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A "Delphi Exercise" as a Tool in Amazon Rainforest Valuation

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Abstract

The Amazon rainforest, the world's largest and most biodiverse, represents a global public good of which 15 percent has already been lost. The worldwide value of preserving the remaining forest is today unknown. A "Delphi" exercise was conducted involving more than 200 environmental valuation experts from 36 countries, who were asked to predict the outcome of a survey to elicit willingness to pay for Amazon forest preservation among their own countries' populations. Expert judgments of average willingness-to-pay levels, per household per year, to fund a plan to protect all of the current Amazon rainforest up to 2050, range from \$4 to \$36 in 12 Asian countries, to near \$100 in Canada, Germany, and Norway, with other high-income countries in between. Somewhat lower willingness-to-pay values were found for a less strict plan that allows a 12 percent further rainforest area reduction. The elasticity of experts' willingness-to-pay assessments with respect to own-country per capita income is slightly below but not significantly different from unity when results are pooled across countries and income is adjusted for purchasing power parity.

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A "Delphi Exercise" as a Tool in Amazon Rainforest Valuation

By

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1. Introduction

No complete valuation of an ecological public good of the magnitude and complexity of the Amazon rainforest has yet been undertaken. Such a project faces several daunting challenges, which include choice of time frame and the fact that many impacts are likely to require very long time horizons; the intangibility of many value components (passive-use and carbon values; also biodiversity and other ecosystem services); and the likely changing nature of many relevant value components.

This paper focuses on the global public-good benefits of the Amazon forest, to populations in other parts of the world than the South American region where the Amazon is located. We can distinguish between two main aspects of global value or benefits of preserving the Amazon rainforest, namely

A. The rainforest as a carbon sink, and

B. All other global values, which include rainforest-derived products (including pharmaceutical ones), various ecosystem externality effects, recreation and ecotourism, and passive use (or existence) values attached to preserving the Amazon by the worldwide population.

Aspect A should most reasonably rely on assessed "social cost of (SCC) carbon" values, which correspond to (present discounted) losses to the global economy from additional carbon emissions (Tol 2005, 2008), multiplied by net amounts of carbon emitted when forest is lost. Aspect B is more complex. Much or most of it is likely to consist of passive-use or existence value, which can be captured only with the use of stated preference (SP) studies.

Surprisingly little is known about willingness to pay (WTP) to protect the Amazon rainforest, in countries both inside and outside South America. Two previous SP studies, Kramer and Mercer (1997) and Horton et al. (2003), might throw some light on the latter issue. Kramer and Mercer conducted a random population survey among the U.S. population in 1995, to elicit WTP for protecting 5% of *global* rainforests (thus not specifically in the Amazon), as a *one-time* payment per U.S. household, finding an average expressed WTP per household in the range $21-

$31 (in 1995 dollars). Horton et al., surveying convenience samples at a small number of outdoor recreation sites in the U.K. and Italy in 1999, found much higher numbers, around $45 per household *per year*, in each of the two countries, for a program to protect 5% of the Amazonian rainforest (and $60 for a 20% protection program). Apart from design issues—the latter study was limited in scope, with small and geographically concentrated samples that were not representative of the national populations—these differences could reflect preference differences between Europe and the United States. Alternatively or additionally, they could signal greater public attention to, and support of, rainforest issues during the period of the latter study.

Traditional SP elicitation involves for the most part random population surveys using contingent valuation (CV).[2] In particular, the two cited surveys by Kramer and Mercer and Horton et al. both utilized the CV technique. While we have more than 40 years of experience with CV, choice experiments (CE) have become widely applied to environmental valuation only over the last 10 years or so.[3]

In this paper we present a "Delphi exercise" in which environmental valuation experts from several countries were asked to predict WTP for such preservation, on behalf of their respective national populations, in the event that a CV survey was done in their respective countries. Experts taking part in this exercise came from Europe (49 experts from 21 different countries); the U.S. and Canada (82 experts); Australia and New Zealand (16 experts); and Asia (70 experts from Bangladesh, Cambodia, China, India, Indonesia, Malaysia, Nepal, Pakistan, the Philippines, Sri Lanka, Thailand and Vietnam).

The "Delphi method" was developed by the RAND Corporation during the 1950s and 1960s, principally by Dalkey and Helmer (1963), and has by now a long background and tradition as a management decision tool.[4] The key elements are: (a) anonymous responses by

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[2]See Mitchell and Carson (1989), Carson, Flores and Meade (2001), and Carson (2011), for presentations of the CV method. The latter reference contains a comprehensive bibliography. See Carson (1998) for a more specific discussion of CV in the context of rainforest valuation.

[3] For a discussion of CE studies see Adamowicz et al (1998), Hanley, Wright and Adamowicz (1998), and Louviere, Hensher and Swait (2000). Among prominent, more specific and recent, applications to environmental and resource economics, are Bennett and Blamey (2001), Bateman et al. (2002), Holmes and Adamowicz (2004), Rolfe and Bennett (2006), and Bennett and Birol (2010). It may be argued, as do Carson and Louviere (2011), that CE in its environmental applications is best seen as a particular approach to doing contingent valuation.

[4] See also Dalkey (1967, 1969), and Linstone and Turoff (1975), for overviews and further discussions of the Delphi method.

experts to formal questionnaires; (b) an exercise incorporating iterative, controlled feedback with respect to information provided at each round; and (c) statistical summary of the group's responses. The approach was designed to minimize influence of dominant individuals, group pressure and irrelevant communication, and to reduce (statistical) noise. By the early 1970s, hundreds of studies had appeared all over the world. But by the mid-1970s, methodological development seemed to stall, perhaps due to heavy criticism of the method as unscientific and its results as speculative.[5] The critique seems to have been rebutted, for many, in a satisfactory way (see e.g. Ziglio, 1996). In any event, the basic method has more recently seen much use in a wide variety of contexts where it can produce information that is not readily obtainable in other ways.

The Delphi method has however seldom been used for environmental or similar valuation.[6] The only other similar such exercise of which we are aware is for the Fez Medina in Morocco, in 1998.[7] In both that study and the current one, experts predicted the outcome of a hypothetical CV survey questionnaire. The exercise is intended to provide expert predictions of population mean and median WTP in the event that such national CV surveys were to be actually conducted in the experts' respective countries.

Other expert-based work on environmental valuation, related to our study, however exist. We will here mention three such studies. One is Weitzman's (2001) study involving more than 2000 Ph.D.-level economists, who were each asked to provide their own assessment of the appropriate rate for discounting future climate-related damages. A second study, Roman et al. (2012), involved only three experts whose assessments of the (air-pollution related) value of statistical life in the United States were elicited. While the Weitzman study involved a broader range of "experts" (virtually all types of economists) and a less detailed valuation procedure than ours, the expert range in the Roman et al. study was narrower, and the procedure more detailed. The third study, León et al. (2003), considered whether environmental values elicited through expert opinion can be used as the basis for "benefit transfer". It dealt with outdoor recreation at national parks in Spain, and compared experts' predictions to the results of actual CV studies at

[5] For a comprehensive summary of the critique see Sackman (1975).

[6] The first mention of the method as suitable for environmental valuation that we have found (albeit with no reference to particular applications) was in Hufschmidt et al (1983).

[7] Carson, et al. (2013). That study involved two researchers in this project, Richard Carson and Stale Navrud.

the sites. We further discuss the potential for Delphi results to be helpful for benefit transfer, in the final section below.

Our Delphi exercise could, in principle, serve several objectives. First, and most obviously, it provides estimates of population WTP which can be held up against estimates from the population SP surveys that we intend to undertake. A large discrepancy between the Delphi exercises and the population surveys, absolutely and/or relatively across the countries for which we will have estimates from both, may signal a need for further analysis and refinement of our overall valuation approach. Second, note that our Delphi exercise provides us with average population WTP assessments for some countries where population surveys will, and will not, be done. We do not have the resources to carry out population surveys in all major countries. Our expert surveys will then give us useful relative WTP assessments for these two groups of countries. Such relative assessments could be more useful than the absolute WTP numbers from our Delphi exercise, as concluded also by León et al. (2003). Even persons who view themselves as experts are likely to have limited knowledge of true WTP levels in their own countries, for the particular value object in question here, as population data on these levels are generally lacking.

Thirdly, the distribution of experts' WTP predictions could serve as a guide to planning more efficient experimental designs (Ferrini and Scarpa 2007). Finally, as part of the Delphi exercise we also sought all experts' comments on various aspects of design of those population SP surveys we intend to undertake. Several leading environmental valuation experts participated in our exercise, and their feedback provided us with highly useful information. Most importantly, the expert group as a whole confirmed some of our beliefs about the most difficult problems we will face in conducting these surveys; and also led us to reevaluate certain design choices and raised some new issues.

2. Our Delphi Exercise

2.1 Expert Participants

Some key data concerning the distribution of participating experts are given in Tables 1 (experts from other countries than Europe) and 2 (European experts). Overall, 49 experts from 21 different European countries; 98 experts from other OECD countries (the U.S., Canada, Australia and New Zealand); and 70 experts from 12 (lower- and middle-income) Asian countries participated; 217 experts in total. The experts were identified from membership lists of regional associations of environmental and resource economists, and contact lists of the current authors (all experts on the lists are environmental valuation practitioners).

Table 1: Experts including WTP statements by country and region other than Europe

Country group (number of experts)	Country (number of experts)	Stated Mean WTP for Plan A, Round 2, US$/household/year	GDP (PPP-adjusted), US$/capita/year
OECD countries (98)	U.S. (71)	67.7	50,000 (50,000)
	Canada (11)	90.2	52,200 (42,500)
	Australia (9)	44.9	67,000 (44,600)
	New Zealand (7)	24.7	37,700 (32,200)
Low-income Asian countries (6)	Bangladesh (1)	10.0	800 (1900)
	Cambodia (1)	4.0	1000 (2500)
	Nepal (4)	4.2	700 (1500)
Lower-middle-income Asian countries (40)	India (10)	23.8	1,500 (3,900)
	Indonesia (6)	6.2	3,600 (5,000)
	Pakistan (3)	11.0	1,300 (2,900)
	Philippines (11)	6.5	2,600 (4,400)
	Sri Lanka (2)	36.5	2,900 (6,200)
	Vietnam (8)	5.8	1,600 (3,600)
Upper-middle-income Asian countries (24)	China (6)	23.4	6,200 (9,200)
	Malaysia (11)	31.5	10,400 (17,100)
	Thailand (7)	18.9	5,500 (9,800)

In Tables 1-2, the Asian experts are grouped by main country income characteristics,[8] and the European experts by region. The tables also indicate GDP per capita (standard and PPP adjusted), on average by region in Europe, and otherwise by country. All experts except 11 have PhDs (among the rest, 10 have Master's degrees). Women comprise 39 out of 147 experts (26.5%) from regions apart from Asia, and 30 out of 70 experts (42.9%) from Asia.

2.2 Survey Instrument

We conducted the Delphi exercise by email. Each expert was provided with a description, including key visual aids, of two Amazon protection scenarios that might be presented to a population sample in the expert's home country. The survey instrument provided to the U.S. experts is reproduced in the appendix. The instruments used in the other regions were similar,

[8] The European survey was conducted in the spring and summer of 2012. The other surveys were conducted over the period May – September 2013. Altogether 299 experts were contacted. The overall response rate was 70.2%, highest in Europe (82.7%), and lowest in Oceania (41%), where less effort was directed toward non-respondents.

although some changes were made to the order of information and the words used to describe it in the Asian instrument, given that English was not the first language of most of the Asian experts.[9]

Table 2: Distribution of experts and WTP statements by country in Europe

Country group (numbers of experts)	Country (number of experts)	Stated Mean WTP for Plan A, Round 2; US$/household/year	Mean Group GDP (PPP-adjusted), US$/capita/year, unweighted
Nordic countries (11)	Denmark (2)	49.0	70,000 (43,900)
	Finland (3)	34.5	
	Norway (3)	114.2	
	Sweden (3)	40.4	
Northern and Central Europe (18)	Austria (2)	78.2	48,900 (39,800)
	Belgium (1)	61.2	
	Germany (3)	102.0	
	Ireland (2)	32.6	
	Netherlands (3)	40.8	
	Switzerland (2)	30.6	
	United Kingdom (5)	31.8	
Southern Europe (12)	France (3)	47.6	36,200 (31,600)
	Greece (2)	10.9	
	Italy (4)	22.1	
	Portugal (1)	27.2	
	Spain (2)	31.3	
Eastern Europe (8)	Croatia (2)	5.0	15,700 (21,300)
	Czech Republic (2)	27.2	
	Hungary (1)	5.4	
	Poland (2)	27.2	
	Romania (1)	34.0	

The more extensive protection plan, Plan A, implies no further forest loss from now until 2050. The less extensive plan, Plan B, implies that 12% of the current Amazon rainforest would be lost by that time. Both plans are compared to a costless (in terms of incremental *protection* costs) "business as usual" (BAU) alternative, under which 30% of the current Amazon rainforest is assumed to be lost by 2050.[10] Respondents would incur annual payments on a per household

[9] These changes were made as a result of cognitive interviews of a small number of Asian environmental economists conducted before the Asian exercise. Some smaller differences also exist between the European survey and the others. E.g., European experts were not shown pictures of possible threatened species.

[10] This BAU alternative corresponds to the deforestation scenario set out by Soares-Filho et al. (2006), still considered the most authoritative. Note that the "good" to be valued was different in the Horton, et al. (2003) study,

basis and the program for reducing forest losses would remain in force only as long as payments are made. Any protection plan would go into force only when supported by a population majority in a majority of contributing countries.

Our Delphi exercise had two rounds. After an initial round 1, mean and median values across the respective surveyed experts in each country or region were calculated and reported back to the experts,[11] who then got the opportunity to adjust their value estimates in round 2. National values were reported to the experts except for Europe and Asia, where regional values were reported. The information provided to experts after round 1 may have influenced their round 2 answers, typically by drawing round 2 responses toward the round 1 summary statistics. Such effects are however in the "spirit" of the Delphi method as an implicit objective of a Delphi exercise is to reduce the variance of participants' answers, thus achieving more of a group consensus, while at the same time not pressuring those with tightly held positions to change.

To induce maximum participation among experts, we introduced a (limited) incentive scheme which took slightly different forms to different groups. For completing both rounds of the survey, European experts received a small cash award; experts from North America and Oceania received a gift card on Amazon.com; and Asian experts received a personally signed copy of Partha Dasgupta's book: "Economics: A Very Short Introduction". In total 216 out of 308 contacted experts completed both survey rounds.[12]

In each round of the Delphi exercise, each expert was asked to provide four numbers: their estimate of the mean and median annual household WTP in their own country, to implement each of Plan A and Plan B, given that a valuation survey would be undertaken in their country.[13] Tables 3-4 in Section 3 below provide an overview of the main summary results from these two rounds.

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when compared to our protection plans, namely the establishment of specific, protected, areas, comprising respectively 5% and 20% of the total Amazon forest, and where no further deforestation is permitted.

[11] In the Asian survey, the distribution of responses by WTP ranges ($0, $0-1, etc.) was provided instead of the mean and median.

[12] Completion rates were 63% in North America, 83% in Europe, 78% in Asia, and 53% in Oceania.

[13] European experts were asked to provide 4 additional estimates, of equivalent values for all of Europe. These are reported in Navrud and Strand (2013).

Experts were asked to specify only the non-carbon values of rainforest preservation, as the political process will likely identify carbon values separately.[14] We recognize that such a separation may be hard to achieve, and several of the experts pointed to this as being the most difficult aspect our stylized survey instrument.

Experts were told to assume that, if the program were enacted in their country, payments would in general be collected as an annual national tax on all households. Later in their questionnaire, experts were asked which of two specific payment vehicles, an income tax or an increase in a utility bill, would be preferable to use. They were also asked whether they thought the payment vehicle would bias WTP estimates in the population surveys upwards or downwards.[15] The preferred payment mechanism varied across experts. Many, in particular those from the United States, indicated that a tax payment vehicle would bias answers in the downward direction.

2.3 Other Questions

The Delphi expert questionnaires contained several other questions with various aims: to inform on background variables in estimating WTP functions; as background for understanding other features of the experts and their credibility; as a way to control for whether answers from experts were "real" or could rather be distorted by misunderstandings or lack of knowledge; and to gather information that could be useful in design of the population surveys that we aim to do later. Among issues questioned were:

- Perceived difficulty in answering the questions, whether the overall exercise was viewed as meaningful, and whether experts viewed their own answers as reliable.
- Experts' own background in SP research, in terms of work time allocated to such activities, knowledge of the SP literature, numbers of CV and CE studies conducted and papers published and reviewed, and benefit transfer studies carried out and refereed.
- Familiarity with specific key journals covering environmental economics.
- Highest educational degree.
- Gender.

[14] The issue here is similar to that encountered with assessing air pollution policy options in the United States where health effects are not quantified in economic terms while other impacts are quantified in economic terms.
[15] These questions were not posed to the European sample.

Experts also faced a final debriefing section where they were asked, among other things, to suggest reformulations of the survey; possible problems in implementing the population surveys; and possible perceived differences between the "preservation" plans, which we used, versus an alternative "loss prevention" scenario for forest protection.

3. Main Survey Results

3.1 Experts' Estimates of Public's WTP for Amazon Forest Preservation

Key results from the survey are presented in Tables 3-4. Table 3 provides an overview of experts' answers for (the more comprehensive) Plan A, while Table 4 presents results for (the less comprehensive) Plan B. For both plans, experts provided estimates of both mean and median WTP for their home countries' populations.[16] Such figures are here presented for all experts in each category, given separately by world region (and within Asia, distinguishing between low/lower-middle income countries and upper-middle-income countries, with China, Malaysia and Thailand in the latter group). Only overview numbers for each of the regions are included in these tables; for more detailed figures consult the authors.

The average figures across experts mask high variability, varying by expert from a low of zero to a high of $500 per household per year. Overall, experts' evaluations of WTP levels in their own countries are higher for means than medians. This is reasonable as these distributions are (viewed by most experts as) skewed with some high WTP households that pull averages up.

Another interesting feature is that average expert answers are lower in round 2 than in round 1. This holds for all regions and for both mean and median WTP answers, but more so for means. This follows (discussed more in section 4 below) from many experts changing their valuations from round 1 to round 2, and more, absolutely speaking, down than up.

We see that overall mean stated WTP is highest in North America and lowest in Asia, with Oceania and Europe in between at similar levels. Within Asia, WTP levels are substantially lower for low/lower-middle-income than for upper-middle-income countries. There were also considerable differences by country within each of the specified groups (not shown). Overall, the

[16] Note that the European data (and only these) have already been documented in Navrud and Strand (2013).

relationship between average stated WTP by experts and per-capita income appears strong and reasonable. We come back to these relationships later.

Table 3: Main results from the Delphi surveys for Plan A. Figures in US$ per household per year in the country of the respective expert, calculated as group averages. R1 = Round 1, R2 = Round 2.

WTP measure	North America (82)	Oceania (16)	Europe (49)	Asia (70)	Low/Lower-middle-income Asia (46)	Upper-middle income Asia (24)
Mean, R1	89.2	45.6	46.6	27.8	22.5	38.0
Mean, R2	71.1	39.3	42.8	16.1	11.0	25.8
Median, R1	51.1	25.6	25.6	25.2	22.3	30.8
Median, R2	41.1	22.9	22.6	13.8	11.9	17.5

Table 4 is analogous to Table 3, but with lower figures as the “good” valued is less comprehensive: a 12% further deforestation is accepted under Plan B, while there is no further deforestation under Plan A. The differences are consistent, on the order 25-35% (and similar to the relative differences in deforestation rates that are being valued).

Table 4: Main results from the Delphi surveys for Plan B. Figures in US$ per household per year in the country of the respective expert, calculated as group averages. R1 = Round 1, R2 = Round 2.

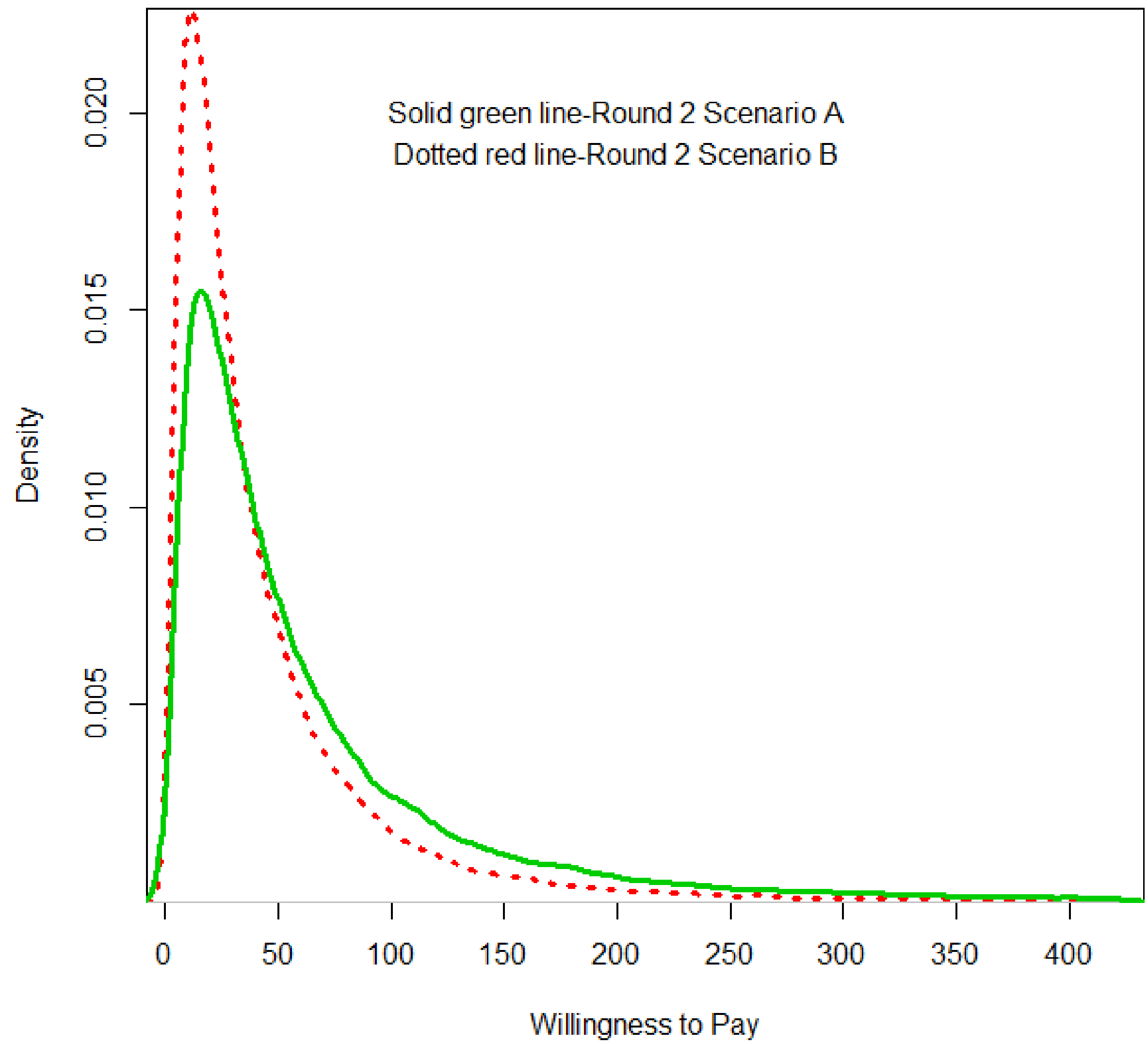
WTP measure	North America (82)	Oceania (16)	Europe (48)	Asia (70)	Low/Lower-middle-income Asia (46)	Upper-middle-income Asia (24)
Mean, R1	56.9	28.8	39.9	19.9	17.1	25.0
Mean, R2	47.5	25.0	32.4	11.3	8.1	17.6
Median, R1	33.1	15.9	19.5	16.4	15.6	18.0
Median, R2	28.4	13.9	16.5	9.2	8.3	10.9

Having estimates of mean and median WTP for a particular area allows us to trace out the probability density function of the WTP distribution if we are prepared to assume a two-parameter parametric distribution.[17] Effectively one has two equations, one for the mean and one for the median, that are expressed in terms of the assumed distribution’s two underlying parameters so that it is possible to solve for those parameters. These parameter estimates can

[17] In retrospect it would have been desirable to ask our experts to estimate the fraction of their country’s households that would hold a zero WTP for each of our Amazon protection programs.

then be used as initial priors for experimental design where the variance in the estimated parameters can be used as an initial measure of parameter precision in a full Bayesian design (Choicemetrics, 2012; Rose and Bleimer, 2013). Later, we will present regression results that indicate the effects of national income on these parameter values. Here, we use nonparametric methods to trace out the probability density function. Figure 1 displays the round 2 estimate of the probability distribution function for WTP, for Plans A and B, based on the North American (U.S. and Canadian) experts under the (standard) assumption that WTP is log-normally distributed. The sensitivity of the design to alternative distributions that have a shorter right tail (such as the Weibull) could also be examined. The prior distribution derived from our experts' answers can also be sequentially updated with more information such as that obtained by various types of survey development work.

Figure 1: North American Projected Round 2 WTP Distributions for Plans A and B



3.2 Experts' Estimates of Public WTP Levels in Relation to National Income

An important issue for our Delphi surveys is the relationship between national income and assessed WTP in experts' own countries. This relationship may, if properly identified, provide one main set of information in using results from the surveys for valuation purposes, and then, possibly, also for countries for which we do not expect to get access to national population sample data. A plausible hypothesis is that experts do not know the true levels of WTP for Amazon preservation in their countries, as generally no studies are available for such judgment. But experts may reach similar relative-to-income WTP conclusions. This is a hypothesis that we can probe with our data.

Table 5 provides "raw-data" estimates of elasticities of experts' stated WTP figures with respect to two separate measures of per-capita gross domestic product in experts' home countries: regular GDP; and purchasing power parity (PPP) adjusted GDP. We estimate the elasticities by regressing the log of experts' WTP values on the log of the corresponding country income measure. Such estimates are provided for the entire sample, and in addition separately for the Asian and European samples for which such calculations are meaningful.[18] As expected, these elasticities are on the whole larger with respect to PPP-adjusted GDP than with respect to regular GDP.[19] While elasticities with respect to regular GDP are, in most cases, in the range 0.6-0.8, elasticities with respect to PPP-adjusted GDP are, in most cases, in excess of 0.8, and for Europe even far higher (1.4-1.6). All income elasticities are highly significant with respect to the null hypothesis of zero. Full-sample elasticities are here particularly interesting. These are all rather stable around 0.6-0.7 for regular GDP figures, and around 0.8-0.9 for PPP-adjusted GDP figures. Such numbers may appear as plausible at least in light of other similar elasticity assessment (such as for general environmental improvements, and values of statistical life; e. g., OECD 2012). As potentially important from the perspective of a benefit transfer, no full-sample elasticity with respect to PPP-adjusted incomes is significantly different from unity. This indicates that the ratio of (PPP-adjusted) incomes between two countries can be used to scale results in the transfer exercise, without too large error (Flores and Carson, 1997).

Figure 2 below provides a further visualization of the main relationship between PPP-adjusted GDP per capita and the Round 2 expert assessments of country mean WTP per household per year for Plan A. We find a reasonably regular increasing relationship between mean WTP and average national (PPP-adjusted) income, which is still not entirely regular due to relatively high variability of WTP estimates across individual experts.

Table 5: Elasticities of experts' estimated WTP with respect to per-capita national GDP (regular and PPP-adjusted), in total and by region, and by calculation, raw data estimates (based on log-log regressions with no controls for other country or expert characteristics)

Type of GDP measure	Group included	Plan A, R1	Plan A, R2	Plan B, R1	Plan B, R2

[18] It is not meaningful to calculate income elasticities for the North American or Oceanian experts, as each group has only two countries. Moreover, average income levels are close together in the North American case.

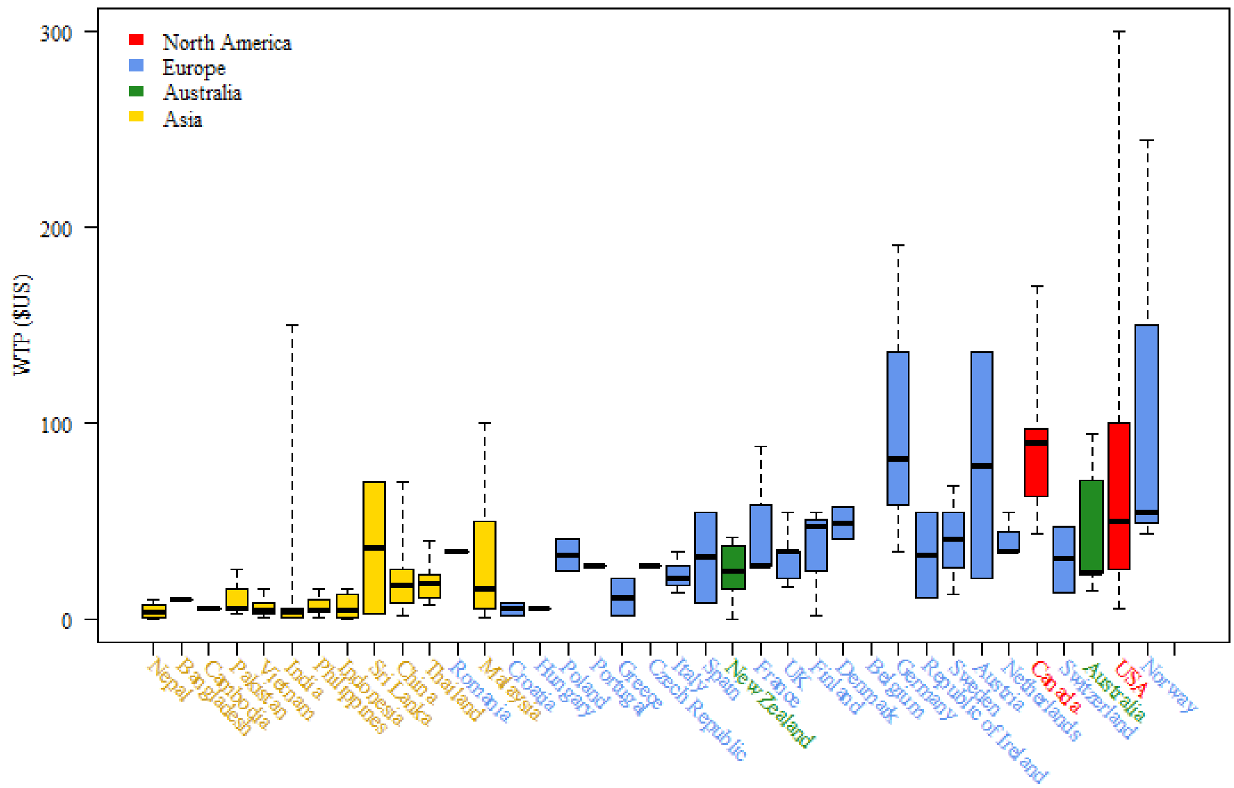
[19] See Navrud and Strand (2013) for an analytical discussion. The reason is that PPP-adjusted per capita figures are, generally, less variable across countries than regular GDP per capita figures. The WTP figures will then generally exhibit greater relative variation, when regressed against the less-spread-out PPP-adjusted figures.

included					
Regular GDP	Full sample	0.67	0.64	0.61	0.64
	Asia only	0.66	0.64	0.54	0.52
	Europe only	0.65	0.76	0.67	0.78
PPP adjusted GDP	Full sample	0.92	0.87	0.83	0.87
	Asia only	0.82	0.80	0.71	0.66
	Europe only	1.42	1.53	1.43	1.56

The "raw-data" elasticity estimates suffer from two problems. First, the estimates for the European and Asian subsamples are based on small sets of countries, 21 and 12, respectively. This is a problem because the GDP estimates within a given country are the same across experts from that country, which causes the standard errors for the regression coefficients to be biased downward, thus exaggerating the precision of the coefficient estimates (Moulton 1986, 1990). Clustering the standard errors by country would be the usual response to this problem, but clustering does not yield consistent estimates when the number of clusters (here, countries) is small. Clustering can be expected to work better in the full sample, which includes 37 countries, a number close to the minimum of 42 recommended by Angrist and Pischke (2009). The second problem affects the "raw-data" estimates even for the full sample: the estimates do not account for the high variation in the number of experts by country, from a low of one in Bangladesh, Belgium, Cambodia, Hungary, Portugal, and Romania to a high of 70 in the United States. Countries are the implicit units of observation when estimating the income elasticities, but countries with more experts have greater influence on the estimation results than countries with fewer experts. Treating countries equally requires estimating weighted models, with the inverse of the number of experts from each country used as weights.[20] This problem can alternatively be addressed by estimating a model based on mean values across the experts from each country. We addressed the problem both ways, as reported below.

Figure 2: Distributions of mean WTP answers under Plans A and B, Round 2, with countries ranked by increasing PPP-adjusted per capita incomes.

[20] Note that the reason for weighting is not to address heteroskedasticity; we use robust standard errors to address that problem. Additional weighting could arguably be done to account for differences in population across the countries, but weighting by population makes more sense when individuals are implicitly the units of observation (e.g., in studies on the effects of economic growth on poverty alleviation), not countries as in our study.



Note: The solid band inside the box represents the median. The box extremities represent the first and third quartiles. Whiskers extend to data extremes.

Table 6 presents results from estimating full-sample models that address these two problems. The sample for these models included only WTP predictions from Round 2, which are assumed to be more accurate than predictions from Round 1. It included WTP predictions for both Plan A and Plan B, with a dummy variable used to control for the larger area protected under Plan A. PPP-adjusted GDP per capita was used as the measure of income in all the models; other measures, including regular GDP and GNI per capita and PPP-adjusted GNI per capita, yielded virtually identical results. The models also include dummy variables to control for regional differences in the timing of the surveys, the wording of the questionnaires, and the distances of the regions from the Amazon; Europe was the excluded region.[21]

Table 6. Effect of income on mean and median WTP, with regional differences controlled by dummies. Dependent variables: ln(1 + mean WTP) and ln(1 + median WTP). Observations: individual respondents in the models in the first two columns; countries in the models in the last two columns.

	Individual predictions		Country means	
Variables	Mean	Median	Mean	Median
ln(GDP per capita, PPP)	0.707***	0.735***	0.905***	0.932***
	(0.210)	(0.154)	(0.195)	(0.157)
Dummy: plan A	0.285***	0.293***	0.301***	0.317***
	(0.0347)	(0.0367)	(0.0299)	(0.0315)
Dummy: Asia	0.0304	0.369	0.608	0.894**
	(0.405)	(0.322)	(0.403)	(0.368)
Dummy: North America	0.575**	0.757**	0.535**	0.661***
	(0.284)	(0.314)	(0.216)	(0.253)
Dummy: Oceania	-0.234	-0.298	-0.137	-0.141
	(0.243)	(0.476)	(0.169)	(0.251)
Country FEs?	No	No	No	No
Weighted regression?	Yes	Yes	No	No
Income elasticity	0.729	0.775	0.940	0.996
P-value for H_0: elasticity = 1	0.211	0.167	0.767	0.982
R^2	0.359	0.283	0.612	0.611
F statistic	47.4	33.3	21.2	21.1
Observations	429	429	73	73

*** p<0.01, ** p<0.05, * p<0.1. Standard errors are in parentheses and were estimated jointly for the pair of equations (Mean, Median), with clustering by country.
Weights: inverse to number of respondents from a given country.

[21] A weaker control would be to include a regional dummy only for Europe, where the survey was conducted a year earlier than in the other regions. One benefit of doing this is to increase the income variation in the sample (e.g., Canada and the U.S. have similar income, whose effect is largely absorbed by the North America dummy). The income elasticity estimates change little, however, if we do this.

The weighted models based on WTP predictions by individual experts yielded very similar income elasticities for mean and median WTP, 0.729 and 0.775, respectively.[22] Neither estimate was significantly different from unity. The income elasticities were higher in the models based on country means of the WTP predictions, 0.940 and 0.996, and again were not significantly different from unity. These more carefully controlled results provide stronger support for a hypothesis that income elasticities equal unity, than the "raw-data" results in Table 5. As expected, WTP was higher for Plan A (positive and significant coefficients on the order of 0.3). It was also higher on average in North America than in any of the other regions.

If one is prepared to assume a specific distribution for WTP, the mean and median predictions can be used to estimate the parameters in that distribution. We assumed a log-normal distribution, a common and often realistic assumption in stated-preference studies. The location parameter for this distribution (mu) equals the natural logarithm of the median, while the scale parameter (sigma) equals the square root of twice the difference between the logs of the mean and median. Using these relationships, we constructed variables for mu and sigma[23], and re-estimated the models in Table 6.

Results are shown in Table 7. Given that the location parameter in a log-normal distribution equals the log of the median, the results for mu in Table 7 are the same as the results for median WTP in Table 6. The results for the scale parameter, sigma, are thus more interesting, and they indicate that income has no effect on it in either the model based on WTP predictions by individual experts or the model based on country means of the WTP predictions. The only significant effect pertains to the home regions of the experts, with the scale parameter being smaller in Asia than in the other regions. These results could be used to generate parametric versions of Figure 1 for any country in the sample, given information on its region and income level.

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[22] Note that the income elasticities differ from the coefficient estimates on ln(GDP per capita, PPP), because the dependent variables in the models are ln(1 + WTP), not ln(WTP), to account for WTP values equals to zero. The elasticity estimates change little if the models are estimated without the weights. The standard errors become much smaller, however, which suggests that clustering does not fully address the Moulton problem. Including the weights also serves to address that problem.

[23] Because the WTP predictions can equal 0, as in Table A we added 1 to all the WTP predictions to avoid taking the log of zero.

Table 7. Effect of income on log-normal location and scale parameters (mu and sigma, respectively), with regional differences controlled by dummies. Dependent variables: mu and sigma. Observations: individual respondents in the models in the first two columns; countries in the models in the last two columns.

	Individual predictions		Country means	
Variables	Mu	Sigma	Mu	Sigma
ln(GDP per capita, PPP)	0.735***	-0.0422	0.932***	-0.0268
	(0.154)	(0.0800)	(0.157)	(0.0775)
Dummy: plan A	0.293***	-0.0114	0.317***	-0.000672
	(0.0367)	(0.0185)	(0.0315)	(0.0256)
Dummy: Asia	0.369	-0.343**	0.894**	-0.284**
	(0.321)	(0.140)	(0.368)	(0.131)
Dummy: North America	0.757**	-0.140**	0.661***	-0.104
	(0.314)	(0.0696)	(0.253)	(0.0764)
Dummy: Oceania	-0.298	-0.0876	-0.141	0.0145
	(0.475)	(0.165)	(0.251)	(0.112)
Country FEs?	No	No	No	No
Weighted regression?	Yes	Yes	No	No
R^2	0.283	0.084	0.611	0.211
F statistic	33.3	7.61	21.1	3.52
Observations	428	428	73	73

*** p<0.01, ** p<0.05, * p<0.1. Standard errors are in parentheses and were estimated jointly for the pair of equations (mu, sigma), with clustering by country.
Weights: inverse number of respondents from a given country.

Returning to the analysis of WTP, the models in Table 6 did not control for the characteristics of the individual experts. The two leftmost columns in Table 8 show results for models that include such controls. In addition to PPP-adjusted GDP per capita and dummies for Plan A and the three non-European regions (as in Table 6), the models in Table 8 include controls based on all survey questions that provided objective information on expert characteristics; questions that asked experts to evaluate their own expertise were excluded. The controls included the expert's perceived error in the Delphi estimate; the expert's perceived difficulty with doing such valuation; the expert's reported number of surveys, publications, reviewed papers, and benefit transfer exercises; the journals the expert reads regularly; the expert's highest academic degree; and the expert's gender.

With one exception, we set the controls equal to the experts' responses. The exception was for the journals they read regularly. Instead of including dummy variables for the various journals, we included the first four principal components (PC) for the dummies, which accounted for two-thirds of the variation embodied in the journal dummies. The loadings indicate that PC1 (27% of the variation) represents a reading pattern that emphasizes the 4 best-established journals (*AJAE*, *ERE*, *JEEM*, *Land Economics*), while PC2 (15%) represents a pattern that emphasizes two newer journals that tend to publish more papers on developing country topics (*EDE*, *Ecological Economics*). PC3 (14%) represents a pattern that emphasizes the two journals that have made the most effort to target a policy audience (*EDE*, *REEP*). Finally, PC4 (12%) represents a pattern that emphasizes miscellaneous other journals.

Table 8. Effects of respondent characteristics on mean and median WTP. Dependent variables: ln(1 + mean WTP) and ln(1 + median WTP). Observations: individual respondents in all models. Dummies are used to control for regional differences in the models in the first two columns and country differences in the models in the last two columns.

	Include income, exclude FE		Exclude income, include FE	
Variables	Mean	Median	Mean	Median
ln(GDP per capita, PPP)	0.820***	0.829***		
	(0.237)	(0.191)		
Dummy: plan A	0.287***	0.297***	0.347***	0.333***
	(0.0283)	(0.0301)	(0.0243)	(0.0188)
Dummy: Asia	0.293	0.676		
	(0.486)	(0.416)		
Dummy: North America	0.530**	0.755***		
	(0.262)	(0.248)		
Dummy: Oceania	-0.363	-0.294		
	(0.366)	(0.452)		
Accuracy of Delphi prediction	-0.0493	-0.0149	0.0409	0.0638*
	(0.0540)	(0.0515)	(0.0330)	(0.0357)
Difficulty of CV study	-0.0470	-0.0525	-0.0673***	-0.0658***
	(0.0473)	(0.0459)	(0.0213)	(0.0209)
No. CV surveys	-0.0119	-0.0203*	-0.00961	-0.0199***
	(0.0120)	(0.0123)	(0.00696)	(0.00770)
No. CE surveys	-0.0179	-0.0188	-0.0411*	-0.0417*
	(0.0260)	(0.0240)	(0.0219)	(0.0224)
No. SP surveys (biodiversity)	-0.0140	0.000274	-0.0114	-0.00155
	(0.0177)	(0.0190)	(0.0236)	(0.0242)
No. benefit transfer exercises	0.0153	0.0168	-0.00358	4.57e-05
	(0.0136)	(0.0114)	(0.0183)	(0.0159)
Journals: PC 1	0.124	0.133*	0.142***	0.138***
	(0.0766)	(0.0798)	(0.0516)	(0.0437)
Journals: PC 2	0.103	0.0987	-0.0497	-0.0426
	(0.123)	(0.127)	(0.116)	(0.0980)
Journals: PC 3	-0.0592	-0.0863	-0.127**	-0.0766

	(0.118)	(0.125)	(0.0622)	(0.0645)
Journals: PC 4	-0.00168	-0.0394	0.0466	0.0615
	(0.109)	(0.102)	(0.0617)	(0.0705)
No. SP papers published	0.0525	0.0708**	0.0350**	0.0486***
	(0.0331)	(0.0322)	(0.0156)	(0.0146)
No. SP papers reviewed	-0.0175**	-0.0198***	-0.00297	-0.00370
	(0.00815)	(0.00763)	(0.00802)	(0.00875)
Dummy: BSc	2.181***	2.193***	2.779***	2.609***
	(0.323)	(0.286)	(0.193)	(0.226)
Dummy: MSc	0.327	0.458	1.147***	1.147***
	(0.262)	(0.319)	(0.238)	(0.277)
Dummy: female	-0.126	-0.156	-0.264	-0.244
	(0.230)	(0.248)	(0.257)	(0.274)
Country FEs?	No	No	Yes	Yes
Weighted regression?	Yes	Yes	No	No
Income elasticity	0.847	0.876	-	-
P-value for H_0: elasticity = 1	0.533	0.538	-	-
R^2	0.424	0.380	0.633	0.571
F statistic	14.1	11.7	11.6	8.95
Observations	403	403	403	403

*** p<0.01, ** p<0.05, * p<0.1. Standard errors are in parentheses and were estimated jointly for the pair of equations (mean, median), with clustering by country.
Weights: inverse of number of respondents from a given country.

Comparing the results in the two leftmost columns of Table 8 to the corresponding columns in Table 6, we find that inclusion of these additional controls raised income elasticities somewhat, to 0.820 (mean WTP) and 0.829 (median WTP). Neither estimate was significantly different from unity. The estimates in Table 6 were therefore only mildly biased downward by correlations between national income and expert characteristics.

Results from the models in Table 8 could potentially be used to formulate more accurate predictions of mean or median WTP for a given country, than the simple average of the predictions by the experts from that country. Prior experience with Delphi exercises suggests that, while an estimate based on a group of experts is typically substantially better than that from any randomly chosen expert, giving more weight to experts with greater expertise is often preferable.[24] One straightforward way to do this is to estimate WTP as a function of expert

[24] If expert characteristics do not have any systematic influence on estimates of WTP summary statistics then no issues arise. If this is not the case, however, then problems may arise that suggest the examination of alternative estimates. An example here is where lack of substantial valuation experience is associated with giving higher WTP

characteristics, as in Table 8, and then obtain predictions from the model by setting all expert characteristics at their ideal (i.e., most "expert") level. Many of the variables in the models in Table 8 have ideal levels, such as having a Ph.D. instead of an M.Sc. or a B.Sc. and having considerable experience doing SP studies (many surveys, many publications). Other variables, such as gender, do not, and can be set equal to the mean across the experts from a given country.

3.3 Effects of Other Variables on Experts' WTP Predictions

The models in the first pair of columns in Table 8 imply that the only expert characteristics that are significantly (5%) correlated with their WTP predictions are the number of SP papers they had reviewed (a negative effect) and the B.Sc. dummy (a positive effect). Estimates that are less prone to omitted variables bias resulting from correlation of expert characteristics with unobserved country characteristics can be obtained by estimating models that include country fixed effects. Results for these models are shown in the last two columns of Table 8. Inclusion of the fixed effects knocks out the income variable and the regional dummies, but it reveals that several additional expert characteristics have a significant effect on the WTP predictions.

We find that reading the four most established journals (PC1) has a positive effect, as does publishing a larger number of SP papers and having an M.Sc. or (especially) a B.Sc. instead of a Ph.D. While the association with highest degree likely represents a learning effect, the association with journal reading might represent either that, a selection effect, or more likely a combination of the two. Interestingly, the number of CV surveys undertaken has a negative effect, as does the number of CE surveys undertaken (although it is less significant). This could indicate a desirable learning effect. When combined with the positive effect of the number of SP papers published, it suggests that experience with publishing and experience with surveys are qualitatively different dimensions of expertise.

Experts who rated conducting a CV study like the one described in the Delphi exercise as more difficult had lower WTP predictions. Other expert characteristics were generally not found to have significant effects.

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estimates and this characteristic is at the same time negatively correlated with income in experts' home countries. Such a correlation can distort the estimated relationship between country income and WTP.

4. Changes in Valuation from Round 1 to Round 2

Roughly half of the experts in each region changed their WTP predictions for Plan A from round 1 to round 2: 6 of 16 in Australia/New Zealand, 32 of 69 in Asia, 24 of 48 in Europe, and 42 of 81 in Canada/U.S. Among those who made changes, five-sixths of European experts reduced their predictions for this plan; about two-thirds of experts from Australia/New Zealand and Asia did; and about half of Canada/U.S. experts did. Table 9 provides an overview of changes, upward and downward, in total, and by the main regions for each of the plans. Focusing on Plan A figures, Table 9 shows that, across all experts (those who did and did not revise), there was an average downward revision of US$12.60. The average revision among those 65 respondents who revised their answers downward was much greater, -$49.50. Among those 40 who revised upward, the average revision was more moderate, +$12.80. We also find that average (downward or upward) revisions were largest among North American experts (who also had highest average WTP in round 1); and smallest among European experts. The structure of Plan B revisions was similar to that for Plan A, except that revisions were smaller for Plan B (in line with average WTP figures expressed in Round 1 being lower).

Table 9: Overview of average changes in mean WTP from round 1 to round 2 of the survey, Plans A and B, in total and by major regions. All figures in US$ per expert. Numbers of experts in parentheses.

Plan	Region	All experts	Downward revisions only	Upward revisions only
Plan A	All experts	-12.6 (216)	-49.5 (65)	12.8 (40)
	Europe	-7.1 (48)	-19.7 (20)	12.9 (4)
	Asia	-11.7 (70)	-40.4 (21)	2.2 (12)
	North America	-18.0 (82)	-94.1 (20)	19.3 (22)
Plan B	All experts	-7.4 (216)	-31.1 (61)	8.4 (35)
	Europe	-4.0 (48)	-15.6 (15)	7.9 (5)
	Asia	-8.5 (70)	-23.3 (26)	1.6 (7)
	North America	-9.4 (82)	-65.5 (16)	10.8 (22)

Figure 3: Distributions for changes in stated WTP from round 1 to round 2, by plan

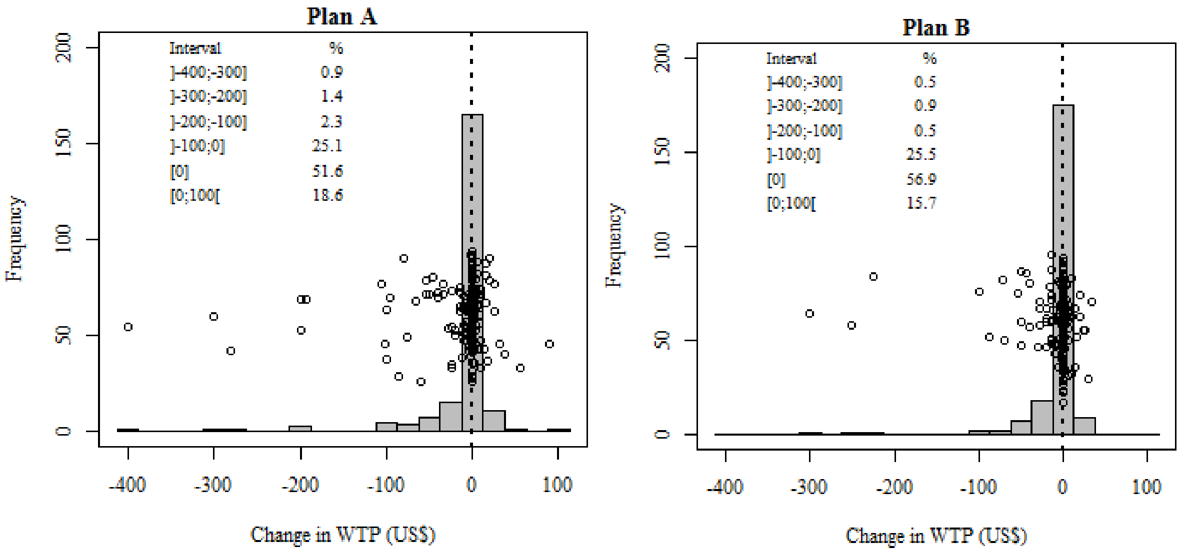
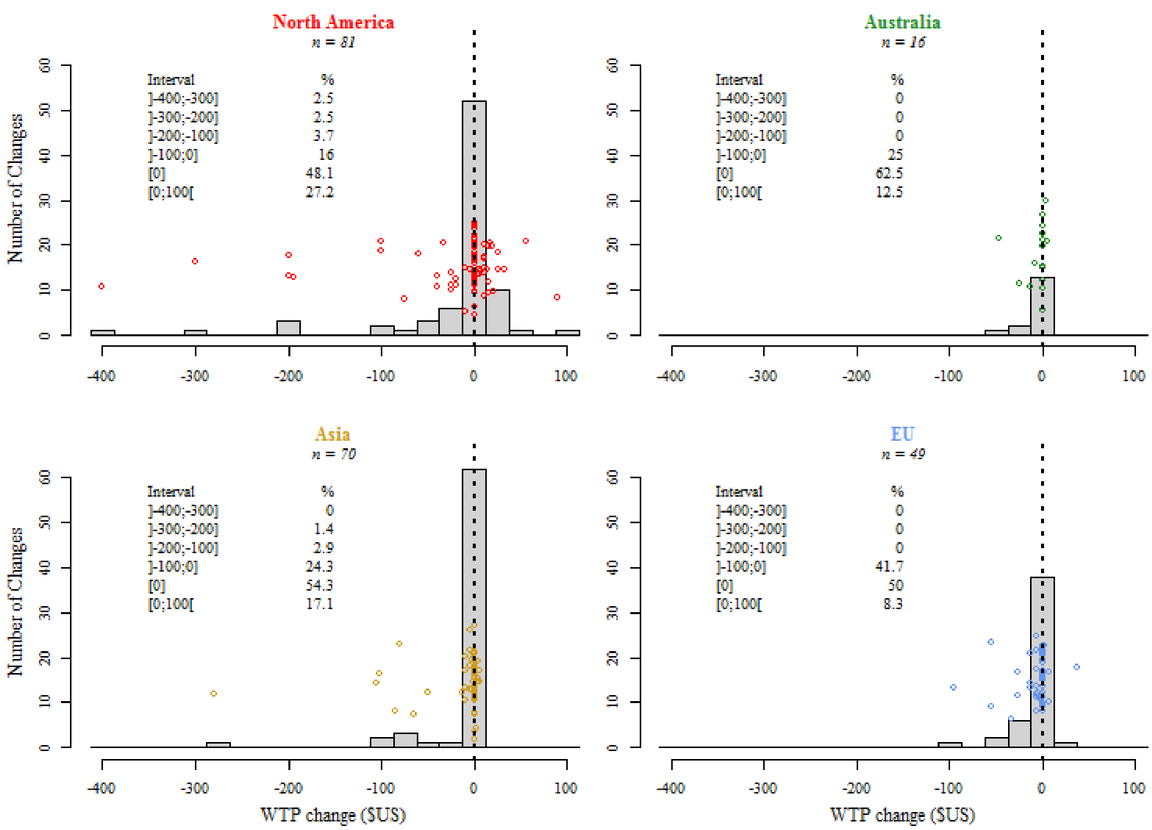


Figure 4: Changes in mean WTP answers related to Plan A by main region



Figures 3-4 plot changes for experts' mean WTP answers by experts' regions. Figure 3 plots changes under each of Plans A and B, for all experts. Figure 4 shows changes under Plan A by region. The figures vividly illustrate that downward adjustments are typically far greater than upward adjustments.[25] One, perhaps plausible, hypothesis could here be that round 2 serves as a mechanism for downward adjustment of very (possibly, too) high initial round 1 answers, mostly by less experienced experts. But such a conclusion may be questioned. A skeptic might view round 2 answers as being biased downward (upward) for those with high (low) round 1 figures, by the information about average expert responses in round 1 that is provided. The alternative view, more favorable to the stated hypothesis, is that round 2 serves as useful information for individual experts who were initially unsure of the appropriate answer, and revise their round 1 estimate to reduce error. Indeed, the motivation behind the Delphi method is that a decision made by the entire group is more robust than that by the individual; and that any such procedure will need to involve some degree of learning by experts who are, initially, not fully informed about the issue on which they are to provide an expert opinion. This is also our own main view. In this particular case it implies a measure of conservatism, as average WTP estimates based on round 2 values are lower than those based on round 1 values.

We conducted simple *t*-tests of mean differences in selected characteristics of the experts who reduced their WTP predictions for Plan A between round 1 and round 2 (Group 0) and those who increased their predictions (Group 1). Table 10 shows these results. As expected, the mean value of the Round 1 WTP estimates was much higher for Group 0 ($116.47) than for Group 1 ($20.16): experts with high Round 1 WTP estimates tended to reduce their estimates, while experts with low Round 1 WTP estimates tended to increase them. Also as expected, experts who reduced their estimates had Round 1 estimates that were above-average for their country (Canada, US, Australia, New Zealand) or region (Europe, low-income/lower-middle-income Asia, upper-middle-income Asia) (Group 0 mean difference from average = $61.43), while experts who increased their estimates had Round 1 estimates that were below-average (Group 1 mean difference from average = -$44.38). This suggests that the Delphi method "worked" in terms of reducing the variance of the country/regional means. Similarly, experts who reduced their estimates had Round 1 estimates that were larger relative to their country/regional means

[25] In particular, for the Asian sample all "substantial" changes in response from Round 1 to Round 2 are in the downward direction.

(Group 0 mean = 2.17), while experts who increased their estimates had Round 1 estimates that were lower relative to their country/regional means (Group 1 mean = 0.27). Among the other variables tested, only two had means that differed significantly ($P < 0.05$, one-sided test) between Groups 0 and 1: experts who believed more strongly that the Delphi estimates were close to actual WTP in their countries were more likely to reduce their estimates; the same pattern holds for experts who published more CV and CE papers.

Table 10. Tests of mean differences between experts who decreased their predictions for Plan A between rounds 1 and 2 (Group 0) and experts who increased their predictions (Group 1). Table shows means for each group and *P*-values for one-sided *t*-tests (null hypothesis: Group 0 mean equals Group 1; alternative hypothesis: Group 0 mean is greater than or less than Group 1 mean, depending on which mean is larger). Sample size varies slightly from variable to variable, but in most cases is 65 for Group 0 and 39 for Group 1.

Variable	*Group 0 mean*	*Group 1 mean*	*P-value*
Round 1 prediction	\$116.47	\$20.16	0.000
Discrepancy between expert's Round 1 prediction and mean for his/her country/region	\$61.43	\$44.38	0.000
Ratio of expert's Round 1 prediction to mean for his/her country/region	2.17	0.27	0.000
Proximity of Delphi estimate to result of an actual SP survey	6.48	5.78	0.043
Difficulty of successfully implementing a SP survey on this topic	5.47	5.85	0.230
Number of CV surveys carried out	7.22	7.18	0.490
Number of CE surveys carried out	3.77	3.63	0.448
Number of surveys (CV+CE) carried out about biodiversity and ecosystem services	3.22	3.56	0.363
Number of benefit transfer exercises	2.58	2.20	0.329
Journals: 1st principal component	-0.079	-0.272	0.261
Journals: 2nd principal component	-0.118	0.112	0.166
Journals: 3rd principal component	-0.104	-0.215	0.291
Journals: 4th principal component	0.072	0.148	0.352
Number of CV and CE papers published in national and international journals in past 5 years	4.65	2.72	0.012
Number of CV and CE papers reviewed in national and international journals in past 5 years	9.48	8.66	0.379
Highest degree: BSc	0.015	0	0.161
Highest degree: MSc	0.077	0.026	0.113
Gender: female	0.354	0.282	0.224

5. Other Issues

In this section we provide some information about certain key characteristics of experts, by region, that may have had systematic influence on valuation answers. Table 11 indicates some of the most important of these variables. The most noticeable aspect of the numbers in this table is that Asian experts appear to be relatively less experienced than experts from the three other regions, in two main respects: in terms of the numbers of SP-related papers written and refereed during the last 5 years; and the numbers of empirical SP studies conducted over their career. This discrepancy is particularly striking for the latter measure; which reflects the fact that most of the Asian experts are young relative to those from other regions. Somewhat fewer of the Asian experts, as compared to other regions, also have PhDs. There is little difference between the other regions, except that the average number of lifetime SP valuation studies carried out is smaller for the North American experts than for those from Europe and Oceania (which likely reflects North American experts being on average somewhat younger than experts from Europe and Oceania).

Table11: Some key distributional characteristics of the experts: Numbers of experts in different categories, and averages across experts, by region

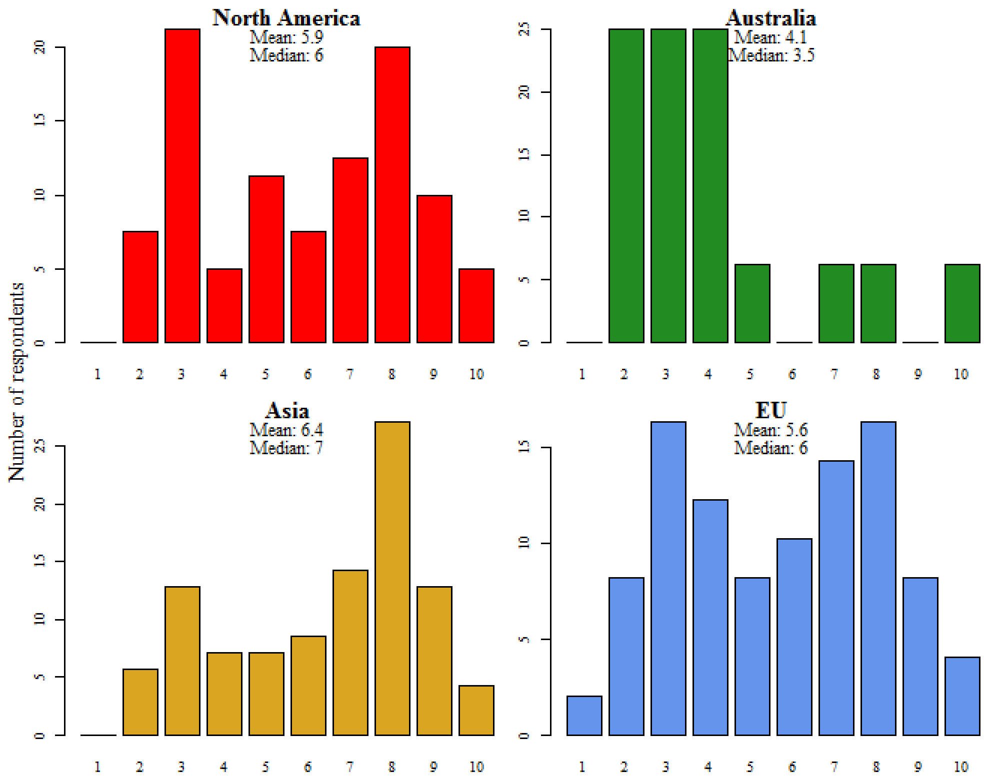
(Total numbers of experts answering in parentheses)

Characteristic	North America (82)	Asia (70)	Europe (49)	Oceania (16)
Share of men (%)	77	57	65	75
Share of PhDs (%)	99	87	94	100
Average number of SP papers written and refereed last 5 years	22.1 (66)	9.1 (63)	25.7 (49)	23.1 (14)
Average number of SP studies conducted over career	14.8 (76)	4.2 (63)	23.7 (49)	24.2 (14)

Note: Numbers in parentheses in the last two lines indicate numbers of experts who answered to these questions.

Figures 5-6 provide information on distributions of experts' views on how difficult they think it is to do such a survey in their own country, and how precise the Delphi estimate is likely to be in assessing true average population WTP. Figure 5 gives the distribution of respondents with respect to perceived difficulty. We find a tendency for "two modes" (at a low, and high, difficultly level respectively) at least for the North American and European experts. In Figure 6 we show experts' belief in the accuracy of the Delphi estimate in mimicking an actual survey. Here experts are generally optimistic.

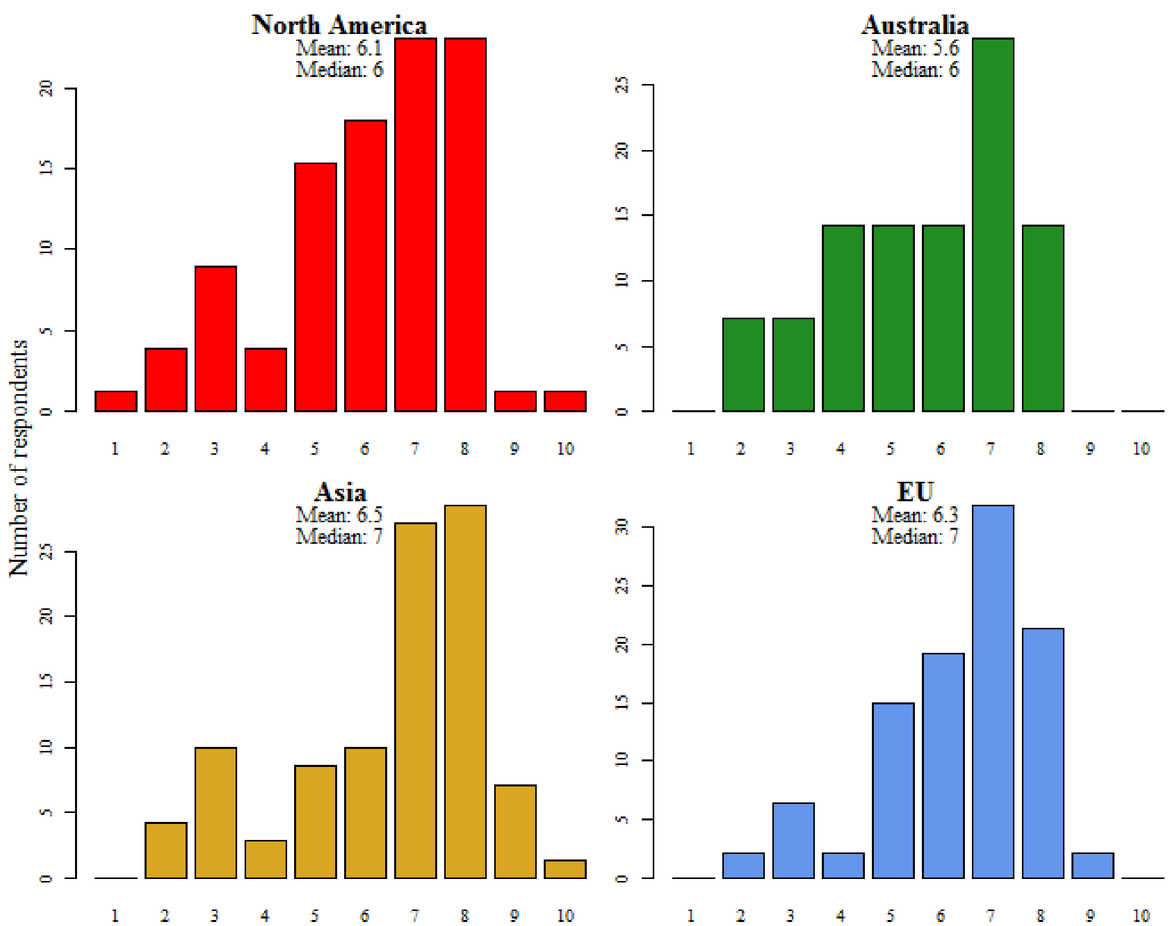
Figure 5: Distributions of experts by perceived difficulty in answering to the survey, and region (higher score = more difficult to implement SP survey)



6. Conclusions and Final Comments

Our expert Delphi exercise suggests, according to the almost 220 international environmental valuation experts who participated in our study, that there could be considerable aggregate willingness to pay (WTP), among the global population outside of Latin America, to avoid further forest losses in the Amazon region. Focusing as we have done on experts' answers in round 2 of our survey, for (the more comprehensive) rainforest protection Plan A, mean annual WTP per household as assessed by experts varies from a high level near \$100 in Canada, Norway and Germany, via intermediate levels closer to \$50 in a broader set of OECD countries, to lower varying from \$4 to \$35, for the Asian countries surveyed.

Figure 6: Distribution of experts by perceived accuracy of Delphi survey estimate, by region (higher score = more accurate estimate)



We recognize that our "Delphi exercise" represents a so far virtually untried technique for environmental valuation. Its usefulness for assessing average WTP levels in populations that are not covered by national sample surveys is still an open question. A particularly thorny issue is what our Delphi exercise is able to tell us about "true" global WTP for protecting Amazon rainforests, outside of the region of Amazon countries. We would then need to evaluate whether our experts have the basis to correctly gauge such valuation levels in their respective populations. Indeed, a handful of experts who were approached by us (although only 5, and all from the U.S.; but among them are some of the most respected environmental economists in the profession) refused to participate in our survey on the ground that they viewed themselves as having little or no basis for providing correct or qualified answers.

Still, we will argue, the results from our Delphi exercises can be helpful. The greatest help might be not in terms of providing accurate *valuation levels*, but rather by indicating how WTP for Amazon forest protection is likely to *vary across countries at different income levels*. The elasticity estimates of WTP per household with respect to national per-household GDP levels then represent a key, and interesting, set of results. From Tables 5-8, these elasticities are, rather consistently, in the range 0.7-0.9 with respect to regular GDP levels per capita; and (also consistently) even more consistently close to unity when measured with respect to PPP-adjusted GDP levels per capita, and not significantly different from unity when results are pooled across all countries in the sample. We view these findings as encouraging, and consistent with similar results found for other environmentally-related goods and features (e.g. for assessments of environmentally-related premature deaths using Value of Statistical Life estimates; see Lindhjem et al 2011; OECD 2012).[26] The already cited expert elicitation study by León et al (2003) seems, as noted, to provide some (limited) support to the idea that experts' WTP answers can be used constructively in this way. Such an assessment is based on their conclusion that experts' relative evaluations of alternative projects appear to be far more precise than their absolute-level valuations of individual projects; and the former is the crucial aspect in predicting how WTP is likely to vary with average per-capita incomes across countries.

There are few existing studies against which the numbers coming out of our exercise can be compared. The only reasonably similar existing study cited above, Horton et al. (2003), gave average annual per-household WTP of about $60 among Italian and U.K. households in 1999 for an Amazon forest protection plan that was, admittedly, less comprehensive than that presented to our experts. The equivalent expert-based figures for these two countries from our survey (see Table 1b) were closer to $25-30. This might indicate that experts' assessments in our survey are too low. Alternatively, Horton et al.'s values could be high (despite having been collected 15 years ago). But note that Horton et al. surveyed not random population samples but rather convenience samples of users of outdoor recreation sites, who might have stronger

[26] In particular, if an elasticity estimate of 1 for PPP-adjusted per-capita GDP is appropriate as an approximate global value, an approximate aggregate global WTP value can be obtained from a smaller set of national surveys, by scaling the aggregate, global WTP value up proportionately to the PPP-adjusted GDP values by country.

environmental preferences than the overall national populations. On the other hand, the discrepancy could be due to the fact that experts in our survey were asked to explicitly ignore the carbon values in assessing the protection value of rainforests; such values represented a major component of value in the Horton et al study.

Another, very different and perhaps more speculative, "calibration" of our results can be obtained from comparisons with the Norwegian government's funding for its forest protection program with Brazil, the most comprehensive such plan to date based on external funding. This program aims to provide $1 billion to Brazil over a 10-year period for "delivered" forest protection in that country (verified reductions in forest loss rates resulting from the funds being made available). With about 2 million households in Norway, this represents a total WTP per Norwegian household, reflected by this program, of about $500 to protect the Amazon rainforest over a 10-year period; thus $50 per household per year (or somewhat higher when applying the Norwegian government's risk-adjusted project discount rate of 4%). Expert evaluation by the Norwegian experts in our survey is closer to $100 per household per year; thus higher than values directly embedded in the Norwegian program, but the difference is moderate. We here need to keep in mind that our survey attempted to keep carbon values out, while in the Norwegian Brazil program carbon values play a major role. On the other hand, this Norwegian program is hardly likely to represent the entire WTP within the Norwegian population.

A more open question is what such expert answers really can tell us. It is not clear whether all experts are "consistent" in the sense of answering to the same set of underlying questions. Experts' answers have at least two alternative interpretations: (A) as their predictions of what would be the actual outcome of SP-CV surveys conducted in their respective countries, or (B) as their assessments of "true" household WTP in their respective countries. While we asked for (A), some of our experts may have been thinking in terms of (B). The two are not necessarily identical. Practical problems, such as acceptance of the payment vehicle and assurances that the good will be provided, can drive differences between the values associated with these two interpretations. Little was done formally in our survey to investigate this issue, so it will not be further pursued here.[27]

[27] It seems clear that some confusion over this issue was present with some expert respondents, from their comments made at Round 2.

An issue, perhaps most important for Asian experts, is whether expert valuation figures can be interpreted as representing the entire homeland populations or only fractions of them. In several of the Asian countries, most households pay no income taxes, and many do not have formal utility services nor utility bills. Although we asked experts to consider all households in their countries when predicting mean and median WTP, they might have felt it unreasonable to assume that payments could be collected from informal households that do not have formal relationships to taxing authorities nor to utilities. It is unclear how our valuation questions were interpreted by experts from these countries; it represents an area ripe for future exploration on this and other global initiatives.

Finally, even professional environmental economists, who may feel they are “experts” on general issues of the type addressed in our study, do not necessarily have (or feel they have) much insight with respect to the true population values at stake here. As noted, some of the most experienced economists in our sample refused to answer as they felt their basis for doing so was too weak. Such uncertainty is to some degree reflected by the great variety of experts’ answers for any one given country; any claim that an individual expert’s answers “represent” their populations would thus be shaky at best, and so we have more confidence in country averages that are based on larger numbers of experts. Our best hope, however, is that the groups of experts from the different countries have a common set of “anchors” that level their answers and reveal the relative relationships among the answers, if not their differences in absolute terms. If so, one of our main aims with these surveys, to probe average WTP relationships to average national incomes, will have been fulfilled.

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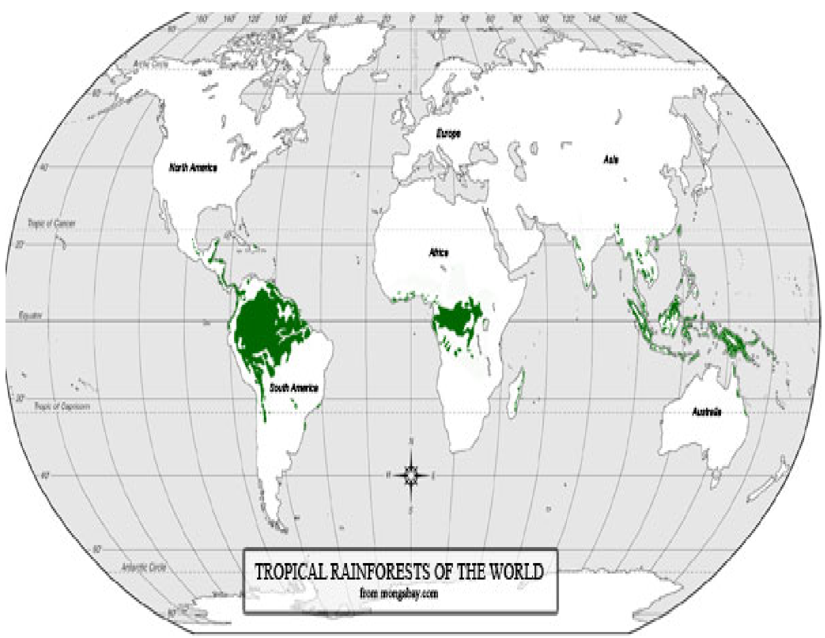
Appendix: Questionnaire for U.S. Delphi survey, Round 1

(Other surveys were similar)

I. BRIEF DESCRIPTION AND VISUAL PRESENTATION OF GOOD TO BE VALUED

The map below (FIGURE 1) shows the location of the world's tropical rainforests. Rainforests cover only a small part of the earth's land surface; about 6%. Yet they are home to over half the species of plants and animals in the world. The **Amazon rainforest** is the world's largest rainforest, representing 40 percent of the global total. The Amazon is also home to the greatest variety of plants and animals on Earth. About 1/5 of all the world's plants and birds and about 1/10 of all mammal species are found there. The rainforest also serves as carbon storage, but **the carbon sequestration value is computed separately and should <u>not</u> be considered as part of your valuation assessments in this exercise.**

<u>FIGURE 1</u> THE WORLD´s RAINFORESTS (IN GREEN)



For you to get an impression of the size of the Amazon rainforest, FIGURE 2 shows its size relative to the continental United States. The current total area of the Amazon rainforest is 2.2 million square miles, or about 70% of the size of the continental United States.

FIGURE 2. LOCATION AND RELATIVE SIZE OF THE AMAZON RAINFOREST

FIGURE 3. A SMALL PART OF THE AMAZON RAINFOREST AS SEEN FROM THE AIR

A recent World Bank study (Vergara, W. & S.M. Scholz (2011): *Assessment of the Risk of Amazon Dieback*) describes a development where a substantial fraction of the biomass in the standing Amazon rainforest could disappear over time if the current development continues. There are several, man-made, drivers of such a development. One central such driver is man-made deforestation in the region due to cattle ranching/grazing, other agricultural activities, and timber extraction.

The disappearing rainforest would then be transformed into less dense forest, or savannah. A significant fraction of the trees in the Amazon rainforest would dry out and die. Less oxygen would be produced, the standing biomass would shrink dramatically, the ecosystem of the rainforests would change markedly, and numerous species would disappear.

II. BASIC SCENARIO ELEMENTS

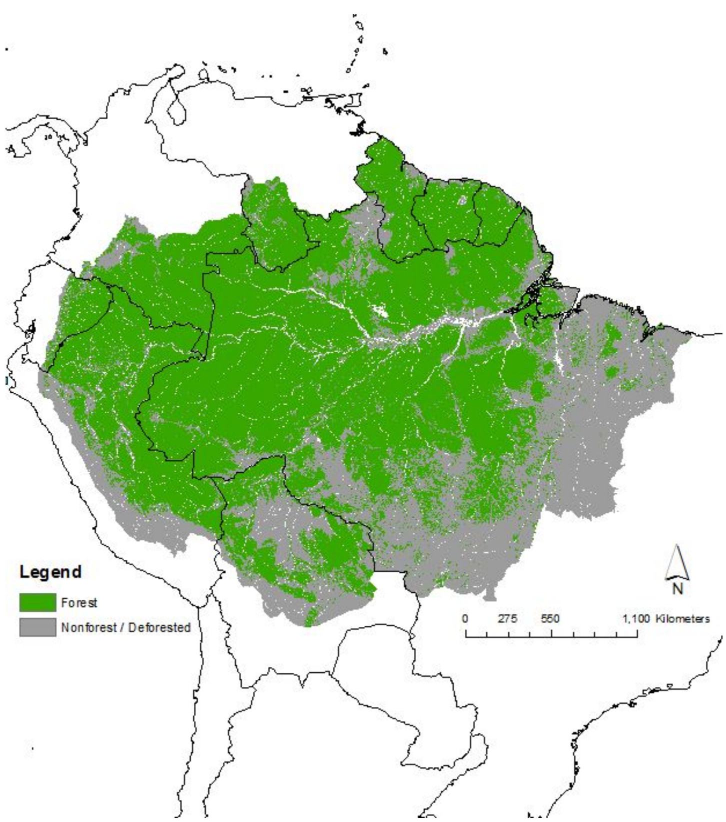
There is concern that only about 70 % of the current Amazon rainforest area will remain in 2050 **with no new preservation measures.** This means at the same time that 30% of the current forest would be lost by then.

The Brazilian Government, in collaboration with experts from international agencies, has developed two different rainforest preservation plans. These preservation plans will be expensive to carry out, since a large number of farmers and other property holders must be compensated for preserving their parts of the forest. It cannot be implemented by the Brazilian government without additional sources of support. If the funds raised by the Brazilian government and internationally exceed the costs of preservation, the preservation plans will be implemented.

Under **Plan A, no** further forest losses would occur by 2050, and the required payments will be collected from households in all contributing countries. This is the most expensive plan. It compares to the Business as Usual alternative, with no plan implemented (and thus with no implementation cost), under which only 70% of the present forest cover would remain by 2050.

Under **Plan B, some** forest losses would occur up to 2050, but about 88% of the current forest cover would still remain by then. This plan is less expensive to carry out than Plan A. Also in this case, with no plan, only 70% of the present forest cover would remain by 2050.

FIGURE 4. This represents the way the Amazon rainforest appears today



Species Loss

Along with this forest loss there are likely to be losses of species, some of which are found only in the Amazon. If nothing is done to slow the rate of deforestation in the Amazon, scientists estimate that 105 mammal species, out of 442 currently known to be found there, will (under the Business as Usual alternative) face a high risk of extinction by 2050. Eighty three (83) of these endangered species are found **only** in the Amazon. FIGURE 5, below, shows a random selection of 19 of the 105 mammal species that will be at a high risk of extinction by 2050 if no new forest protection measures are passed. A similar fraction (about 20%) of other animal species, such as birds and amphibians, will also in the same way be threatened.

Under **Plan A** (which preserves all (100 %) of the current Amazon rainforest by 2050), none of these species would be lost by 2050.

Under **Plan B** (which preserves 88% of the current Amazon rainforest by 2050), 41 of these species would face a high likelihood of extinction by 2050.

FIGURE 5. Some of the mammals threatened with extinction by 2050 with no new forest protection plan

Plan A

With **PLAN A** no further deforestation would occur. The current area of the Amazon Rainforest will be maintained through 2050 and all (100%) currently existing species will be preserved.

FIGURE 6 compares the Business as Usual Scenario (to the left) to Plan A (to the right). Note that Plan A protects all forest. This is the *most ambitious and expensive plan*.

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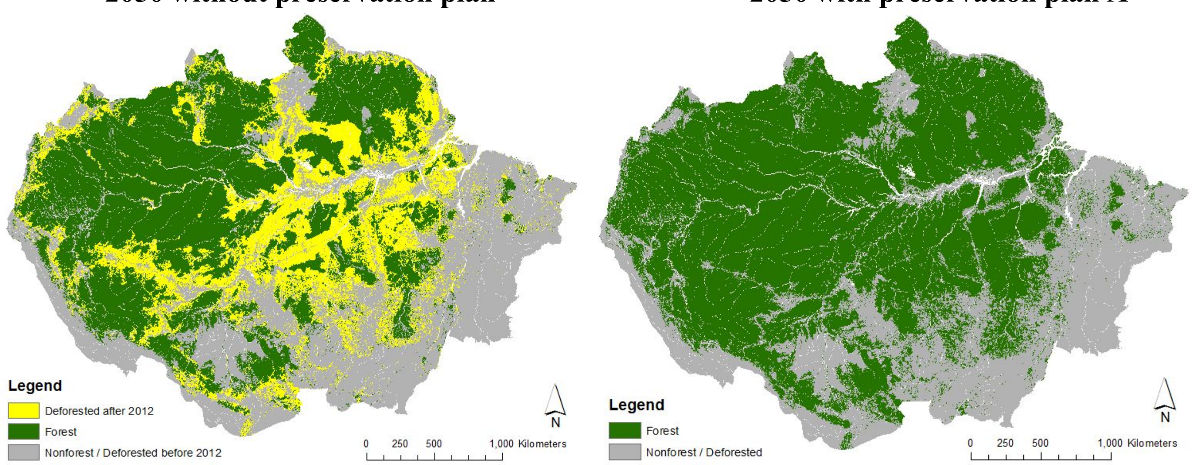
FIGURE 6. State of the Amazon Rainforest in 2050 with no new preservation plan, and with Plan A

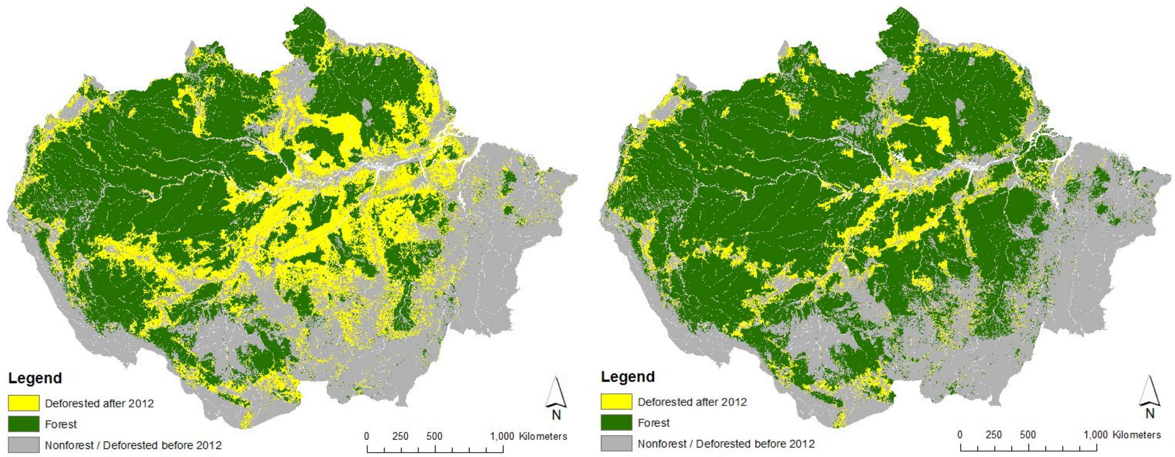
2050 without preservation plan | **2050 with preservation plan A**



With **Plan B** there will be some further losses of rainforest area, but more forest will remain by 2050 than if no measures are taken. 88% of the current rainforest area will remain in 2050, and 41 of the currently existing mammal species (10%) will face a high risk of extinction. FIGURE 7 compares the Business as Usual Scenario (to the left) to Plan B (to the right).

FIGURE 7. State of the Amazon Rainforest in 2050 with no new preservation plan, and with Plan B

2050 without preservation plan | **2050 with preservation plan B**



III. PAYMENT MECHANISM

Households in the United States will be asked for an *annual payment per household* in terms of a national tax that would be collected by the federal government and submitted to an international Amazon Rainforest Fund. The Fund will be controlled by an international governing body, and the money will be used exclusively and fully for this Amazon Rainforest Preservation Plan (PLAN A or B). Key factors are: (1) payment *per household* rather than individual, (2) *annual* for all future years rather than a one-time payment (since the Amazon will provide these ecosystem service every year for infinity if the preservation plan is implemented), and (3) payment is *coercive* (*e.g.*, tax) rather than a voluntary contribution; (4) the plan will go through if and only if *a majority of households in high-income countries approve it*.

IV. TWO WTP ESTIMATES NEEDED FOR EACH PLAN (PLAN A and PLAN B)

All of your estimates should be provided in US$ per year. In the actual CV survey we will show a payment card indicating both monthly and annual payment amounts to the respondents. Payments are assumed to be required indefinitely or as long as the forest is to be protected. Assume that the survey design and the statistical analysis of the data would be done according to what you perceive as the current state-of-the-art. The payment card for annual payments is shown in the box below. You are free to report an amount that is not shown on the payment card if you feel it provides a better estimate of average WTP per household per year.

0 1 3 5 10 15 20 25 30 40 50 60 70 80 90 100 125 150 200 300 500 750 1000 1500
US dollars /household/year

We will first ask you to state WTP numbers for PLAN A (FIGURE 6), which preserves all (100%) of the current Amazon rainforest area from now and until 2050. Next, we ask you to state WTP numbers for the less ambitious PLAN B (FIGURE 7) which preserves 88 % of the currently forested area in 2050. Both plans should be compared to the 70% of the current forest area that is being preserved if there is no new preservation plan (the left figures in FIGURES 6 and 7)

PLAN A (FIGURE 6; the most ambitious and expensive plan, to fully protect today's rainforest)

V1. Mean per household WTP (annual payment)

___________ ( ) US$/household/ year

V2. Median per household WTP (annual payment)

___________ ( ) US$/household/ year

PLAN B (FIGURE 7; a less ambitious, and less expensive, plan than plan A, to protect only 88% of today's rainforest)

W1. Mean per household WTP (annual payment)

___________ US$/household/ year

W2. Median per household WTP (annual payment)

___________ US$/household/ year

X1. In the population survey of the U.S. population, our payment vehicle will be either an increase in households' utility bills, or in their income taxes. Which payment vehicle would, in your opinion, be most appropriate in such a survey:

a) The utility bill

b) The income tax

c) Other (specify)

X2. Which payment vehicle would, in your view, yield the higher mean WTP value, if this vehicle alone was used in a survey of the entire U.S. population?

a) The utility bill

b) The income tax

c) No difference

X3. In your opinion, would using either the utility bill or income tax as payment vehicle in such a survey be likely to lead to either an upward or downward bias of population WTP, or to no bias? Please specify for each.

a) The utility bill

b) The income tax

V. YOUR JUDGEMENT ABOUT THE DIFFICULTY OF IMPLEMENTING THIS SP SURVEY

J1. How close do you think the average estimate for this Delphi exercise would be to the number which would be obtained from undertaking an actual SP survey? [Answer on 10 point scale and record your score]

Not Very Close 1 2 3 4 5 6 7 8 9 10 Very Close Score:_________

J2. How difficult do you think it would be to successfully implement a SP survey on this topic (value of avoiding losses of Amazon Rainforest), for the entire U.S.?

Not At All Difficult 1 2 3 4 5 6 7 8 9 10 Very Difficult Score:_________

J3. How difficult do you think it would be to successfully implement a SP survey to value non-use values of biodiversity in the U.S.?

Not At All Difficult 1 2 3 4 5 6 7 8 9 10 Very Difficult Score:_________

J4. How difficult do you think it would be to successfully implement a SP survey to value a recreational activity in the U.S.?

Not At All Difficult 1 2 3 4 5 6 7 8 9 10 Very Difficult Score:_________

VI. BACKGROUND QUESTIONS

B1. How familiar are you with the literature on Stated Preference (SP) surveys in general?

Not At All Familiar 1 2 3 4 5 6 7 8 9 10 Very Familiar Score:_________

B1a. How familiar are you with the literature on Contingent Valuation (CV) surveys?

Not At All Familiar 1 2 3 4 5 6 7 8 9 10 Very Familiar Score:_________

B2. How familiar are you with the literature on Choice Experiment (CE) surveys?

Not At All Familiar 1 2 3 4 5 6 7 8 9 10 Very Familiar Score:_________

B3. Approximately how many CV surveys, if any, have you worked on (alone or in cooperation with others)?

_________ (write zero if you have not done any CV surveys)

B4. Approximately how many CE surveys, if any, have you worked on (alone or in cooperation with others)?

_________ (write zero if you have not done any CE surveys)

B5. Approximately how many SP (CV and/or CE) surveys of biodiversity and ecosystem services, if any, have you worked on (alone or in co-operation with others)?

_________ (write zero if you have not done any SP surveys of biodiversity and ecosystem services)

B6. Approximately how many empirical studies using valuation methods other than SP

(*e.g.*, hedonic pricing, travel cost analysis) have you worked on (alone or in cooperation with others)?

________studies (write zero if you have not done any empirical studies using other methods than SP))

B7. Approximately how many benefit transfer exercises have you conducted (i.e. transferring estimates from primary environmental valuation studies to a new geographical site to perform e.g. cost-benefit analysis (CBA)).

________studies (write zero if you have not done any benefit transfer exercises for use in e.g. CBA))

B8. Approximately, what fraction of your research would you say was on contingent valuation, choice experiments, other valuation methods, and what fraction on other topics? (Sum to 100%)

_______% Contingent valuation

_______ % Choice Experiments

_______% Other valuation methods

______ % Benefit transfer (not involving doing new primary valuation studies)

_______% Topics other than valuation

Sum: 100 %

B9. Which of the following environmental economics journals do you read or look through regularly?

(Put "X" next to all that are relevant)

__1. American Journal of Agricultural Economics

__2. Ecological Economics

__3. Environment and Development Economics

__4. Environmental and Resource Economics

__5. Journal of Environmental Economics and Management (JEEM)

__6. Land Economics

__7. Australian Journal of Agricultural and Resource Economics

__8. Review of Environmental Economics and Policy

__9. Other journals; which_______________________________

B10. Approximately how many papers on CV and CE (both theoretical and empirical studies) have you published in national and international journals the last five years?

____________papers

B11. Approximately how many papers on contingent valuation and choice experiments (both theoretical and empirical studies) have you reviewed for national and international journals the last five years?

(Write zero if you have not reviewed any paper on CV or CE the last 5 years)

____________papers

B12. Approximately how many nation-wide CV or CE studies, with representative samples of the U.S. population, have you been part of, if any?

________nation-wide CV or CE studies (write zero if you have not done any)

B13. What is your highest academic degree?

1. ___ Ph.D. or equivalent

2. ___ M.Sc. or equivalent

3. ___ B.Sc. or equivalent

B14. Your gender

1 __ Female

2 __ Male

VII. LAST THOUGHTS

L1. What other information, if any, would you like to see included in the CV scenario Plan A and B descriptions if this CV survey were conducted on a random sample of U.S. households?

L2. What do you think are the major problems in designing an SP survey of WTP for Amazon rainforest protection, to be administered in the United States?

L3. Are you aware of empirical SP (CV or CE) studies which you think would be helpful in designing an Amazon preservation project CV survey administered in the United States?

L4. In this survey we ask about WTP to **preserve** 100% of the forest (under Plan A) and 88% (under Plan B). If there is no plan 70% of the current forest area will be preserved.

Instead we could have asked about WTP to **prevent losing** 30% forest **(**under Plan A) and prevent losing 12% (under Plan B); compared to "No Plan" .

Do you think that such an alternative formulation in terms of **preventing losses** (instead of **preservation**) would have made a difference for the mean and median WTP? 1) Yes 2) No 3) "Don´t know"

L5. If "yes" or "Don´t know" to question L4: In what way would there be a difference in mean and median WTP of the U.S. population?

L6. Any other comments you might have to this Delphi exercise or the planned CV and CE surveys are most welcome.

THANK YOU FOR YOUR COOPERATION!