There was no significant difference in “demographics” or “financial dependence” of those willing and unwilling to pay for the vaccine. However, there seems to be significant heterogeneity in respondents' “attitudes” as well as belief about the safety of vaccines (‘Safety’) and the relative importance of the HPV vaccination for the campus community (‘Community’).

For Program 2, smaller proportions of students were willing to vote for the program as the increase in student fees required grew larger (with the exception of $100). Intriguingly, no relationship between price and WTP/vote was discernible for Program 3, which may be due to the fact that no out-of-pocket payment is required. Over half of respondents were willing to vote for Program 3 at any implicit price level (besides the lowest price of $10). Among these same respondents, less than half were willing to vote/pay for Program 2 at any price level (besides the lowest price of $10). Thus, holding cost constant, it appears that students tend to prefer to reallocate funds away from existing school programs rather than incur higher fees.

For Programs 2 and 3, students who were willing to vote in favor of the program were substantially more likely to believe that a majority of other CSU students would also vote in favor of the program (‘Others' intensions’) ($p<0.001$ and $p=0.030$, respectively). Similar to respondents under Program 1, there appears to be significant heterogeneity in respondents' attitudes and belief in the relative importance of the HPV vaccination for the campus community ($p<=0.001$ for all). Compared to respondents not in favor of Program 2, those in favor of Program 2 were less likely to pay for their overall student fees out of their own pocket (‘Fees’) ($p<0.016$). Under Program 3, significant heterogeneity was exhibited in regard to beliefs of HPV as a consequence of socially unacceptable sexual behavior (‘Sex’) ($p=0.008$) and respondents' own susceptibility to contracting HPV (‘Risk’) ($p=0.029$).

Table III. Descriptive statistics of survey responses by willingness to pay/vote for Programs 1 (women only), 2, and 3.

	Frequencies†								
	Program 1			Program 2			Program 3		
Dichotomous Questions	yes	no	*p-value*	yes	no	*p-value*	yes	no	*p-value*
Total observations:	53	49		65	129		87	105	
Cost									
$10	12	3	*<0.001*	20	14	*0.002*	12	22	*0.114*
$25	14	3		14	22		22	14	
$50	15	12		7	22		19	8	
$100	4	5		12	17		16	13	
$200	4	12		7	25		16	16	
$400	4	14		5	29		20	14	
Demographics									
Age *(mean, s.d.)**	19.8 (2.3)	19.8 (1.7)	*0.309*	20.44 (5.3)	19.8 (2.3)	*0.647*	20.2 (4.3)	19.8 (2.2)	*0.934*
Male	--	--		32	68	*0.380*	56	38	*0.118*
Caucasion	48	44	*0.578*	59	107	*0.104*	92	72	*0.228*
Dormitory	25	24	*0.506*	31	55	*0.302*	46	40	*0.438*
Married	3	5	*0.476*	6	10	*0.459*	10	6	*0.350*
Financial dependence									
Own income >$10k	5	6	*0.444*	11	14	*0.167*	14	10	*0.437*
Parent's income <$50k	13	7	*0.307*	11	32	*0.300*	22	21	*0.443*
Parent's income $50k-$100k	19	24		26	55		41	39	
Parent's income >$100k	21	18		28	42		42	27	
History with HPV									
Diagnosed (dx)	1	0	*0.520*	0	0	*1.000*	0	0	*1.000*
Friend or family dx	12	7	*0.204*	2	12	*0.094*	7	7	*0.462*
Vaccinated	38	26	*0.041*	28	37	*0.033*	37	28	*0.386*
Prior knowledge	51	44	*0.187*	48	87	*0.228*	77	57	*0.155*
Attitudes									
Others' intentions	--	--		28	12	*<0.001*	27	12	*0.030*
	Medians‡								
	Program 1			**Program 2**			**Program 3**		
Ranked Questions [1,5]	**yes**	**no**	*p-value*	**yes**	**no**	*p-value*	**yes**	**no**	*p-value*
Financial dependence									
Tuition	2	2	*0.740*	2	3	*0.060*	3	3	*0.576*
Fees	2	3	*0.399*	2	4	*0.016*	3	3	*0.783*
Living expenses	2	4	*0.122*	4	4	*0.456*	4	4	*0.637*
Attitudes									
Self-interest	5	5	*0.008*	5	4	*0.001*	5	4	*<0.001*
Altruism	5	4	*0.084*	5	4	*<0.001*	5	4	*<0.001*
Fairness	4	3	*0.026*	4	3	*<0.001*	4	3	*<0.001*
Beliefs									
Safety	4	4	*0.001*	4	4	*0.173*	4	4	*0.516*
Sex	3	3	*0.350*	3	3	*0.872*	3	3	*0.008*
Risk	2	2	*0.178*	2	3	*0.469*	3	2	*0.029*
Community	4	3	*<0.001*	4	3	*<0.001*	4	3	*<0.001*

† P-values are calculated using the two-sided Fisher's exact test for multiple categorical variables and one-sided Fisher's exact test for dichotomous categories

‡ P-values calculated using Kruskal-Wallis equality of populations rank test to show significant heterogeneity in responses (despite Possibly similar median responses).

* P-value represents Prob>|z|,estimated using the Wilcoxen-Mann-Whitney test for different means

Multivariate analyses

Table IV presents the conditional probabilities (95% C.I.) for students' WTP for the vaccine (Program 1) or vote for Programs 2 and 3, adjusting for significant factors (i.e., $p<0.05$). Average marginal effects (ME) for the significant factors are also presented. Again, it was found that Program 3 (Pr=54.8%, 95%CI: 49.9%, 59.8%) is much more favorable than Program 2 (Pr=33.5%, 95%CI: 28.5%, 38.5%) among these respondents. The conditional probability that women under Program 1 would pay out of pocket for the vaccine was 52.7% (95%CI: 46.2%, 59.2%).

The law of demand seems to still hold for program 1 and the relationships between costs and the favorability of Programs 2 and 3 are similar to those discussed in the previous section[8]. A stronger belief in the importance of community vaccination leads to a greater probability of paying or voting for any of the programs. Students were much more likely to vote in favor of Program 2 or 3 if they believed that a majority of their campus-mates would vote similarly ('Others' intensions').

Under Program 1, females 20 to 22 years old were more likely to purchase the HPV vaccination when compared to all other ages (ME=0.21, p=0.015). Females who agreed that they tend to pay out-of-pocket for living expenses were less likely to pay than others (ME=-0.25, p=0.001). Interestingly, a woman was 26% *less* likely to pay for the vaccine if she stated that she agreed or strongly agreed with the altruistic notion that others should be able to be protected against HPV ('Altruism'). Since this program involves self-payment for self-vaccination, motivations beyond self-interest play no positive role. Those that are influenced by a motivation of altruism are less likely to pay out of pocket for the more self-oriented action of only self-vaccination. Therefore, not surprisingly, no other attitudes or beliefs were significant predictors of WTP by women under Program 1.

Regarding Program 2, men or women 23 years or older were more likely to vote in favor (ME=0.23, p=0.010), as were those who were neutral with regard to who pays for their living expenses (ME=0.173, p=0.044) and those who indicated that their parents' income was higher than others' (ME=0.25, p<0.001). Respondents who were neutral regarding their susceptibility to contracting HPV ('Risk') were less likely than others to vote for Program 2 (ME=-0.23, p<0.001). Unexpectedly, a person with a friend or family member who was previously diagnosed with HPV was 22% (p=0.001) *less* likely be in favor of the program[9]. None of these factors were significant in predicting favorability towards Program 3, however.

Given that the average cost for the HPV vaccine is approximately $390, the above results were used to calculate the probability that the responding students would purchase the vaccine under Program 1 or vote in favor of Programs 2 or 3 conditional on the price of the vaccine being $400. As expected at the highest price, the programs that require greater out-of-pocket expenses have reduced favorability when compared to those reported above. Approximately

[8] The negative marginal effects of cost on the WTP is 2 to 7 percentage points stronger when restricting models 2 and 3 to females, yet the relative magnitudes between price levels remain the same.
[9] Of 14 individuals who reported a friend or family member diagnosed with HPV, 12 indicated an unwillingness to pay for program 2 and half indicated an unwillingness to pay for program 3 (Table III). While perhaps a spurious result, further elucidation of this result would have required specific follow up within the questionnaire.

Table IV. Marginal effects from multivariate logistic regression models for the willingness to pay/vote for Programs 1, 2, and 3

	Program 1 (women only)		Program 2		Program 3	
	(*n*=102)		(*n*=194)		(*n*=191)	
Conditional Probability *(95% Confidence Interval)*	52.7% (46.2% , 59.2%)		33.5% (28.5% , 38.5%)		54.8% (49.9% , 59.8%)	
Significant predictors ‡	Marginal Effect	*p-value*	Marginal Effect	*p-value*	Marginal Effect	*p-value*
Cost = $10	*reference*					
Cost = $25	-0.073	*0.621*	-0.212	*<0.001*	0.219	*0.004*
Cost = $50	-0.229	*0.028*	-0.288	*<0.001*	0.259	*0.002*
Cost = $100	-0.319	*0.009*	-0.222	*<0.001*	0.147	*0.088*
Cost = $200	-0.491	*<0.001*	-0.283	*<0.001*	0.167	*0.035*
Cost = $400	-0.513	*<0.001*	-0.280	*<0.001*	0.199	*0.013*
Age [<20]	*reference*					
Age [20, 21, 22]	0.209	*0.015*	-0.074	*0.175*	--	
Age [23 +]	0.147	*0.366*	0.226	*0.010*	--	
Living expenses (disagree/strongly disagree)	*reference*					
Living expenses (neutral)	-0.124	*0.371*	0.173	*0.044*	--	
Living expenses (agree/strongly agree)	-0.252	*0.001*	0.029	*0.612*	--	
Parents' annual income [<$50,000]	*reference*					
Parents' annual income [$50,000 , $100,000)	--		0.129	*0.061*	--	
Parents' annual income [$100,000 +]	--		0.248	*<0.001*	--	
Friend or Family diagnosed with HPV (no)	*reference*					
Friend or Family diagnosed with HPV (yes)	--		-0.216	*0.001*	--	
Others' intentions (no)	*reference*					
Others' intentions (yes)	n/a		0.254	*<0.001*	0.471	*<0.001*
Community (neutral/disagree/strongly disagree)	*reference*					
Community (agree)	0.324	*<0.001*	0.136	*0.014*	0.131	*0.024*
Community (strongly agree)	0.371	*<0.001*	0.295	*<0.001*	0.219	*0.007*
Altruism (neutral/disagree/strongly disagree)	*reference*					
Altruism (agree/strongly agree)	-0.264	*0.027*	--		--	
Fairness (disagree/strongly disagree) †	*reference*					
Fairness (neutral)	--		0.151	*0.051*	0.135	*0.043*
Fairness (agree/strongly agree)	--		0.420	*<0.001*	0.282	*0.001*
Sex (disagree/strongly disagree)	*reference*					
Sex (neutral)	--		-0.128	*0.039*	-0.035	*0.614*
Sex (agree/Strongly agree)	--		-0.101	*0.107*	-0.147	*0.042*
Risk (disagree/strongly disagree)	*reference*					
Risk (neutral)	--		-0.227	*<0.001*	--	
Risk (agree/strongly agree)	--		-0.091	*0.101*	--	
Pseudo R-squared	0.380		0.511		0.418	

† Collinear with altruism, reciprocity, and commitment - estimates which substitute each in place of fairness reveal positive relationships similar to those on fairness, and expected probabilities remain nearly identical as reported above.

‡ All missing estimates or unlisted predictors from table 2 were estimated to have no significant impact (p>0.10) on predicting willingness to pay/vote.

21% (95%CI: 17%, 25%) of female students would be expected to purchase the HPV vaccination, and 25% (95%CI: 21%, 30%) of men and women would be expected to favor an equal increase in student fees. On the other hand, there is little response to stated price when students are asked their opinion about a reallocation of existing fees away from other campus-wide programs to fund the HPV vaccination; 58% (95%CI: 53%, 63%) would be expected to favor Program 3.

Conclusion

A successful HPV vaccination program on a university campus may hinge on subsidization by the University and taxpayers if it were to require an increase in out-of-pocket expenses for students who are already burdened by the cost of a college education. Results suggest that the high cost of the HPV vaccination series (around $390) may be a strong deterrent for self-vaccination if female students are encouraged to voluntarily pay out-of-pocket for the preventive measure (Program 1). Encouragingly though, it is also found that a similar student body may be more willing to sacrifice student funds previously allocated for existing campus programs (Program 3) than to increase obligatory student fees by the same amount (Program 2) to make the vaccine available to the entire student body. Even given an implicit cost of $400 per vaccine series, this survey shows that such a program would be favored by a majority of the student body, even knowing that the cost would be a reduction in funding for other programs. Hence, from a policy perspective, a reallocation of student fees seems to provide a potentially more successful HPV vaccination program. The costs of providing the vaccine would be paid entirely by the students themselves through already existing student fees.

These results suggest that Universities providing the HPV vaccine to students for the current out-of-pocket price of $390 may not be successful in achieving a high rate of vaccination response. Results predict that only approximately 21% of female students would purchase the vaccine at this cost. Combined with the fact that only 1% of males have received the vaccine to date (Harris, 2011), in order to have a greater participation rate in a student paid vaccination program, the university and taxpayers may have to highly subsidize the program.

Thus, from an administration's perspective, a program to promote the prevention of an HPV outbreak may be more feasible and incur less direct costs if implemented under the design of Program 3. Since funding for the program will come from already collected student fees, no new direct costs to the university or individual students will be incurred.

Another important contribution by this survey study is that it provides evidence suggesting that the likelihood of gaining a favorable response to a campus-wide HPV vaccination program not only depends upon economic considerations but also on the students' personal beliefs and attitudes towards the HPV vaccine. This study finds that, for all of the proposed vaccination programs, a personal belief that the community needs protection against HPV was associated with an increased probability of willingness to pay for the program. Therefore, in order to promote favorable attitudes toward such a program, efforts should be made to promote a sense of community within the student body. Although only found to influence Program 2, education about the safety of the vaccine may increase the probability of paying for a vaccination program. For programs that involve universal coverage (Programs 2 and 3), promotion should include a sense of fairness and the sense that others within the community are committed to campus safety and are willing to vote for such programs. Both of these motivations are found to increase the likelihood of respondents voting in favor of the vaccination programs. It should also be noted that students may also be more likely to support a vaccination program if it is successful in separating HPV with notions of unacceptable sexual behavior.

The recent passage of the Affordable Care Act, and the continuation of the mandate for HPV vaccine coverage by private insurance, may reduce the need for HPV vaccination programs on some college campuses. Yet, this study may provide insights into successful HPV vaccination programs for college-aged individuals within a broader community (i.e., not limited to students) who are not covered by health insurance. This study also gives insights into the motivations behind paying for other vaccination programs on a college campus. Particularly, for vaccines not mandated for coverage under current or future health care policies.

This study focused on student's support for HPV programs at CSU. The results show that the rate of vaccination of CSU students is higher than in previous studies that focused on other geographic regions or on the US as a whole. This is consistent with earlier evidence of geographic differences in HPV vaccine uptake. Heterogeneity in HPV vaccine uptake across geographic regions suggests further need for regional analyses and minimizing the use of general data to predict behavior in specific regions.

Given the varying demographic make-up of students at institutions in other regions, these results should be extrapolated with caution. The results of this survey study should also only be applied to the HPV vaccine, but the design of the survey may be applied to study the WTP for other vaccine programs. The sampling method used is derived solely from students enrolled in certain courses. However, this work represents a start in examining ways to help reduce payment barriers and encourage students to get vaccinated. In sum, this study provides results that give insight into an important health and community issue.

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Valuation of Recreation in the National Parks: Estimating Micro Meta Models for Benefit Transfer[1]

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Introduction

The 397 units of the U.S. National Park System (NPS) are an extremely important U.S. recreational asset, supporting upwards of 280 million recreational visits annually (Street 2012) and driving the tourism economies of many U.S. regions (Stynes *et al.* 2000). Recreation values are an important policy analysis tool to inform management decisions affecting those park units. However, until very recently recreation values had only been directly estimated for a relatively small number of parks (Kaval and Loomis 2003; Duffield *et al.* 2009). Benefit transfer is an efficient approach for estimating values for a given park unit based on known values from sites that have been previously studied. This paper presents empirical estimates of benefit transfer functions for the U.S. National Park System based on stated preference survey responses from an NPS visitor survey administered at a cross-section of NPS park units. The study focuses on a subset of ecosystem service values including recreational, aesthetic, historical, and cultural values associated with on-site visitation. Left unaddressed is consideration of any passive use values.

Recreation use values are human benefits received from ecosystems such as rivers, wetlands, forests, etc. (Daily 1997; Brown *et al.* 2007). In national parks, nearly all the recreation is non-market in the sense that many sites are free and, where charged, entrance fees are only nominal amounts. Being non-market, economists must infer the non-priced benefits of ecosystems using visitor travel behavior (travel cost method), intended behavior as stated in surveys (for example, contingent valuation method) or from existing values in the literature derived from these methods. This last method is known as benefit transfer. Economic information developed for a given study site is used to make inferences about the economic value of environmental goods and services at another place and time, often referred to as the policy site (Boyle and Bergstrom 1992).

The motivation for benefit transfer is that regulatory and land management agencies are often required to assess the full economic benefits and costs of management and policy decisions. For example under Executive Order 12866, U.S. federal agencies must evaluate the benefits and costs from every economically-significant regulatory action. However, even if funding was available to complete original studies as needed, rarely can studies be completed in a timely way because of another federal policy: the Paperwork Reduction Act of 1995, which requires a lengthy Office of Management and Budget (OMB) review (often taking up to a year or more) of survey sample plans and instruments for federally funded research prior to conducting any survey work. Not all proposed surveys are approved. Given these time and resource constraints, it is not feasible to conduct original research for every regulatory issue that arises. As Ready and Navrud (2006) observe (at p. 198): “The choice is not between benefit transfer

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and conducting original studies. The choice, in many cases, is between conducting a benefit transfer and not including any estimate of the benefits from environmental goods and services."

Like the other federal natural resource management agencies, the NPS has a need for valuing recreation for policy, management, planning, and natural resource damage assessment. The founding legislation for the national parks in 1916 defined the dual mandate under which these parks are managed: "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same" (U.S. Department of Interior 1995). The "use and enjoyment" side of this mandate is manifested in the nearly 300 million visits to the system annually. These visits for recreational, aesthetic, cultural, and historical uses are an important component of the value derived from national parks.

While national parks were among the first settings considered for application of nonmarket valuation (Hotelling 1949; Clawson 1959), to date, valuation of recreational visits to NPS park units has been largely unsystematic and fragmented. Duffield *et al.* (2009) updated a literature review of NPS valuation studies by Kaval and Loomis (2003), and identified 27 different studies of NPS visitor WTP which included 128 different estimates of WTP. These estimates ranged from valuation of a trip floating the whitewater of the Grand Canyon of the Colorado (Bishop *et al.* 1989) to valuing the impact of climate change on recreational benefits in Rocky Mountain NP (Richardson and Loomis 2005). Hardner and McKenny (2006) developed a generalized estimate of total NPS system visitor WTP based on benefits transfer from existing studies of park unit net economic value (Kaval and Loomis 2003; Leggett *et al.* 2003). Heberling and Templeton (2009) were the first to use data collected by the NPS Visitor Services Project (VSP) within a count data travel cost (TC) model to estimate visitor WTP at Great Sand Dunes NP and Preserve. Building on the methods of Heberling and Templeton, a forthcoming paper used a broad spectrum of VSP survey data to estimate count data TC model estimates of park visitor WTP at 58 different NPS units system wide. These estimates were in turn employed in a meta-regression analysis to predict average visitor WTP per trip for all units in the NPS system (Neher *et al.* forthcoming).

While significant advances have been made in recent years in estimation of NPS visitor WTP, the current paper offers four unique extensions of this work. First, the paper reports WTP estimates for 12 NPS-sponsored representative cross-sectional park surveys that to date have not been reported in the literature. Second, the multi-park underlying data used in the analysis is stated preference, based on a dichotomous choice (DC) CV survey question. This CV methodology distinguishes the work from the recent revealed preference TC estimates reported by Neher *et al.* (forthcoming) and Heberling and Templeton (2009). The third contribution is in the reporting and comparison of estimated park-level WTP from both separate park-level CV models, and from an aggregated individual observation model of CV responses. A final contribution lies in exploring the robust nature of an estimated micro-meta model of WTP based on only 12 park observations. These different models are compared in terms of statistical model selection criteria, including model validity, usefulness for benefit transfer, and theoretical consistency.

Kaval and Loomis (2003) suggest that benefit transfer results may be biased because of uniqueness of the study site. While it could be argued that national parks fall into this category where benefit transfer results might be biased, we view the general recreation models presented as addressing this issue. These models are based on park visitor responses and are intended to be applied to other NPS units with similar park or visitor characteristics. Estimating WTP of the "average" core-season visitor to a specific park unit minimizes the severity of potential bias associated with a unique site (as compared to use of an estimated value from a different, dissimilar site. However, in the case of specialized user subgroups or activities (such as snowmobilers in Yellowstone NP), the general visitor WTP estimates provided could be biased. In these cases, researchers or park managers should also reference the broader set of valuation studies in the literature for estimates more closely tailored to the issues at hand.

The authors recognize the limitations of inherent in a meta-regression model based on only 12 park units. Accordingly, the meta-regression results are offered as a preliminary "proof of concept" rather than a definitive final model for general application to other park units. The methods and models presented are intended to inform the ongoing search for convergent validity in WTP estimation methods for NPS visitation, and for an appropriate reference methodology for use in valuation.

Methods for Benefit Transfer

Rosenberger and Loomis (2003) and Wilson and Hoehn (2006) provide overviews of methods for benefit transfer. Benefit transfer is generally one of three types: value transfer, value function transfer, and meta-analysis benefit transfer. Value transfer is simply using the most similar point estimate, for example of value per visitor day or per trip, or using an average of similar studies (for example the average value from all studies of a given type of activity). Value function transfer applies the estimated willingness to pay, or demand function, based on individual observations from an original study to the policy setting by setting the covariates in the estimated function at their policy-setting levels. The transferred function is modified in order to fit the specifics of the policy site by varying such factors as socioeconomic characteristics, extent of market, and environmental impact, and other characteristics that differ between the study site and the policy site. Meta-analysis benefit transfers utilize an estimated meta-regression equation where each observation is at the estimate or study level, the dependent variable is the willingness to pay measure, and the covariates typically include methodological variables, site specific variables, and user characteristics. However, practitioners must recognize that all three of these benefit transfer approaches are only as good as the underlying quality of the primary studies.

Data

We utilize a data set based on visitor surveys related to the NPS Fee Demonstration Program (Duffield *et al.* 1999). The 1998 NPS visitor survey was administered at 12 NPS park units selected to be representative of the diversity of the NPS system in terms of unit location, size, and type. The surveys used a stratified random sampling design and a repeat contact handout-mail back survey design (Dillman 1978; 2000). Overall, 2,644 of 3,735 distributed surveys were completed and returned for a response rate of 70.8%. Surveys were administered within the primary June-August tourist season, and were distributed over a one week period at each park.

The survey included one dichotomous choice contingent valuation question intended to value the visitors current trip, using increased travel costs as a payment vehicle (Boyle and Bishop 1988; Loomis and Caughlan 2003) and employing seven bid amounts ranging from $10 to $1,000 in roughly equal log intervals, to facilitate non-parametric analysis (for example, *Kriström 1990*) and to support tests for goodness of fit. Because the study was sampling for and valuing the average trip (not sampling for the average visitor), there was no need to correct for endogenous stratification (Shaw 1988).

Estimated Models

As a base-case model specification, bivariate logistic regression models, with log bid as the explanatory variable, were fit to the data for each park. The bid coefficients were all statistically significant (regression coefficients are not reported to conserve space). However, deviance goodness of fit statistics (Table 1) indicated the model did not fit well for some parks. Some smaller P-values are expected even if the model fits at all parks because of the multiple tests being performed, but not to the extent observed (four less than 0.05). Two alternatives were considered. One was including covariates in the logit models to obtain a better fit, which would complicate estimation of median WTP. Inclusion of covariates in the individual park models resulted in either varying specifications across parks or equivalent specifications with a large number of non-significant covariate parameters within the models. Both methods were problematic in regards to comparing estimated WTP across park units. The second alternative considered was using a nonparametric model for each park based on isotonic regression (*Kriström* 1990). However, sample sizes for some parks were too small to reliably estimate median WTP non-parametrically. Hence, we chose the median trip values calculated from the 12 separate bivariate logit models as reported in Table 1. Like some other analysts (Hanemann 1989), we prefer the median here as a more robust measure that is not as sensitive to the "fat tails" of the skewed willingness to pay distributions (Boyle *et al.* 1988) often identified in dichotomous choice studies. Estimated median trip valuation estimates (Table 1) range from a low of $44 per person at Allegheny National Historic Site to a high of $179 at Yellowstone National Park in 1998 (study year dollars).

Table 1. NPS 12-Park study park-level bivariate logit model results.

		Bivariate Logit Model			
Park Unit	**Sample Size**	**Median WTP($)**	**SE**	**Deviance**	**P-value[a]**
Allegheny	104	43.8	21.3	1.83	0.873
Colonial	232	79.1	19.4	17.04	0.004
Everglades	151	85.5	26.9	5.14	0.399
Frederick Douglass	26	69.9	42.6	3.97	0.554
Glen Canyon	142	138.0	44.4	11.32	0.045
Golden Gate	253	84.6	18.2	6.79	0.236
Grand Canyon	233	116.8	20.8	7.14	0.210
Independence	166	65.8	16.2	7.07	0.215
Mesa Verde	179	132.9	30.6	1.98	0.852
Sleeping Bear	112	45.2	13.2	9.93	0.077
Yellowstone	394	179.3	29.4	21.44	0.001
Yosemite	371	95.6	13.8	12.31	0.031

[a] from chi-square distribution with 5 d.f.

For comparison to the base-case estimates in Table 1, two other models were also specified. The first was an aggregated individual observation CV model combining the data from all park surveys. The second specification was a meta-regression model with the Table 1 bivariate WTP estimates as the dependent variable. In each case, the commodity valued was the current trip. Hanemann and Kanninen (1999) provide formula for measures of central tendency for Hicksian consumer surplus measures per trip for this model. Trip valuation was estimated rather than day values because the trip is the primary decision unit for NPS visitors, and trip values are a better match to how the NPS quantifies recreational use (reporting visits rather than activity days).

Model #1 Micro-data Meta-Analysis Model Based on Sample of 2,073 Individuals

There is some support in the literature for increased accuracy of benefit transfers using regional, pooled data models (Loomis 1992; VandenBerg *et al*. 2001; Piper and Martin 2001; Rosenberger and Stanley 2006). The Fee Demonstration data set was used to build a pooled WTP model via logistic regression using all 2,073 individuals across the 12 parks. We used log(BID), rather than BID, as an explanatory variable, both because the models tended to fit better with log (BID), and because it implies a non-negative WTP distribution. Because using log(BID) implies the WTP distribution is skewed to the right , we used median WTP as the measure of consumer surplus.

We selected a set of individual and park-level variables as candidates for inclusion in the model (Table 2). The variables selected were mostly the "core economic variables" suggested by theory (Bergstrom and Taylor 2006) and include visitor characteristics such as income, age and gender, and three park characteristics. With only 12 parks, it was not possible to consider a large set of park characteristics.

Table 2. NPS 12-Park Sample Models, Variable Coding.

	Variable Coding	
Variable	**Individual Observation Model**	**12 Park Meta-analysis Model**
BID	DCCV bid; 7 bid levels were included ranging from $10 to $1000	--
GENDER	0 or 1; 1 = male	Proportion of visitors who are male
AGE	Age in years	Mean age in years
UNDER25K	0 or 1; 1= person reported household income under $25,000	Proportion of visitors reporting household income under $25,000
OVER65K	0 or 1; 1= person reported household income over $65,000	Proportion of visitors reporting household income over $65,000
DAYS	Reported number of days spent at park (less than 1 day coded as 1 day)	Mean number of days spent at park
AFTER	0 or 1; 1 if visitor decided to visit the park after already being in the area	Proportion of visitors deciding to visit the park after already being in the area
NP	0 or 1; 1 if park unit is classified as a National Park	0 or 1; 1 if park unit is classified as a National Park
HISTORIC	0 or 1; 1 if park unit is classified as a National Historic Park or National Historic Site	0 or 1; 1 if park unit is classified as a National Historic Park or National Historic Site
ACRES	Size of the park unit in acres	Size of the park unit in acres

We selected the final model based on AIC and cross-validation (Fox 2008). In cross-validation, the data are partitioned into disjoint subsets of one or more individuals each. Each subset is considered in turn. The model is fit to all the data except that subset and the resulting model is used to predict the values of the response for the omitted subset. After all the subsets have been treated in this way, a predicted value has been generated for each individual that is based on data not including that individual. A measure of discrepancy between the actual and predicted values is then computed and aggregated over the entire data set. Since our data were collected by park, for the cross-validation we omitted all the data from each park in turn and used the candidate model fit to the remaining parks to predict responses for all the individuals in the omitted park. To measure the agreement between the observed 0-1 responses and the predicted probabilities, we used the sum of squared deviance residuals (Hosmer and Lemeshow 2000).

We first fit a model including all the variables (the right-skewed variables ACRES and DAYS were log-transformed) which fit adequately (Hosmer-Lemeshow goodness-of-fit test (Hosmer and Lemeshow 2000), X^2= 12.3, df=8, P=0.14). We then sought a reduced set of variables with adequate explanatory power using AIC as the criterion. The main effects model with lowest AIC and lowest cross-validation prediction error is given in Table 3 as Model 1A (the same model with GENDER had almost identical AIC and cross-validation accuracy; we chose the model with fewer variables). The fit of Model 1A was also adequate (Hosmer-Lemeshow X^2= 12.1, df=8, P=0.15) and the likelihood ratio test (LRT) test of this model versus the full model was not significant (G^2=2.10, df=3, P=0.55). The signs of the coefficients on all variables including income were consistent with expectations. The only park level variable retained in the model was NP, an indicator of whether the park is a national park.

Table 3. Model 1A: 12-park individual observation model.

Variable	Estimate (*b*)	Std. Error	z	Pr(>|z|)	exp(*b*)
(Intercept)	2.416	0.274	8.81	< 0.001	
log(BID)	-0.781	0.039	-19.96	< 0.001	0.46
NP	0.328	0.111	2.95	0.003	1.39
AGE	0.016	0.004	3.89	< 0.001	1.02
log(DAYS)	0.225	0.094	2.38	0.017	1.25
UNDER25K	-0.637	0.190	-3.35	0.001	0.53
OVER65K	0.749	0.110	6.83	< 0.001	2.12
AFTER	-0.395	0.156	-2.53	0.011	0.67

Hosmer-Lemeshow goodness-of-fit test: X^2 =12.13, df=8, P=0.145

We next investigated interactions among the variables (excluding BID) in Model 1A. As a group, the interactions were not statistically significant (LRT: G^2=11.8, df=14, P=0.62) and no interaction or combination of interactions improved the fit of the model as measured by cross-validation and AIC. Therefore, we retained Model 1A as the final model. The coefficients all had the expected signs. The column "Exp(*b*)" can be interpreted as the increase in the odds of a positive response for a one-unit increase in that variable. For example, the odds that a person with income level below $25K will respond positively to a given bid are estimated to be 0.529 times less than the odds that a person with income $25K-65K will respond positively, other variables being equal. In turn, the odds that a person with income over $65K will respond positively to a given bid are estimated to be 2.115 times greater than the odds that a person with income $25K-65K will respond positively, given other variables equal.

The estimated median WTP for a fixed set of values of the explanatory variables is exp($-b'x/a$) where x is the vector of explanatory variables, excluding log(BID) but including a 1 for the constant, b is the vector of estimated coefficients corresponding to those variables, and a is the coefficient on log(BID) (Hanemann 1989). A standard error can be computed via the delta method from the estimated covariance matrix of b and a.

The use of Model 1A for park-level predictions is complicated by the fact that the model is for individuals. One way to use the model is to estimate median WTP for a representative sample of visitors to a park for which the appropriate covariates (such as age and income) have been recorded and then average the estimated WTP's. We tried this approach on the current data and found the estimated mean WTP's to be substantially higher in some cases than estimated median WTP from a bivariate logit model fit to each park. The reason was that some individual predicted WTP's were unrealistically high (usually for individuals at extremes of the covariates where prediction is much less reliable). More reasonable estimates were obtained by estimating median WTP at the average of the explanatory variables for each park and are reported in Table 5. However, this approach is not completely satisfying either as the WTP of an "average visitor" to a given park is not the same as the mean WTP across all visitors to the park. Alternative approaches would be to truncate the estimates for individuals in some way before aggregating, or to use the median of the median values for individual observations.

In order to apply this model to calculate estimated median WTP for out-of-sample parks, it was necessary to consider which variables are available from existing surveys for national park units. The NPS Visitor Services Project (VSP) located at the University of Idaho has surveyed many park units and all VSP park reports are available on the VSP website (Visitor Services Project 2009). While the VSP data set has many surveys that include most of the explanatory variables in Model 1A, only a few have a variable that corresponds well to AFTER. Income and days per trip are also reported in only a limited number of surveys. Income is problematic in that the reported measure is sometimes on a per-person basis and sometimes on a household basis in the VSP data set. There is also a problem with varying endpoints for income categories (e.g., under $25,000 versus under $20,000) and with adjusting for changes in income across different years.

In order to utilize the VSP data set, we identified the income category that corresponded most closely to variables UNDER25K and OVER65K after adjusting for inflation. To address the limited availability of AFTER, we built a second model, Model 1B, excluding this variable (Table 4). Although omission of the variable AFTER caused both the full model and the reduced model to have a significant lack of fit by the Hosmer-Lemeshow test (X^2 = 21.9,df=8, P=0.005 for the full model, X^2 = 21.9,df=8, P=0.005 for Model 1B), Model 1B fit nearly as well as Model 1A according to AIC and cross-validation. Predicted values at the covariate means and standard errors for the in-sample parks were also similar for the two models (Table 5). The significant Hosmer-Lemeshow tests may be a function of the large sample size and corresponding high power to detect small deviations from the model (a test of fit based on smoothed residuals was not significant for either model). The leave-one-out (LOO) park estimates of median WTP are, in general, very similar to the fitted values for both models with the exception of Yosemite National Park where the LOO estimate was about 30% higher than the full model estimate ($229 vs. $176). This indicates the models are fairly robust to small changes in the data set.

Table 4. Model 1B: 12-park individual observation model. Same as Model 1A with variable AFTER omitted.

Variable	Estimate (*b*)	Std. Error	*z*	Pr(>|z|)	exp(*b*)
(Intercept)	2.372	0.271	8.74	< 0.001	
log(BID)	-0.783	0.039	-20.08	< 0.001	0.46
NP	0.365	0.110	3.32	0.001	1.44
AGE	0.015	0.004	3.72	< 0.001	1.02
log(DAYS2)	0.269	0.093	2.89	0.004	1.31
UNDER25K	-0.670	0.189	-3.53	< 0.001	0.51
OVER65K	0.745	0.109	6.81	< 0.001	2.11

Hosmer-Lemeshow goodness-of-fit test: X^2 = 21.9,df=8, P=0.005

Table 5. Comparison of estimated median WTP from individual park bivariate logit models with model 1A and 1B predictions at park-level covariate means. Also includes leave-one-out (LOO) estimated WTP for each park from models 1A and 1B fitted to the data excluding that park.

	Bivariate Logit		Model 1A			Model 1B		
Park	**Estimate**	**SE**	**Estimate**	**SE**	**LOO**	**Estimate**	**SE**	**LOO**
Allegheny	43.8	21.3	63.2	7.1	63.5	65.2	7.2	65.5
Colonial	79.1	19.4	85.7	8.6	85.6	84.1	8.4	83.6
Everglades	85.5	26.9	108.8	11.4	109.9	110.4	11.4	112.3
Frederick Douglass	69.9	42.6	66.2	7.2	66.5	70.2	7.3	70.6
Glen Canyon	138.0	44.4	128.2	20.2	121.1	125.3	19.5	117.7
Golden Gate	84.6	18.2	89.3	9.4	83.9	86.9	9.0	80.1
Grand Canyon	116.8	20.8	122.5	11.2	118.1	119.4	10.8	115.5
Independence	65.8	16.2	83.7	8.5	85.3	85.5	8.5	87.3
Mesa Verde	132.9	30.6	109.5	10.8	100.4	112.1	10.9	103.0
Sleeping Bear	45.2	13.2	69.8	7.4	75.0	71.4	7.4	77.3
Yellowstone	179.3	29.4	146.9	13.8	134.2	146.8	13.8	133.3
Yosemite	95.6	13.8	175.1	20.0	220.5	175.9	20.0	228.7

We then used Model 1B to predict median WTP at a selection of eight VSP-surveyed park units (Table 6). These parks were chosen as having the most recent VSP survey data available for average length of visitor trip. Also reported are 95% confidence intervals for the median consumer surplus at the park in question. Relative to the in-sample estimates, the predicted values have a broad and reasonable range from $54 for Stones River National Battlefield in Tennessee to $237 for Katmai National Park.

Table 6. Model 1B: 12-park individual observation micro-meta model out-of-sample predicted median WTP at covariate means.

PARK	**NP**	**Mean Age**	**Mean Days**	**Under 25K**	**Over 65K**	**Predicted WTP**	**SE**	**95% CI**
Bryce Canyon NP	1	43.22	1.37	0.233	0.470	110.5	10.6	89.7 -- 131.3
Biscayne NP	1	45.19	1.76	0.159	0.372	120.8	10.7	99.8 -- 141.9
Crater Lake NP	1	47.81	1.30	0.334	0.220	86.0	9.2	67.9 -- 104.1
Stone River NB	0	49.64	1.10	0.296	0.210	53.7	6.4	41.2 -- 66.2
Apostle Islands NL	0	48.83	4.02	0.212	0.307	97.9	18.0	62.8 -- 133.0
Katmai NP & Preserve	1	51.02	2.02	0.041	0.797	237.1	25.7	186.6 -- 287.5
Great Smokey Mtns. NP	1	49.64	2.21	0.134	0.499	165.6	16.3	133.8 -- 197.5
City of Rocks NR	0	45.45	2.28	0.201	0.406	83.6	11.0	62.1 -- 105.2

Model #2: Meta-Analysis Model Based on Identical CV Methods Applied to 12 Parks

Another approach to using the 12-park data set is to build a park-level prediction model, as in Model 1, where an estimated WTP value for each park from Table 1 is used as the dependent variable in a linear regression model. The advantage of this data set is that the methodology and survey time frame are identical across parks compared to the disparate methods and dates of the expanded Kaval-Loomis data set. Potential explanatory variables (Table 4) are analogous to those used in Model 1, but aggregated or averaged at the park level. Since the number of cases was small, we considered a limited set of explanatory variables based on Model 1 and the variables available for prediction at parks outside of the data set. These variables include NP, HISTORIC, ACRES (log transformed), AGE (mean), UNDER25K (proportion), and OVER65K (proportion).

Compared to Model 1, there are several potential advantages of this approach. There may be a stronger relationship between aggregated WTP and park-level explanatory variables than between individual WTP and individual-level and park-level explanatory variables. Second, individual data are not required for prediction. Finally, the response is an aggregated WTP rather than a binary response which makes interpretation of the coefficients easier. Disadvantages are the limited number of data points (one per park) and the loss of information about individuals that may be useful in a predictive model. In addition, the value attached to each park in the sample must be estimated from the dichotomous choice CV data in some fashion and the resulting model may be dependent on how this is done.

Table 7. Model 2: 12-park weighted regression meta-model.

Variable	Estimate	SE	z	Pr(>|z|)
(Intercept)	4.466	0.167	26.78	< 0.001
NP	0.601	0.144	4.21	0.002
UNDER25K	-3.336	1.340	-2.49	0.034

$R^2 = 0.71$, F = 11.2 on 2 and 9 df, P = 0.0036

Model 2 is estimated using median WTP values (MEDIAN) derived from the bivariate logit models at each park separately (see Table 1). We also estimated the variance of each estimated median and used weighted least squares (with weights inversely proportional to the variances) to model log(MEDIAN) as a function of the explanatory variables. We again used AIC and cross-validation (with the sum of the weighted squared errors as the criterion), focusing primarily on the latter, to build a model. The final model, Model 2 in Table 7, had only two explanatory variables, NP (0 or 1) and UNDER25K (proportion of visitors with income under $25K). Two models with more variables and lower AIC performed considerably worse by cross-validation. Residual analysis of both the full and final weighted least squares models indicated no problems with the standard regression assumptions regarding uncorrected heteroskedasticity or excessive non-normality.

Table 8. Comparison of median WTP (estimated from individual park bivariate logit models) to predicted median WTP from Model 2.

Park	NP	UNDER 25K	Bivariate Logit Estimate	Bivariate Logit SE	Model 2 Prediction	Model 2 95% CI[a]	Model 2 LOO[b]
Allegheny	0	0.148	43.8	21.3	53.1	42.0 – 67.2	55.2
Colonial	0	0.052	79.1	19.4	73.2	56.6 – 94.6	71.3
Everglades	1	0.120	85.5	26.9	106.4	82.5 – 137.3	109.8
Frederick Douglass	0	0.160	69.9	42.6	51.0	39.5 – 65.9	50.2
Glen Canyon	0	0.069	138.0	44.4	69.1	55.0 – 86.6	67.3
Golden Gate	0	0.048	84.6	18.2	74.1	56.9 – 96.5	70.1
Grand Canyon	1	0.167	116.8	20.8	91.0	67.5 – 122.8	82.3
Independence	0	0.049	65.8	16.2	73.8	56.8 – 95.9	78.7
Mesa Verde	1	0.118	132.9	30.6	107.0	83.0 – 138.1	104.6
Sleeping Bear	0	0.182	45.2	13.2	47.4	35.0 – 64.2	54.0
Yellowstone	1	0.110	179.3	29.4	110.1	85.3 – 142.1	104.0
Yosemite	1	0.090	95.6	13.8	117.4	90.1 – 153.0	145.0

[a] Since Model 2 used log(median WTP) as the response variable, the 95% confidence intervals for the predicted values were computed by transforming back 95% confidence intervals for log(median WTP).

[b] Leave-one-out predicted value.

Since the response variable is logged, exp(*b*) is an estimate of the multiplicative effect of a one-unit increase in a variable on estimated median WTP. Thus a national park has estimated value exp(0.6013) = 1.82 times higher than a non-national park given the same income distribution of visitors. A 0.01 (one percentage point) increase in the proportion of visitors with incomes under $25K results in a predicted median WTP exp(.01 x -3.3362)= 0.967 times as big, or a 3.3% reduction in predicted median WTP. Table 8 shows a comparison of the original Table 1 median WTP estimates and the estimates based on Model 2.

Predicted values for the out-of-sample parks using Model 2 are reported in Table 9. Even though Model 2 has only two explanatory variables, the predicted values have a reasonable range relative to the literature, from $32 for Stones River National Battlefield to $138 for Katmai National Park.

Table 9. Model 2: 12-park weighted regression meta model out-of-sample predicted median WTP.

Park	NP	UNDER25K	Model 2 Prediction	Model 2 95% CI[a]
Bryce Canyon NP	1	0.233	72.9	47.0 – 113.2
Biscayne NP	1	0.159	93.5	70.2 – 124.6
Crater Lake NP	1	0.334	52.1	25.5 – 106.1
Stone River NB	0	0.296	32.4	17.6 – 59.5
Apostle Islands NL	0	0.212	42.9	29.4 – 62.5
Katmai NP & Preserve	1	0.041	138.4	98.7 – 194.1
Great Smokey Mtns. NP	1	0.134	101.5	78.2 – 131.8
City of Rocks NR	0	0.201	44.5	31.4 – 63.1

[a] Confidence intervals back-transformed from confidence intervals for log(WTP) as in Table 8.

Discussion

We have estimated two different models that can provide a basis for benefit transfer related to visitor use at sites in the National Park System based on a 1998 NPS survey of 12 NPS units. Our conclusion is that both models work as demonstrated however their wide applicability is limited by the small sample of park units available for the analysis. What is needed is to expand this set of consistently estimated park values. The estimated models demonstrate that it is feasible to predict values for a large set of park units from a relatively small set of original studies. We further compared the models in terms of model validity, consistency with theoretical guidelines, and usefulness for benefit transfer.

Both Models 1 and 2 are valid and theoretically consistent models that can be utilized in benefit transfer. Their utility in conjunction with the existing VSP data set is demonstrated on an out-of-sample set of parks (Tables 6 and 9). These predictions have sufficiently precise confidence intervals to inform valuation differences across parks. For the models estimated, using a consistent methodology on an original data set avoids some of the problems associated with studies of varying age, sampling methods, and valuation methodology.

The chief limitation of these models is that they are based on a relatively small sample of parks. One way to increase the sample would be by including a valuation question in the on-going VSP studies referenced earlier. We would also recommend including standardized measures of core economic variables such as income. Including a valuation question in future VSP surveys would parallel in part the valuation effort by the U.S. Fish and Wildlife Service for wildlife refuges in the U.S. (Aiken and La Rouche 2003), and would quickly expand the sample of parks available for modeling. It should be noted, however, that NPS is limited under its OMB approval in the type and wording of questions allowed in the VSP surveys. Inclusion of additional valuation questions would necessitate securing OMB approval under the Paperwork Reduction Act. Expansion of the set of park unit survey data sets available for CV modeling would also facilitate inclusion of an expanded set of park and visitor characteristics in the WTP models.

A second possible limitation of the models presented is they do not provide activity-specific values, but rather average visitor values. Many park planning decisions involve consideration of actions specific to specialized subsets of the visitor population. Examples might be changes in park access policy for snowmobiles in Yellowstone NP or for whitewater floaters in Grand Canyon NP. In these cases values for the average visitor (based on a sample of summer visitation) may provide a biased estimate. If a given policy issue requires activity-specific values, an alternative is to use an average activity-specific value from the larger literature (for example, as summarized in Rosenberger and Loomis (2001)). For the specific activity of fishing, sources are Markowski et al. 1997 and Aiken and La Rouche (2003). However, in many cases, and for many NPS units (such as the myriad of relatively small historical sites), visitor use is likely much more homogeneous than in the cases of high-profile, large area units such as Yellowstone or the Grand Canyon. In these cases, WTP estimates for the average core season visitor are likely a good metric to use in policy analysis. Significant expansion of the park unit data available for analysis could also allow for inclusion of activity-specific covariates in estimated models, thus mitigating to an extent this limitation of the current analysis.

In sum, there are a variety of benefit transfer approaches that can be tailored to the available data on a particular ecosystem service. While it is true that benefit transfer only provides an approximate estimate of the value of an ecosystem service relative to original site-specific survey based estimates, omission of economic values of recreation often implies a zero value to many decision makers. Any of the benefit transfer models presented in this paper yield estimates statistically greater than zero. While economists should continue to improve the accuracy of benefit transfer, we should not lose sight of the fact that it is important to convey to decision makers and the public that recreation does in fact have economic value that is in addition to visitor expenditure impacts on local economies.

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Estimating the Economic Value of Recreation Losses in Rocky Mountain National Park Due to a Mountain Pine Beetle Outbreak

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Introduction

Forest insects have long-standing ecological relationships with their host trees. Many insects have a benign or beneficial relationship with trees, but a few species are characterized by unpredictable population eruptions that have great ecological and economic implications (Logan, Régnière, and Powell 2003). These insect outbreaks are a major agent of natural disturbance in North American forests. In the United States alone the area impacted by forest pests is approximately 45 times larger than the area affected by forest fire, yielding an economic effect that is five times greater than fire (Dale et al. 2001). Forest pests also contribute to the occurrence and severity of wildfires and have adverse effects on nutrient cycling, carbon sequestration, and biodiversity (Ayers and Lombardero 2000).

The forest insect of particular interest to this study is the mountain pine beetle (MPB), *Dendroctonus ponderosae*. Bark beetles of the *Dendroctonus* family, found from sea level to 11,000 feet, co-exist with many tree and wildlife species. MPB are an integral part of forest development and regeneration (Logan, Régnière, and Powell 2003). There are 17 different species of bark beetles native to Rocky Mountain National Park (RMNP) and the western Front Range of Colorado. Periodic outbreaks of MPB have been recorded in RMNP since 1915, but none as excessive as the most recent outbreak. Since 1996 bark beetle outbreaks have killed over 6.6 million acres of forests in Colorado, in particular targeting lodgepole pine (*Pinus contorta*) and ponderosa pine (*Pinus ponderosa*) (Romme et al. 2006). MPB outbreaks have severe consequences on forest ecosystem dynamics through mortality and repressed growth of trees (Kurz et al. 2008). During sporadic outbreaks, MPB can kill a large number of trees over a widespread area. Outbreaks result in a reduction of forest carbon uptake and further increase the level of future carbon emissions from decaying trees (Kurz et al. 2008).

Tree mortality, caused by MPB, also may contribute to short term losses in timber production (Romme, Knight, and Yavitt 1986), pose as hazards in recreation areas (Walsh and Olienyk 1981), reduce the aesthetic beauty of landscapes (Jakus and Smith 1991), and depreciate the value of housing near outbreak areas (Price, McCollum, and Berrens 2010). Long term effects of forest insects on ecosystems may be realized if forest structure changes (i.e., a different mix

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of species after infestation). Romme, Knight, and Yavitt (1986), citing Mattson and Addy (1975) and Moore and Hatch (1981), argued that outbreaks of MPB led to only a brief drop in a forest's primary productivity. Over the short term (5-20 years) MPB populations, in natural or outbreak levels, actually introduce more variation into long term primary production and result in a more equitable distribution of biomass and resources among canopy, sub-canopy, and understory trees (Romme, Knight, and Yavitt 1986). Thus, in the long run, forest ecosystems may benefit from forest insect outbreaks and their residual effects.

The economic literature reveals that there is a negative relationship between the effects of forest insects and the quality and visitation rate for recreation (Rosenberger et al. 2012). These negative effects are associated with visible damages (Haefele, Kramer, and Holmes 1992; Holmes and Kramer 1996; Kramer, Holmes, and Haefele 2003; Michalson 1975; Walsh and Olienyk 1981), tree density (Leuschner and Young 1978; Loomis and Walsh 1988; Walsh and Olienyk 1981; Walsh, Ward, and Olienyk 1989; Walsh et al. 1990; Wickman and Renton 1975), and tree size (Loomis and Walsh 1988; Walsh and Olienyk 1981). MPB infestations can also lead to a reduction in the quality of the recreation experience, measured through decreased consumer surplus and decreased number of total visits.

This study uses the benefit transfer approach to estimate the recreational damages associated with MPB infestation in RMNP, Colorado. Benefit transfer uses existing information from primary and secondary sources to estimate values for nonmarket goods such as recreation (Rosenberger and Loomis, 2003). For an extensive review of benefit transfer, see Johnston and Rosenberger (2010). Here, we measure damages by completing benefit transfers that assume reductions in live tree density per acre are directly correlated with MPB infestation rates. The remainder of this paper provides additional information on MPB in the Rocky Mountain region, sources of data and methods used, results, and conclusions based on this research.

Methods

In this study the method of benefit transfer is used to retroactively examine the effects of MPB on total recreation value for RMNP. In general, benefit transfer develops information for a policy site (in this case RMNP) from existing data or original research conducted at a different site or for a different purpose (Rosenberger and Loomis 2003). This study combines adjusted point estimate information with reduced form functions that relate changes in consumer surplus per user day and changes in the number of user days with changes in live tree density. The outcomes of this study provide estimates of the total recreation value of RMNP at different levels of MPB infestation rates.

Klutsch et al. (2009) estimate that MPB have infested 5.5 percent (the natural rate of MPB infestation in the Colorado Front Range) to 100 percent of lodgepole pine in areas within the Arapaho National Forest, which borders RMNP to the south. However, infestations are often patchy and do not always kill all of the susceptible trees (Klutsch et al. 2009). We assume live tree density changes occur at some lower rate of infestation rates, calculating changes in 0, 25, 50, and 75 percent reductions in live tree density. Total recreation value estimates for RMNP due to different MPB infestation rates are derived based on changes in the number of live trees per acre in RMNP. Thus, we need an estimate of the number of live trees per acre, total number of user days, and the value of a recreation user day.

The U.S. Forest Service provides estimates of number of live trees greater than 5 inches diameter at breast height (dbh) by tree type for 2009 in RMNP (U.S. Forest Service 2012). The mean number of live trees per acre is calculated as total number of live trees in RMNP divided by 171,166 acres of forested lands, resulting in a mean of 270 trees per acre. The total number of user days in 2009 for RMNP is 2,822,325 user days as provided by the National Park Service (National Park Service 2012). And the value per user day is $26.66, which is provided by a contingent valuation study conducted at RMNP by Richardson and Loomis (2005), adjusted to 2009 dollars (in comparison, Walsh and Olienyk (1981) provide an estimate of $25.25 (adjusted to 2009 dollars) per user day for the Colorado Front Range). Total recreation value is total user days times the value per user day. However, changes in live tree density caused by MPB may have two effects on recreation values: (1) changes in the value per user day, and (2) changes in the number of user days. Thus, functions that link value per user day and total user days with changes in live tree density are needed.

Walsh and Olienyk's (1981) study of MPB infestation in the Colorado Front Range provides the needed functions. They estimated a reduced form function for average value (i.e., consumer surplus (*CS*)) per user day of recreation contingent on the change in number of live trees per acre (*T*), holding all else constant:

$$Average\ daily\ CS = -2.97 + 0.0917T - 0.00017T^2 \qquad (1)$$

Equation 1 indicates that an individual would, on average, have disutility of $2.97 in CS per user day if there were no live trees. With otherwise identical conditions, an individual's consumer surplus would increase by $0.0917 per user day with each additional live tree (Walsh and Olienyk 1981). The squared term indicates that the increase in consumer surplus per live tree per visit increases at a decreasing rate.

Walsh and Olienyk (1981) also provide a reduced form function for average annual user days (*UD*) of forest recreation contingent on number of live trees per acre (*T*), holding all else constant:

$$Average\ user\ day\ = 9.32 + 0.0923T - 0.0002T^2. \qquad (2)$$

Equation 2 shows that an individual would demand, on average, 9.32 days of recreation per year with no live trees. The individual would increase her demand for recreation by 0.0923 days with every additional live tree per acre, given that all other conditions remain constant. An individual's demand for number of days recreated contingent on number of live trees increases at a decreasing rate, as is indicated by the squared term.

Based on these two reduced form functions, average arc elasticities are calculated. The average arc elasticities approximate the percent change in consumer surplus and total user days for a 1 percent change in total live trees greater than 5 inches dbh per acre. Average arc elasticities are calculated for the intervals 0 – 25, 0 – 50, and 0 – 75 percent reduction in live trees per acre due to MPB damage. It should be noted that Walsh and Olienyk's (1981) equation represents average user days per person per year given live trees per acre. This study uses the Walsh and Olienyk (1981) equation to estimate total user days and the change in total user days for each level of MPB damage. Because Equation 2 is based on average rates per person in the Walsh and Olienyk (1981) study, it is assumed that these elasticities are the same for a person as for a population (i.e., if each person in the relevant population reduced their visitation by 4 percent, then total visitation would also be reduced by 4 percent).

Beginning with Richardson and Loomis' (2005) estimate of $26.66 per user day (adjusted to 2009 dollars) for recreation in RMNP (CS_{2009}) and the calculated elasticity for consumer surplus (E_{CS}), changes in consumer surplus for different damage rates (R_i) are estimated following Equation 3:

$$CS_i = CS_{2009} - (R_i * E_{CSi} * CS_{2009}), \quad (3)$$

where i refers to each range of decreased live tree density (i.e., i = 0 – 25, 0 – 50, or 0 – 75 percent reduction in live trees per acre). Similarly, total user days for the range of MPB infestation rates are calculated beginning with the National Park Service estimate of 2,822,325 user days in 2009 (UD_{2009}), damage rates (R_i) and total user days elasticities (E_{UD}) following Equation 4:

$$UD_i = UD_{2009} - (R_i * E_{UDi} * UD_{2009}), \quad (4)$$

where i is as previously defined.

The baseline total recreation value is then $TRV_{2009} = CS_{2009} * UD_{2009}$. Total recreation value for each level of MPB infestation (i.e., damage as reduced live tree density) is $TRV_i = CS_i * UD_i$, for each i = 0 – 25, 0 – 50, and 0 – 75 percent reduction in live trees per acre. Thus, the total recreation damages due to MPB infestation are $TRV_{di} = TRV_{2009} - TRV_i$.

Results

Table 1 provides the average arc elasticity estimates for consumer surplus and user days with respect to live tree density as they were calculated over the ranges of percent decreases in number of live trees per acre from the mean number of total live trees per acre, 270. The estimated arc elasticities show decreases in CS for reductions in live tree density per acre, including -0.298 percent, -0.589 percent, and -0.978 percent for each 1 percent decrease in number of live trees greater than 5 inches dbh per acre for 25, 50, and 75 percent reductions in live tree density. The quadratic function relating CS to live trees per acre shows an increasing effect of tree density reductions: a 25 percent reduction in live trees results in a 7 percent reduction in CS per user day; whereas a 75 percent reduction in live trees results in a 73 percent reduction in CS per user day (Table 1).

Table 1 – Elasticity of Consumer Surplus and User Days with Respect to Live Trees

Percent Change in Tree Density	Elasticity of Consumer Surplus[a]	Percent Change in Consumer Surplus	Elasticity of User Days[a]	Percent Change in User Days
25	-0.298	-7	0.026	1
50	-0.589	-29	-0.121	-6
75	-0.978	-73	-0.244	-18

[a]Percent change in consumer surplus or user days for a 1 percent change in trees.

Conversely for total user days, the initial reduction in live trees per acre results in an increase in total user days, then falls with increasing reductions in live trees. User days increase by 0.026 percent for each 1 percent decrease in tree density for a 25 percent change, to a loss in user days of -0.121 and -0.244 percent for each 1 percent decrease in live tree density for 50 and 75 percent reductions, respectively. Overall, user days increased by 1 percent for 25 percent reduction in live tree density, and decreased by 6 and 18 percent for 50 and 75 percent reductions in live tree density, respectively.

The cumulative effects of a MPB infestation on consumer surplus per day, user days, and total value of recreation are provided in Table 2. Following the pattern of elasticity estimates and percent change estimates in Table 1, consumer surplus per user day decreases as live tree density declines. Conversely, total user days initially increase with decreases in live tree density, but then decline as tree density declines. These combined effects result in total recreation value changes of -$5 million, -$25 million and -$59 million with 25, 50 and 75 percent reductions in live tree density. These losses are from a baseline total recreation value of $75 million.

Table 2 – Consumer Surplus per Day, Total User Days, and Total Value of Recreation

Percent Change in Tree Density	Consumer Surplus per Day	Total User Days	Total Value	Change in Total Value
0[a]	$26.66	2,822,325	$75,243,185	$0
25	$24.67	2,840,907	$70,092,408	-$5,150,777
50	$18.81	2,651,458	$49,864,257	-$25,378,927
75	$7.10	2,305,790	$16,366,787	-$58,876,397

[a]Baseline case of natural infestation rate with 270 total live trees per acre.

Conclusions

In this article we have provided estimates of the potential economic damages to recreation value within RMNP due to a MPB infestation based on integrating secondary information from several sources. At a minimum these estimates provide a thumbnail sketch of the possible benefits from control programs or policies. This article also provides evidence that MPB outbreaks result in significant losses in recreation values, at least in the short term. Moderate to severe MPB outbreaks can cause losses in the total recreation values from $5 million to $59 million, and may reduce recreation visitation by 0.5 million user days at maximum outbreak levels. External validity of these visitation changes would be achieved if actual visitation estimates were similar; however, because of many confounding factors (changes in economic conditions, changes in recreation travel patterns, etc.), actual visitation increased from 2009 to 2010 (National Park Service 2012). Nonetheless, the cost of mitigation strategies and preventative measures should be investigated and warrant comparison against the recreation loss estimates provided in this report.

There are several ways to control MPB outbreaks and mitigate their effects, including dynamic forest management, pesticides use, stand clearing fires, and selective or clear cutting trees. Manipulating the estimates for total recreation value, given in Table 2, we divide by the forested acreage of RMNP (172,751 acres). We find that damages caused by MPB to live trees reduce total recreation value by $30 - $341 per acre per year. The loss per acre in recreation value may be compared with the cost per acre of mitigation or prevention.

One method of prevention that has significantly reduced tree mortality (up to 90 percent) in high value forests of Washington, Montana, Idaho and California is the application of the pheromone verbenone. The cost for the application of verbenone is $107 per acre (McGlynn 2012). This implies a total cost of $29,367,670 to apply the pheromone on forested acres in RMNP. Except for the most severe of modeled MPB outbreaks, the cost of applying verbenone exceeds the loss of total recreation value in RMNP. However, as MPB outbreaks intensify, evidence suggests that verbenone becomes ineffective (Bentz et al. 2005). Furthermore, we assume trees, pests, damages, and recreationists are evenly distributed across space. Perceived damages to recreation are likely clustered spatially around high visitation and viewable areas. Thus, the National Park Service's policy to use Integrated Pest Management (e.g., removal of beetle infested or hazardous trees, fuel reduction, prescribed fire) and to apply pesticides to protect high valued trees in high use and unique areas only is a reasonable defense against MPB in comparison with the cost of total control (National Park Service 2005).

Our estimate of total recreation value damages is conservative, but how it is interrelated to other factors affecting recreation value, and other value types, is unknown for this analysis. For example, our assumption is that reductions in live trees per acre, holding all else constant, is associated with these live trees disappearing from the landscape. In reality, beetle killed trees become standing and downed dead trees. Walsh and Olienyk (1981) estimated that dead and down trees reduce recreation demand by 2.3% for every 1 percent increase in dead and down trees per acre in the range of 1 to 15 percent increase in dead and down trees per acre. Unfortunately, how dead and down trees interact with live trees per acre in the demand for and value of recreation visits was not modeled in the sources of information we used in this study.

It also should be noted that this comparison does not consider aesthetic, passive-use (option, existence and bequest values) or housing value enhancements generated by live trees within RMNP. The literature also shows that nonuse or passive-use benefits are more than three and a half times greater than recreation-use benefits (Holmes and Kramer 1996; Kramer, Holmes, and Haefele 2003; Walsh et al. 1990). Without the inclusion of passive use values an economic assessment for management or policy use, including only direct use benefits, would understate the true value of a forest and its realized ecosystem services. Without adequate information, a sub-optimal conclusion or decision could be reached. However, even if the results of this project suggested that a park wide treatment of verbenone or insecticide was economically feasible, it may not be technically, physically, or socially feasible.

Confidence in our ability to transfer knowledge may decay over time. As noted by Pendleton, Atiyah, and Moorthy (2007:370), "for values to be relevant to current policy-making, they need to reflect current estimates of nonmarket values." Although the economic value per recreation user day is fairly recent and specific to RMNP, the functional relationships between user days demanded and consumer surplus per trip are based on a study over 30 years old. Because methods for nonmarket valuation have been critiqued and updated, stakeholder preferences may have changed, and the scale and intensity of outbreaks may have increased over time, dependence on older data may affect, whether real or perceived, the accuracy and relevance of values obtained through benefit transfer (Johnston and Rosenberger 2010; Pendleton, Atiyah, and Moorthy 2007). Therefore, not only do we need to expand our stock of knowledge through new primary research, we also need to replenish or verify older results.

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The Potential of Valuing Rangeland Ecosystem Services on Public Rangelands[1]

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Introduction

The spring 2012 issue of the Western Economics Forum (WEF) highlighted issues related to the economic analysis of land management decisions and ecosystem service valuation on public lands. Two papers addressed issues related to the use of the contingent valuation method (CVM) (Little et al. 2012; Loomis 2012) and a third paper discussed the use of a state-and-transition model (STM) framework for valuing ecological change (Taylor and Rollins 2012). It was noted that in the past two decades there has been a shift of the federal land management agencies from multiple uses to ecosystem management and this has brought an increased recognition for the need to value ecosystem services in land management planning efforts (Loomis 2012). As noted by Taylor and Rollins (2012), despite a growing recognition of the need for placing an economic value on the ecosystem services provided from rangelands, there is a perception among scientists and public land decision makers that economic theory and methods are not up to the task of providing accurate, timely and policy-relevant estimates of the economic values associated with ecosystem changes. Taylor and Rollins dismissed this pessimistic view and suggested there are steps that can be taken to counter criticisms about attempting to place an economic value on the ecosystem services provided on both public and private lands. Loomis (2012) similarly dismissed the notion that economists are not up to the task and detailed ways to integrate non-market values into land agency decision making and planning.

We agree that resource economists can provide site-specific valuations of rangeland ecosystem services but believe there are major obstacles that will result in questionable reliability of those estimates at various levels. Some of those obstacles relate directly to the procedures and model extensions and extrapolations proposed in the Western Economic Forum papers. Most notably, the Forum papers suggest a reliance on the Contingent Valuation Method (CVM) with many noted shortcomings; an extrapolation of study results using benefits transfer; and reliance on rangeland state-and-transition models to measure ecosystem differences between management alternatives. In this paper we detail our concerns about relying extensively on these procedures and highlight what we perceive to be major obstacles for providing accurate, timely, and policy-relevant estimates of the ecosystem values associated with changes on rangeland. We conclude that land managers should maintain their justified concern about site-specific ecosystem service valuations as widely needed for policy analysis and planning. The linkages

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required to value rangeland ecosystem services are poorly defined and with current staffing, land management agencies have a great potential to extrapolate economic values well beyond an appropriate level of applicability. This also assumes that the federal agencies will have adequate staff, expertise and budget to make the initial economic valuation estimate in the first place. Given the significant valuation limitations for rangeland ecosystem services we suggest that identifying an expected direction of change in the level of goods and services provided is a realistic goal of project assessments.

Limitations to Economic Valuation

Non-Market Valuation

In some environmental applications, revealed preference techniques such as the travel cost method and hedonic models are applicable and can be used for ecosystem service valuation (Champ 2003). But, for some public goods there are no behavioral trails or observed market transactions; thus, stated preference methods and surveys are needed to elicit a willingness to pay (WTP). Reliance on WTP studies to value ecosystem services should be of concern to land managers and decision makers given the hypothetical bias described by the WEF paper authored by Little et al. (2012) and widely discussed in the literature (see for example Champ 2003, Loomis 2011, List and Shogren 1998). As noted in the Little et al. paper, valuation responses in a survey setting are typically larger than in some actual settings involving net economic commitments. Little et al. (2012) noted that 60% of the 225 studies considered in their meta-analysis were found to show a statistically significant disparity between hypothetical and actual valuation responses. As further noted by Little et al. (2012), a 1993 ”blue ribbon” NOAA panel report greatly increased and highlighted the concerns about hypothetical bias. The report recommended that hypothetical bids be deflated using a ‘divide by 2’ rule unless the bids can be calibrated using actual market data (List and Shogren 1998, Loomis 2011).

Traditional benefit/cost studies of range improvement projects have underestimated the net economic benefit of improvement practices because the economic value of conservation benefits have largely been excluded from the limited economic assessments that have been done (Tanaka et al. 2011). Using WTP studies with inflated values in the conservation benefit assessment has the potential to move the other way and overstate project benefits. Further, the comparison of non-market values for some public land uses (e.g. wildlife) to market-derived values for other uses (e.g. livestock grazing) is also an obvious concern given the bias of CVM valuation procedures. As noted by Loomis et al. (1989), an economically efficient allocation of forage would involve providing additional forage to wildlife until the marginal values between wildlife and livestock are equal. This optimal efficiency condition obviously assumes that both estimates of forage value are correct and comparable, a questionable result if valuation bias exists.

Undefined Linkages and Production Relationships

The most fundamental challenge for valuing ecosystem services is an adequate description and assessment of the linkages between the structure and function of natural systems and the goods and services derived under alternative actions (NRC 2005). Taylor and Rollins (2012) argued that the ecological site and State-and-Transition Model (STM) framework can provide the necessary detail needed to measure rangeland ecosystem provisioning under alternative management actions. Ecologists and other scientists suggested a similar promise for the ecological site description and STM framework (Bestelmeyer and Brown 2010; Herrick et al. 2010; Bestelmeyer et al. 2011). As Brown and MacLeod (2011) noted, the STM framework is a soil/vegetation-based system in which locations with similar climate, geomorphology and edaphic properties are grouped into ecological sites based on their response to disturbance. Within each ecological site, a unique STM describes the dynamics of vegetation and soil surface properties, and provides indicators of the vegetation structure and soil properties. Alternative management actions potentially move the process within and between states. Because the ecological model is soil/vegetation-based, provisioning of different types of ecosystem goods and services can be predicted if there is a defined and predictable linkage to soil and vegetation characteristics.

While vegetation conditions link directly to livestock grazing output potential and the potential benefits from vegetation management practices, estimating the complex linkage from altered soil and vegetation conditions to the provisioning of other rangeland outputs is complex and largely undefined. Even for the case of forage production, changes over time and space are not always well known. If an ecological site is over- (or under-) grazed in a drought year the impact on future long-term production is not known in many cases. Further, STMs have been developed using expert knowledge from primarily land agency personnel; site-specific and long-term ecological data are rarely available and used for STM development (Knapp et al. 2011). As noted by Allen-Diaz and Bartolome (1998, p. 803), “most of our information about rangeland ecosystem behavior is based on comparisons of deteriorated and protected areas, thus we really only have good information about the process of rangeland deterioration, not recovery. More and longer term studies of community behavior in response to changes in grazing, following fire, and following vegetation treatment, are sorely needed for rangeland ecosystems.” An assessment of Natural Resource Conservation Service (NRCS) rangeland conservation efforts indicated that it was not possible to determine the magnitude or trend of conservation benefits originating from NRCS conservation investments because of the paucity of information documenting benefits (Briske 2011, P. 11). As documented in the various NRCS study chapters, the benefits of conservation practices are seldom quantified and lack consistent measurement over time and space.

In agreement with this observation, and considered as a specific example, a review article about the economics of prescribed burning noted that the major limitation for evaluating prescribed burning treatments is the lack of understanding between economic outcomes and ecological effects. Hesseln (2000, p. 332) suggested that future research should focus on defining a production function that describes the long-term relationships between prescribed burning and ecological effects and enhancement. Further, the author noted that beneficial effects of prescribed fire must be systematically identified and evaluated with specific land management objectives in mind. STM models can be useful in defining those relationships in some cases but will not be useful for valuing ecosystem goods and services that are not tied to soil and vegetation characteristics. An adequate description and assessment of the many linkages between the structure and function of natural systems and the goods and services derived under alternative actions remains the key challenge.

Economic Value Extrapolation

Taylor and Rollins (2012) cited the writings of Robert H. Nelson, an economist with a career in the Department of Interior. They used his writings as an example of the skepticism about economic valuations of rangeland ecosystem services. In the cited journal paper (Nelson 2006) and an earlier text book about the failures of public land management (Nelson 1995), Nelson detailed the history and minimal role of economic analysis in federal agency land use decisions. Many of his thoughts are relevant and should not be overlooked. As noted by Nelson, while the Office of Management and Budget (OMB) and others pushed for increased use of benefit-cost analysis within the Bureau of Land Management (BLM) the agency had few economists and little experience with doing economic analysis. This lack of social science expertise within the federal land agencies continues. Survey responses from an internal social and economic capabilities assessment conducted within BLM in 2007 (Tanaka et al. 2009) indicated that at that time only about 7% of BLM professional staff had significant training and/or experience in the social sciences and this expertise was especially lacking below the state level.

As noted by Loomis (2012), given limited social-science staff and economic analysis capabilities, economic analysis performed by public land management agencies has primarily been limited to standard regional economic analyses using IMPLAN. These regional assessments provide little insight into the nonmarket ecosystem values for which management actions are proposed. In some cases, crude estimates of nonmarket benefits are used in planning documents but usually with a single value for each output applied across broad areas and without consideration of local circumstances and conditions (Nelson 2006).

Legal mandates to consider social and economic impacts in planning efforts coupled with their own limited social science staff motivated the land agencies to seek economic models and tools for use in resource planning and assessment. They seek tools for estimating economic impacts of grazing decisions from the Resource Management Plan level all the way down to the grazing permit renewal level. Loomis (2012) and Taylor and Rollins (2012) noted similar agency needs for other landscape management decisions and planning efforts. The proposed solution suggested in the WEF papers would be to use benefit transfer which uses values and other information from a ‘study site’ where data are collected to a ‘policy site’ with little or no data. A site-to-site transfer function is defined that considers the spatial, temporal, and ecological details specific to the target ecosystem (Taylor and Rollins 2012, P. 14). Meta-analysis equations have been used to tailor the benefit transfer to a specific study site (Loomis et al. 2012). Taylor and Rollins (2012) suggested that with a rangeland application the benefit transfer would apply to other rangeland areas having the same ecological site characteristics.

Loomis (2012) noted that the land management agencies would find it most useful to have site-specific per acre values of ecosystem services for different landscape conditions. Land agencies seek a “turn-key” valuation of ecosystem services. As noted above, this implies that we know which ecosystem services each acre of land will provide (i.e., the production functions). Loomis recognized the challenge in generating site-specific values that can be spatially mapped onto GIS layers, but we believe he minimizes the challenge for rangelands in particular. As noted by Briske (2011, P. 11) there has been minimal investment by the USDA and the rangeland profession in assessing conservation practice effectiveness. Consequently, conservation practices have seldom been monitored across spatial areas (even within the same ecological site) and through time as needed to adequately assess conservation practice outcomes. The biggest problem we see for benefit transfer application on rangelands, besides the benefit estimation component, is the limited number of studies from which to extrapolate and project ecosystem service responses by ecological site, given the time, space, and response issues raised earlier. Yet, in many cases it may not be economical to undertake the long-term studies replicated across time and space required to fill the information void. As noted by Nelson (2006, p. 539) “It might cost more to collect the necessary data and to conduct the economic analysis than the total social benefits of doing the analysis in the first place.” Cost is an obvious reason why documentation of conservation benefits from rangeland improvements is lacking and long-term rangeland studies are rare. The wetland-area and wildlife valuation studies cited by Loomis (2012) may have much more potential for benefit-transfer extrapolation then do heterogeneous rangeland areas.

Valuation Alternatives

The pessimistic view that adequate definition of key linkages about the structure and function of rangeland systems limits our ability to provide reliable estimates of the economic value of many rangeland ecosystem goods and services is disheartening and a continuing dilemma. For the most part, selection of rangeland restoration projects and management alternatives has relied on the judgment of rangeland managers without economic consideration beyond project costs. Obviously, expanded benefit/cost assessments should be undertaken when sound data are available. Research should be undertaken to define key economic and ecological relationships when justified. But, with current knowledge, identifying the expected direction of change and relative magnitude of change may be more useful. This is the type of assessment proposed by the Sustainable Rangeland Roundtable (SRR)[6].The SRR framework compares the expected progression of biophysical conditions, natural resource capital, social capacity, economic capital, and human conditions when alternative management actions are followed (Fox et al. 2009). Assessment is more along the lines of direction of change, tradeoffs, and expected strength of change rather than applying values and conducting economic efficiency analyses. Kreuter et al. (2012, Table 1) applies the conceptual SRR framework to alternative energy development options, summarizing expected bio-physical and social-economic impacts with a relative ranking of +, ++, 0, - and --. Indicators of social, economic, and ecological sustainability are monitored over time and impacts assessed by the decision- or policy-maker. Ideally, the indicators would help decision- and policy-makers identify which data are important to collect and that more quantitative relationships can be developed over time. It is left up to the decision- or policy-maker to determine whether the direction of change is "good or bad." We argue that in most cases this is the best that can reliably be done given the current state of knowledge about the critical linkages required for rangeland ecosystem valuation. We are far from being able to reliably estimate the levels of goods and services provided under alternative management actions, to extrapolate those value estimates across the western public lands, or to use those values to evaluate trade-offs in many management and policy decisions. Solutions to these problems will require consideration of current and foreseeable federal agency and research funding, staffing and resources, and the potential net social value of the information gained. It will require across-discipline cooperation and research efforts to describe and quantify the levels of key ecosystem goods and services realized under alternative management actions measured across broad landscapes.

[6] It is the ranking of alternatives that we find appealing about the SRR framework but alternative ranking models and processes could work equally well.

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