Valuing a Global Environmental Good: U.S. Residents' Willingness to Pay to Protect Tropical Rain Forests

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ABSTRACT. *(CV) is the most common technique for valuing nonmarket environmental resources, rarely has it been applied to global environmental goods. This study uses CV in a national survey to assess the value U.S. residents place on tropical rain forest protection. On average, respondents were willing to make a one-time payment of approximately $21–31 per household to protect an additional 5 percent of tropical forests. Although respondents were able to give consistent responses across two different CV formats, focus groups were unwilling or unable to allocate their aggregate rainforest valuations across or among regions or specific rain forests.* (JEL Q23)

I. INTRODUCTION

To address the problems associated with rapid tropical deforestation, many development organizations are calling for the establishment of an international fund for rainforest conservation efforts. Given the limited financial resources of most countries owning tropical rain forests and the fact that many of the benefits are now seen to be global in nature, strong arguments are being made for international cost-sharing for tropical rain forest preservation (see, for example, Sharma et al. 1992). Furthermore, as evidenced by the debate surrounding the Convention on Biological Diversity at the Rio Conference (Hass, Levy, and Parson 1992), it is clear that policymakers are concerned about the level and distribution of benefits and costs associated with rain forest protection and the extent and intensity of public support. However, in reviewing the empirical evidence on the benefits of protecting tropical forests, Pearce (1994) notes little economic quantification of the non-use benefits.

Tropical rain forests produce a variety of market and nonmarket benefits. These include local consumptive uses such as timber, medicinal plants, and forage as well as local non-consumptive uses such as recreation and watershed protection.[1] Identifying the beneficiaries and measuring benefits for these local goods and services is relatively straightforward. Recent initiatives for protecting tropical rain forests, however, have been driven by the perception of another flow of benefits that are global in nature. The increasing concern by developed countries over the role that tropical forests play in carbon cycles, climate regulation, and genetic resource conservation has produced another set of beneficiaries who live thousands of miles from the locales where protection activities take place. Identifying these distant beneficiaries and measuring their willingness to pay for rain forest protection is a challenging task for economists.*

Although contingent valuation (CV) is the most common technique for valuing nonmarket environmental resources, rarely has it been applied to the problem of determining the willingness to pay (WTP) for global environmental goods. The most common applications of CV have been to value local programs to improve water quality, restore wetlands, preserve natural areas, and reduce health risks. The method has also frequently been applied to regional and national level problems such as natural resource damage assessments for oil spills and

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[1] See Kramer, Healy, and Mendeisohn (1992) for a review of forest valuation.

[2] Epp and Gripp (1992) surveyed Pennsylvania residents and applied the CV method to estimate mean household willingness to pay to protect all remaining tropical forests. They resurveyed many of the same households 10 months later to examine the stability of preferences and reliability of CV estimates. They did not report mean bids, but did conclude that respondents gave similar answers to each round of the survey.

the preservation of endangered species and national environmental monuments such as the Grand Canyon (Smith 1993).

Carson (1995) suggests that both philosophical and practical issues have limited the application of contingent valuation to global environmental goods. First, Carson reviews and rebuts the major philosophical arguments opposing the use of CV for global goods. Countering the argument that CV surveys provide less than perfect information sets to respondents, Carson states that consumers regularly make decisions on private, market goods with incomplete information. Furthermore, CV surveys provide an easy means for respondents to obtain information about environmental goods; in the absence of the CV survey and markets for the environmental good, there would be little incentive to obtain that detailed information. Opposing the "misguided" argument that economics is relevant only in the case of goods over which agents have narrowly defined self-interests, Carson correctly replies that economic theory does not *a priori* exclude any goods from agents' preferences. Rather, since economic theory insists only that preferences are consistent with the several axioms of choice, economic models are appropriate and capable of handling nonmarket environmental goods. The third argument against CV is that it does not measure what it purports to measure due to the insensitivity of valuations to the scope of the good (the "embedding effect") and that CV tends to overestimate values (the "calibration issue"). Carson rebuts the former by referring to a review of 34 different split sample CV experiments, 30 of which reject the null hypothesis of scope insensitivity (Carson 1994). Likewise, to rebut the overestimation criticism, he cites Carson et al.'s (1994) meta analysis of 616 comparisons of CV and revealed preference (RP) studies over 30 years. The results indicate that CV estimates on average were smaller than RP estimates and that the correlation between CV and RP estimates were in the 0.7 to 0.9 range. Finally, he rejects the argument that consumer sovereignty, public preferences, and economic values are inappropriate for government, environmental decision-making on the basis that no evidence suggests that public preferences are inconsistent with sustainable development or that public preferences are unchanging in the face of information about actions or policies detrimental to the environment. Finally, Carson (1994, 2) argues that "without CV, a comprehensive benefit-cost analysis involving non-marketed goods with substantial passive/non-use values is impossible."

Next, using tropical rain forests as an example, he discusses the following constraints to applying CV to global environmental goods: (1) defining the commodity (how to describe the set of tropical rain forests?), (2) extent of the market (who will be asked to pay for the rain forests?), (3) payment and provision mechanisms (how much will it cost, how will it be paid for, and how will it be provided?). While these problems apply to all contingent valuation studies, they present special difficulties in applying CV to global environmental goods (see Carson 1995 for further discussion). This paper presents an approach to overcoming these constraints and presents the results from one of the first attempts to apply CV to a global environmental good, tropical rainforest preservation. More specifically, the present study was designed to address three problems: (1) assessing the feasibility of using CV for valuing global environmental goods, (2) estimating the willingness to pay of U.S. residents for protecting a portion of the world's tropical forests, and (3) determining the attitudes of U.S. residents toward issues concerning tropical rain forest protection and management (such as compensation).

II. CONCEPTUAL FRAMEWORK

U.S. residents may be willing to pay for tropical rain forest protection for a variety of reasons. For example, they may value rain forests for their tourism or recreational values, the current wood and non-wood products produced in the forest, the potential pharmaceutical and other products that might be discovered within the biodiversity of the rainforest, the forests' role in ameliorating global climate change, and finally for

the knowledge that these ecosystems and the flora and fauna they contain exist.

This myriad of potential values can be classified into three broad categories: (1) consumptive use values, (2) non-consumptive use values, and (3) existence values. Consumptive use values include the value for all products or activities in which at least one component (biotic or abiotic) is extracted from the forest. This would include recreational activities such as hunting or fishing in addition to the harvest and consumption of wood and non-wood products from the forests. Non-consumptive uses consist of all uses in which the item being "consumed" is not extracted or harvested from the forest. These would include on-site recreational activities such as hiking, bird watching, or photography and off-site activities such as watching television shows or reading magazine articles about tropical rain forests. Existence values include all other values that are independent of any current use behavior by the individual. These values may arise from a variety of motivations including bequest or stewardship concerns and a desire to preserve options for future use (Freeman 1993). For tropical rain forests this would include their future value for ameliorating global climate change, maintaining healthy ecosystems, serving as a storehouse for potential pharmaceuticals and genetic material, as well as the value that arises from knowing that these forests and their biotic and abiotic attributes exist.

Thus, assuming that utility is weakly separable with respect to tropical rainforest use and existence values, an individual's preference function might be expressed as:

$$U(RF(l, s), z) \qquad [1]$$

where $U(*)$ is the direct utility function and $RF(*)$ is the sub-utility function associated with tropical rain forests, l represents a vector of activities associated with consumptive and non-consumptive uses of rain forests, s is the stock of existing tropical rain forests, and z is a vector of all other goods and services. The consumptive and non-consumptive use values enter the individual's utility function as purchased arguments in l, while the existence values enter as the non-purchased argument s. If p_l is the vector of associated market prices for l, p_z is the price of z, and y is income, then the individual's indirect utility function can be stated as:

$$V(p_l, s, p_z, y). \qquad [2]$$

According to [2], when the stock of rain forest falls, consumptive and non-consumptive use values are reduced through the impact on the vector of purchase prices, p_l, and the existence values are reduced through the impact on s. Therefore, the total value of the stock of all remaining tropical rain forests, TV_{RF}, can be defined as:

$$V(p_l^N, s^N, p_z, y) = V(p_l^0, s^0, p_z, y + TV_{RF}) \qquad [3]$$

where s^N is the stock of rain forests existing now and p_l^N is the vector of current prices. s^0 indicates that the stock of rain forests has been driven to zero, while the vector p_l^0 represents the choke prices for consumptive and non-consumptive uses. Thus, TV_{RF} is the amount of compensation required to make the individual indifferent between losing all tropical rain forests or protecting the current level.

Given the current rate of tropical deforestation and the relatively small amount of remaining tropical forests, estimating the total value of all forests would soon be irrelevant. Under the Convention on Biological Diversity, the U.S. and many other governments have committed to help expand the world's network of protected areas. Thus, the relevant policy question posed for the current study is "How much are Americans willing to pay to insure that a large enough stock of rain forests will be protected so that the services rain forests provide will continue to be produced in perpetuity?" According to international conservation organizations, this requires that at least 10 percent of all rain forests are preserved in national parks, reserves, or other protected areas. Currently only 5 percent of all rain

forests are so protected (Barzetti 1993). Therefore, this study estimates Americans' willingness to pay (donate to a fund) to insure that 10 percent of all rain forests is protected.

It is assumed that individuals should be willing to pay $\$w$ today if their utility with the lower income ($y - w$) and the expectation that s will never fall below 10 percent of the current stock is at least as large as their utility with current income, y, and the expectation that rainforest stocks will fall to zero at some time in the future. That is, when

$$V(p_l^N, s^N, p_z, y: p_l^0, s^0) \leq V(p_l^N, s^N, p_z, y - w: p_l^{10\%}, s^{10\%}). \quad [4]$$

The left-hand side of equation [4] gives the indirect utility with current prices, stock of rain forests and income, conditional on the expectation that the stock of rain forests will fall to zero, s^0, and rainforest use prices will be at the choke level, p_l^0. In contrast, the right-hand side of equation [4] provides the indirect utility with current prices and stock of rain forests but with income reduced by the donation amount, w, and conditional on the expectation that the rainforest stock will never fall below 10 percent of the current stock, $s^{10\%}$, and that rainforest use prices will be $p_l^{10\%}$.[3] The empirical problem then becomes how to measure w.

III. ECONOMETRIC METHODS

Econometric methods are used to (1) estimate behavioral models of responses to the valuation questions, and (2) to estimate welfare changes that would result from an increased level of rainforest protection. It is assumed that each respondent's true willingness to pay w_i for rainforest preservation is influenced by a vector of explanatory variables X_i. Given that valuations of environmental goods should be positive and are frequently found to be skewed, a lognormal distribution is assumed. Thus, $\log w_i = X_i'\beta + u_i$, where β is a vector of behavioral parameters and u_i is an independently and normally distributed error term with mean zero and standard deviation σ.

Given the lack of consensus in the literature about the question format for CV questions (Mitchell and Carson 1989), the contingent valuation question was posed with two different formats: a referendum ("take-it-or-leave-it") and a payment card format. Because of the different types of CV data generated for the two samples, separate econometric methods are employed to estimate the conditional distributions.

Respondents to a payment card CV question (sample A) chose among an ordered set of threshold values. Because payment card data presumably reflect an interval within which true WTP values lie, an econometric method must be used to estimate the true underlying value. Selecting the midpoint of the range and estimating an ordinary least squares regression model can lead to biased parameter estimates and misleading mean WTP estimates (Carson and Huppert 1989). To avoid these potential problems, a completely censored regression model is estimated. If the respondent's true WTP, w_i, is found in the interval between the lower limit t_{li} and the upper limit t_{ui} given by the adjacent payment card values, the probability that the true WTP value falls within the reported interval is given by

$$\Pr(\log w_i \subseteq (\log t_{li}, \log t_{ui})) = \Pr((\log t_{li} - X_i'\beta)/\sigma < z_i < (\log t_{ui} - X_i'\beta)/\sigma) \quad [5]$$

where z_i is the standard normal random variable. Because the probability given by equation [5] can be written as the difference between two standard cumulative densities, a likelihood function can be defined over the parameters β and σ. These parameters are estimated using the "GROUPED

[3] We have not introduced probabilities into the indirect utility function, but as a reviewer pointed out, there may be considerable uncertainty about prices and ending stock levels.

DATA" procedure in the LIMDEP econometric package (Greene 1992). In keeping with the assumption about the underlying WTP distribution, logarithmic transformations of the limits were used. Mean WTP is computed as $\exp(X_i'\beta)\exp(\sigma^2/2)$ (Cameron and Huppert 1989).

Those respondents who received the referendum version of the CV question (sample B) were confronted with an offered amount t_i that varied across individuals. Denoting an acceptance of t_i by $d_i = 1$ and rejection by $d_i = 0$, then the probability of acceptance is:

$$\begin{aligned}\Pr(d_i = 1 \mid X_i) &= \Pr(\log w_i > \log t_i) \\ &= \Pr(z_i > (\log t_i - X_i'\beta)/\sigma) \\ &= 1 - \Phi((\log t_i - X_i'\beta)/\sigma) \quad [6]\end{aligned}$$

where Φ represents the standard normal cumulative density and z is the assumed distribution of the error term (normal with mean = 0 and standard deviation = a). The assumed lognormal distribution for WTP can be imposed by taking logarithmic transformations of t_i. After reparameterizing the logit regression parameters, mean WTP is computed as before as $\exp(X_i'\beta)\exp(\sigma^2/2)$ (Cameron 1991).

IV. SURVEY DESIGN AND IMPLEMENTATION

The survey was developed and refined through the use of focus groups, review by experts,[4] and a mail pre-test. The survey conveyed information on reasons why rain forest conservation is advocated by some and why forest conversion to other land uses is advocated by others. It contained questions on ranking social problems and environmental problems, questions about familiarity with and causes of deforestation, contingent valuation questions, and socioeconomic questions. The survey also contained a world map showing the location of tropical rain forests. In this section, the use of focus groups to address Carson's design questions is discussed, and survey implementation procedures are described.

Focus groups were relied on to address many of the issues involved in designing a CV study to value a global environmental good such as tropical rain forest preservation. In particular, three focus groups provided input for decisions concerning the following issues raised by Carson (1995):

1. Defining the global environmental commodity:
   - What are the best means/ tools for describing the rainforest commodity?
   - Which tropical rain forests are to be valued?
   - What service flows are provided by the protected rain forests?
2. Extent of market:
   - Who will be asked to pay for rainforest protection?
3. Payment and provision mechanisms:
   - What is the payment mechanism and its time dimension?
   - How will rain forests be protected?

The focus groups consisted of one group of non-faculty, university staff (15 participants) and two groups recruited from members of local church groups (11 and 13 participants, respectively). The focus groups were presented with a variety of informational materials describing tropical rain forests. The information included statistics and maps on the distribution of rain forests, rates and locations of deforestation, in addition to written information on why some people are concerned about tropical deforestation and why others are deforesting. Then focus group members were asked to answer hypothetical survey questions based on these information sources. The hypothetical questions differed for each group depending on the specific issue on which the

[4] Without implicating them for any errors in the design, the authors appreciate the review of the survey instrument provided by Mimi Becker, Richard Dunford, Paul Ferraro, Bob Healy, Tom Holmes, Jan Laarman, Peter Principe, Dixie Reeves, Priya Shyamsundar, Kerry Smith, Stephen Swallow, and John Terborgh.

group was being focused. Finally, the focus group facilitator led the group in discussions of the effectiveness and impact of the information and how it affected the way participants responded to the questions. Discussions also focused on the particular questions themselves; for example, how participants responded to CV questions with different payment vehicles.

In addition to written notes by two to three observers, the focus groups were recorded on audiotape. Focus groups were evaluated by examining the answers given to the hypothetical survey questions and by thorough and repeated review of the written notes and audiotapes. Consensus (whenever possible) was arrived at in two primary ways. First, the focus group facilitator consistently requested focus group members to continue responding (positively or negatively) until all opinions were expressed. For example the facilitator would ask "Does anyone agree (disagree) with that statement and why (why not)?" or "Do we have a consensus on that?" Second, through repeated review of notes and tapes, the investigators made subjective determinations of which issues the focus groups held substantial agreement or disagreement. Consensus was assumed whenever over 80 percent of the participants agreed. Finally, the answers to the hypothetical questions were tabulated and evaluated.

Two main objectives for improving the description of the commodity to be valued were addressed in the focus groups. First, the focus groups were used to evaluate information, methods, and techniques for describing the good. A variety of written and visual information on rain forests (what they are, where they occur, how they differ from other forests, rates of deforestation, and benefits from preserving forests vs. benefits from cutting forests) were tested. The second objective involved determining the extent of knowledge people had concerning specific tropical rain forests/regions. In particular, can ordinary citizens place values on specific rain forests as well as rain forests in general?

Results from the focus groups suggested that most participants had heard of tropical rain forests (primarily through television), had seen pictures of rain forests (television, magazines), and knew something about the causes of tropical deforestation and why it was a problem. As a result, most focus group members had sufficient knowledge to be comfortable valuing tropical rain forests in general. However, when asked to allocate this value amongst specific rain forests or rain forests in different regions (e.g., Asia, Latin America, Africa), people responded negatively. A common response was that they did not care how it was allocated as long as rain forests and the benefits they provide were preserved. Focus group participants were equally concerned about rain forests in all regions and areas, reported that they did not have enough information to make intelligent allocations between rain forests or regions and that efforts to provide a sufficient level of information would be overwhelming.

The second major area addressed by the focus groups concerned information on the service flows provided by protected rain forests versus those provided by cutting and converting rain forests to other land uses. Based on the focus group responses, information was provided on the service flows provided by intact rain forests by describing the reasons some people want to save rain forests as well as the opportunity costs of preserving rain forests (or why some people want to cut tropical rain forests).

The focus groups were also used to refine the mechanism for protecting the rain forests to insure that the mechanism was realistic, believable, and perceived to have a reasonable chance of success. As expected, focus groups reported the need to have specifics on the type of program that would be undertaken to preserve the rain forests. Information needed for a believable mechanism included references to respected sources, information on the costs of the mechanism, and why this mechanism was being used rather than others. The most satisfactory mechanism was the creation of enough national parks and protected areas to protect at least 10 percent of all remaining rain forests, the minimal percentage (estimated by scientists and groups such as the World Wildlife Fund [WWF]) to ensure

survival of the rainforest ecosystem. Estimates by the WWF on the cost per acre (and total costs for protecting 10 percent of all rain forests) to establish and manage the protected areas were also presented.

The final major use of the focus groups was the testing of alternative payment vehicles-higher taxes, higher prices, and donations to nonprofit organizations. After extensive discussions with the focus group participants and contingent valuation experts, the following payment vehicle was selected: contributions to a hypothetical United Nations Save the Rain Forests Fund. This payment vehicle does not meet all criteria for incentive compatibility, that is, it may be subject to the free-rider problem, however, given the intense political debates over taxes during the 1992 presidential campaign being waged during the survey period, focus group participants were overwhelming in their opposition to "any new taxes" or other government mandated "takings." Since almost all of the focus group participants responded that they would respond negatively to any increase in taxes no matter the cause, the authors felt that using taxes as the payment vehicle would distort the true willingness to pay more than the potential free-riding problem associated with voluntary contributions.

Following the focus groups, a pretest was employed with a national mail sample of 100 households. Responses to the two most popular payment vehicles in the focus groups (higher prices and contributions to a fund) were pretested as well as the amount of rain forests to be preserved. The pretest results validated the focus group results.

To test differential responses to question format, a split-sample experiment was conducted with 600 surveys sent to each subsample. Sample A received the payment card version and Sample B received the referendum format question. The two questionnaires and the cover letters were identical in all other respects. Those individuals receiving the referendum version of the survey (Sample B) were randomly assigned to the following bid offers: $5, 10, 15, 25, 50, 100, 200,400, 600,800, and 1,000.[5] Each respondent was asked to respond "yes" or "no" to the offered bid. The referendum question was double-bounded: if the answer was "yes" ("no") to the offered amount, the respondent was presented with a second offer that was twice as high (half as large) as the initial offer. Thus the referendum values for the second bid ranged from $2.5 to $2,000. Sample A respondents were presented with the following values to circle: $0, 5, 10, 15, 25, 35, 50, 75, 100, 150, 200, 300, 400, 500, 600, 700, 800, 900, 1,000, and 1,500. Respondents were also given the option of writing in another value.[6] The two CV question formats are presented in the Appendix.

The final version of the survey was mailed to a random sample of 1,200 U.S. residents between April and June 1992. A mailing list was purchased from a commercial marketing firm. The sampling frame was all households with listed telephone numbers. Returned surveys were received from 542 households. Correcting for bad addresses (approximately 15 percent), the response rate was 56 percent.[7] The design and implementation of the survey followed the Total Design Method developed by sociologist Don Dillman (1978), including the use of three follow-up mailings.

V. RESULTS AND DISCUSSION

Characteristics and Attitudes of Sampled Population

This section reports on the socioeconomic characteristics of respondent households and draws comparisons to summary statistics for the overall U.S. population re-

[5] The range of offered bid amounts were established using the open-ended responses from the Epp and Gripp (1992) study.

[6] Out of 280 respondents receiving the payment card question, only 3 chose the "OTHER" option. All three respondents wrote in $3.

[7] Low response rates may result in non-response bias due to self-selection. However, Mitchell and Carson (1989) calculated response rates for 16 published contingent valuation studies utilizing mail surveys. The mean response rate was 47.6 percent and the median was 41 percent. The current study's 56 percent response rate was higher than 62.5 percent of those surveyed by Mitchell and Carson and very close to their arbitrary 60 percent benchmark.

ported in the 1992 Statistical Abstract of the U.S. (U.S. Bureau of the Census 1992). Summaries of responses to questions about environmental attitudes and knowledge are also presented. The respondents exhibited characteristics quite similar to the overall U.S. population (see Table 1). The median income of the respondents was $31,500, whereas the 1990 median money income of all U.S. households was $29,943. The median number of school years completed by survey participants, 13.6, was slightly above that of the U.S. population, 12.4 years in 1991. Average household size was 2.51 persons, somewhat smaller than the 1991 national average of 2.63. The respondents were overwhelmingly male (67 percent), which reflects the bias of drawing the sample from names in telephone directories. Most U.S. households list their phone numbers in the name of male heads of households. The reported political affiliation of the surveyed sample was 32 percent Democrat, 31 percent Republican, and 33 percent Independent. Comparable percentages for the U.S. in 1988 were 36 percent, 28 percent, and 36 percent, respectively. Therefore, the sample appears to be well representative of the U.S. population except for the high proportion of males.

Tropical deforestation appears to be a well-known issue among the general public. Ninety-one percent of the respondents responded affirmatively to the question "Before today, have you ever read, heard, or seen TV shows about tropical rain forests?" and 81 percent claimed to be familiar with reasons for deforestation (see Table 2). This is not surprising since the timing of the survey was just before the Rio Conference when there was considerable media coverage of tropical deforestation and other international environmental issues. Two thirds of the sample answered yes to the question: "Should industrialized countries help developing countries pay for preserving their rain forests?" This has important ramifications for the ongoing political debate about the role of industrialized countries in bearing some of the costs of environmental protec-

TABLE 1
SOCIOECONOMIC CHARACTERISTICS OF SURVEYED NATIONAL SAMPLE

Variable	Range	Median	U.S. Median[a]
Income	$7,500–127,500	$31,500	$29,943
Education	8-24 years	13.6 years	12.4 years
Age (head of household)	18-95 years	47.9 years	45.9 years
		Mean	U.S. Mean[b]
Household Size	1-9	2.51	2.63

Variable	Percentage
Sex	
Male	67%
Female	33%
Conservation Organization Membership	25%
Political Affiliation	
Democrat	32%
Republican	31%
Independent	33%
Other	4%

Notes: Number of respondents: 542; response rate: 56 percent.
[a]Median estimates for the entire U.S. population in 1990 (U.S. Bureau of the Census 1992).
[b]Mean estimates for the entire U.S. population in 1990 (U.S. Bureau of the Census 1992).

TABLE 2
PERCENTAGE OF RESPONDENTS ANSWERING "YES" AND "NO" TO **QUESTIONS** ABOUT KNOWLEDGE OF, **VISITS** TO, **AND** OBLIGATIONS TO PAY FOR RAIN **FORESTS**

	Yes	No
Any knowledge of rain forests	91%	9%
Knowledge of causes of deforestation	81%	19%
Previously visited a rain forest	11%	89%
Plan to visit a rain forest	8%	61%*
Should industrialized countries help developing countries pay for preserving their rain forests	67%**	33%

*Thirty-one percent were uncertain if they would visit a rain forest in the future.
For those responding "Yes," **the percentage amount industrialized countries should pay ranged from l-100 percent with a median of 41 percent.

tion in less developed countries. A follow-up question asked what percentage of the costs should be borne by the industrialized world. The median response was 41 percent. Only 11 percent of the respondents had visited a tropical rain forest, while only 8 percent planned to visit one in the future (another 31 percent were uncertain). This low percentage of visitors suggests that much of the willingness to pay discussed below reflects non-use or passive-use values. Of course, to the extent that individuals expect to consume pharmaceutical and other products derived from rain forests, then non-visitors may hold use values as well.

To encourage the respondents to think about tropical deforestation relative to other problems, they were asked to rank seven "general problems" on a 1 to 7 scale with "1" being most important (see Table 3). Air pollution (2.63) and water pollution (2.73) were ranked as the two most important problems. This is not surprising since the local effects of these problems are more pronounced than other problems in the list, and there may be a perceived greater link with the health of respondents and their families. Next in average order of importance were two international environmental problems that have received extensive media attention: stratospheric ozone depletion (3.47) and global warming (3.65). Considerably lower rankings were given to the other problems on the survey list: deforestation

TABLE 3
RELATIVE RANKINGS OF SEVEN MAJOR ENVIRONMENTAL PROBLEMS

Environmental Problem	Average[a] Rank	Percentage For Each Rank						
		1	2	3	4	5	6	7
Air pollution	2.63	29	26	17	15	9	4	2
Water pollution	2.73	29	24	17	13	12	4	2
The hole in the ozone layer	3.47	29	12	13	12	12	11	12
The greenhouse effect (global warming)	3.65	17	18	13	18	13	17	8
Tropical deforestation	4.52	8	7	12	15	24	24	12
Acid rain	4.60	6	8	18	12	18	15	23
Cutting ancient forests in the northwestern U.S.	5.37	0	6	5	12	7	22	42

[a]1 = most important,. . ,7 = least important.

(4.521, acid rain (4.60), and harvesting old-growth forests in the northwestern U.S. (5.37). It is of interest to compare these results with those of the Gallup Organization's 1992 Health of the Planet survey in which the following percentages of U.S. respondents said the following world environmental problems were "very serious": water pollution (71%), air pollution (60%), loss of rain forests (63%), loss of ozone (56%), contaminated soil (54%), loss of species (50%), and global warming (47%) (Dunlap, Gallup, and Gallup 1992).

Factors Affecting Willingness to Pay

The frequency and percentage of "yes" responses to the payment card values and to the referendum bid amounts are presented in Tables 4 and 5. To examine factors affecting willingness to pay for rain forest protection, the CV responses were regressed against a number of socioeconomic and attitudinal variables. Results are given in Table 6 for both subsamples. The first column indicates the effects of the variables on the dollar amount selected by the payment card respondents.* The second column shows the effects of the independent variables on the probability of saying "yes" to the offered bid by the referendum format respondents. Although the coefficients have different interpretations for the two different question formats, the results will be discussed jointly in terms of the direction of influence of the independent variables on WTP.[9]

Because of the inherent nature of the question formats, only the referendum model has a variable for the offered bid. The log of the offered bid has a negative and significant effect on the likelihood of bid acceptance. Hence, there is confirmation of the expected negative relation between price and quantity of rain forest protection. Income has the expected positive effect on the WTP in both models. As incomes rise, there is a shift in the demand for this environmental good. Political affiliation has no significant effect in the payment card model, but in the referendum model Republican affiliation has a negative association with accepting offered bids (at the 10 percent significance level). In both models, a dummy variable for whether or not respondents made charitable contribu-

TABLE 4
FREQUENCY AND PERCENTAGE OF RESPONSES TO PAYMENT CARD CV QUESTION

Payment Card Amount	Frequency	Percentage of Total
$0	91	40%
$3*	3	1.3%
$5	22	9.8%
$10	26	11.7%
$15	6	2.7%
$25	27	12%
$35	6	2.7%
$50	18	8%
$75	1	0.4%
$100	14	6.25%
$150	0	0
$200	2	0.8%
$300	1	0.4%
$400	0	0
$500	3	1.3%
$600	0	0
$700	0	0
$800	0	0
$900	0	0
$1,000	3	1.3%
$1,500	1	0.4%

*Three respondents wrote in $3 in the "OTHER $ " category.

[8] Respondents to the payment card version who circled $1,000 (3 people) or $1,500 (1 person) were considered outliers and dropped from the sample. Of these four individuals, three reported no contributions to environmental organizations in the previous year and one reported a $300 contribution. Hence, their circled amounts appeared to be unreasonably high. Furthermore, no bid amount above $400 was accepted by the respondents who received the referendum version of the survey.

[9] The estimated regression coefficients for the payment card responses are marginal impacts on the dollar amount that respondents are willing to pay. The estimated coefficients for the referendum responses cannot be interpreted as marginal influences on the probability of accepting offered bids, but the sign of the estimated coefficients indicates the direction of influence.

TABLE 5

FREQUENCY, PROBABILITY OF "YES," AND PERCENTAGE OF POSITIVE RESPONSES TO REFERENDUM CONTINGENT VALUATION QUESTIONS

initial Bid	Total Number of Yes	Prob. of Yes	2nd Bid (halved)	Total Number of Yes	Prob. of Yes	2nd Bid (doubled)	Total Number of Yes	Prob. of Yes
$5	7	47%	$2.5	0	0%	$10	5	41.7%
$10	14	64%	$5	0	0%	$20	10	52.6%
$15	5	28%	$7.5	2	22%	$30	3	33.3%
$25	5	25%	$12.5	1	8.3%	$50	1	8.33%
$50	3	18%	$25	5	55.5%	$100	1	11.1%
$100	1	7%	$50	3	23%	$200	2	20%
$200	1	8%	$100	0	0%	$400	0	0%
$400	1	4%	$200	0	0%	$800	0	0%
$600	0	0%	$300	0	0%	$1,200	0	0%
$800	0	0%	$400	0	0%	$1,600	0	0%
$1,000	0	0%	$500	0	0%	$2,000	0	0%

TABLE 6

MAXIMUM LIKELIHOOD ESTIMATIONS OF RESPONSES TO WILLINGNESS-TO-PAY QUESTIONS

	Payment Card Response[a]	Referendum Responses[b]
Constant	−3.522 (−1.747)[d]	15.914 (−2.641)[c]
Log of Bid		−1.165 (−5.093)[c]
Log of Income	0.379 (1.904)[c]	1.426 (2.516)[c]
Political Affiliation Dummy (1 = Republican)	0.231 (0.769)	−1.190 (−1.857)[d]
Charitable Contributions Dummy (1 = contributed to charities in previous year)	1.04 (3.045)[c]	2.194 (2.059)[c]
Rain Forest Visitor Dummy (1 = visited or plans to visit Rain Forests)	0.711 (1.943)[c]	−0.942 (−1.182)
Ranking of Tropical Deforestation Problem (1 = most important.. .7 = least important environmental problem)	-0.151 (−1.817)[d]	0.230 (1.015)
Ranking of U.S. Old-Growth Forests Problem (1 = most important.. .7 = least important environmental problem)	-0.047 (−0.613)	0.377 (1.954)[c]
Cost-sharing Dummy (1 = believes industrialized countries should help pay for tropical rain forest preservation)	1.921 (5.883)[c]	1.947 (2.464)[c]
Family Size (number of household members)	0.190 (2.088)[c]	−0.018 (−0.083)
σ	1.5965 (13.753)	0.8585 (5.092)[c]
Number of observations	173	163
Goodness of fit	—	McFadden R^2 = .48 Correct Pred. = 89%

Note: t-ratio in parentheses.
[a]Dependent variable is the log of the amount (ranging from 0 to $800) which was circled
[b]Dependent variable is the yes/no response to the offered bid level.
[c]Significant at 5 percent level.
[d]Significant at 10 percent level.

tions has a significant and positive coefficient as expected. A dummy variable which reflects past or planned visits to rain forests increases the WTP in the payment card model. The ranking given tropical deforestation relative to six other major environmental problems (see Table 3) was also included as an independent variable. If the respondent ranked tropical deforestation as the most important of the seven problems, the variable received a value of "1"; if it was ranked the least important problem, the variable's value was "7"; intermediate rankings received values from "2" to "6." As expected, the more important the ranking, the higher the WTP in the payment card model (at the 10 percent significance level). Surprisingly, the importance given to the cutting of old-growth forests in the northwestern U.S. had the opposite effect in the referendum model. One possible explanation is that people who are concerned about old-growth forests in the U.S. may have more of a national focus and be less concerned about tropical forests. Hence, they may have a lower propensity to pay for protection in the tropics. Respondents who said that industrialized countries should help pay for rain forest protection had higher WTP in the payment card model and were more likely to accept offered bids in the other model. Finally, family size had a positive relationship with WTP in the payment card model perhaps indicating a bequest or intergenerational equity motive.

Since the dependent variables of the two models differ (the payment card dependent variable is willingness to pay the amount circled on the payment card-while the referendum dependent variable is the probability of saying "yes" to an offered bid amount), testing for statistical differences between the behavioral coefficients requires transformation of the referendum model. Following Cameron's (1991) approach for transforming logit referendum models for estimating confidence intervals, t-tests were performed to test for statistical differences between the coefficients on the behavioral parameters. The hypothesis that the behavioral parameters were the same across models could not be rejected at the 5 percent level for the following parameters: Charitable Contributions Dummy, Tropical Deforestation Dummy, Cost-sharing Dummy, and Family Size. The hypothesis that the parameters for Log of Income were the same across models could not be rejected at the 10 percent level. The only parameters for which significant differences exist below the 10 percent level are the following: Political Affiliation Dummy, Rainforest Visitor Dummy, Old-Growth Dummy, and σ. The three dummy variables were all strongly insignificant in one or more of the models. Holmes and Kramer (1995) found similar results for the dispersion parameter (a).

Willingness to Pay

Estimated willingness to pay is shown in Table 7. In contrast to a split-sample survey on protection of the Southern Appalachian spruce-fir forest (Holmes and Kramer 1995), the two different question formats gave similar WTP estimates for rain forest protection. The payment card format gives a mean WTP of $31 per household (standard error = 4.5), while the referendum question format produced a mean WTP per household of $21 (standard error = 6.8). The WTP estimates for the referendum format are based on a double-bounded formulation of the referendum question analyzed with the Hanemann, Loomis, and Kanninen (1991)

TABLE 7
WILLINGNESS-TO-PAY ESTIMATES FOR TROPICAL RAIN FOREST PRESERVATION

Type of Question Format	Mean WTP / Household (standard error)	Total WTP All Households*
Payment Card	$31 (4.5)	$2,821,000,000
Referendum Double-Bounded	$21 (6.8)	$1,911,000,000

*Assuming 91 million households in U.S. in 1989 (U.S. Bureau of Census 1992).

procedure.[10] The double-bounded approach has become a popular way to present valuation questions on the grounds that it enhances the amount of information per subject and improves statistical efficiency.

Aggregating over the 91 million households in the U.S. gives a total WTP of $1.9 billion and $2.8 billion for the two methods. While this total figure appears quite large, it should be viewed in context. Recall that the CV question asked for a one-time contribution. Hence the $1.9–$2.8 billion dollars can be thought of as a revolving fund that would be used over a number of years to finance tropical forest programs.

IV. CONCLUSIONS

This study represents an application of the contingent valuation method to a global environmental good. Most previous applications of contingent valuation have focused on local or regional environmental goods. The results suggest that U.S. residents are able to respond to valuation questions about the value of tropical rain forest protection and to give consistent responses across two different CV formats. Thus, global environmental goods appear to be appropriate subjects for CV studies. However, despite the fact that tropical rain forests may be one of the more well-known global environmental goods (81 percent of respondents were familiar with rain forest problems), focus group participants were not familiar enough with rain forests to allocate their values across or among specific rain forests or regions. This suggests that CV may be appropriate for determining aggregate valuations for global goods but not for informing allocation or preservation decisions among regions. Additional empirical work is needed to address other potential problems with applying CV to global environmental goods. In particular, as Carson (1995) suggests, multi-country studies are needed to assess the feasibility of global valuations of global goods. With the entire world (or even just the entire industrialized world) as the relevant sample population, one is faced with the additional challenges of how to develop scenarios that are plausible cross-culturally and how to interpret and aggregate the results.

Perhaps the most interesting policy finding of the current study is that two-thirds of the households indicated that industrialized countries should share the costs of protecting remaining rain forests. The Convention on Biological Diversity, now ratified by more than 140 nations, was based in part on a principle of shared costs between beneficiaries in industrialized and less developed countries. The results of this study suggest that the U.S. public not only supports this international financing approach but is also willing to make significant monetary contributions to ensure tropical rain forest protection.

For the sample, tropical deforestation ranked below most other environmental problems, perhaps reflecting a higher priority for domestic environmental issues. Despite this low relative ranking, households are willing to contribute $21-$31 on average (including confidence intervals, the range of WTP is $8–$40). This could create a substantial global endowment if households in other industrialized countries are willing to make similar sized donations. Such an endowment could go a long way toward meeting the goal of financing the protection of an additional 5 percent of the world's tropical rain forests and improving the operations of the existing network of parks. The endowment could be managed as a series of trust funds to create an income stream that would outlive the financing mechanisms of

[10] Following Brown et al. (1994), the likelihood of an observation can be expressed as

$$(1 - d_1)(1 \quad d_2)\int_{-\infty}^{b_2} dF(x) + d_1(1 - d_2)\int_{b_1}^{b_2} dF(x) + (1 - d_1)d_2\int_{b_2}^{b_1} dF(x) + d_1 d_2\int_{b_2}^{\infty} dF(x)$$

where F(x) is the cumulative distribution of willingness to pay and d_i = 1 if bid I is accepted and 0 otherwise.

traditional development and conservation projects (five-year loans). The most widely known conservation trust funds that have been used to establish protected areas have been supported by debt-for-nature swaps (e.g., Bolivia's National Fund for the Environment) (Wells 1991). Yet trust funds can also be underwritten by private contributions and user fees. For example, Belize's Protected Areas Conservation Fund is funded by a $20 levy on foreign tourists, site entrance fees, and recreation-related licenses.

APPENDIX
CV QUESTION FORMATS

Referendum CV Question

Recall that experts say that we need to preserve at least 10% of all tropical rain forests in national parks and reserves. Currently only 5% of all rain forests is preserved. Assume that the United Nations creates a special ***Save the Rain Forests Fund*** to raise enough money to preserve 110 million more acres (about the size of California) of rain forests in national parks and nature reserves in 57 tropical countries. This would be enough to reach the goal of saving 10% of all tropical rain forests. Assume that all of the donations to the Fund will go directly toward saving tropical rain forests by creating and managing national parks and reserves. **Would you be willing to make a one-time donation of $_____ to this fund?**

| → If YES, would you be willing to
YES contribute $(twice original amount)?

I I | |
YES NO

→ If NO, would you be willing to
NO contribute $(half original amount)?

I I | |
YES NO

Payment Card CV Question

Recall that experts say that we need to preserve at least 10% of all tropical rain forests in national parks and reserves. Currently only 5% of all rain forests is preserved. Assume that the United Nations creates a special ***Save the Rain Forests Fund*** to raise enough money to preserve 110 million more acres (about the size of California) of rain forests in national parks and nature reserves in 57 tropical countries. This would be enough to reach the goal of saving 10% of all tropical rain forests. Assume that all of the donations to the Fund will go directly toward saving tropical rain forests by creating and managing national parks and reserves. **If you were asked to make a one-time donation to this fund, how much would you contribute? (Please circle the amount which is the most you would pay.)**

$0	$5	$10	$15	***$25***	***$35***
$50	$75	***$100***	***$150***	***$200***	***$300***
$400	***$500***	***$600***	***$700***	***$800***	***$900***
$1000	$1500	OTHER	$_____		

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