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A Simple Lesson in Economic Valuation:

Do Scientists Value Expanding the Nutrient Network?

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Introduction

Scientific knowledge is considered a cultural ecosystem service, at least within the framework of the Millennium Ecosystem Assessment (MEA 2005). The concept of ecosystem services captures the tangible and intangible ways by which Nature, or ecosystems, benefit humans. For example, see the review of Johnston and Russell (2011) who focus on identifying ecosystem services based on whether at least one rational person would be willing to pay to increase an outcome from an ecosystem (cf., Kareiva 2011). Ecosystem services have become a focal point for developing research and policy to aid society generally in better balancing the contributions to quality of life from conservation or use of environmental resources and growth of the commercial economy.

This paper reports on a small-scale experiment in which a broad group of ecological scientists were challenged to consider their own values within an economic framework, by considering whether to contribute financially (i.e., to donate) to support a global research initiative designed to investigate the implications of global change for grassland ecosystems. In this paper, we explore the concepts and foundations for economic valuation and use this small-scale experiment to illustrate some of the basic approaches of economics as they might apply to choices about ecosystem services, particularly using an application to the potential to enhance scientific knowledge.

Scientists have invested substantial time and other resources in better understanding the interactions of humans with the environment. Recently, a group of scientists, some associated with the NSF-funded Long-Term Ecological Research network, initiated a grass-roots, global network of individuals who are interested and willing to contribute to an inter-continentally coordinated experiment concerning how alteration of the global nutrient budget affects grassland ecosystems, particularly through changes in the abundance and identity of consumers. At the September 2012 All Scientists Meeting (ASM) of the LTER network in Estes Park, CO, one of the founders and leaders of this research cooperative, the Nutrient Network (NutNet), provided a plenary-session introduction to the NutNet's structure, procedures, and collaboration, presenting a well-illustrated picture of the potential contributions to science that the NutNet might generate, including its initial record of peer-reviewed publications and policies for co-authorship across a truly large number of collaborators.

The audience reaction to this presentation in plenary session at the ASM, as qualitatively gauged through observation of the discussion and questions, revealed that many (not necessarily all) in the audience viewed the NutNet approach and its potential contribution to science as a good that they (audience members as individuals) personally found interesting, important, and of potential value as something they personally would like to see enhanced. For example, Elizabeth Borer's presentation described a network of over 60 sites, primarily in North American and Europe, with some sites in Asia, Australia, Africa, and South America, as well as an array of publications already completed. A core of the NutNet approach is that individual investigators may decide, voluntarily, to invest a $4000 start-up cost to add a site to the network, simultaneously making a commitment to sustain $300-$600 in annual expenses and 6 person-days annually to implement a standard, experimental protocol at the individual's contributed site.

Economic valuation, at its most fundamental level, concerns identifying and measuring the degree to which individuals are willing to sacrifice some good thing in order to obtain some other good thing that the individual desires. The goods ("good things") involved can be private goods, benefiting only the individual, or public goods, benefiting the individual and many others simultaneously. The fact that individual investigators join the NutNet comprises the evidence that scientists around the world feel the allocation of their scarce research funds toward adding a site to the network is worth the sacrifice of alternatives that the financial resources and commitment of time could have supported for their own research agenda. Of course, members of NutNet contributing as scientist-collaborators not only contribute to scientific knowledge generally, but also these collaborators stand to gain at a more personal level, at least within the professional arena, as collaborators on future scientific reports. Yet the individual's benefit from the public good – generation of scientific knowledge – is most likely a major part of each individual's motivation. Such values might exist more broadly in the scientific community. Individuals might be willing to contribute from their own, personal, resources to add a site to the NutNet, even though a simple financial donation would not put individual donors in a position to benefit professionally.

At the ASM, the presentation and audience reaction created the opportunity to ask a straightforward question from the perspective an economist: Do scientists personally value experimental data? In particular, do scientists within the LTER network value the addition of one more site to the Nutrient Network, and what factors might influence their personal valuation of such a change? This paper reports on a simple economics experiment, conducted opportunistically at the ASM of LTER, to address this question and to illustrate how characteristics of individuals might alter their values. Based on the verbal feedback of numerous participants, the experiment challenged individuals to reflect on their own priorities in an unexpected way;[1] this report gives readers an opportunity to share in that experience.

Here, values will be discussed (or measured) in dollar terms, but readers should be aware that dollar measurement is not the key to economic value. Rather, economic value is, as stated above, measured in relative terms as the willingness of an individual to sacrifice some good thing(s) to obtain some other good thing. Money simply provides a convenient (if sometimes controversial) standard of measure. Money is used to identify the level of one or another individual's willingness to sacrifice of something to obtain a public good (an additional NutNet sampling site in South America); that sacrifice for the NutNet collaborators might be the sacrifice of a summer graduate intern that might have been supported by the $4000 start-up cost, or the piece of equipment that had to be financed through additional fundraising by the scientist-collaborator. Or it could be, for the individual conference participant, the sacrifice of whatever the person might have spent $40 to obtain had they not made a donation to the NutNet, rather than some other personal priority, including entertainment or a $40 donation to a favored conservation organization. It is not money that implies value; it is the willingness of the individual to sacrifice part of their ability to obtain other desirable goods, services, or even public action supporting environmental stewardship, that reveals whether one "good thing" is *relatively* more valuable than some other good thing that the *individual believes* is desirable.

[1] It should be noted that dozens of verbal comments came to the authors, but verbal interactions tend to favor agreeable or diplomatic exchange. About a half-dozen written comments were also received, and some of these were of a negative nature that will be mentioned below.

Purposes of the Experiment and the Framework for Economic Valuation and Experiment

The LTER Network, while heavily invested in the ecological sciences, broadly defined, has also been working to integrate the social sciences, including economics (LTER 2007). Yet network members are typically unfamiliar with the concepts of economic value or the potential to use an experimental approach in economics research. The purposes of the experiment then were three-fold: (1) to provide an experiential-based opportunity for participants to consider their values within an economic context; (2) to obtain an illustrative measure of the potential value that individuals scientists, as represented by ASM attendees, might have for support of their science; (3) to test whether a modest change to the typical donations approach would affect the potential amount of donations an individual might offer.

This third purpose derives from a line of research in the field of experimental economics, which examines the behavioral, informational, or incentive-based factors that affect the measurement of economic value (often called "willingness to pay") and that affect the propensity of individuals to contribute, financially or otherwise, to the provision of public goods. The commercial economy is widely known to undervalue many ecosystem services, particularly those for which socio-political institutions or natural factors fail to allow providers to exclude potential beneficiaries who have not contributed toward the cost of stewardship or provision. In many cases, the underappreciated or undervalued ecosystem services are public goods, i.e., services that benefit many people simultaneously, regardless of whether an individual has contributed toward the cost of provision. Aesthetically pleasing species and landscapes provided through ecosystem preservation or restoration and associated habitat services comprise one example, and the stock of scientific knowledge about ecosystems comprises another example.

Within an economic framework, values are only measurable in relative terms (Hicks 1946; Samuelson 1954). Economic value does not involve an absolute scale, because values are observable only within the context of constrained choice. Economists define willingness to pay (WTP) (technically called compensating variation) as the maximum amount of money an individual would be willing to contribute to obtain a particular good (or change from the status quo) if his or her contribution was necessary to obtain the good. This economic framework assumes that at any higher amount (cost) than maximum WTP the individual would rather do without the good and retain his or her money for support of others, personally appreciated good things. Because the value to the individual derives from that person's subjective preferences, different people may value the good differently (at different levels of willingness to sacrifice money or what that money could provide). Measuring this WTP value is relatively straightforward for private goods, the items we typically buy in the commercial economy, because one can observe whether individuals decide to pay a market price or do without obtaining more of the good for personal use. Unfortunately, measuring the value for public goods is particularly challenging because individuals can strategically withhold any personal payment while nonetheless benefiting from the contributions, or philanthropic actions, of others. This strategic behavior is often called free-riding or cheap-riding, where the latter term distinguishes the individual's choice to make a non-zero contribution which, however, remains less than their full WTP.

Experimental economists have tested a variety of approaches and incentives that might lead individuals who believe a public good contributes to their quality of life to, in turn, contribute more of their personal financial resources in support of provision (see Ledyard 1995). Note here that we recognize that not all individuals will value, or "care about," a particular public good, so making a zero contribution can be fully consistent with such an individual's personal values and priorities.[2] Many economic experiments are conducted in a laboratory setting, using induced values to facilitate a focus on the fundamental incentive-structure presented in a particular choice situation. These laboratory experiments are typically decision games in which induced values are monetary payoffs an individual can earn for making good decisions within the context of the institution comprised by the rules of the game.

For an example related to our own experiment, the voluntary contributions mechanism (VCM) game mimics the familiar institution of philanthropic donations to provide a public good. For a group of individuals in the laboratory, the public good is an investment-fund that individual contributors create but that pays a benefit (the induced value) to all individuals in the group, whether or not they paid to help create the fund. This laboratory setting removes emotional or contextual factors, such as an attraction or aversion to a real good like an ecosystem restoration project or adding a site to the NutNet, allowing researchers to focus on how changes to the VCM institution might stimulate individuals to make higher contributions relative to their personal induced-value for the laboratory good. A well-studied modification to the VCM involves the addition of a provision point, or funding threshold, that must be reached before the laboratory version of the public good – the investment fund – pays off benefits to anyone in the group. In the laboratory, the provision point may simply be a minimum amount required to generate the payoffs to individuals. Outside the lab, the provision point may be the cost to provide a unit of the good, such as the cost to restore an additional acre of seagrass, or it may be a separately identified threshold for funding that must be raised through individual contributions; in the latter case, contributions might be combined with a source of matching funds to pay the cost of provision.

Poe et al. (2002; Rose et al. 2002; cf., Rondeau et al. 1999, 2005) provide a review of threshold-level funding mechanisms in economics experiments. The basic motivation for the provision point approach is that the threshold creates a threat of non-provision, so that there is a lower chance that someone who values the good could benefit from its provision by others. This threshold approach is applied with finite groups of potential contributors, so it is not an open-ended fundraising or donations approach in the usual sense. The provision point method comes with a money-back-guarantee that if total contributions fall short of the threshold, each contributor receives a full refund.

Other authors have explored modifications to the provision point methods, particularly involving the disposition of funds raised in excess of the provision point threshold. For example, Marks and Croson (1998) show that if excess funds are rebated to contributors in proportion to their

[2] Some of these individuals may believe the good is important to society, and express that society should support the good, perhaps through government action. However, if the individual is not *willing* to pay anything to provide the good, under the construct that his or her payment would be necessary to obtain any provision and its benefit, then the economic framework simply assumes that individual values all other good things more highly than the particular public good for pursuit of his or her own well-being as constrained by personal income.

contribution, the rebate rule can lower the incentive for a contributor to cheap-ride a bit more because he or she is better assured that any money that is collected will only be used for the good being provided. Spencer et al.'s (2009) experiment shows that such a mechanism can generate contributions that are, on average, equivalent to the individual's full value or WTP for the good. These types of mechanisms have been used in field experiments involving actual ecosystem services. For example, Swallow et al. (2008) provide a non-technical introduction to an extensive field experiment in which residents of Jamestown, Rhode Island, USA, were asked to contribute funds to support payments to farmers who agreed to manage hayfields for grassland nesting birds (cf., Swallow et al. 2012). Smith and Swallow (2013) provide a non-technical overview of experiments in the Virginia Coast Reserve LTER site, in which local residents made choices to invest in seagrass restoration or restoration of coastal bird habitat using a novel auction approach that extends the provision point mechanisms to multiple units (e.g., acres) of the public good (cf., Smith 2011).

A challenge with field experiments comes from working with real goods and the idiosyncratic values that individuals may hold. We report here on a field experiment with LTER scientists, regarding a request to contribute to support the addition of one site to the Nutrient Network. Like any choice situation, within a heterogeneous group some individuals may value a particular good, some may not, and others may feel that our society has mechanisms, other than donations, for encouraging provision of the good. But one indication of whether something is, actually, a good is whether at least one individual is willing to make some sort of sacrifice to help assure the good is provided. For example, Johnston and Russell (2011) use the willingness of one rational individual to pay for some change in ecosystem outputs, even if no change occurs in human-produced goods, as a core criteria for identifying when an ecosystem change represents as final ecosystem service. Our field experiment tests the notion of whether or not the provision of an additional site in the Nutrient Network might be considered as a good, a desirable outcome that at least some scientists desire to obtain.

<u>The Setting and Experiment</u>

On Wednesday morning, September 12, Elizabeth Borer gave a plenary presentation (as described above) to the ASM of LTER, with an audience numbering between 400 and 500 individuals. This presentation created an opportunity[3] to both conduct an experiment to measure audience-members' (scientists') relative value for adding a site and to illustrate some of the concepts that economists use for measuring value. We identified that the NutNet still had few sites in South America, where scientists in several countries might feel adding a site would be an important contribution supporting the NutNet's objectives, but where individual scientists might be operating under substantial financial constraints limiting their ability to obtain and allocate the $4000 in start-up costs. For the purposes of the experiment reported here, we identified adding a single, South American site to the NutNet as the good we would use.

[3] It should be noted that S.K. Swallow was in the audience and brought forward this suggestion *<u>following</u>* the presentation. It was neither planned nor anticipated by Elizabeth Borer or other members of the Nutrient Network that within 24 hours their creation would become a subject of a short valuation experiment. At that time and at this writing, the NutNet had not and does not conduct fundraising or "donation" drives among its member colleagues. The authors are grateful for the indulgence of NutNet members and the LTER participants.

The experimental design anticipated dividing the attendees at the Thursday morning plenary session into two groups, with each group receiving a slightly different treatment, or instructions, soliciting donations. Group Two (the Control Group) was assigned to the standard donations treatment, which instructed participants that it requires about $4000 to cover start-up costs and any donations raised from the Control Group participants would be transferred to a South American scientist capable of committing to the NutNet protocols, adding one site. The Group One's (the Threshold Group) treatment included a provision point, set at $2000, with the information that if $2000 were raised from the Threshold Group participants, an anonymous donor had already been identified to contribute the other $2000 to meet the start up costs for a South American site. Both groups were introduced to an established scientist at the ASM meeting and participants were told that this individual had volunteered to transfer to South American colleagues any funds raised and to assure appropriate training at the new site. Thus both groups were reminded of the $4000 start up cost, but the Threshold Group had the provision point set at only $2000; this threshold was determined based on a subjective assessment that we could anticipate approximately 100 participants in each group,[4] so that an average of $20 per contributor might be a feasible, but still challenging, target. In addition, the anonymous donor set $2000 as the matching funds available for the Threshold Group. The written instructions for each group are included in the Appendices.

Conference organizers permitted this experiment to occur Thursday morning following the end of the scheduled plenary, and overlapping with the scheduled refreshment break. These leaders agreed to introduce the concept of the experiment and to request that attendees "give their break" to science. An economist gave a short Powerpoint presentation reminding conference attendees of the main purposes and objectives of the Nutrient Network, providing common instructions, informing everyone that there were two treatments being administered and, therefore, that each person should read their own paper instructions carefully. Participants were reminded that participation was voluntary, and they were asked not to look at their neighbor's response to the request to contribute. In order to create an opportunity for individuals to keep their contribution decision confidential, all participants received business-size envelop in which to enclose their contribution, an "I owe you" note that would record their intention to contribute, or to leave empty but hand in; this allowed both contributors and non-contributors to appear the same within the audience, as all participants were instructed to hand in their envelope, whether or not it contained a contribution. Individuals were informed that they could pay any "I owe you's" to the experiment moderator at the common lunch site at noon, and the Threshold Group participants were told they could learn the outcome at noon as well, with the opportunity to retrieve refunds if the Threshold Group's contributions fell short of the $2000 target. These envelopes bore a unique identification number that matched a number on each person's copy of the instructions, enabling the experiment moderator to match any refunds to their contributor without recording names.[5]

[4] Conference organizers indicated that about 300 attendees were scheduled to stay overnight Wednesday. Our estimate was somewhat conservative based on the fact that Thursday was the last day of the conference and many attendees could be leaving for travel or other pursuits outside the Thursday plenary session.
[5] In a few cases, individuals wrote a check or IOU that indicated their identity.

To manage the logistics in a short timeframe, participants were assigned systematically, not randomly, to treatment groups. Conference staffers handed out experimental instructions by row, assigning the first row of seats to treatment the Threshold Group, the second row to the Control Group, and proceeding in alternate rows to the back of the auditorium. This procedure has the disadvantage that scientists with common interests may tend to sit together, such as individuals working at a single LTER site or representing a particular academic, private, or government entity. However, audience size assured mixing by rows and we designed a follow-up survey to identify individual characteristics that might reasonably relate to their willingness to contribute and enable statistical analysis to control for these factors. The follow-up survey (see Appendix) requested information on the LTER site with which the individual was most closely associated, their highest degree earned, their expertise, their career stage, age, gender, typical level of annual donations to all causes, and their income range.

Results

In total, 221 individuals participated in the experiment by returning their envelope, with 152 completing the follow-up survey. Of the participants, 78 contributed zero, three contributed less than \$1, and 140 individuals contributed amounts ranging from \$1 to \$100. Table 1 breaks down the participants by characteristics reported on the follow-up survey. Participants represented the spectrum of LTER sites, with Coastal-Marine sites and Montane-Forest-Boreal sites, followed by Grassland sites forming the largest clusters. Participants who completed the survey generally represent U.S. sites; with over half holding a Ph.D.; with more than half in faculty, research, or other positions other than students or post-docs. About 69% reported making donations to various causes in excess of \$25 over the past 12 months; while half reported their income exceeded \$60,000 annually. By inspection, it is clear that the two groups differ on the distribution of individual characteristics reported; these variables may affect the contributions from Groups One and Two.

Table 2 reports the frequency of dollar-amount donations, by group. These data reveal that donations were clustered around whole-dollar amounts related to the denomination of common currency (\$1, \$5, \$10, \$20) with a scattering of contributions up to \$100. This clustering likely indicates that contributors were constrained by their immediate access to money in their possession, as the conference site (the YMCA of the Rockies) did not require most participants to carry cash routinely. In addition, it is clear that a large share of participants chose a zero contribution, so that there is a selection problem in the data that we address in the econometric analysis below.

Considering simple statistics in Table 3, it is clear that the Control Group contributed about 12.5% more, on average, than the Threshold Group participants, with contributions across all participants at \$9 versus \$8, respectively. Of those who contributed at least \$1, the average contributions for the Control Group participants was about 26% higher, at \$15 versus \$12 respectively (Table 3). This result is contrary to the initial hypothesis that adding the provision point requirement would stimulate an increase in contributions. However, these simple statistics do not account for heterogeneity in individuals' willingness to donate.

We therefore consider correlation between participant characteristics and donations, using a two-step analysis to account for the large fraction of participants who made a zero contribution (or near zero, as we lump those contributing less than $1 with those contributing zero). In addition, because it was inconvenient for participants to obtain exact change, we treat the contributions in a manner to account for the clustering around common denominations of dollar bills ($1, $5, $10, $20, etc.).

In the first step, our analysis uses a Probit model to predict the probability that an individual decided to contribute $1 or more. The first two models in Table 4 report the Probit model for 221 participants using all the individual characteristics reported, and a dummy variable for those who did not complete the follow-up survey. The Model 1 tests all of the characteristics of participants as predictors of whether they decided to make a positive contribution. We used a dummy-variable taking a value of 1 if the individual completed the follow-up survey and a zero otherwise. Similarly we used a dummy variable identifying to which group the individual was assigned; ControlGroup equals 1 for those in the Control Group, zero otherwise. PresentationNo is a dummy variable indicating whether one attended the presentation before taking the survey; it takes a value of 1 if the individual did not attend the plenary talk and zero otherwise. Table 1 shows how the characteristics in the follow-up survey were combined to assure a reasonable sample of individuals in each category retained for analysis. For example, individuals associated with Coastal or Marine LTER sites were identified by a like-named dummy variable taking a value of 1 for individuals with these sites, zero otherwise; while the Montane, Forest, and Boreal sites were merged to a single dummy variable. The areas of expertise were collapsed into a set of dummy variables identifying biogeochemistry as one category, other natural scientists except ecologists as another, and social scientists as a third category retained in the first model of Table 3.

Table 1 identifies the "combined" categories used in the analysis and which categories were designated as the base case in the probit regression. For example, Ecologist was used as the base case for the dummy variables identifying the participant's expertise, so that the dummy variables retained in the model reflect the effect of those expertise-categories on the probability that the individual made a positive contribution. However, individuals who responded to the follow-up survey but left a particular item blank were treated as a member of the base category.[6]

Model 1 in Table 4 itself is statistically significant ($P<0.0001$), but it shows that several of these participant characteristics are not statistically significant at conventional levels. We therefore estimated a restricted model which retained the treatment variables (ControlGroup, PresentationNo) and the age characteristic, in an effort to eliminate spurious correlations between participant characteristics and the probability that a participant contributed money. The result is model 2 in Table 4, which is statistically significantly ($P<0.0001$) and does not impose statistically significant restrictions on model 1 (chi-square 23.790, 21 df, $P>0.30$). This restricted model 2 shows that the PresentationNo variable indicating that a participant had not seen Dr. Borer's presentation reduced their probability of contribution at a significance level of $P<0.06$, while the probability that a participant contributed a dollar or more increases with the

[6] We tried alternative ways of handling the item-non-response rate, including dropping these individuals from the analysis and we found no substantial changes to the main results.

individual's age. We suspect the age variable is correlated with the donation and income variables, which are eliminated in the restricted model.

We use the inverse Mills ratio (IMR) from model 2 in Table 4 to control for selection bias in the a regression equation used to predict the amount that an individual contributed, conditional on having contributed at least $1. This approach follows Heckman's (1979) correction for selection bias associated with the substantial share of participants who contributed zero. The regression model for contributions follows the form:

$$C = b_0 + \beta X + \gamma \, IMR + \varepsilon$$

where C is the individual's contribution, b_0 is a constant term, X is a vector of independent variables, β is a corresponding vector of coefficients capture the impact of the elements of X on the level of contribution, ε is the error term assumed to be distributed as the standard-normal, while the coefficient, γ, on the IMR is used to correct for selectivity bias following Heckman (1979).

In Table 4, model 3 uses all the available individual characteristics, a dummy for whether the participant completed the survey, ControlGroup, and PresentationNo to examine the factors influencing an individual's contribution. Model 3 can be used to estimate the expected (i.e., average) contribution from an individual who decided to contribute at least a dollar and who has characteristics defined by the independent variables shown. However, to acknowledge the fact that contributions are clustered around the denominations of paper money, we used an interval form of the regression analysis. The interval regression (Stewart, 1983) treats the independent variable as an indication that the person's maximum willingness to contribute is at least as large as the amount actually contributed but less than the next higher denomination of paper currency. For example, an individual who contributed $5 is assumed to have a *maximum* willingness to contribute of at least $5 but less than $10; a contributor of $11 is assumed to have a *maximum* willingness to contribute of at least $11 but less than $20. For contributions of $20 or more, we based the intervals on multiples of $20. For example, a contribution of $40 was treated as indicating a *maximum* willingness to donate of $40 but less than $60, while a contribution of $50 indicated an interval of $50 but also less than $60.

Model 3 in Table 4 is statistically significant ($P<0.0001$), but contains numerous variables that are not individually significant at conventional levels. To aid in identifying which factors are more significant predictors of contributions, we estimated model 4 in Table 4, which is also significant ($P<0.0001$) but is not significantly different from the unrestricted model 3 (chi-square 4.316, 12 df, $P>0.97$).

Coefficients in Model 4 may be interpreted as measuring the impact of that variable on the mean contribution. Thus, individuals who did not hear Dr. Borer's presentation contributed about $12.13 *more* than individual who did hear Dr. Borer's presentation. This result appears contrary to what we might expect, until we consider that these individuals were less likely to make the decision to contribute at all. Table 5 shows estimates of the probability to donate given four different scenarios for an average aged (41.6) person. We find that hearing the presentation greatly increases individuals' propensities to donate, in both treatment groups. Conditioning on participation, individuals who heard the talk have a lower estimated mean willingness to pay compared to those who did no hear the talk; the dummy variable *PresentationNo* is positively significant at a 10% level. However, the overall effect is that individuals hearing Dr. Borer's presentation tended to contribute more than other individuals, on average; this is consistent with those individuals having a more certain or complete understanding of the potential good being offered.

Results of model 4 (Table 4) also indicate that the Control Group, which was solicited for an ordinary donation, contributed about $4.95 more than those in the Control Group who faced the provision point, although this effect is only statistically significant at 10%. This result indicates that, in this case, the provision point did not lead to increased contributions. This unexpected outcome may reflect that participants felt the mechanism was too unfamiliar and, in the time permitted, did not react positively to the additional criteria for funding. On the other hand, the result could reflect transactions costs that have been assumed irrelevant in laboratory testing of the provision-point mechanism; that is, because the provision point mechanism carried the possibility that contributors might need to appear to retrieve their contribution if the group failed to meet the $2000 provision point, contributors may have been less inclined to contribute close to their full willingness to donate.

Results in Table 4 show that participants expertise, association with the LTER network, gender, or career stage all affected likely contributions. Variables identifying individuals' affiliation with a type of LTER site show that participants from Coastal or Marine sites tended to contribute $7.72 less, while participants from Urban or Arctic-Antarctic sites tended to contribute $14 to $15 less, all relative to the base level of contributions from individuals affiliated with grassland sites, while individuals from Montane-Forest, Boreal, or Agricultural sites did not contribute a statistically significantly lower amount than individuals from grassland sites. Table 6 lists the average willingness to pay estimates for individuals' affiliations with different types of LTER sites, conditioned on participation (i.e., the individual having decided to contribute)[7]. These results seem intuitively reasonable as we might expect individuals from grassland sites to be willing to contribute higher amounts, since their professional activity reveals that their personal interests may be more closely tied to the mission of the Nutrient Network, and this is what the results indicate to hold, on average.

We also see reasonable patterns with regard to career stage or other individual characteristics. University faculty members tended to contribute more, as indicated by the negative coefficients on Student, NonFacultyResearcher, and OtherCareer, which are all significant at 10% and the latter two are highly statistically significant ($P<0.01$). Individuals who were male contributed about $6 less than others (females or those who did not report their gender). One unexpected result is that contributors who were not from the U.S. were willing to contribute about $16 more than U.S. participants. However, this result is based on only 7 individuals reporting a non-U.S. affiliation and these individuals may have had a relatively higher income level or a greater interest in adding sites from outside the U.S. to begin with (consistent with the proposition that donations would support adding a South American site). Table 7 lists the average willingness to pay estimates for individuals' different career stage, conditioned on participation[8].

[7] The average willingness to pay is estimated for a "representative" individual that has completed the survey, with average age (41.6), base level of career (professorship), female, US affiliation.
[8] The "representative" individual is of the same characteristics as in footnote 7.

We also tested alternative model specifications; e.g., an ordered logit regression model, where individual donations are divided into five categories from lower to higher contributions. This model used identical explanatory variables[9]. The ordered logit model is an extension of the logistic regression model for dichotomous dependent choices, allowing for more than two response categories. Instead of following a continuous distribution, individual contributions are assumed to fall into one of the five categories. The ordered logit regression results support our main conclusions: the PresentationNo dummy is still positive and significant, meaning individuals who (having decided to contribute at least $1) actually contributed a higher amount despite not having heard Dr. Borer's presentation than did individuals who had heard the presentation; people affiliated with grassland sites contributed more than others; professors contributed higher than people at other career stages. Appendix 4 shows the ordered logit regression results. The Probit regression used to correct selection bias in the ordered logit is the same as Model 2 in Table 4. We chose the interval regression for the above analyses since the estimated value can be interpreted as changes to willingness to donate (pay) directly while estimates from the ordered logit regression requires additional calculations to convert to monetary measures of changes in donations.

Discussion

Results of this simple experiment demonstrate that a large proportion of scientists participating at the LTER's ASM may hold a personal value for broad activities to advance science, beyond their own personal or professional benefit. Contributors to the Nutrient Network provided evidence, based on their actual behavior and choice, that they viewed adding a South American site as a good priority worth at least some sacrifice of their own personal financial resources.

Many contributors expressed interest in testing the economic mechanisms, and expressed gratitude for being nudged to consider their personal values. The experiment placed participants unexpectedly in the position of considering a science network as a good of personal value, justifying some sacrifice. A few others, in writing or in diplomatic verbal comments, suggested that a donations approach was not an appropriate way to enhance a science network.

These comments were not detailed, but there may be some value in speculating the potential motivations for the comments and, possibly for individuals' choice not to contribute even in cases where they personally believe the Nutrient Network is valuable. First, an economist must note almost anyone can identify some good that is not of high enough personal value to be worth the personal sacrifice of any financial contribution to assure provision of the good; these individuals simply are not part of "the market" and there is nothing in economics that suggests any pejorative conclusions can be drawn. Second, several participating scientists (including some on both sides, who voluntarily revealed their decision to be or to not be a contributor) suggested that society funds research often through government action, which implies taxpayers broadly share the responsibility for producing knowledge for the common good. These

[9] In the ordered logit, based only on individuals who contributed at least $1, category 0, means the individual contributed an amount in the interval [$1, $5); category 1 in [$5, $10); category 2in [$5, $10); category 3in [$10, $20); category 4in [$20, $40); category 5, amount is equal or higher than $40.

individuals might personally value enhancing the Nutrient Network, but may adopt the view that their tax contributions already support such scientific activity.

Aspects of the choice setting may well affect the response that anyone gives to requests for payment or contribution. Participants were all constrained by whatever cash they had on hand, rather than having a broader range of options to contribute any amount as might be possible from home or in ordinary interactions with stores or charitable organizations. In this case, it appears the provision point rule did not encourage higher contributions, and may actually have discouraged some from contributing more consistently with their full value for adding a site to the NutNet. During the experiment, the moderator declined to answer questions concerning how much the average contribution needed to be to achieve the provision point or fully fund the start up cost at a site; existing research shows that suggested contributions or information on the average per-capita cost can influence individual contributions (Fehr and Gachter, 2000). Finally, unlike economics laboratory experiments, the setting of actual contributions with a provision point faced potential transaction costs in the event that contributions fell short of the provision point. It is for this type of reason that social marketing sites, like Kickstart.com or CleanWaterFuture.org record commitments to contribute to a good during a specified time, recording potential contributors' credit card numbers, but not billing credit cards until the provision point has been reached. Such a delay avoids the transactions cost of collecting funds and then processing refunds.

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Appendix 1

Following are the instructions given to Group One and Group Two participants. On the upper right corner of each instruction page, a header stated "Your Number is 1-xxx" or "…2-xxx."

You are in "Group ONE."

This instructional experiment today has the potential to add one or more sites to the Nutrient Network: A Global Research Cooperative, as described by Elizabeth Borer during the Wednesday Plenary session.

The Network is still missing sites in several biogeographic realms in less developed countries like Argentina or Brazil.

Group ONE has a chance to ADD at least one site from South America to the Nutrient Network. We have (overnight) secured funding of $2000 toward the $4000 start-up cost for a site…

> **BUT:** in order to use it we MUST raise the other $2000 right now, in this room, from members of Group One.

Your Task as a Volunteer

Please think about the most you would be willing to contribute to make this addition to the Nutrient Network.

- What would it be worth to you, personally, to make this happen?
- How does this fit with your priorities and all your expenses, including other good projects you might support elsewhere?

- If we raise $2000 or more from Group One, Elizabeth Borer will be able to secure a site in South America.
- Professor Osvaldo Sala of Arizona State University has agreed to recruit and train the on-site scientists to follow the Nutrient Network protocol at the site.
- 100% of the money will be used for the start up costs for the site.

But this is ***not*** a simple donation:

> *If Group ONE does not raise the full $2000, then we will return all the contributions to you* …
>
> The number on your envelop will allow us to return your contribution, to you, if we fail to reach the $2000 target.

Instructions: *How to contribute…or not*.

- To keep your decision confidential, please use the envelope provided.
- You can put any amount of money in the envelope, including zero.
- *If you do not wish to contribute*, please just turn in the envelope empty.
  . . . that way no one else will know your choice.
- Please keep your envelop flap which shows the number.
- This number will enable us to return your envelop to you *without* revealing your choice.
  . . . we will return all contributions from Group One if we fail to collect $2000

You are in "Group TWO."

This instructional experiment today has the potential to add one or more sites to the Nutrient Network: A Global Research Cooperative, as described by Elizabeth Borer during the Wednesday Plenary session.

The Network is still missing sites in several biogeographic realms in less developed countries like Argentina or Brazil.

Group TWO has a chance to help ADD a site from South America to the Nutrient Network. We are asking Group TWO to contribute toward the $4000 start-up cost for a site.

Your Task as a Volunteer

Please think about the most you would be willing to contribute to make this addition to the Nutrient Network.

- What would it be worth to you, personally, to make this happen?
- How does this fit with your priorities and all your expenses, including other good projects you might support elsewhere?

- Whatever funds we raise from Group TWO, Elizabeth Borer will use these funds to defray the start up costs for a site in South America.
- Professor Osvaldo Sala of Arizona State University has agreed to recruit and train the on-site scientists to follow the Nutrient Network protocol at the site.
- 100% of the money will be used for the start up costs for the site.

Instructions: *How to contribute…or not*.

- To keep your decision confidential, please use the envelope provided.
- You can put any amount of money in the envelope, including zero.
- *If you do not wish to contribute*, please just turn in the envelope empty.
  . . . that way no one else will know your choice.

Appendix 2:

The following is the follow-up survey that participants were asked to complete after making their decision on contributions.

Please answer the following questions, which will help us better compare the results from our groups in this instructional experiment.

All questions are voluntary (but we hope you will complete them).

1. Please copy your number here: ________________

2. Which of the following best describes the LTER site with which you are most closely associated (circle one):

Coastal Grassland Montane Forest Agriculture

Arctic/Antarctic Boreal Marine

3. Is your LTER affiliation (circle one): U.S. International

4. What is the highest degree you have completed (circle one):

Bachelor's Master's Ph.D.

5. Please circle the field that most closely represents your expertise (circle one):

Ecologist Biogeochemist Atmospheric-Scientist

Geologist Anthropologist Economist Sociologist

Oceanographer OtherSocialScientist____________

6. What category best describes your career-stage: (circle one)

Undergraduate-Student Graduate-Student Assistant-Professor

Associate/Full-Professor Researcher-Government Researcher-NGO

Other: ________________

7. Please tell us your age: _________

8. Please tell us your gender (circle one): Male Female

9. Which category best describes the total amount of money you donated to all causes in the last 12 months: (circle one)

$0-$25 $26-$100 $101-$500 $501-$1000 >$1000

10. Please indicate which income-range best describes your household: (circle one)

<$35,000 $35,001-$60,000 $60,001-$100,000 >$100,000

Appendix 3:

Ordered Logit Regression

Amount Contributed	Model 5, Ordered Logit (Donation Equation, Full)			Model 6, Interval Regression (Donation Equation, Restricted)		
	Coff.	Std.	P value	Coff.	Std.	P value
SurveyComplete	0.444	2.039	0.827	0.484	1.443	0.737
ControlGroup	0.105	0.575	0.855	0.111	0.362	0.760
PresentationNo	1.438	2.308	0.533	1.501	0.906	0.098
Coastal/Marine	-0.898	0.539	0.096	-0.861	0.507	0.090
Montane/Forest/Boreal	-0.142	0.526	0.787	-0.171	0.506	0.736
Agricultureal	-2.396	0.915	0.009	-2.173	0.824	0.008
Urban	-3.139	1.218	0.010	-2.748	1.134	0.015
OtherSite	-2.404	0.887	0.007	-2.378	0.852	0.005
U.S.	-0.675	0.983	0.492			
Bachelor	0.052	0.746	0.945			
Master	-0.394	0.603	0.513			
Biogeochemistry	0.607	0.874	0.488			
Natural Scientist	-0.095	0.489	0.845			
Social Scientist	0.047	0.540	0.931			
Student	-1.540	0.821	0.061	-1.881	0.760	0.013
NonFaculty Researcher	-1.662	0.631	0.008	-1.754	0.576	0.002
OtherCareer	-1.288	0.736	0.080	-1.724	0.600	0.004
Age	0.009	0.076	0.906			
Male	-0.856	0.441	0.052	-0.866	0.432	0.045
Donation2	0.334	0.634	0.598			
Donation3	0.476	0.615	0.439			
Donation4	0.342	0.690	0.620			
Income2	-0.827	0.759	0.276	-0.855	0.669	0.201
Income3	-2.078	0.862	0.016	-2.044	0.741	0.006
Income4	-1.099	0.988	0.266	-1.056	0.791	0.182
IMR	-22.263	25.769	0.388	-22.997	8.383	0.006
Cut1	-13.289	13.502		-13.650	4.457	
Cut2	-11.624	13.488		-12.017	4.431	
Cut3	-10.307	13.480		-10.725	4.402	
Cut3	-8.099	13.487		-8.542	4.369	
Log-Likelihood(df)	-185.06	(26)		-186.47	(16)	
Number of Observations	140			140		

Table 1. Summary of Respondents Characteristics and Merged Categories

Original	Characteristics	Count (TG, CG[b])	Combined	Count (TG, CG)
Question 2[a] (LTER site-type)	Coastal	37 (23, 14)	Coastal/Marine	48 (31,17)
	Marine	11 (8, 3)		
	Montane	3 (2,1)	Montane/Forest/Boreal	49 (34,15)
	Forest	44 (31,13)		
	Boreal	2 (1,1)		
	Agricultural	15 (10,5)	Agricultural	15 (10,5)
	Grassland	27 (8,19)	***Grassland (Base level)***	27 (8,19)
	Urban	7 (2,5)	Urban	7 (2,5)
	Arctic/Antarctic	3 (2,1)	Other_site(Arctic/Antarctic)	9 (4,5)
	Other_site	6 (2,4)		
Question 3	U.S.	144 (83,61)	U.S.	144 (83,61)
	International	7 (4,3)	***International (Base level)***	7 (4,3)
Question 4 (Highest Degree)	Bachelor	30 (15,15)	Bachelor	30 (15,15)
	Master	40 (24,16)	Master	40 (24,16)
	Ph.D.	82 (48,34)	***Ph.D. (Base level)***	82 (48,34)
Question 5 (Expertise)	Biogeochemist	16 (10,6)	Biogeochemistry	16 (10,6)
	Atmospheric	2 (2,0)	Natural Scientist (except Ecologist and Biogeochemist)	32 (22,10)
	Geologist	8 (6,2)		
	Quantitative[c]	6 (3,3)		
	Oceanographer	8 (5,3)		
	Other Natural Science	8 (6,2)		
	Anthropologist	1 (0,1)	Social Scientist	17 (10,7)
	Economist	3 (2,1)		
	Sociologist	1 (1,0)		
	Other Social Science	12 (7,5)		
	Ecologist	91 (49,42)	***Ecologist (Base level)***	91 (49,43)
Question 6 (Career Stage)	Undergraduate	1 (0,1)	Student	69 (39,30)
	Graduate	54 (31,23)		
	Post-doc	14 (8,6)		
	Assistant Professor	8 (7,1)	***Faculty (Base level)***	46 (28,18)
	Associate/Full Professor	38 (21,17)		
	Researcher-Government	15 (9,6)	Non-Faculty researcher	18 (11,7)
	Researcher-NGO	3 (2,1)		
	Other Career	20 (10,10)	Other Career	20 (10,10)
Question 8 (Gender)	Male	77 (43,34)	Male	77 (43,34)
	Female	39	***Female (Base level)***	39
Question 9 (Money denoted in the last 12 months)	$0-$25	39 (20,19)	***Donation1 (Base level)***	39 (20,19)
	$25-$100	34 (24,10)	Donation2	34 (24,10)
	$101-$500	34 (17,17)	Donation3	34 (17,17)
	$501-$1000	12 (8,4)	Donation4	45 (26,19)
	>$1000	33 (18,15)		
Question 10 (Household Income range)	<$35,000	49 (26,23)	***Income1 (Base level)***	49 (26,23)
	$35,001-$60,000	27 (18,9)	Income2	27 (18,9)
	$60,001-$100,000	35 (21,14)	Income3	35 (21,14)
	>$100,000	40 (21,9)	Income4	40 (21,9)

[a]Some individuals are affiliated with more than one category.
[c]TG stands for the Threshold Group (Group 1), CG stands for the Control Group (Group 2).
[c]Statistics, Computer science, GIS.

Table 2. The Frequency of Dollar-Amount Donations by Group.

Amount	0	0.03	0.25	1	1.85	2	3	4	5	6	10	12	15	16	20	40	50	50.8	60	100	Total
Threshold Group	41	0	0	6	1	4	3	0	22	1	17	1	3	0	20	1	0	0	1	1	122
Control Group	37	1	2	6	0	3	1	4	15	1	10	0	0	1	11	2	1	1	1	2	99
Total	78	1	2	12	1	7	4	4	37	2	27	1	3	1	31	3	1	1	2	3	221

Table 3. Average and Total Contribution by Group

Group	Average Contribution	Total Contribution	Number of Individuals
Threshold Group	7.87[a]	967.85	123
Control Group	8.98[a]	889.33	99
Threshold Group (contributed at least $1)	11.95[b]	967.85	81
Control Group (contributed at least $1)	15.06[b]	888.8	59

[a]The p-value for two-sample Wilcoxon rank-sum test for the equivalence of the distribution of donations between the Threshold Group and the Control Group is 0.3880.
[a]The p-value for two-sample Wilcoxon rank-sum test for the equivalence of the distribution of donations of more than $1 between the Threshold Group and the Control Group is 0.8360.

Table 4. Heckman Two-Stage Estimation

Probablity to Contribute/ Amount Contributed	Model 1, Probit Regression (Selection Equation, Full)			Model 2, Probit Regression (Selection Equation, Restricted)			Model 3, Interval Regression (Donation Equation, Full)			Model 4, Interval Regression (Donation Equation, Restricted)		
	Coff.	Std.	P value	Coff.	Std.	P value	Coff.	Std.	P value	Coff.	Std.	P value
SurveyComplete	-0.556	1.147	0.628	-0.172	0.394	0.663	16.204	16.238	0.318	15.141	12.836	0.238
ControlGroup	-0.111	0.200	0.581	-0.111	0.182	0.540	6.689	4.671	0.152	5.030	2.953	0.088
PresentationNo	-0.433	0.298	0.146	-0.487	0.256	0.057	19.621	17.757	0.269	12.133	6.452	0.060
Coastal/Marine	-0.676	0.383	0.078				-8.908	4.354	0.041	-7.720	4.115	0.061
Montane/Forest/Boreal	-0.287	0.394	0.466				-4.768	4.308	0.268	-5.021	4.211	0.233
Agricultureal	-0.457	0.536	0.394				-9.776	6.692	0.144	-7.910	6.123	0.196
Urban	-0.695	0.697	0.319				-17.023	8.986	0.058	-16.132	8.317	0.052
OtherSite	-1.349	0.620	0.030				-14.771	6.836	0.031	-15.869	6.441	0.014
U.S.	0.680	0.589	0.248				-18.521	7.999	0.021	-17.075	7.533	0.023
Bachelor	-0.040	0.488	0.934				2.134	6.358	0.737			
Master	-0.223	0.428	0.602				-0.910	4.898	0.853			
Biogeochemistry	-0.488	0.449	0.276				-1.514	6.488	0.816			
Natural Scientist	0.002	0.416	0.996				-2.713	4.180	0.516			
Social Scientist	0.258	0.375	0.492				1.626	4.125	0.694			
Student	-0.372	0.546	0.495				-11.875	6.739	0.078	-9.149	5.646	0.105
NonFaculty Researcher	0.380	0.463	0.412				-18.683	4.721	0.000	-18.455	4.503	0.000
OtherCareer	1.079	0.688	0.117				-15.456	5.774	0.007	-15.355	4.759	0.001
Age	0.040	0.020	0.044	0.023	0.009	0.009	-0.318	0.602	0.597			
Male	-0.402	0.313	0.199				-6.183	3.557	0.082	-6.119	3.368	0.069
Donation2	0.735	0.385	0.056				5.844	5.192	0.260			
Donation3	0.911	0.420	0.030				1.596	5.049	0.752			
Donation4	0.499	0.466	0.284				5.933	5.529	0.283			
Income2	-0.485	0.492	0.324				-0.290	6.063	0.962			
Income3	-1.134	0.555	0.041				-5.281	7.066	0.455			
Income4	-1.070	0.665	0.107				-2.367	8.236	0.774			
IMR							-271.016	204.282	0.185	-175.246	57.865	0.002
Constant	-0.047	0.183	0.799	-0.039	0.178	0.828	154.069	106.907	0.150	103.894	30.667	0.001
Log-Likelihood(df)	-119.04	(25)		-130.94	(4)		-297.70	(26)		-299.85	(14)	
Number of Observations	221			221			140			140		

Table 5. Estimated probability to participant under different treatments[a].

Treatment	Presentation Yes		Presentation No	
	Threshold Group	Control Group	Threshold Group	Control Group
Probability to Contribute	0.81	0.32	0.70	0.21

[a]Estimated probability to participant (contribute at least $1) for those who completed the survey, average age (41.6).

Table 6. WTP estimates conditioning on participation for different expertise[a].

Treatment/ LTER Site-type	Presentation Yes		Presentation No	
	Threshold Group	Control Group	Threshold Group	Control Group
Grassland	51.52 (11.21)	56.47 (14.84)	64.28 (13.28)	69.23 (9.08)
Costal/Marine	43.84 (11.29)	48.79 (11.35)	56.60 (8.99)	61.55 (9.35)
Montane/Forest/Boreal	46.57 (12.02)	51.52 (10.70)	59.33 (8.98)	64.28 (9.32)
Agricultural	43.23 (12.74)	48.18 (12.89)	55.99 (11.03)	60.94 (11.42)
Urban	37.03 (12.93)	41.98 (12.82)	49.79 (11.33)	54.74 (11.20)
Othersite (Arctic/Antarctic)	36.03 (12.94)	40.98 (12.71)	48.79 (10.65)	53.74 (10.61)

[a]Estimated willingness to pay conditioning on participation (contribute at least $1) for those who completed the survey, average age (41.6), base level of career (professorship), female, US nationality. Standard deviations are in parentheses.

Table 7. WTP estimates conditioning on participation for different career stages[a].

Treatment/ LTER Site-type	Presentation Yes		Presentation No	
	Threshold Group	Control Group	Threshold Group	Control Group
Professor	51.52 (11.21)	56.47 (14.84)	64.28 (13.28)	69.23 (9.08)
Student	44.06 (7.53)	49.00 (7.47)	56.81 (6.94)	61.76 (7.24)
Researcher	45.57 (11.23)	50.52 (11.54)	58.33 (9.43)	63.28 (4.30)
Othercareer	46.91 (10.58)	51.86 (10.31)	59.67 (8.54)	64.62 (8.51)

[a]Estimated willingness to pay conditioning on participation (contribute at least $1) for those who completed the survey, average age (41.6), base level of expertise (grassland), female, US nationality. Standard deviations are in parentheses.