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ANALYSIS

Valuing environmental benefits of silvopasture practice: a case study of the Lake Okeechobee watershed in Florida

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Abstract

Silvopasture, which combines trees, forages, and shrubs with livestock operations, has potential for limiting phosphorus runoff, sequestering atmospheric carbon dioxide, and improving habitat for wildlife. This study estimates the public demand for these environmental services in south-central Florida's Lake Okeechobee watershed using a stated preference approach. The results from a random parameter logit model reveal that households would pay US$30.24–71.17 per year for 5 years for these environmental benefits. These estimates provide a basis for formulating policies to promote silvopasture practices in the Lake Okeechobee watershed.

Keywords: Pollution runoff; Public good; Stated preference; Willingness to pay

1. Introduction

Silvopasture practice is an agroforestry technology combining trees, forage, and shrubs with livestock operation. Many researchers have noted that silvopasture practices provide environmental benefits such as water quality improvement, soil conservation, carbon sequestration, wildlife habitat protection, and aesthetics (Alavalapati and Nair, 2001; Clason and Sharrow, 2000; Garrett et al., 2000; Kurtz, 2000). These environmental benefits are largely attributed to tree and other vegetation cover on cattle ranches. Besides the above environmental benefits, trees and vegetation cover complement livestock operations by providing shade to cattle (Kurtz, 2000; Clason and Sharrow, 2000; Pimentel et al., 1995).

Water quality benefits of maintaining trees and other vegetation on farms and ranches are realized by reducing pollution runoff, maintaining long-term water cycle, and recharging ground water aquifers (Wu et al., 2001; Stednick, 1996). Research on riparian buffer strips' impact on surface runoff suggests that tree and grass buffer strips 20–30 m wide control up to 77% phosphorus and 80% of nitrogen runoff (EPA, 1995; Garrett et al., 2000). For these reasons, silvopasture is an important land-use practice through which ranchers can contribute to the improvement of water quality.

Carbon sequestration is another important benefit that silvopasture can generate by storing atmospheric carbon dioxide in the form of tree biomass. Added tree

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cover on pasturelands is expected to increase carbon storage. Under the Kyoto Protocol, it is likely that carbon credits can be obtained for new or expanded tree cover in silvopasture (Sedjo, 2001; Cannell, 1999). Literature suggests that an acre of southern pine grown in silvopasture with 20-year rotation could absorb anywhere between 145 and 220 tons of carbon dioxide (Cannell, 1999; Grierson et al., 1992).

Private lands play a key role in supporting habitat for various wildlife species.[1] In particular, private pasture and ranchlands of south-central Florida support various wildlife species including Sandhill Crane, Burrowing Owl, White-tailed Deer, and the endangered Crested Caracara (*Caracara cheriway*) (Morrison and Humphrey, 2001; Swisher et al., 2000). Trees and other vegetation on private forests, farms, and ranches often provide critical habitats for many threatened and endangered species (Loomis and Helfand, 1993).

Silvopasture, considered highly compatible with traditional ranching, includes several elements of best management practices for ranchers. In addition, silvopasture addresses non-point source pollution runoff and other key environmental problems in a more rigorous and systematic way (Bottcher et al., 1995; Clason and Sharrow, 2000; Ribaudo et al., 1999). Environmental benefits associated with silvopasture are public goods as they are not exclusive to ranchers, yet ranchers bear the entire cost of producing them. For this reason, ranchers may not consider these services in their production decisions and are less likely to adopt silvopasture practices on voluntary basis. If these services are internalized through compensation policies, however, ranchers may begin to adopt silvopasture and generate environmental services at optimum levels. The first step in formulating compensation policies is to generate information about the demand for environmental services as valued by the public. In this study, we estimate the value of environmental goods and services of silvopasture using the stated preference method. In particular, we elicit public willingness to pay (WTP) for improvements in water quality, carbon sequestration, and wildlife habitat through silvopasture practices in the Lake Okeechobee watershed, Florida.

The value of a public good is the sum of what individuals would be willing to pay for it (Varian, 1992; Sugden, 1999; Ley, 1996; Besley and Ghatak, 2001; Falkinger et al., 2000). Valuation of environmental improvement associated with forestry and agricultural practices has been extensively studied (Cooper and Keim, 1996; Lohr and Park, 1994; Mitchell and Carson, 1989; Bateman and Willis, 1999; Champ et al., 1997). For example, Cameron et al. (2002) estimated non-market value of tree plantation on public lands accounting for the benefits of providing shade in summer, windbreaks in winter, and absorbing carbon dioxide. Loomis et al. (2000) assessed the value of vegetation buffer strips along streams, which increase ecosystem services such as erosion control, water quality, and fish and wildlife habitat. However, the value of agroforestry environmental benefits in terms of public willingness to pay has rarely been studied. To our knowledge, this is the first study that attempts to value environmental benefits of silvopasture practices from the public perspective.

2. Study area

The northern watershed of Lake Okeechobee in Florida extends nearly 12,950 km^2 in the central peninsula, encompassing the Kissimmee River to the north and its ensuing flow into the Everglades to the south (SFWMD, 2002). The watershed drains into the Lake Okeechobee, a large, shallow fresh water lake with a surface area of 1890 km^2. It is the largest freshwater lake in Florida and the second largest in the US, after the Great Lakes (EPA, 2000). As a source of drinking water, Lake Okeechobee is designated as a Class I water body. In addition, it is a source of irrigation and ground water, habitat for fish and waterfowl, as well as an avenue for flood control, navigation, and recreational uses.

Cattle ranching is the dominant land-use practice in the Lake Okeechobee watershed (Boggess et al., 1995;

[1] In the US, private farms and forests covered 66% of total land area and support 80% of wildlife habitat (Benson, 2001).

[2] Pasture improvement includes designing site drainage, growing improved forage grasses, and applying inorganic fertilizers (Boggess et al., 1995).

FAS, 2000) with over 65% of the area under improved and semi-improved pasture.[2] The watershed currently supports approximately 700,000 cows and calves, nearly 40% of Florida's total cattle population (FCA, 1999; FAS, 2000). Florida ranks the 10th in the US and the 3rd in states east of the Mississippi River for beef cattle herd size. While most (98%) of Florida's ranches are relatively small and entirely dependent on cultivated grasses and legumes for grazing, the remaining 2% primarily located in central and south Florida comprise about 75% of the pastureland and support 48% of Florida's cattle. These large ranches each consist of more than 750 cows (Wade et al., 2001).

Despite great economic significance of cattle ranches in the Lake Okeechobee watershed, there has been a growing public concern about the pollution runoff caused by these ranches. Cattle ranches are identified as one of the non-point sources of phosphorus loading, which causes nutrient enrichment and eutrophication in lake waters (Boggess et al., 1995; SFWMD, 2002; Zhang and Essex, 1997). As cattle pastures are developed with improved grasses such as bahia grass (*Paspalum notatum*) and to accommodate higher stocking density of animals, more feed and fertilizer are imported into the watershed (Boggess et al., 1995). These imported nutrients ultimately leach into the streams and lakes through surface runoff and increase the phosphorus concentration in Lake Okeechobee. The concentration has increased from about 0.025 μg/l (25 parts per billion) in 1968 to 0.11 μg/l in 1998, exceeding the US Environmental Protection Agency recommended level of 0.040 μg/l (EPA, 1995). Silvopasture has the potential to not only reduce phosphorus run-off but also to sequester additional carbon dioxide and improve habitat for wildlife in the watershed.

3. Method and model specification

The theoretical construct of stated preference choice experiment (CE) approach stems from discrete choice analysis of consumer preferences. Random utility theory provides the basis for CE valuation method (McFadden, 1974). It is a rigorous approach to estimate consumers' willingness to pay for public goods (Adamowicz et al., 1998; Hanley et al., 2001; DeShazo and Fermo, 2002). The CE method utilizes experimental design and repeated choice process in value elicitation. Using CE valuation method, we consider each of the environmental attributes of silvopasture in the watershed as an alternative j in a choice set c. Alternative j represent one specific type of consumption bundle which is an improvement in the environmental quality of the watershed with its conditional indirect utility level V_j for a household i and is expressed as

$$V_{ij} = v_{ij} + \varepsilon_{ij} \tag{1}$$

where v_{ij} is the deterministic component of the model and ε_{ij} is the random component. Thus, selection of alternative j over alternative h implies that the utility of V_{ij} is greater than that of V_{ih}. Overall, the utility is random suggesting that one can only analyze the probability of choosing one alternative over another. The probability of an individual i choosing alternative j, $p(\cdot)$ can be expressed as

$$p(ij \mid c) = p[V_{ij} > V_{ih}] = p[(v_{ij} + \varepsilon_{ij}) > (v_{ih} + \varepsilon_{ih})], \quad j \neq h \tag{2}$$

Assuming the error terms of the utility function are independently and identically distributed (IID) and follow an extreme-value (Weibull) distribution and the choice probabilities have a closed-form solution, they are appropriately estimated using a multinomial logit (MNL) specification (Adamowicz et al., 1998; Louviere et al., 2000; McFadden, 1974). The MNL model represents the probability of choosing an alternative j such that the utility of this alternative is greater than the utility of all other alternatives. This probability model can be represented as

$$p(ij) = \frac{\exp^{\mu v_{ij}}}{\sum_{ij \in c} \exp^{\mu v_{ih}}} \tag{3}$$

where μ is a scale parameter, which is often normalized to 1 for a particular application. Assuming v_{ij} to be linear and an additive function in the attribute vector, it can be represented as

$$V_{ij} = \mu(\beta + \beta_1 z_1 + \beta_2 z_2 + \ldots + \beta_n z_n + \beta_a s_1 + \beta_b s_2 + \ldots + \beta_m s_k) \tag{4}$$

where β is a constant term that can be partitioned into alternative specific constants (ASC), and β_n and β_m are vectors of coefficients attached to the vector of environmental attributes z and vector of respondents' individual characteristics s that influence utility.

A strong assumption implicit in MNL model is that the independence of irrelevant alternatives (IIA) condition holds. This particular restriction in MNL model implies that the presence or absence of an alternative preserves the ratio of the probability associated with other alternatives in the choice set (Louviere et al., 2000). However, it is suggested that the MNL model should be tested for IIA property using the following Hausman and McFadden test to ensure that the assumption is not violated (Louviere et al., 2000; Hausman and McFadden, 1984),

$$q = [b_u - b_r]' \, [\Omega_r - \Omega_u]^{-1} [b_u - b_r] \tag{5}$$

where u and r indicate unrestricted and restricted models, b is a vector of estimated parameters, and Ω is variance–covariance matrix for the estimates.

To avoid IIA restriction in the MNL model, one could use less restrictive specifications such as random parameters logit (RPL) or mixed logit models (Bhat, 1997; Revelt and Train, 1996). The RPL model is specified as follows:

$$P(j \mid \mu_i) = \frac{\exp(\alpha_{ij} + \theta_j z_i + \varphi_j g_{ij} + \beta_{ij} x_{ij})}{\sum_{j=1}^{J} \exp(\alpha_{ij} + \theta_j z_i + \varphi_j g_{ij} + \beta_{ij} x_{ij})} \tag{6}$$

where α_{ij} is a fixed or random alternative-specific constant associated with alternative j or individual i, φ_j is a vector of non-random parameter, β_{ij} is a parameter vector randomly distributed across individuals (includes μ_{ij} as a component), μ_{ij} is the individual specific random disturbance of unobserved heterogeneity, z_i is a vector of individual specific characteristics, g_{ij} is a vector of individual and alternative-specific attributes associated with φ_j, and x_{ij} is a vector of individual and alternative-specific attributes associated with β_{ij}.

The subsets of alternative-specific constants (α_{ij}) and the parameters vector β_{ij} can be randomly distributed across individuals such that a new parameter ρ_{ki} for each random parameter can be defined as a function of individual characteristics and other attributes which are choice invariant. The functional form for ρ_{ki} can be normal or lognormal. The parameter ρ_{ki} induces a relatively free utility structure in RPL model such that IIA condition is relaxed (Louviere et al., 2000).

Respondent's WTP representing the compensating surplus (CS) can be estimated using RPL model as follows (Hanemann, 1984; Adamowicz et al., 1998; Train, 1998),

$$\mathrm{CS} = -\frac{1}{\beta_c}\left[\ln\left(\sum \exp(\beta' x_{ij}^0)\right) - \ln\left(\sum \exp(\beta' x_{ij}^1)\right)\right] \tag{7}$$

where β_c is the marginal utility of income, which represents the coefficient of the cost attribute in the model. The x_{ij}^0 and x_{ij}^1 represent the attributes at initial state and after the change, respectively. A simplified version of the above CS function for a marginal change in environmental quality of a single site is represented by the ratio of the estimated coefficient of the attribute β_j and the coefficient of the cost attribute β_c. This ratio is commonly known as part-worth or utility representing the marginal value of a change in the attribute, i.e., the marginal rate of substitution between income change and the change in the attribute under consideration.

4. Experimental design and survey

4.1. Experimental design

Relevant benefit attributes of a good must be identified in order to value environmental benefits using choice experiment method. We identified important environmental benefit attributes of silvopasture from extensive literature review and discussions with ranchers, other landowners, agroforestry professionals, and the general public. Field visits and focus group discussions were conducted in the Range Cattle Research and Education Center, Ona and Archbold Biological Station, Lake Placid, Florida to obtain input into the survey instrument design. We also visited two ranchers (a small landholder and a large landholder) in Sarasota, Florida currently practicing silvopasture to discuss various attributes of this technology (Shrestha and Alavalapati, 2004). Drawing on the above sources, we defined three levels in each of the following environmental attributes: water quality improvement, carbon sequestration (CO_2), and wildlife habitat protection (Table 1).

The state utility tax was used as the cost attribute in our experimental design. We used this as the payment vehicle because Florida does not have the state income tax commonly used in valuation surveys (Milon et al., 1999). The utility tax is a form of utility bill that is familiar to respondents and closely linked to the goods valued in the survey (Cameron et al., 2002; Mitchell and Carson, 1989). The tax attribute was detailed to six levels (Table 1). We used an experimental design to construct choice sets of these attributes and levels.

We followed an orthogonal main effect experimental design representing 3^3 x 6 x 2 factorials. Following the smallest orthogonal main effect plan we identified 12 pairs of profiles in two blocks using autocall macros of SAS version 8 (Kuhfeld et al., 1994). The application of these macros in the experimental design helped control proliferation of profiles with nominal effect on design efficiency. As the sample is drawn from a general public not highly knowledgeable about silvopasture technologies, we tried to keep our choice sets at the minimum, reducing choice complexity and the overall length of the questionnaire (DeShazo and Fermo, 2002). In summary each respondent was asked to value two options and a 'status quo' option in each scenario and to continue the choice task with six scenarios.

Table 1
Definition of silvopasture land-use attributes used for choice experiment

Environmental attributes	Level of change in environmental attributes
1. Water quality	Reduce phosphorus runoff anywhere between 0 and 30%
	Reduce phosphorus runoff anywhere between 31% and 60%
	Reduce phosphorus runoff anywhere between 61% and 90%
2. Carbon sequestration	Limited absorption of CO_2 from the atmosphere
	Moderate absorption of CO_2 from the atmosphere
	High absorption of CO_2 from the atmosphere
3. Wildlife habitat	Limited improvement of habitats for wildlife
	Moderate improvement of habitats for wildlife
	High improvement of habitats for wildlife
4. Increase in state utility tax (per year for 5 years), US$	0, 10, 20, 40, 80, 120, 140

The first level of each attribute indicates the environmental quality without silvopasture.

4.2. Survey instrument and administration

Several steps were taken in developing the survey instrument. First, a map of the Lake Okeechobee watershed was presented and the rationale for selecting the study area was given. Second, a brief description of the traditional ranching, water pollution issues in the watershed, as well as potential environmental benefits and costs of silvopasture practices were outlined in the survey. Color photos and drawings were used to illustrate the silvopasture land-use changes. Third, directions and an example of how to answer survey questions were provided. Fourth, the respondents were given six choice tasks, each with two options (A, B) and a status quo option (C), representing current condition of the Lake Okeechobee watershed, and asked to choose one of the options (Fig. 1). The choice question was followed by a rating question asking respondents to rate their confidence level in each choice task. Finally, the respondents were asked to provide their socioeconomic and demographic information. The survey questionnaire was pretested with respondents from diverse educational and demographic backgrounds. Based on the pretesting, the survey was revised to minimize technical terms and reduce the length of the description. We enclosed a glossary of technical terms used in the questionnaire.

The survey sample was drawn randomly from the households of 10 counties in south-central Florida, namely, Glades, Hendry, Highlands, Martin, Okeechobee, Orange, Osceola, Palm Beach, Polk, and St. Lucie. Sample design assistance was provided by the Bureau of Economic and Business Research (BEBR), University of Florida. The households were identified using a random digit dialing approach and contacted to find if they would be willing to participate in the survey. The initial responses were categorized into several groups, Choice Scenario 1

Please vote for the plan that you prefer:

Environmental Response	Option A	Option B	Option C Current Condition
Water Quality Improvement (reduction of phosphorus runoff)	31 - 60%	61 - 90%	No change
Air Quality Improvement (absorption of CO_2)	No change	high	No change
Wildlife habitat Improvement (better habitat for wildlife)	Moderate	No change	No change
Annual Tax Increase (per year for 5 years)	\$40	\$120	\$0

If the above plans are in a referendum, which one would you vote for?

☐ Option A ☐ Option B ☐ Option C

Please circle one number to indicate how certain you are with the choice you have just made:

Not certain Very certain

1———2————3————4————5

Fig. 1. Example of a choice set presented in choice experiment tasks.

including complete agreement, soft refusal, strong refusal, and other technical-related barriers.[3] The technical barriers consisted primarily of the respondent being unavailable and telephone number dialed being owned by institutions or groups. We mailed 504 survey packets in February 2002, containing a questionnaire, cover letter explaining the intent of the survey, and a magnet sticker with School of Forest Resources and Conservation and University of Florida logos. Reminder post cards were sent to individuals who had not responded within 2 weeks. With second mailing and post card follow-ups we received total of 152 survey responses. Thirty-four surveys were undelivered and seven were incomplete, therefore the resulting response rate for our survey was just above 32%. While the response rate is relatively low in our survey, it is still within the range of similar valuation surveys. Loomis et al. (2000) reported a response rate ranging from 25.7% to 41% depending the method of contacting respondents.

[3] Here, refusal implies the households' unwillingness to participate in any survey, but not protest against the valuation research because very limited information about the research was provided on the phone.

5. Results and discussion

The demographic characteristics of the respondents revealed a majority of males (69%) with average age about 58 years. Proportion of male respondents in our survey is relatively higher compared to 49% in a similar survey (in-person interview) by Milon et al. (1999) and 47% in 1998 Florida census. Furthermore, respondents in our survey were relatively more educated. Nearly 22% of respondents to our survey had university degree, which was the case in only 10% in the Milon et al. survey and 6% in the Florida census. The distribution of average household income also followed a different trend from previous surveys. The average income value in our survey, for example, was US\$59,871, higher than both the Florida census (US\$38,819) and Milon et al. (US\$33,941). Household size, however, was very similar at 2.4, 2.7, and 2.5 persons per household in current survey, Milon et al., and the Florida census, respectively. The differences in some of these household characteristics may have been due to seasonal variations in Florida's population. Florida has the nation's highest net domestic migration, of more than 1 million (US Census Bureau, 2000), including seasonal or short-term immigration.

We initially specified a multinomial logit model and tested for IIA restrictions using the Hausman and McFadden test as specified in Eq. (5). The test results indicated the violation of IIA assumption in MNL model suggesting the use of a relatively non-restrictive model. Therefore, we estimated a random parameter logit model to relax the IIA assumption.[4]

Two levels of improvements in water quality, carbon sequestration, and wildlife habitat are estimated in the model. Qualitative attributes in the model are analyzed using effect codes, which allowed us to estimate slope coefficients for the status quo or excluded category of each qualitative attribute (Adamowicz et al., 1998; Louviere et al., 2000). For example, two levels of the water quality variable (*WATER1*, *WATER2*) are coded as '1', whereas the third level (*WATER0*) or the current level without silvopasture is coded '−1'. Thus, the coefficient for *WATER0* is the negative sum of the coefficients on the other two levels.

The signs and significance of the coefficients in the model are found to be consistent as expected. All slope coefficients on attribute variables are significant at $p < 0.10$ and four attribute coefficients and one coefficient on tax variable are significant at $p < 0.01$. All attribute coefficients are positive suggesting a positive utility of the environmental quality attributes. The cost variable (*UTAX*) representing state utility tax has negative coefficient as expected, implying a higher tax reduces the utility of the environmental quality improvement (Table 2).

The individual-specific variables were interacted with alternative specific constant term (ASC). The variable representing respondents' association with the ranch or dairy farm (*RANCH*) is positive and highly significant indicating that the probability of choosing the status quo, everything else held constant, increases if the respondent is a rancher. This result is expected because landowners would normally perceive that provision of public good would require a change in their current practices, a decrease in land productivity, and an increase in operating costs. The coefficient representing respondents' education level (*EDUCATION*) is negative and highly significant, suggesting the probability of choosing status quo is decreased if the respondent holds a college degree. This confirms our expectation that the respondents with higher education place higher value on environmental benefits of silvopasture. The variable representing respondents' membership in an environmental organization (*MEMBER*) is positive and significant, which indicates an increase in the probability of choosing status quo if the respondent is a member

Table 2
The random parameter logit model results

Variable	Coefficient	Standard error	t-ratio
Parameter in utility function			
WATER1	0.1181	0.0704	1.6763
WATER2	0.2778	0.0793	3.5035
CARBON1	0.2266	0.0822	2.7578
CARBON2	0.2448	0.0821	2.9824
WILDLIFE1	0.1939	0.0713	2.7181
WILDLIFE2	0.1603	0.0830	1.9304
UTAX	−0.0039	0.0015	−2.6390
INCOME	−0.0008	0.0036	−0.2134
RANCH	0.8896	0.4005	2.2210
GENDER	−0.0526	0.1259	−0.4177
EDUCATION	−0.5475	0.1377	−3.9765
AGE	0.0927	0.1445	0.6418
MEMBER	0.4846	0.2098	2.3097
ASC	0.2602	0.5245	0.4962
Standard deviations of parameter distribution[a]			
sWAT1	0.0015	0.0565	0.0273
sWAT2	0.0062	0.0635	0.0975
sAIR1	0.0040	0.0651	0.0608
sAIR2	0.0019	0.0605	0.0318
sWILD1	0.0045	0.0633	0.0707
sWILD2	0.0029	0.0657	0.0442
sUTAX	3.7E−05	0.0009	0.0411
McFadden R^2	0.10		
Log L	−693.87		
N	2142		

Socioeconomic variables are interacted with the alternative specific constants (ASC).

[a] The standard deviations of parameter distribution indicate insignificance of the parameters as the source of heterogeneity suggesting the source of heterogeneity in our RPL model results could potentially be individual-specific.

[4] The results of basic MNL and extended MNL model with socioeconomic variables can be obtained upon request.

Table 3
Marginal willingness to pay estimate for environmental improvement (in US$ per household)

Environmental attributes	Value for environmental improvement	
	Moderate	High
Water quality	30.24 (19.63–40.86)	71.17 (53.41–88.93)
Carbon sequestration	58.05 (43.72–72.37)	62.72 (54.38–71.06)
Wildlife habitat	49.68 (38.08–61.28)	41.06 (35.41–46.72)

Numbers in parentheses are 95% confidence interval calculated from 1000 draws from the distribution of coefficients in the model.

of an environmental organization. For many environmental groups, paying for silvopasture may not be a preferred option to ensure environmental protection. Perhaps, purchasing environmentally sensitive lands or formulating stringent environmental regulations may be preferred ways to control pollution.[5] The variables representing respondents' household income, gender, and age are not significant in the model.

The implicit prices or part-worth utilities representing marginal value of the environmental quality improvement are derived. The WTP estimates for moderate and high water quality improvement through reduced phosphorus runoff are, respectively, US$30.24 and US$71.17 (Table 3). Corresponding estimates for moderate and high carbon sequestration levels are US$58.05 and US$62.72. Similarly, the WTP estimates for wildlife habitat improvements are US$49.68 and US$41.06. Our WTP estimates are within the range of values reported by Milon et al. (1999). Using a stated preference approach, they estimated household net WTP of US$59 and US$70 per year for hydrological and species restoration, respectively, in south Florida.

The WTP estimates indicate a relatively smaller value of high-level improvement in wildlife habitat attribute, which may be due to non-linearity in household utility function that is unaccounted for in a simple two level attribute modeling.[6] Overall, WTP estimates from current to high-level improvement increased at a decreasing rate suggesting quadratic representation, a result consistent with Adamowicz et al. (1998). The aggregate WTP values for all three environmental quality attributes indicates a greater value for high-level improvements (US$174.96) compared to moderate level improvement (US$137.97). The coefficients for status quo or current level attributes are the negative sums of the moderate and higher level attribute coefficients. We obtained coefficients of − 0.396, − 0.471, and − 0.354 for current levels of water, carbon, and wildlife habitat, respectively. Then, we estimated WTP values of US$ − 101.41, US$ − 120.77, and US$ − 90.74 for water, carbon, and wildlife habitat, respectively, with a combined value of US$ − 312.92 for all three attributes. This indicates that a loss of utility in terms of water quality, carbon sequestration, and wildlife habitat while maintaining status quo is even greater, thus justifying the positive value of the environmental quality.

We estimated 95% confidence interval around the mean WTP values using 1000 draws from the distribution of the coefficients in the model (see Table 3). Fig. 2 indicates that the difference between mean WTP values for moderate and high improvements in water quality is significant, as the two confidence intervals do not overlap. However, the differences in the WTP values for two levels of improvements in carbon sequestration and wildlife habitat are not significant.

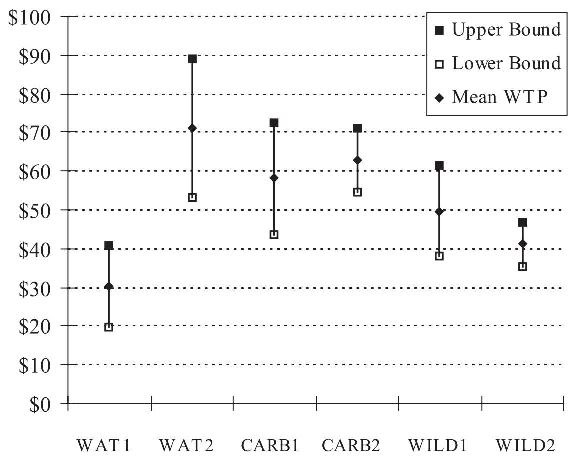

Fig. 2. Confidence interval of welfare estimates.

[5] Similar to many states in the US, Florida sponsored land acquisition programs spending a cumulative $3.7 billion to acquire environmentally sensitive lands in the state since 1972 (FDEP, 2001).

[6] A relatively smaller WTP estimate for higher level of wildlife habitat improvement raises concerns often discussed in valuation literature about the internal consistency of the value estimates using stated preference methods (Smith and Osborne, 1996).

6. Conclusions

Many studies have suggested that silvopasture provides environmental services such as water quality improvement, soil conservation, carbon sequestration, wildlife habitat protection, and aesthetics. Since these environmental services are largely public goods, ranchers have little incentive to adopt silvopasture and produce them at optimum levels. Thus, it is imperative to develop incentives to internalize these externalities. In this study we generated key information that helps develop incentive policies based on public willingness to pay (WTP) for these environmental services. The random parameter logit model results indicate that an average household in south-central Florida would pay US$30.24–71.17 per year for 5 years for water quality improvement, carbon sequestration, and wildlife habitat protection in the Lake Okeechobee watershed. The results indicate that the WTP for a moderate level of improvement in these environmental attributes amounts to US$137.97. With 1.34 million households in the watershed, the total WTP for the environmental improvement would be 924.40 million. When adjusted for the response rate of 32%, a lower bound estimate can be US$295.81 million. Shrestha and Alavalapati (2004) noted that the cost of silvopasture, as perceived by ranchers in Florida, is US$9.32 per acre per year. This implies that the annual opportunity cost of silvopasture adoption on 2.62 million acres of ranchlands in the watershed would be US$24.41 million. Using the total WTP as a trust fund, its annual returns can be used to compensate ranchers for the provision of environmental services through silvopasture.

On its own merits, silvopasture may be beneficial for alternative land uses including sustainable forest management, outdoor recreation, and ecotourism. For example, recreational hunting leases represent a growing land use in southern US, which can be highly compatible with silvopasture. Similarly, long-leaf pine forest provides longer rotation age, thus can contribute to sustainable land uses and better returns. Yet, ranchers may find these benefits small compared to the major fixed costs needed for initial establishment of silvopasture.

Several issues warrant closer examination before developing incentive policies to promote silvopasture adoption. First, many potential incentive mechanisms exist including information and extension services, lump-sum payments on per acre basis, price premium to reflect environmentally friendly beef production, and cost-sharing programs. These schemes are not uniform in terms of management efficiency and social acceptability. Therefore, careful examination is required in determining socially efficient and acceptable schemes. Second, institutional arrangements for effective implementation of incentive schemes must be explored. Collaboration with the Florida Forestry Association, Florida Cattlemen's Association, and Florida Farm Bureau will be critical in developing incentive schemes and their successful implementation. Third, it is crucial to explore markets for timber grown on ranchlands. Currently, markets for pulpwood and sawtimber are weak in southern Florida. In the absence of established markets for timber, ranchers will perceive timber growing as a liability. Finally, other compatible land uses along with silvopasture, such as sustainable forest management, recreational hunting leases, and ecotourism, should be taken into consideration. These land-use opportunities will provide market-based incentives for ranchers to sustain their traditional vocations, while costing less to society than a direct payment to compensate ranchers for their beneficial land-use practices.

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