# Money Growing on Trees:
# A Classroom Game about Payments for Ecosystem Services and Tropical Deforestation

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**Abstract (125 words):**
Payments for ecosystem services programs use an incentive-based approach to pursue environmental goals. While they are common policy tools, key concepts that can determine their efficacy are nuanced and hard to grasp. We present a new interactive game that explores the functioning and implications of payments for ecosystem services programs. Participants play the role of rural households in a developing country. They decide individually or as groups whether to enter into contracts to receive payment from a forest-based payments for ecosystem services initiative to refrain from reducing local forests. The game explores topics including: payments for ecosystem services programs; climate change; tropical deforestation; cost-effectiveness; additionality; illegal harvest and enforcement; and community resource management. We provide customizable materials, a detailed reading list, and prompts for discussion.

**Keywords:** classroom game, payments for ecosystem services, tropical deforestation, community resource management, incentive-based regulation

**JEL Codes:** A22, Q23, Q54, Q56, Q57, Q58

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## Introduction

Payments for ecosystem services (PES) programs are incentive-based tools for environmental regulation and have been used to address important environmental issues like watershed management, deforestation, species preservation, and non-point source pollution (Engel, 2016; Engel et al., 2008; Wunder, 2005). Payments for ecosystem services programs worldwide have grown rapidly from about transactions worth $8 billion in 2010 to over $36 billion in 2018 (Salzman et al., 2018; TEEB, 2010). This growth has been accompanied by a rapid growth in the academic literature focused on the implementation and effectiveness of these programs (Alix-Garcia and Wolff, 2014; Alix-Garcia et al., 2018; Andam et al., 2010; Engel, 2016; Engel et al., 2008; Ferraro et al., 2011; Jayachandran et al., 2017; Senadheera et al., 2019; Wunder, 2005). However, key concepts about payments for ecosystem services can be hard to grasp. We describe a new interactive game, set in the context of tropical deforestation, that explores issues with payments for ecosystem services programs, particularly cost-effectiveness, additionality, verifiability, and community governance. This detailed, context-rich game is well suited to use in a variety of classes, particularly those on environmental and resource economics and environmental policy, as well as in trainings for policymakers and researchers.

Our game explores payments for ecosystem services in the context of deforestation and forest degradation, an area that deservedly receives a great deal of policy attention and one in which such programs have been used frequently. Globally, over 50% of forests have been converted to human use since the advent of agriculture, and currently almost 70% of forest area is located within one kilometer of a forest edge (Bluffstone, 2013; Haddad et al., 2015; Millennium Ecosystem Assessment, 2005; Pan et al., 2011). Since 1990 the world has lost 178

million hectares of forest, an area about the size of Libya (FAO, 2020). Much of the recent deforestation has occurred in tropical developing countries. Deforestation is consequential because forests provide global public goods, including providing a sink for greenhouse gas emissions. Deforestation happens as communities living in or near forests harvest firewood and other material, and when they convert forests to agricultural land. Our game depicts this former form of deforestation and forest degradation through small-scale harvesting of forest materials, and the potentials and pitfalls associated with global payments for ecosystem services programs aimed at reducing deforestation in such a context.

The United Nations Framework Convention on Climate Change (UNFCCC) proposed decades ago a global program to fight deforestation and forest degradation using payments for ecosystem services. While the global program hasn't come fruition because there is no global carbon market, related efforts led to the creation of the UN-REDD Programme, a joint effort between UNEP, UNDP, and FAO to incentivize countries to reduce deforestation and forest degradation (Angelsen et al., 2018; Duchelle et al., 2019).[1] The 2015 Paris agreement expanded the scope of activities that can be included in forest carbon programs (Griscom et al., 2017; Popkin, 2019). There are now many bilateral and multilateral programs funded through the Green Climate Fund and the World Bank aimed at incentivizing reductions in deforestation.

In our game, participants play the role of rural households in a developing country. Games are an effective way to engage students with challenging material (Durham et al., 2007). Our game progresses through scenarios in which the households individually or as communities

[1] The implementation of global forest-based payments for ecosystem services has evolved over the last decade. The UN-REDD Programme is now primarily financed by individual countries or funds, and the implementation of programs has evolved from projects to national and subnational initiatives (Angelsen et al., 2018; Duchelle et al., 2019). For an overview of the broader institutional and national/international implementation aspects of REDD+, please see Angelsen et al. (2018).

decide whether to enter into contracts that will pay them to refrain from harvesting from a local forest. We have designed a set of treatments that can be mixed and matched to provide hands-on learning of topics including: payments for ecosystem services programs; climate change; tropical deforestation; cost-effectiveness and opportunity cost; additionality; verifiability, illegal harvest, auditing, and enforcement; community governance and common pool resource management; and the challenges facing rural households in developing countries.[2] While we present the game in the context of a payments for ecosystem services program to reduce deforestation, it could be adapted to any setting in which payments for ecosystem services programs present similar issues.

The game is suitable for undergraduate or graduate classes covering subjects such as environmental or resource economics, public economics, environmental policy, and development economics, and for continuing education or capacity-building training for policymakers and researchers. While some background in economic ideas like opportunity cost and expected value can help participants achieve higher levels of understanding through game play, the game is accessible even to people with no prior knowledge. It is best suited for groups of 10 to 60 players, though it can be used in larger groups, and usually takes 45 to 90 minutes to play depending on which treatments and extensions you use. We provide a wealth of materials to make it easy for you to customize and run the game, including an Excel recording spreadsheet that automates all calculations, Instructions and Recording Sheets for participants (Appendix I), a Handout you can provide to participants with background information (Appendix II), an Instructor How-To (Appendix III), and slides you can use if desired. In this paper, we discuss the

[2] Because these are the topics that this game is designed to focus on, we deliberately abstract away from the common pool resource feature of forests and the basic idea that public goods are underprovided. Games that explore common pool resource issues include Hazlett (1997) and Zetland (2017), and games that study public good provision include Holt and Laury (1997) and Pickhardt (2005).

game at a higher level and provide theoretical and conceptual background, suggested readings, discussion prompts, and ideas for different ways to modify and use the game.

This game has been played in academic settings from an R1 research university to liberal arts colleges, and in trainings for policymakers and capacity-building for mid-career professional in developing countries. Participants have given strongly positive feedback about the game; for example, nearly all respondents to post-game surveys agreed that the game helped them understand payments for ecosystem services programs and that the game was a good use of time.

This paper proceeds as follows. First, we provide background on the policy context and the economic issues the game explores. Next, we suggest readings to share with participants, including readings that are more and less technical and those that can suit different kinds of audiences. Next, we describe the game and how to play it. We then give suggestions for discussions relating to the game; as we suggest discussion points for each treatment, we also outline theoretical predictions for that treatment. We next discuss the feedback we have received from past game play. Before concluding, we give examples of some modifications and extensions you can use to fine-tune the game to your interests.

## Background: Climate Policy, Deforestation, and Forest Conservation in Developing Countries

Globally, deforestation and forest degradation are significant issues. While over 30% of the total global land area is identified as forests, the world has lost 178 million hectares of forests since 1990 (FAO, 2020). Twenty-nine countries have lost over 90% of their forests, and tropical forest area is decreasing at over 10 million hectares per year (Millennium Ecosystem Assessment, 2005; Pan et al., 2011). Nearly half of the world's population relies on solid fuels like wood or charcoal for cooking, and the main direct use of forest ecosystems in low-income

countries is the harvesting of biomass for cooking and heating. Africa had the largest net forest loss in the last decade, losing 3.9 million ha between 2010-2020 (FAO, 2020). The number of people in Africa using biomass for these purposes is projected to increase in the next decade from 793 million people in 2014 to 823 million people in 2030, after which it should start decreasing, but slowly (Bluffstone, 2013; Chao, 2012; OECD, 2017).

The resulting deforestation and forest degradation has direct implications for climate change:[3] over the past 150 years, deforestation and forest degradation has caused an estimated 30% of the atmospheric build-up of $CO_2$ (Brown, 1998). Deforestation and forest degradation accounts for approximately 11% of the flow of annual greenhouse gas emissions, with tropical countries releasing about 2.1 billion tons of carbon dioxide from forest degradation per year (IPCC, 2014; Saatchi et al., 2011; Van der Werf et al., 2009).[4] Further, fuelwood use and timber harvesting are unsustainable in many developing counties (Bailis et al., 2015; Damette and Delacote, 2011).[5] Curbing deforestation and forest degradation and improving forest management is likely a highly cost-effective way to address climate change and support adaptation (Angelsen, 2009; McKenney et al., 2004; Stavins and Richards, 2005; Stern, 2006).

As a result, restoring forests and preventing forest degradation can be a vital part of greenhouse gas emissions reduction initiatives. The 2015 Paris climate accord committed

[3] While we focus on the impact of forests on climate change, forests provide a host of other benefits and ecosystem services, including (but not limited to) provision of non-timber forest products, water filtration and storage, other watershed services (including serving as a biotic pump), pollination, biodiversity, recreation, and cultural values (Brauman et al., 2007; Millennium Ecosystem Assessment, 2005; Sukhdev et al., 2010).

[4] Deforestation and forest degradation can be defined and measured in many ways and estimates of their impacts on climate change vary widely. The measure we present here comes from IPCC (2014), which estimates that forest degradation and deforestation directly cause 11% of greenhouse gas emissions. The broader category of AFLU (agriculture, forestry, and land use) is responsible for 24% of greenhouse gas emissions.

[5] The forest harvest in our game is forest degradation, which is defined as "the long-term reduction in carbon stocks such that the forest cover, height, and area are not reduced sufficiently to reclassify the land as non-forest." This is distinct from deforestation, which damages forest land enough so it does become reclassified (IPCC, 2014; Pearson et al., 2017). Forest degradation is driven by factors that include harvesting of timber, collection of fuel wood, and grazing of livestock (Pearson et al., 2017). Unsustainable timber harvesting is no small matter, as it can lead to deforestation (see Bailis et al., 2015 for a global review; and Damette and Delacote, 2011 for a discussion).

signatories to limit "the increase in the global average temperature to well below 2°C above preindustrial levels" and allowed countries' to plant or protect forests as part of their climate commitments (Griscom et al., 2017; Popkin, 2019). The climate impact of attention to forests could be substantial: Bastin et al. (2019) find that "there is room for an extra 0.8 billion hectares of canopy cover, which would store 205 gigatonnes of carbon." For comparison, there is approximately 300 gigatonnes of carbon in the atmosphere already; as another point of comparison, this is about twenty times global annual carbon emissions for 2010 (IPCC, 2014).

What policies can leverage forests to fight climate change? The United Nation's Framework Convention on Climate Change (UNFCCC) proposed a global payment for ecosystem service program, Reducing Emissions from Deforestation and forest Degradation (REDD+), to pay for reduced deforestation and forest degradation with funds from a global carbon market. The proposed REDD+ initiative never came to fruition as initially envisioned because a global carbon market never fully developed, but the efforts contributed to the creation of the UN-REDD Programme, a joint effort between UNEP, UNDP, and FAO to reduce deforestation and forest degradation.[6] Financing for the current UN-REDD Programme and other forest conservation programs work has come from individual countries or funds and organizations like the UNFCCC's Green Climate Fund and the Forest Carbon Partnership Facility (FCPF) and the Forest Investment Program (FIP), which are both facilitated by the World Bank. The implementation of programs has evolved from global projects to national and subnational initiatives (Angelsen et al., 2018; Duchelle et al., 2019; Schoene and Netto, 2005).

[6] The UN-REDD Programme grew from the UNFCCC REDD+ initiative that was based on the Clean Development Mechanism, which was established in the Kyoto Protocol and allowed carbon sequestration from afforestation and reforestation, but not from reducing deforestation (Schoene and Netto, 2005). The 2015 Paris climate accord allowed countries to plant or protect forests as part of their climate commitments (Griscom et al., 2017; Popkin, 2019). The UN-REDD Programme website (https://www.unredd.net/about/what-is-redd-plus.html) describes in detail the policy history and organizational interactions between UNFCCC, the UN-REDD Programme, and REDD+.

Some of these programs seek to increase investment in forest management by creating a market for ecosystem services that links providers of carbon sequestration and other benefits from forests (typically landowners and farmers in tropical countries) with buyers in developed countries (Baker et al., 2019; Bluffstone, 2013; Bluffstone et al., 2013; Goldstein and Ruef, 2016; Rakatama et al., 2017; Senadheera et al., 2019). Because these markets provides payments to those who provide forest-based ecosystem services, and those ecosystem service providers can voluntarily choose whether to enter into agreements, and further, the program makes efforts to ensure that contracts are associated with meaningful reductions relative to reference levels, these markets function as a payments for ecosystem services programs (Wunder, 2005).

These forestry based payments for ecosystem services programs could yield many benefits, including reduced carbon emissions, increased provision of other forest-related ecosystem services, progress toward critical development goals, enhanced forest governance, and poverty reductions (Andam et al., 2010; Bluffstone et al., 2013; Economist, 2010; Senadheera et al., 2019; Sims and Alix-Garcia, 2017; Springate-Baginski and Wollenberg, 2010; Toni, 2011). As of 2014, about 64 counties were engaged in about 300 pilot REDD+ projects (Sills et al., 2014; UN-REDD, 2015) and in 2015, governments and companies committed $888 million in new funding to protecting forests and other carbon-absorbing landscapes (Goldstein and Ruef, 2016).

Two common challenges faced by payments for ecosystem services programs in general, additionality and leakage, are notable concerns with forest-based payments for ecosystem services programs (Engel et al., 2008; Joseph et al., 2013; Mohebalian and Aguilar, 2016; Salas et al., 2018). Additionality, participation in the program by individual that would not harvested the forest even without the program incentives, results in paying someone to “prevent” a forest

reduction or degradation that would not have occurred anyway. Non-additional payments waste funds that could be used to actually achieve the program's ecosystem preservation goals, and as a result decreases the efficacy of the program (Alix-Garcia et al., 2012; Balooni and Lund, 2014; Harrison and Paoli, 2012; Mohebalian and Aguilar, 2016; Salas et al., 2018).

Leakage occurs in this context when the protection of forests through the payments for ecosystem services program causes other forest areas that are not protected to be cut or degraded. For example, conserving one parcel through the program could make that parcel's owner eager to exploit another parcel or could drive up the price of exploitable forest, causing others to offer land for exploitation. This type of spillover decreases the effectiveness of the program, since the net reduction in deforestation is less than expected (Alix-Garcia et al., 2012; Balooni and Lund, 2014; Harrison and Paoli, 2012).

Both additionality and leakage mean that headline numbers of amount of forest preserved cannot be taken at face value: careful study must be done to determine the counterfactual amount of deforestation that would have occurred if the program had not been in place. While our game does not directly demonstrate leakage, it does introduce a rich context that can be used to discuss leakage and the possible solutions to leakage (Honey-Rosés et al., 2011).

Another challenge for the UN-REDD Programme and other forest conservation programs is verifiability: because the contracts are often adopted in remote areas, monitoring is difficult, so compliance and enforcement can be challenging (Engel, 2016; Engel et al., 2008; Honey-Rosés et al., 2009; Joseph et al., 2013; Sloan and Pelletier, 2012). Land protected by a contract may be secretly deforested or degraded, or a given parcel may be resold for offsets multiple times. Fortunately, detailed satellite monitoring data may mitigate these issues (Alix-Garcia et al., 2012; Gonzales, 2019; Honey-Rosés et al., 2011; Olander et al., 2008; Sloan and Pelletier, 2012).

Community forestry management has been proposed as a means to not only to halt deforestation and forest degradation but also to craft institutional mechanisms for equitable benefit sharing in communities. About 25% of developing country forests, or three times as much as is owned by the private sector, is owned by communities (Agrawal et al., 2008; Bluffstone, 2013; Bluffstone et al., 2013; Chhatre and Agrawal, 2009). Therefore, the successful adoption of forest-based payments for ecosystem services programs in developing countries depends on the effectiveness of these programs in community-controlled settings. Community-controlled forestry requires coordination between community members, but, as discussed by Ostrom (1990, 2010), Bluffstone et al. (2013), and Agrawal et al. (2008), such coordination can be challenging.

Of course, other environmental and natural resource problems have similar underlying incentive structures to tropical deforestation, and our game can be modified or even simply reframed to represent those as well. For example, fisheries are common pool resources that also provide global public goods through the relationship between the fish and their ecosystem; issues of monitoring like those we highlight in this game are notably challenging with fisheries, as are issues of collective governance. As another example, agricultural land retirement programs like the US Conservation Reserve Program and China's Sloping Land Conservation Program are payments for ecosystem services programs that struggle with additionality.

## Suggested Readings to Complement the Game

Most simply, you can distribute the Handout we provide (Appendix II) to give a brief overview of climate change, deforestation, forest-based payments for ecosystem services programs, and the UN-REDD Programme. It is a single page, double-sided, and cites many

references that participants can go to for more information. Additionally, if you are using the game in a course, your textbook likely has useful resources on many relevant topics.

Beyond that, you may want to assign academic papers on climate change (Angelsen, 2009; McKenney et al., 2004; Stavins and Richards, 2005; Stern, 2006), how deforestation affects climate change (Angelsen, 2008; Bastin et al., 2019; Griscom et al., 2017; Popkin, 2019), programs that fight deforestation (Alix-Garcia and Wolff, 2014; Andam et al., 2010; Angelsen, 2009; Angelsen et al., 2018; Bluffstone, 2013; Bluffstone et al., 2013; Duchelle et al., 2019; Economist, 2010; Lubowski and Rose, 2013; Ostrom, 2010; Senadheera et al., 2019; Sills et al., 2014; Springate-Baginski and Wollenberg, 2010; Toni, 2011; UN-REDD, 2015) or common pool resources and community management (Agrawal et al., 2008; Chhatre and Agrawal, 2009; Ostrom, 1990, 2010). Pattanayak et al. (2010) provide a comprehensive review of studies of payments for ecosystem services programs in developing countries with skeptical conclusions about their de facto effectiveness. In her Nobel Memorial Prize acceptance speech, Ostrom (2010) provides an accessible, broad overview of community governance and common property management. Another article we have found useful is the brief and accessible Jayachandran et al. (2017), which uses a randomized controlled trial to measure the efficacy of a PES program to reduce conserving forest. For short and illuminating discussions of how forest restoration can yield many benefits, including climate mitigation, the *Nature* Perspective by R. Chazdon (2019) and the *Nature* News Feature by Popkin (2019) can be useful. A longer report by the World Resources Institute (Brown, 1998) provides more details on these topics.

A discussion of issues relating the success of payments for ecosystem services programs like leakage, illegal harvest, enforcement, and governance can be very productive and introduce participants to the practical issues encountered when implementing policies. We recommend

Alix-Garcia et al. (2018), Engel (2016), Ostrom (1990), Balooni and Lund (2014), Bluffstone (2013), and Harrison and Paoli (2012). On enforcement, you can use recent relevant studies like Duchelle et al. (2014), Honey-Rosés et al. (2009), or Robinson and Lokina (2012) or link back to an older and broader literature on rational crime, going back to Becker (1968). The game also provides a good opportunity to discuss methods to evaluate success of conservation programs and to discuss impact evaluation more generally. We recommend Alix-Garcia et al. (2012), Baylis et al. (2016), Honey-Rosés et al. (2011), Olander et al. (2008), and Shah and Baylis (2015) for both the methods and the applications.

Recent journalistic articles or blog posts about issues of climate change, deforestation and forest degradation, payments for ecosystem services programs, and the UN-REDD Programme can highlight the relevance of these topics in current policy discussions; a quick internet search for news items with these keywords will let you choose a story that is fresh and relevant. Song (2019), a report by ProPublica, provides an engaging and highly accessible dive into some pitfalls involved with forest-based offsets. The website for the UN-REDD Programme (https://www.un-redd.org/) and the UN-REDD bi-monthly multi-lingual newsletter (https://www.un-redd.org/newsletter-archive) also have a wealth of additional information on a broad array of topics relating to the UN-REDD Programme. The Ecosystem Services Market Place by Forest Trends (https://www.ecosystemmarketplace.com/) has updated information on PES programs around the world.

## The Game

Participants in the game play the role of rural households in a low-income tropical country. Each household is part of a small community located in a rural area on the margin of a

forest. The community supports itself primarily through small-scale agriculture (subsistence farming)[7] and by harvesting wood and non-timber forest products such as fruits, nuts, medicinal plants, fish, game, bark, and fibers from the local forest. The game consists of a series of rounds ("contract periods"). In each round, participants make individual and/or group decisions about whether to harvest from or conserve the forest. Across the rounds, you lead participants through a series of treatments that vary the policy environment and available actions to demonstrate different concepts.

We do not duplicate here the detailed instructions and information from the materials we provide along with this paper. Instead, we discuss higher-level points about the game, describe the treatments, list the materials we provide, explain how to set up and run the game, and suggest what to do when the game is complete. (Theoretical predictions for behavior in the treatments are in the section "Leading Discussions about the Game.") In this paper, we describe the game in a narrative form and provide background to help you decide whether and how to use the game, whereas the Instructor How-To (Appendix III) provides specific steps for you to follow and the Instructions and Recording Sheet (Appendix I) is for the participants.

## Higher Level Points about the Game

This game is, at heart, a role-playing game. Participants put themselves in the role of people who live in a forest-dependent community in a developing country, and who engage in subsistence farming and harvest from the forest. They make a series of decisions as individuals and as groups regarding forest harvest and adoption of contracts to prevent deforestation.

[7] It need not be subsistence farming; while the story in this game is of small-scale deforestation by communities living near a forest and engaging in subsistence farming and harvesting, you can edit the game materials if you wish to represent a different setting such as large-scale clearing for commercial agriculture.

The game generates variation in the opportunity cost of (i.e., the value foregone by) participating in these contracts by randomly distributing numbers (we use playing cards) to represent the forest harvest values, which we will refer to as *HV* and which ranges from $0-$100. Harvest values vary in real life for many reasons, such as characteristics of the forest, the household, and the locations.

The game stipulates that the forest is commonly owned, but is so large that no-one's harvest affects anyone else through forest degradation; and indeed, the global public good nature of fighting deforestation is abstracted and only appears in the form of the contract payments that are offered from some external agent like the UN-REDD Programme, World Bank, the Green Climate Fund, or other countries and distributed through the country's Forest Department, REDD Secretariat, or other government entity. As most public good or common pool resource issues are thus removed from the game, of the pedagogical focus of the game is on incentive and monitoring issues, as well as community management.

Again, the core decision participants make in each round is whether to harvest from the forest. In most treatments, the alternative to harvesting is to adopt a payments for ecosystem services (PES) contract, which would theoretically forbid forest harvest, although in some treatments it is possible to illegally harvest while under contract. In each round, participant decisions translate into "earnings" based on this formula:

*Earnings = Farming Income + PES Payment + Forest Harvesting* – (*Policing/Fines*)

*Farming Income* comes from subsistence farming on the household's plot of land and is $70 in most treatments. The *PES Payment* is the payment for participants who accept a contract

to prevent deforestation and is $50 in most treatments.[8] *Forest Harvesting* is the amount received from harvesting from the forest: *HV* if the person harvests and $0 otherwise. Recall, as noted above, that *HV* is heterogenous across the participants and is determined randomly. *Policing/Fines* is only present when participants can illegally harvest and is the additional costs from fines or to finance policing.

We provide a spreadsheet for recording participant decisions. Based on the decisions entered, the spreadsheet automatically calculates harvest outcomes, enforcement, and fines in relevant scenarios, as well as each participant's individual outcome, and it provides a great deal of analysis you can present after the game is complete. At the end of the session, we recommend picking one or more participants to receive a money payment proportional to the sum of their earnings in all rounds; our spreadsheet has tools to help you do this. As discussed in Holt (1999), real incentives can improve attention and thus comprehension. We also suggest that you encourage participants to attend to the human stakes involved in the real-life situation that this game simulates. As one way to do this, our instructions state that if the household does not earn a minimum amount, the family is unable to eat for a day and any babies in the family will cry all night; the spreadsheet highlights participants who enter this condition, and you can call attention to that.

## Treatments

We have designed seven treatments for this game, as shown in Table 1. The materials we provide run through each of the treatments once, for seven rounds total. However, you can modify the game structure as you please, such as by repeating or cutting a treatment. For

[8] Participants should consider this a net benefit from contract adoption that comprises both the money from the payments for ecosystem services program and any additional value (e.g., labor earnings) from the time that has been freed up that would have otherwise spent harvesting from the forest.

example, you might skip the simpler early treatments if your participants are experienced. As another example, if time allows, it is fruitful to repeat the treatments in which participants interact as communities. Each treatment adds one or two features to the basic decision environment: the ability to harvest illegally, uncertainty in earnings, auction payment instead of flat payment, and community-level decision-making.

**Table 1: Game Treatments**

| Treatment | Novel Element |
|---|---|
| Baseline | Simple forest harvest decision |
| Payments for Ecosystem Services (PES) | Payment offered to not harvest |
| PES + Illegal Harvest | Ability to illegally harvest even in a contract, with a chance of getting caught |
| Harvest Uncertainty | Uncertainty in return to forest harvesting |
| Auction | PES payment and participation is based on an auction, not a fixed amount |
| Community Contract | PES contract decision is made by community, not individuals |
| Community Contract + Illegal Harvest | PES contract is made by community; individuals can illegally harvest; community can choose to monitor members to prevent illegal harvest |

We now describe each treatment. For each, we describe the treatment's setup, incentives, and major learning outcomes. We relegate theoretical predictions of behavior to the "Leading Discussions about the Game" section. The text that follows refers often to participants' harvest value (*HV*), which as we note above is a randomly-assigned value \$0-\$100.

Baseline: This is the simplest treatment. Participants choose whether to harvest from the forest and get their harvest value, or to not harvest and get no compensation. It can act as a "test run" to ensure everyone understands how the game works, and it also provides a counterfactual against which additionality can be directly measured.

Payments for Ecosystem Services (PES): In this treatment, participants choose between harvesting (and getting their harvest value) and taking the payments for ecosystem services

contract for a flat $50 payment. Illegal harvest is not possible. It provides helps establish understanding of the basics of payments for ecosystem services programs. If you run this treatment after the "Baseline" treatment, you can identify contracts that are de facto non-additional. To be additional, a household must have harvested in "Baseline" and taken a contract in "PES." Therefore, a de facto non-additional contract is a contract made in "Baseline" with a household that did not harvest in "Baseline;" that is, non-additional contracts are with ID's that harvest in neither treatment. If you do not run the "Baseline" treatment, you can identify contracts that are theoretically non-additional as those made with households that have $HV = 0$, as they have no incentive to harvest.

PES + Illegal Harvest: This treatment adds the option to harvest even if a participant has adopted a payments for ecosystem services contract. There is a probabilistic (25% likelihood) audit. Those caught taking a contract but illegally harvesting must give up their PES payment and harvest value and must pay a $70 fine. The difference between this treatment and the Baseline lets you discuss crime and deterrence; it also gives you an opportunity to discuss risk preferences and aversion to lying or cheating.

Harvest Uncertainty: In this treatment, a random force (we call it an illness in the family, but you can change that if desired) adds variance to the forest harvest without changing the mean. Changes in behavior between this treatment and Baseline let you discuss risk aversion. Also, this treatment lets you discuss the insurance role these contracts can play.

Auction: In the other treatments, contracts are allocated through a posted price contract offer with voluntary take-up; in this treatment, participation is based on a procurement auction, as in many payments for ecosystem services programs. A comparison of the allocation of contracts and earnings between this and the Baseline treatment can help participants identify

situations in which the auction would be advantageous: namely, those in which policymakers don't have good information about the potential participants' opportunity costs. You can also discuss how social preferences affect bids, as well as many topics ranging from how one can mathematically prove incentive compatibility to the nuts and bolts of auction implementation.

Community Contract: In this treatment, you will organize the participants into groups that will function as communities to make payments for ecosystem services contract participation decisions. Each community must make two decisions: whether to adopt a contract and, if so, how to divide the contract payments between the group members. It is important to emphasize this latter decision, as it is not a feature of prior treatments and groups may default to a "fair" equal division without thinking about it; if you want to nudge them on this point, you might point out that people with different cards have different benefits from a community contract. We suggest randomly assigning participants to groups.[9] You could instead sort people into rough tranches by harvest value; this shows spatial correlation in harvest value, and makes it more likely that some, but not all, communities will be well served by accepting the contract. Some value variation within a group is desirable, though, to keep things interesting. We provide no rules for how groups should interact because interesting decision-making processes can emerge endogenously. If you prefer, you can add rules. For example, you could assign some people to be local elites who get more say in decisions. This treatment lets you discuss the importance of community owned forests in many developing countries, as well as community governance and informal governance more generally. Issues of within-community inequality and power dynamics can also arise.

[9] The physical act of moving participants around the room to find community members takes time and space as compared to the case in which you use people who are already spatially adjacent as groups. (You could see physical movement as a feature, rather than a bug, though, as getting the blood going can heighten energy mid-session.)

Community Contract + Illegal Harvest: This is the most complicated and time-consuming treatment. Because it builds on the Community Contract treatment, we recommend that you run that treatment before this one. In this treatment, community decision-making determines contract adoption and sharing of contract payments, as in the last treatment; however, in addition, individuals can secretly harvest illegally even when the community has adopted a contract. In this case, the probability of an audit is not exogenous as it is in the earlier Illegal Harvest treatment: rather, it becomes more likely as more people in the community harvest illegally (as forest degradation becomes more obvious). Because of this possibility of cheating, and because any illegal harvest the government detects will cause everyone in the community to be penalized, the community can choose as a group to conduct costly self-policing, which will make illegal harvest impossible. You might want to run this treatment more than once (if you have time) for both comprehension and interpersonal interaction reasons. While this treatment is complex, in our experience, participants enjoy the opportunity to test (and sometimes violate) each other's trust. Relative to the Community Contract treatment, these complex decisions depend more on interpersonal preferences and expectations about others' behavior; as such, this treatment lets you discuss self-governance and intra-community trust issues.

## Materials We Provide

All of the materials we provide are editable, so you can customize them to your needs.

Instructions and Recording Sheet (Appendix I): This is for the participants. It explains the game setup, gives detailed specific information about how each treatment works, and provides a place for the participant to record decisions.

Handout (Appendix II): A short, reference-dense background reading for participants.

Instructor How-To (Appendix III): A step-by-step bullet-point summary for you on the mechanics of running the game, including preparation before, and steps during, the session.

Excel spreadsheet: This workbook has a guidance worksheet, a worksheet for each treatment, a summary worksheet that calculates final earnings across all rounds and creates summary tables and graphs, and a worksheet of parameters you can adjust. All columns in which you will record participant information and decisions are conveniently highlighted in yellow.

Slides: This slide deck, for optional use during the game, provides background about climate change, deforestation, and payments for ecosystem services, has a slide for each treatment summarizing key points, and ends with discussion questions.

## Setup and General Conduct

We suggest you plan for the game to take a single 75-minute period or one 50-minute period plus some time during a following session for discussion. However, you could cut treatments and relegate discussion to online or other modes of exchange to reduce the time to as little as 30 minutes in person, or you could plan detailed in-session work for before and after the game so that the whole activity takes as much as three 75-minute periods. In this section, we describe the game conduct in narrative detail, but see the Instructor How-To (Appendix III) for a detailed, action-oriented guide to running the game.

Send the Instructions and Recording Sheet (Appendix I) and any readings (such as the Handout we provide in Appendix II) to participants in advance and ask them to read them before the session. First, however, you can modify the instructions and the game to suit your needs and interests. In particular, you can pick the treatments that are most relevant to the topics of the course or training session. You may want to also modify the name of the fictional country, e.g., to be a play on a school mascot.

During the game, we use an Excel spreadsheet projected at the front of the room to record decisions and calculate earnings. Earnings calculations are complicated, especially in community rounds, so our spreadsheet is essential to make play smooth and straightforward. Before the game session, prepare the spreadsheet for your needs, reflecting any refinements you made to the game. If you want to use our slides, you may want to modify those as well.

Our instructions for running the game assume you will allow each person's decision to be known by all other players. We find that our participants enjoy seeing others' choices and that it gives the opportunity for some good-natured ribbing and social pressure, and participants sometimes discuss the role that social pressure may or may not play in these types of decisions. You may instead opt for a more sterile environment with less social influence by making decisions anonymous or more strictly enforcing simultaneity of decisions, as discussed below.

The larger (and more talkative) your group, the longer each round will take. The simpler treatments (Baseline, PES, and PES+Illegal Harvest), will be relatively fast. The treatments that introduce Harvest Uncertainty and an Auction mechanism take a bit longer. The treatments that require you to structure participants into communities (Community Contract and Community Contract+Illegal Harvest) take the longest because participants must interact with each other.

The spreadsheet we provide is configured with one each of the above-mentioned treatments by default; additional worksheet copies can be made to repeat a treatment, and if you want to skip a treatment, you can simply skip or delete a worksheet. The following hints on timing might help you choose treatments. In our experience, a 30-40 participant group can complete an abbreviated 3-round version with Contract Periods 1, 2 and 4 in 30-40 minutes with a moderate amount of discussion. You can add the treatments with community decision-making (Contract Periods 5 and 6) if you have at least 50 minutes, though it might require briefer

discussions. A 75-minute session allows you to play all six treatments, followed by a short debriefing and discussion. Additional time would allow treatments to be repeated (which would be particularly fruitful for the community decision treatments) and would make room for more in-depth discussion. Discussion and reflection can also happen outside of the session, through written assignments or online forums.

When the session starts, provide students with printed instructions and cards that will give them their harvest values. We use playing cards (ace through ten, with face cards removed and jokers retained, though you can use face cards in place of jokers) for these values. These values are not private information. Participants keep their values for the whole game. Each participant will also get an ID number that will be assigned as you record their responses in the spreadsheet; this will let you link together all decisions made by a given participant.

Before you start, you may want to emphasize a few points. First, explain how many participants will be paid and what the mode of payment will be. Second, point out that each round is independent of other rounds; for example, in each new round, they get a new Farming Income and can change their decision. Third, note the importance of committing to decisions by writing them down on the recording sheet (see Figure 1) in their instructions. Encourage them to treat this as a simultaneous game in which they cannot change their decision once they hear what their peers have done. Fourth, urge them to be ready to respond quickly when it's time to record their decisions. Finally, point out that they should not jump ahead to future rounds but should wait for the group to move forward in lock step, and that certain payoff-relevant outcomes (like whether they are audited, or what the community decides) cannot be known in advance.

| CP | Conditions | CHOOSE: Bid | CHOOSE: PES / Harvest? | CHOOSE: Illegal Harvest? | Audited? | A Farming Income | B PES Payment | C Forest Harvesting | D Policing, Fines, etc. | Earnings= A+B+C-D |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Baseline | | Harvest No | | | $70 | | $ | | $ |
| 1 | PES | | PES No | | | $70 | $ | $ | | $ |
| 2 | Illegal Harvest | | PES No | Y N | Y N | $70 | $ | $ | $ | $ |
| 3 | Uncertainty | | PES No | | | $70 | $ | $ | | $ |
| 4 | Auction | $ | PES No | | | $70 | $ | $ | | $ |
| 5 | Community | | PES No | | | $70 | $ | $ | | $ |
| 6 | Comm+Ill Hrv | | PES No | Y N | Y N | $70 | $ | $ | $ | $ |
| | | | | | | | | TOTAL | $ | $ |

Figure 1: Participant Decision Recording Sheet

Before the first round, you will record participants' harvest value cards in the enter-harv-val worksheet. Since the ID numbers exist only for recording purposes, as you collect harvest values, tell participants to record the ID numbers they have been assigned. At the start of each round, summarize the high points of the current treatment (on the board or using slides). Then give participants time to make decisions (by circling Y or N and/or writing their bid). Record choices in the yellow highlighted columns of the worksheet; for example, as shown in Figure 2, in the Baseline treatment you'll type "1" for those adopting a PES contract and leave the cell blank for those not adopting.

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ID | Harv Val | PES? | Add'l | Harvest? | Farm Inc | PES Pmnt | Frst Hrvst | Opp co | Earnings | Missed meal? |
| 2 | 1 | 1 | | | 1 | $70 | $0 | $10 | | $80 | FALSE |
| 3 | 2 | 2 | 1 | ADDL | 0 | $70 | $50 | $0 | $20 | $120 | FALSE |
| 4 | 3 | 4 | | | 1 | $70 | $0 | $40 | | $110 | FALSE |
| 5 | 4 | 5 | 1 | ADDL | 0 | $70 | $50 | $0 | $50 | $120 | FALSE |
| 6 | 5 | 6 | | | 1 | $70 | $0 | $60 | | $130 | FALSE |
| 7 | 6 | 9 | 1 | ADDL | 0 | $70 | $50 | $0 | $90 | $120 | FALSE |
| 8 | 7 | J | | | 1 | $70 | $0 | $0 | | $70 | TRUE |
| 9 | 8 | Q | 1 | NOT | 0 | $70 | $50 | $0 | | $120 | FALSE |
| 10 | 9 | K | | | 1 | $70 | $0 | $0 | | $70 | TRUE |
| 11 | 10 | 0 | 1 | NOT | 0 | $70 | $50 | $0 | | $120 | FALSE |
| 12 | 11 | 2 | | | 1 | $70 | $0 | $20 | | $90 | FALSE |
| 13 | 12 | 4 | 1 | ADDL | 0 | $70 | $50 | $0 | $40 | $120 | FALSE |

Figure 2: Excel Worksheet to Record Decisions (Payments for Ecosystem Services Treatment)

Then, in each round, go around the room and have each student verbally report her decision. Move through the room in a systematic pattern to collect their decisions (e.g., row by row). Use the ID numbers to ensure that you are putting each decision in the right row.

If you are concerned about ensuring relatively simultaneous decisions, for treatments other than the Auction, you can give each participant a green and a brown piece of paper. When it's time to announce their decisions, each holds up the green if they choose to adopt a PES contract and brown if they do not. We have not tried this, but we imagine it could yield some mirth as people try to change their decisions and peers monitor and enforce the rule that they cannot. If you further wish for decisions to be both simultaneous and anonymous, you can use an online form (e.g., Google Form) to collect decisions.

Before moving onto the next treatment, ask the participants to briefly reflect on what happened and compare the outcomes from the current treatment with the previous treatments. This can lay the groundwork for a richer discussion at the end of the game.

## After the Game

Once decision-making is complete, and before you start a deeper discussion, show the participants a big picture view of what happened during the game and how they fared, and, if possible, pay one or more participants. The "summaries" worksheet (see Figure 3, which uses fictional data) shows information broken down by participant and by round; you can project it at any time, but it is particularly useful when the game is over. It also has bar graphs that display some of the same information that is in the summary table, but the visual presentation may be easier to consume.

| | M | N | O | P | Q | R | S | T |
|---|---|---|---|---|---|---|---|---|
| 1 | | CP0 | CP1 | CP2 | CP3 | CP4 | CP5 | CP6 |
| 2 | | Baseline | PES | Illegal Harvest | Uncertainty | Auction | Community | Comm+Illegal Harvest |
| 3 | Number of households | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 4 | Number of hungry families | 8 | 2 | 2 | 5 | 2 | 4 | 0 |
| 5 | Minimum household income | $70 | $70 | $70 | $70 | $70 | $70 | $80 |
| 6 | Average household income | $81 | $106 | $118 | $105 | $110 | $100 | $121 |
| 7 | Number of parcels harvested | 6 | 6 | 9 | 6 | 6 | 6 | 9 |
| 8 | Number of PES contracts | | 6 | 6 | 6 | 6 | 6 | 6 |
| 9 | Conservation expenditures | | $300 | $300 | $300 | $240 | $300 | $300 |
| 10 | Average opportunity cost of conservation | $33 | $33 | $20 | $33 | $15 | $45 | $7 |
| 11 | Number of contracts w illegal harvesting | | | 0 | | | | 0 |
| 12 | Number of non-additional contracts | | 2 | 2 | 2 | 2 | 0 | 4 |
| 13 | Money wasted on non-add'l contracts / illegal harvest | | $100 | $100 | $100 | $100 | $0 | $200 |
| 14 | Number of additional, upheld contracts | | 4 | 4 | 4 | 4 | 6 | 2 |
| 15 | Median bid | | | | | $35 | | |
| 16 | Auction PES payment | | | | | $40 | | |
| 17 | Net social benefits (assuming $50 forest benefit) | | $167 | $180 | $167 | $185 | $255 | $93 |
| 18 | | | | | | | | |
| 19 | | **ID** | **Earnings** | | | | | |
| 20 | **Person chosen for payment** | **5** | **$10.10** | | | | | |
| 21 | **Person chosen for payment** | **6** | **$9.10** | | | | | |

Figure 3: Worksheet Summarizing Game Outcomes

We suggest that you randomly pick one or a few students to be paid. The "summaries" sheet of the Excel workbook has a built-in tool for doing this; at the bottom of Figure 3, you can see the "Person chosen for payment" cells indicates participants 7 and 9 were paid in that play of the game. We usually pay participants in cash (you can use a payment app to avoid having to

carry cash), but you could instead use extra credit (if you are playing the game with a class). Alternatives abound: for example, you could donate an amount proportional to class earnings to a land conservation charity chosen by the participants. You might be concerned about fairness in potential earnings since people who randomly got higher cards have larger potential earnings; if this is a problem for you, you could scale each participant's payment by the maximum potential earnings associated with her harvest value.

Allow the participants to keep their instructions and recording sheets. Share the completed spreadsheet with them (e.g., through a course website) after the session.

## Leading Discussions about the Game

Because this game covers many topics, discussions can be wide-ranging, and should obviously be tuned to the topics of greatest interest to you and the participants. While in the description of the treatments above we briefly noted topics that could be discussed with regard to each treatment, in this section we give more detail, first addressing brief discussions connected to each treatment and then addressing a wrap-up discussion after the game is over. When we discuss each treatment, we also note theoretical predictions for behavior, as you may want to discuss those. Of course, if you prefer to hold discussion only after all play is complete, you can do that. If you do have discussion after each treatment but you skip a simpler treatment to move on to a more complex treatment (e.g., skip "Baseline" Treatment to get to "Payments for Ecosystem Services" Treatment), you might want to look at our suggested discussion topics for the simpler one that you skipped as well as the more complex one, as we do not repeat topics that are relevant in multiple treatments. Note that we largely do not repeat citations of relevant resources here, as they are heavily cited in the Background and Suggested Readings sections.

Baseline: *Theoretical prediction:* People with $HV = 0$ will likely choose to conserve since it costs them nothing; some people with $HV > 0$ who are intrinsically motivated to conserve (or who are confused) will also conserve, but (under the assumption of rational self-interest) most will not.

*Discussion:* To illuminate why participants made the choices they did, you can invite discussion about the inherent costs and benefits of forest conservation. The costs are opportunity costs; why might opportunity costs vary across these households? If you are using the game in a class with a forestry economics module, you can link the opportunity cost in the game to forestry model parameters as well as human factors. In this treatment, the benefits of conservation are all intrinsic, since there is no extrinsic incentive. Therefore, various forms of social and non-pecuniary preferences may affect decisions, in the game as in the real-life setting it emulates. Some people may have altruistic or warm glow (Andreoni, 1995) preferences about providing public goods. Some people might have a taste for environmental conservation. Others may have an interest in maintaining a reputation or self-image, or conforming to a social norm.

Payments for Ecosystem Services: *Theoretical Prediction:* Under the assumption of rational self-interest, only those with lower harvest values should take contracts. Specifically, people with $HV < 50$ have an incentive to take the contracts, those with $HV = 50$ are indifferent between taking and not taking a contract, and those with $HV > 50$ have an incentive to not take a contract. We find the discussion about the choices of indifferent participants useful, since their behavior typically shows that if it costs nothing, people will choose the pro-social action; if you prefer to remove this indifference, you can change the PES payment to $55.

*Discussion:* First, a general discussion about payments for ecosystem services schemes and their functioning can help participants use the game to understand concepts they have

encountered in academic material and even in the news. You can ask participants to define efficiency and cost-effectiveness in this context. While this game's incentives do not directly represent forest-based public goods, you can discuss the ecosystem services provided by forests, discussing what those benefits are and at what geographic level (local, national, and global) they accrue. You can connect contract payments to these social benefits of preservation, making the point that monetizing a nonmarket commodity (environmental quality) can internalize an externality, improving efficiency. It is also fruitful to discuss the equity implications of these programs. Discussions about the costs and benefits of preserving forests can link to broader issues about forests and other common pool resources. You might also discuss the possibility that the opportunity cost of preservation is correlated with the ecosystem services a forest area provides, and what implications such a correlation would have for policy.

In discussing cost-effectiveness, you can make the point that in this context, the opportunity costs (generally defined as the value of the best option not taken) of forest preservation are effectively abatement costs (the costs of reducing emissions) for net greenhouse gas emissions. The McKinsey & Company (2009) carbon marginal abatement cost curve can be a good tool for this: you can discuss the whole range of positive and negative marginal costs, and show where avoided deforestation lies in the graph, noting that estimates of these costs have changed in the decade since that report was published. Cost-effectiveness often strikes the uninitiated as a nit-picky technical detail, so this is also an opportunity to show how consequential it can be in overall feasibility of a project and, on the other hand, how pursuit of cost-effectiveness might decrease or increase inequality.

Additionality deserves significant discussion time, since it is a difficult topic to understand (because it revolves around an invisible counterfactual) but one on which economics

offers insights. Further, it is important because it can degrade the efficacy of, and the public's faith in, environmental initiatives. This issue is not unique to forestry-based payments for ecosystem services programs; you can make parallels to applications as similar as the U.S. Conservation Reserve Program and as distant as social policies like paying kids for grades in school. We use forests owned by our own institutions as examples of preservation that is likely non-additional.

You can explore the tension between cost-effectiveness and additionality. Cost-effectiveness requires achieving a policy objective in the cheapest possible way; additionality requires that payments target actions that would not have occurred without payments. Non-additional units are, by definition, the cheapest units to enroll in a program, so an uncareful quest for cost-effectiveness could yield serious additionality failures. Additionality failures, while reducing the effectiveness of the program, don't necessarily hurt efficiency (in a Pareto sense) relative to a no-policy baseline since (again by definition) they represent a transfer that doesn't change behavior. In other words, payments to non-additional units don't distort the outcomes for those units and so don't create inefficiency in the way a classic Econ 101 subsidy might. However, such payments obviously waste money that could yield social benefits if it were used to preserve additional parcels, so efficiency is worse than a perfect-policy counterfactual.

PES + Illegal Harvest: *Theoretical Prediction:* The net gain from taking and upholding a contract is $50 - HV$, which is positive for $HV < 50$. The expected net gain (relative to no contract) from taking a contract and harvesting illegally is $0.75 * 50 + 0.25 * \left(-\left(HV\right) - 70\right) = 20 - 0.25 * HV$, which is positive for $HV < 80$. If a participant is fully self-interested and risk neutral, she will take a contract and harvest illegally if $50 - HV < 20 - 0.25 * HV$, which is true if $30 < 0.75 * HV$ or $HV > 40$. Thus, the theoretical

prediction for rational risk neutral people with purely pecuniary preferences is to take and uphold a contract for $HV < 40$, to harvest illegally for $40 < HV < 80$, and to not take a contract for $HV > 80$. The people at those thresholds will be indifferent: people with $HV = 40$ take a contract and are indifferent between harvesting illegally and not doing so, and those with $HV = 80$ are indifferent between taking a contract they violate and no contract. People who are averse to risk or to lying will need a higher minimum expected return to harvest illegally.

*Discussion:* Verifiability is challenging in offset provision in general, and in forest-based offsets in particular, and this treatment easily tees up discussions about illegal harvest and monitoring. The illegal harvest treatments also let you discuss risk and uncertainty in the context of a model of rational crime and deterrence (Becker, 1968), which is the main model economics uses for all forms of punishable offenses. You can discuss how to improve adherence to contracts; for example, you can discuss the role that satellite imagery can play in forest contract enforcement (Gonzales, 2019; Lynch et al., 2013). You can also reflect on things that would make illegal harvest and detection more complicated: for example, what if the likelihood of detecting contract violation is correlated with the ecosystem services a forest area provides?

We urge some caution when you lead discussions after the illegal harvest treatments. Because cheating can be fun in a classroom context, participants may focus a great deal of energy and attention on illegal behavior. While monitoring is important, and while you can make many interesting points about it, participants should not come away from the game thinking that low-income people in developing countries are lawbreakers. On the contrary, as highlighted by Elinor Ostrom's seminal work (see Ostrom, 2010 for a summary), communities in developing countries have a plethora of informal and formal rules, enforcement mechanisms, and governance structures for managing common pool resources and preventing exploitation of the

resources. At the same time, you will find that not everyone who has an incentive to illegally harvest does so, so this treatment also lets you talk about moral codes or an aversion to lying (Gneezy et al., 2018). You can make analogies to other contexts where these preferences may play out, including academic honesty.

Harvest Uncertainty: *Theoretical Prediction:* The theoretical prediction for risk neutral participants is to behave just as in the Baseline, but risk averse participants are predicted to become more likely to take the contract.

*Discussion:* Risk and uncertainty are important features of the settings that the game is designed to mimic. You can discuss risk preferences, and the way in which conservation contracts can act as insurance in some cases, which may be especially attractive as climate change increases the variability of conditions people are exposed to. You can discuss the role that a community could play, instead, in providing mutual insurance against these idiosyncratic shocks, and how that insurance would become less effective if shocks were more systemic as they will be as climate change progresses.

Auction: *Theoretical Prediction:* The auction mechanism is theoretically incentive compatible: the contract administrator accepts the lowest bids up to the target number of contracts, and people who get contracts are all paid the amount of the lowest bid that was not accepted. The theoretical prediction is for risk neutral bidders to place a bid equal to their cost of participation, which is their opportunity cost: *HV*, the harvest value that they'd have to forego. If cards assigning *HV* are randomly distributed with values 1-10, then in expectation, in a symmetric equilibrium with full knowledge of perfect rationality of other players, each participant will bid her *HV*, and contracts will go to participants with $HV \leq 50$ with payment \$60. Because the cards assigning *HV* have discrete values, there may be tied bids, and if there is

a tie at the median bid, for simplicity the spreadsheet will accept all of those tied bids, which might give contracts to 50% of bidders or more or less than that.

Participants might rationally shade their bids away from their true values because of their knowledge of the distribution of true values and because of guesses about how rational other participants are. Collusion among bidders to drive up the price is also theoretically possible, though we have not seen it in practice. The theoretical prediction if participants are rational is for this treatment to yield the same allocation of contracts as the Payments for Ecosystem Services treatment, except for some parcels at the margin if more or fewer than 50% of the bids are accepted, unless the realized value distribution of harvest values is quite non-uniform. Since the number of contracts is essentially fixed, any participant's bid has no effect on the amount of conservation; therefore, individual tastes for conservation theoretically will not affect bidding in this treatment. By the same token, participants who are purely altruistic will make bids that are indistinguishable from self-interested participants' bids but participants with warm glow (Andreoni, 1990) will want to be the ones with contracts so they may shade their bids down.

*Discussion:* You can discuss the ways in which procurement auctions are used in public policy, in other environmental and natural resource cases (e.g., Cummings et al., 2004 study an auction to retire water use rights) as well as many other situations in which governments buy goods and services. It's useful to compare the relative merits of an auction to a posted price market, which the other treatments use, noting that when the policymaker has as much information as in this game, the auction does not have large advantages, but when the policymaker has less information about participants' opportunity costs, it can help achieve a target at lower cost (or maximize benefit for a fixed budget). In a more theoretically-minded class, you can discuss the incentive compatibility properties of different forms of auction. In the

simplest auction in which the bidder(s) who win pay or receive their bid amount, since a person's bid determines both whether they win the auction and how much payment they will receive, there is an incentive to shade bids away from true values. In a second-price auction, the bid only determines whether the bidder wins, so for risk neutral bidders, the institution is incentive compatible.

Community Contract: *Theoretical Prediction:* The theoretical prediction for this treatment depends on the way in which groups make their participation decision. For example, if they decide by majority vote, groups with a majority of harvest values below 50 will adopt a community contract, those with a majority of harvest values above 50 will not, and those evenly split will face a dilemma. Overall expected total conservation will depend on how the people with value of 50 vote, and realized total conservation will depend on the distribution of harvest values across groups. Therefore, as compared to the Payments for Ecosystem Services treatment, total conservation may be higher or lower.

*Discussion:* This treatment can lead to a discussion of community governance and informal institutions and the conditions under which community governance tends to succeed, including the role of nonpecuniary incentives. You may want to point out that one element that frequently bedevils community management of a resource is not featured in this game: common ownership can lead to a "tragedy of the commons" as discussed in Hardin (1968), since people may not consider the fact that their use of a forest congests it for others.[10] It is also useful to discuss the possibility of power imbalances within countries: if those who depend on the forest for livelihoods do not have agency in decisions about adopting payments for ecosystem services contracts, they can be made unambiguously worse off if contract payments are captured by elites.

[10] If you refer to Hardin (1968), you should to also flag its problematic elements; see, for example, Mildenberger (2019). Ostrom (2010) is a nice counterpoint to Hardin's points as well.

You can make parallels, as well, to other non-forest-related common pool resource management problems, such as ocean fisheries, fertilizer use, and the overuse of pesticides and antibiotics. You can also discuss the mechanics, efficiency, and ethics of persuasion and negotiation.

Community Contract + Illegal Harvest: *Theoretical Prediction:* Theoretical predictions in this treatment are complicated, so we derive them in Appendix IV. In short, the prediction depends on the composition of *HV* in the group as well as risk preferences and social preferences, but all outcomes (no contract, a contract and policing, and a contract and no policing with some people harvesting illegally and some not) are possible depending on those factors.

*Discussion:* This treatment lets you continue your discussion of community governance, but it brings a crucial element of interpersonal trust to bear. You can point out the strategic uncertainty about whether others will harvest illegally, which is best categorized as ambiguity (also known as Knightian uncertainty) because the probabilities are unknown. You can also discuss other elements of trusting behavior as well as determinants of trustworthiness.

Wrap-Up Discussion: We recommend allocating some time to free-form discussion and question-asking initiated by the participants. In addition, we suggest recapping some of the crucial points from the game: opportunity cost and cost-effectiveness, additionality, verifiability, and community governance. You might also discuss leakage, which is not represented in our game but can diminish the effectiveness of forestry-based payments for ecosystem services programs. Leakage is the tendency for program enrollment of some parcels to cause increased exploitation on other unenrolled parcels, so that net conservation is less than a headline assessment of enrollment numbers would imply.

If your participants are interested in international policy, you can discuss the policy history of the UN-REDD Programme, which illustrates some interesting pitfalls with regard to

efficiency, equity, and political feasibility. Broader discussions of climate change and global climate policy are relevant. In particular, many people are extremely skeptical about forest-based offsets, either in practical terms (do they yield the climate benefits promised?), with concerns about justice and exploitation of people in developing countries, or with ethical concerns about "buying out" of the problem rather than reducing greenhouse gases at home. We encourage participants to confront these issues and to reflect on whether these are per se features of these programs or whether they can be avoided with strong policy design. Different people will come to different conclusions, and we emphasize to our participants that even if they believe that this form of offsetting is inherently problematic, the game will help them better understand the mechanics of offsets so they can better critique them.

## Student Feedback and Evidence of Pedagogical Effectiveness

We report results from our and others' experiences playing the game in environmental economics classes at liberal arts colleges and a research university, after which we performed informal surveys with students.[11] We reflect on game play from: School A, a liberal arts school, a two-section environmental economics class in spring of 2017 with 66 total students (from which we received 48 survey responses); School B, a liberal arts school, an environmental economics class in spring of 2017 with 35 students (from which we received 28 responses); and School C, a research university, a class on conservation in spring 2019 with 24 students with limited economics background (from which we received 16 responses).[12]

[11] In these plays of the game, PES was referred to as "REDD+" and illegal harvest was referred to as "fraud."
[12] The game has also been used at capacity building workshops for mid-career government officials, NGO officials, and environmental professionals in developing countries. Feedback from these sessions is available on request.

First, when asked generally whether the game was a good use of class time and whether it helped their comprehension, as shown in Table 2, nearly all students responded affirmatively.

Table 2: Participant Evaluation of Game Value

| | Was the game a good use of class time? | Did the game help you understand deforestation and how schemes like REDD+ can fight it? |
|---|---|---|
| School A | 100% | N/A |
| School B | 96% | 93% |
| School C | 94% | 88% |

Cells contain the percent of post-game survey respondents who said "Yes" to the question. "N/A" indicates that a question was not asked to that population.

At Schools A and C, we asked participants if they agreed that they understood how each of six important concepts was reflected in the game. As shown in Table 3, the majority of participants agreed that these concepts were reflected in their experience with the game, and some of the topics, like illegal harvest (which we described as "fraud" in these plays of the game), community governance, and trust and cooperation, had even stronger recognition. Some topics are naturally harder to communicate; for example, we do not find it surprising that additionality was still challenging for some participants.

Table 3: Participant Recognition of Topics in the Game

| | Percent Agreed or Strongly Agreed | |
|---|---|---|
| Topic | School A | School C |
| Additionality | 54% | 69% |
| Cost-effective abatement | 73% | 69% |
| Verifiability | 83% | 50% |
| Leakage / fraud | 98% | 71% |
| Community governance | 100% | 81% |
| Trust and cooperation (in community resource management) | 94% | 94% |

Note: Cells contain percentages of responses to the question, "Did you understand how each of these concepts were incorporated into the game?" that were "Strongly agree" or "Agree" for the named topic.

The game's success was also reflected in the answers to open-ended questions asking the students what they thought the "main takeaways" from the game were. The words "REDD",

"PES", "fraud" (which corresponds to illegal harvest), "community" and "deforestation" appeared in many student responses. Here are two example responses to that question:

> "the challenges involved in REDD programs. For example, how do you ensure that REDD will actually reduce deforestation that would have happened and how do you make sure there is no illegal logging and people who get the benefit of cutting down trees and joining REDD."

> "1. Need to consider additionality -- how much is the program actually adding compared to the baseline. 2. Need a method of verifying and encouraging participants to follow their contracts. 3. Best to have a method (like the auction) to determine individual values for the contract to increase efficiency of the program."

The instructor from School C said in a personal communication to the authors that the game helped link multiple topics covered in the class and that:

> "Both the individual decisions and the group/community decisions led to some fun conversations and many "Aha!" moments in which people realized how things fit together … And I really liked the part about identifying the additionality — I could tell that they hadn't really gotten that in my presentation of the material earlier on. Of course, I emphasize enforcement costs throughout the course — but it was fun to see who was caught and who got lucky."

## Possible Extensions and Modifications

This game provides flexibility to allow instructors to emphasize the topics and features that are most relevant to the lessons they wish to convey. The materials we share are fully editable to allow easy customization.

In the spreadsheet, you can create duplicate worksheets to repeat treatments more than once, or you can skip treatments by deleting or ignoring the relevant worksheets and deleting the relevant columns in the "summaries" worksheet. You can also modify parameters if you want to shift the incentives of the game by editing cells in the "params" sheet. For example, you can make an audit more or less likely, or the punishment for illegal harvest larger or smaller.

To fine-tune the game to issues more central to your participant group or your local area, you can reframe the context without changing incentives by simply editing the text in the

instructions. For example, instead of being rural households extracting firewood from a communal forest, you could frame the game as fishers harvesting from an open access fishery or farmers in the southwest U.S. extracting groundwater from a common groundwater reservoir. The core structure of the game applies to any situation in which a community of agents receive heterogeneous benefits from extracting some resource that also provides ecosystem service benefits to those outside the community of extractors.

You could create entirely new treatments to explore other ideas or to build up other concepts. In what follows, we list some example ideas, but as the spreadsheet and instructions are fully editable, you are only constrained by your imagination (and your Excel skills).

You can make combinations of the treatments we provide. For example, an auction mechanism or uncertain harvest return can be built into any of the other treatments.

You can create treatments that explore more elements of enforcement and penalties. You can vary parameters to show how participants change their behavior as you change the likelihood that illegal harvest is detected. You can create a peer enforcement treatment in which participants can audit and/or punish each other. (If you want an audit to be necessary to detect illegal harvest, you'll need to find a way to hide the identity of decision-makers, or you'll need to video mute the spreadsheet at strategic times.) You can make peer reporting costly or remunerative.

You can modify any of the treatments to incorporate realistic policy features; for example, you could add a government budget to the auction treatment so that bids will be accepted only up to a maximum total payout.

You can also add realism on many dimensions of the model of the economic situation. For example, the game we present assumes that there is no firewood market. If you want to demonstrate implications of market interconnections, you can introduce a perfectly competitive

firewood market and vary the price of the firewood to see how that changes harvest, either as a new treatment or as a modification of the existing treatments. If you let reduced harvest from contract adoption drive up the price of firewood, then you can directly demonstrate leakage.

The uncertainty treatment can be extended or expanded into more treatments. One possibility is to link the uncertainty to the impact of climate change on agriculture: the households' farming income could be subject to uncertainty. While this doesn't change the marginal incentive to take up a contract, if participants take the "missed meal" rule seriously, then the increased risk of crossing that threshold from a stochastic shock to farming income could make them more conservative. You can allow participants to insure each other, or to buy insurance on an insurance market. You can allow the PES payments to explicitly provide insurance in the sense of being larger in years when farming income is lower. This can feed into a discussion about uncertainty, risk, crop insurance, and climate change.[13]

You could add variation in farming income across participants to represent different gradations of wealth endowment. This could be just exogenous variation that is fixed and random, or you could have random shocks hit farming income (in the way they hit harvest value in the Uncertainty treatment), as discussed in the previous paragraph. You could also have take-up of a contract carry a reduction in farming income; the way we have framed the game is like the situation in some African and South Asian countries where a payments for ecosystem services program would prevent piecemeal harvesting of the forest for firewood use, whereas in some other settings, like Brazil, such a program would prevent clearing of the forest for agriculture. This could be just a relabeling of the foregone forest harvest earnings as foregone

[13] You can add uncertainty (a mean-preserving spread) to the return to farming by adding a "Realized Farming Income" column that differs from the "Farming Income" column by a random offset or multiplier. The shock can be created by a manual die-roll or the rand() function in Excel.

farming earnings. As currently designed, again, none of these changes affect decisions at the margin because farming income does not change the returns from contract adoption, unless participants take actions to stay above the “missed meal" threshold.

## Conclusion

Climate change and deforestation are immense global problems that are attracting increasing concern. Some of the issues that arise in fighting them can be hard to grasp. Active pedagogy can be effective in transmitting complex topics, and classroom games can help participants internalize ideas as they make decisions in scenarios that mimic the real world. In this paper, we have presented a new interactive game that can be used in a variety of classroom and training settings to explore ideas about forest management, incentive-based conservation, community decision-making, and much more through the lens of a forest-based payments for ecosystem services program. The game is flexible and fully customizable, and we provide all of the tools you need to engage your participants with these concepts. We hope you enjoy the game and find it a productive learning experience!

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**Appendix I: Instructions and Recording Sheet: "Money Growing on Trees" Instructions**

**Overview:**

You are a household in the beautiful, but low-income, tropical country of Ephoria. You live in a rural area on the margin of a forest. There used to be much more forest and many fewer people living in this area, but expansion of urban areas and agriculture over the last few decades has put a bit of a crunch on your local area (even though it is not geographically close to urban centers).

You and the members of your small, traditional community support yourselves primarily through small-scale agriculture in your garden plots (subsistence farming) and from harvesting wood and non-timber forest products such as fruits and nuts, medicinal plants, fish and game, and bark and fibers from the local forest. You use the wood you harvest from the forest for cooking and heating, but this harvest contributes to climate change and deforestation. If you don't harvest wood and materials from the forest, you either do without or buy replacement food and fuel on the market.

You were randomly given a playing card at the start of this session. The number on this card (1-10, or Joker or a face card) determines your harvest value: the benefits your family gets when you harvest from the forest. Harvest values vary for many reasons: different parts of the forest yield different harvestable goods, some households have more family members (e.g., children or aging relatives) to support, and some households have better access to other opportunities to earn income, for example. If you got a number card, then your value for harvesting is usually $10 times the number on your card. If you got a Joker or a face card, then your value for harvesting is $0. Note the forest is commonly owned, but is so large that your harvest doesn't affect that of your community members right now, and vice versa.

To fight deforestation and raise revenue, policymakers in your country have decided to experiment with payments for ecosystem service (PES) schemes through an internationally-financed program. Local households and/or communities will make contracts with the program's administrators. Then people or firms outside the country, typically in developed countries, will "buy" units of avoided deforestation from Ephoria to offset their greenhouse gas emissions.

In this session, we will play through contract periods of several different situations. In each period, you must make a decision: usually, whether to enter into a PES contract, which will prohibit you from harvesting wood the forest. You may have another decision to make as well. You will have earnings that will depend on your choices, in some cases the choices of other households, and in some cases on chance. However, if your earnings are not at least $75 in a period, then you and your family are unable to eat for a day, which means that any babies in the family will cry all night and your life will be pretty unpleasant.

At the end of the session, we will pick one or more participants who will earn actual money equal to the sum of their earnings in all rounds divided by $100. Since real money is on the line, you should play close attention and be sure to make the decisions that you really want to make!

**Your earnings:**

In each contract period, your earnings are:

Earnings = Farming Income + PES Payment + Forest Harvesting – (Policing or Fines)

Farming Income: this comes from your subsistence farming on the plot of land in your yard. Except when otherwise noted, this is $70.

PES Payment: if you enter into a contract, you get a PES (payments for ecosystem services) payment. Except when otherwise noted, this is $50. You can think of this as including both the money from the PES contract and any additional value (e.g., labor earnings) you get from the time that has been freed up that you would have otherwise spent harvesting from the forest.

Forest Harvesting: if you enter into a PES contract, you agree not to harvest wood from the forest. If you don't enter into a PES contract, except as noted, you earn an amount from harvesting equal to $10 times your the number on your card or $0 if you got a Joker or face card.

(Policing or Fines): these do not apply in periods in which illegal harvest is impossible. When illegal harvest is possible, you may incur additional costs from fines or to finance policing.

**Contract Period 0: Baseline**

Earnings and decisions are as described above but PES contracts are not available. Your decision is simply to harvest wood or not.

**Contract Period 1: Payments for Ecosystem Services (PES)**

Earnings and decisions are exactly as described above. If you decide to enter into a PES contract, you must not harvest wood. (All PES parcels are audited and monitored to ensure zero harvesting; this is true in all contract periods except as otherwise noted.)

**Contract Period 2: PES + Illegal Harvest**

Everything is as in Baseline except that you can enter into a PES contract and then harvest wood anyway. Each parcel in a PES contract will be audited with a 25% likelihood. If you are audited and found to be harvesting, you will not receive your PES payment and you will have to give up your harvest, and you will also be fined $70.

**Contract Period 3: Harvest Uncertainty**

There is a disease going around your community this year, so some people will by bad luck be incapacitated and unable to harvest! Each household that tries to harvest has a 50% chance of getting $20 times the number on their card and a 50% chance of getting $0. The plague will strike after you have decided whether to participate in the PES program. Otherwise the period proceeds like Baseline.

**Contract Period 4: Auction**

Instead of declaring whether to enter into a PES contract at a fixed price, you will instead declare the price at which you would be willing to enter into a PES contract. The lowest 50% of the bids will be given PES contracts, and they will be paid an amount equal to the lowest bid that was *not* accepted. The households with higher bids will not have PES contracts and may instead harvest wood from the forest.

**Contract Period 5: Community Contract**

You will be randomly grouped into one of six small communities. As a group, you must discuss and decide whether to enter your community's forest into a PES contract, at a payment rate of $50 per household. You must figure out amongst yourself how to decide (e.g., majority vote, consensus, etc.) and, if you enter into a contract, how to divide the PES payments among yourselves. If a community enters into a PES contract, *no-one* in the community can harvest wood from the forest.

**Contract Period 6: Community Contract + Illegal Harvest**

You will be in the same community as before and again decide collectively on whether to enter into a PES contract and, if so, how to share PES payments. But individual households in the group can now break their contract promise: they can secretly harvest from the forest even though their community has entered into a PES contract.

The community can collectively choose to police itself. If it does, each household pays $5 and all member households will be monitored by trustworthy locals. This monitoring prevents illegal harvest because potential illegal harvesters are totally deterred from entering the forest. If the community does not police itself, there is a chance it will be audited by the government body overseeing the PES project. The audit likelihood increases by 10% for each person in the community who illegally harvests (starting from 0% if there is no illegal harvest), because more harvest makes it easier to detect. Note that auditing happens at the community level: an entire community is either audited or not. If it is audited and *any* illegal harvest is found, no-one in the community will get PES payments or harvest value (harvested wood must be returned), and *each* member of the community will be fined $70.

So the order of actions for this contract period is:

1. Community decision: Join the PES program or not?
2. If adopt the PES contract: Community decision: Engage in policing or not?
3. If no policing: Household decision: Conduct illegal harvesting or not?
4. Government action: each *community* that adopted a PES contract and is unpoliced is audited with probability 10% times number of people committing harvesting illegally

**"Money Growing on Trees" Recording Sheet**

**Name:**_____

My playing card (1-10 or J, Q, or K for joker or face card): _____

My ID number (1 to # participants) from spreadsheet: _____

My decisions and my earnings (fill in the table below as the contract periods progress):

| CP | Conditions | CHOOSE: Bid | CHOOSE: PES / Harvest? (circle one for each row) | CHOOSE: Illegal Harvest? | Audited? | A Farming Income | B PES Payment | C Forest Harvesting | D Policing, Fines, etc. | Earnings= A+B+C-D |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Baseline | | Harvest No | | | $70 | | $ | | $ |
| 1 | PES | | PES No | | | $70 | $ | $ | | $ |
| 2 | Illegal Harvest | | PES No | Y N | Y N | $70 | $ | $ | $ | $ |
| 3 | Uncertainty | | PES No | | | $70 | $ | $ | | $ |
| 4 | Auction | $ | PES No | | | $70 | $ | $ | | $ |
| 5 | Community | | PES No | | | $70 | $ | $ | | $ |
| 6 | Comm + Ill Hrv | | PES No | Y N | Y N | $70 | $ | $ | $ | $ |
| | | | | | | | | TOTAL | $ | $ |

(Reminder: if in some round you illegally harvest, are audited, and are fined, cross out your B and C columns for that round – their values are zero if you are caught cheating on a contract!)

**Appendix II: "Money Growing on Trees" Background: Global Deforestation & Payments for Ecosystem Services**

Over 50% of global forests have been converted to human use since the advent of agriculture (MEA, 2005) and the world has lost 178 million hectares of forests since 1990 (FAO 2020). Tropical forest area is decreasing at over 10 million hectares per year, with much of the deforestation occurring in developing countries (Bluffstone et al., 2013; MEA, 2005; Pan et al., 2011, FAO 2020). Forest degradation accounts for about 11% of annual greenhouse gas emissions (IPCC, 2014; Saatchi et al., 2011; Van der Werf et al., 2009).

Restoring forests and preventing forest degradation can help fight climate change. The 2015 Paris climate accord committed signatories to limit "the increase in the global average temperature to well below 2°C above preindustrial levels" and counted countries' efforts to offset their emissions by planting or protecting forests toward emission reduction targets (Griscom et al., 2017; Popkin, 2019). Bastin et al. (2019) find "there is room for an extra 0.8 billion hectares of canopy cover, which would store 205 gigatonnes of carbon," which is about twenty times global annual carbon emissions in 2010 (IPCC, 2014). Curbing deforestation and forest degradation is believed to be a very cost-effective way to address climate change and also support adaptation (Angelsen, 2009; McKenney et al., 2004; McKinsey & Company, 2009; Stavins and Richards, 2005; Stern, 2006).

The United Nation's Framework Convention on Climate Change (UNFCCC) proposed a payment for ecosystem service program, Reducing Emissions from Deforestation and forest Degradation (REDD+), to pay for reduced deforestation and forest degradation with funds from a global carbon market. While the program as initially envisioned never came to fruition due to the lack of a global carbon market, the efforts contributed to the created of the UN-REDD Programme, a joint effort between UNEP, UNDP, and FAO to reduce deforestation and forest degradation (UNFCCC, 2011, Angelson et al. 2018, Duchelle 2019). There are similar bilateral and multilateral efforts funded by the Green Climate Fund, the World Bank and other countries and entities focused on creating markets to reduce deforestation. Many of these programs are examples of payments for ecosystem services (PES), an incentive-based approach to environmental regulation that is a key part of the policy toolkit for goals like watershed management, reducing deforestation, species preservation, and managing non-point source pollution (Engel, 2016; Engel et al., 2008; Wunder, 2005).

PES programs use a market to connect the receivers of an ecosystem service (a benefit generated by an ecosystem, often public goods like improved air and water quality) to the providers of that service. Global forest-based PES programs create a market for net reductions in greenhouse gas emissions by linking providers of carbon sequestration with countries or entities that are required, or voluntarily choose, to reduce emissions (FAO 2020, Goldstein and Ruef 2016). These programs provide incentives for some countries to release less, and sequester more, carbon and for countries that are required to reduce emissions to fund these efforts by purchasing credits (Baker et al., 2019; Bluffstone, 2013; Bluffstone et al., 2013; Rakatama et al., 2017).

Forest-based PES programs may create an opportunity to increase investment in forest management. This investment can bring many benefits, including achieving critical development goals, enhancing forest governance, bolstering global conservation efforts, reducing carbon emissions and deforestation, and contributing to poverty reduction, particularly in communities that manage forests (Andam et al. 2010; Bluffstone et al., 2013; Economist, 2010; Sims and Alix-Garcia, 2017; Senadheera et al., 2019; Springate-Baginski and Wollenberg, 2010; Toni, 2011). As of 2014, about 64 counties were engaged in conducting about 300 pilot forest preservation projects through REDD+ alone (Sills et al., 2014; UN-REDD, 2015) and in 2015, governments and companies committed $888 million in new funding for protecting forests and other carbon-absorbing landscapes (Goldstein and Ruef 2016).

Community forestry management has generally been considered a successful means to not only to halt deforestation and forest degradation but also to craft institutional mechanisms for equitable benefit sharing in communities. About 25% of forest area in developing country is owned by communities, and this is about three times as much as is owned by the private sector (Agrawal et al., 2008; Bluffstone, 2013; Bluffstone et al., 2013; Chhatre and Agrawal, 2009). Therefore, the successful adoption of forest-based PES in developing countries depends on the effectiveness of these programs in community-controlled settings. Community-controlled forestry requires coordination between community members, but, as discussed by Ostrom (1990, 2010), Bluffstone et al. (2013), and Agrawal et al. (2008), such coordination can be challenging.

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**Appendix III: "Money Growing on Trees" Instructor How-To:**

Before session:

- Prepare the spreadsheet:
  - Delete data if necessary
  - If desired, add or delete contract periods by pasting copies of worksheets or deleting worksheets respectively
    - You don't have to delete worksheets for contract periods you will not run, but if you don't, they might confuse the participants if you share the spreadsheet with them later.
    - If you add or delete contract periods, update the "summaries" worksheet to sum only, and all of, the contract periods that will actually be run.
  - If you want to change any parameters, do so in the "params" worksheet.
  - Decide in advance how you plan to assign participants to communities (if you plan to use the treatments with community decision-making).
- Ensure that Excel on the computer that you will use to project the spreadsheet during the session is set to automatically perform calculations.[1]
- If desired, modify our slides to customize them to your needs. However, if you use slides, you'll have to switch the projector back and forth between the spreadsheet and the slides. Alternately, instead of slides, you can write information on the board.
- If possible, send the instructions and any desired reading materials to participants.
- If you want to make decisions anonymous:
  - Prepare some way to assign ID numbers anonymously to participants, e.g. shuffle numbered notecards and hand them out randomly in class
  - Prepare a Google Form in which participants can submit their ID number and decision for each round; you can use a different form for each round, or use a single form and then either include round number as a thing they would enter or simply rely on the timestamp to differentiate rounds.
  - Note: the rest of this document will assume you will use non-anonymous verbal decisions; if you choose the anonymous Google Form, your decision recording will consist of opening the Google Sheet associated with the Google Form, sorting the decisions for that round by ID number, and pasting the IDs and decisions into the recording spreadsheet.

[1] On a PC:
- 2003: Tools > Options > Calculation > Calculation > Automatic.
- 2007: Office button > Excel options > Formulas > Workbook Calculation > Automatic.
- 2010 and 2013: File > Options > Formulas > Workbook Calculation > Automatic.

On a Mac:
- 2008: Excel Preferences > Calculation > Automatically.

Bring to session:

- If you plan to pay one or more participants their earnings: money (in one dollar bills, up to $10 per payee if possible; you could include change but people rarely mind rounding up); alternately, you can use a payment app. We prefer payment to happen right away at the end of the session so everyone can see that it really happens.
- Playing cards. A full deck well shuffled would work; you want to ensure that about 5-20% of the cards are either jokers or face cards.
- Printed instructions, one for each participant (or, if they will be in teams, for each team).
- If desired, printed background handouts, though we prefer to distribute them in advance.

In the session: (note we suggest some discussion topics in relevant places; more detail is in our accompanying paper)

- On the computer that will be projected, open the spreadsheet (and, if desired, the slides).
- Distribute to each person or team:
    - Instructions
    - A playing card (don't let them look through the deck to choose their own card, but once they have their card they need not keep it hidden)
- Tell players to read the instructions and record their card numbers on the recording sheet on the last page.
- We find it useful to give background about the context before playing the game. The slide deck we provide does this. The basic points we make sure to hit are:
    - Climate change is a problem.
    - We can fight it by reducing sources or increasing sinks.
    - Some entities (e.g., firms or countries) are regulated in a way that forces them to reduce their emissions or are self-regulating (voluntarily reducing emissions without being forced to do so).
        - They can do it directly by cutting down on activities that create emissions (sources); for example, they can reduce their energy use.
        - Alternatively, they can cut emissions indirectly by paying a non-regulated entity to reduce an emissions source or increase a sink. This is an offset.
    - Deforestation is a significant source of net greenhouse gas emissions, and afforestation and forest management may have a large potential to increase sinkage of greenhouse gases.
    - People across the world have been working for a while to generate forest-based offsets to integrate into climate change regulation systems.
    - These are often PES systems: since the preserved forest is providing ecosystem services that are a global public good, the PES system monetizes those benefits, i.e., it internalizes the externality to incentivize optimal conservation (if the payment is of the right size).

  - They reduce deforestation as compared to some baseline; here, the baseline is an expectation that that the forest area the offset corresponds to would be cut down if the offset had not been created.
  - An example is the UN-REDD Programme
- Next, summarize basic information about the game:
  - You're rural households.
  - You do subsistence farming and exploit the local forest to support your family.
  - Your forest exploitation can hurt the forest, which is bad because the forest provides global public goods, including carbon sequestration.
  - Let's see how a payment for environmental services scheme can change your choices about whether to harvest from the forest.
  - Your earnings in a contract period come from:
    - Farming Income – subsistence (usually $70).
    - Forest Harvesting – if you harvest from the forest, you get a harvest value of $10*your playing card number (or 0 for jokers and face cards).
    - PES Payment – payment for being in a PES contract (usually $50).
    - (Policing or Fines) – in treatments where there can be illegal harvest, you may lose money to police your community or as fines for cheating.
- As you record information and decisions from the participants, it is useful to project your progress on the screen so participants can correct any mistakes you make.
- Enter participants' Harvest Values in the spreadsheet, and have them record their ID numbers:
  - Project the spreadsheet on the screen and go to the "enter-harv-val" worksheet
  - Go around the room and have each participant call out their card number (Harvest Value), recording them in the yellow "Harv Val" column.
  - As you do, participants must record the ID number this process assigns them.
  - Make this process brisk (each person calls out their number right away when you get to them and you type it quickly), and proceed around the room in an order you can replicate each time (e.g., go across one row then the next, etc.).
  - Record J, Q, K, or 0 for jokers and face cards – any of these works, and the spreadsheet is not case sensitive.
- Next, you are ready to start your first contract period. Skip up to the bullet point with the contract period you will start with. First, some general thoughts:
  - Even if you are projecting slides with detailed instructions, it's often helpful to also write basic information on the board because eventually you will return to projecting the spreadsheet and you need participants to remember the rules.
  - When you record decisions, in most cases, they are binary (yes or no) decisions. Be sure to ask the question in an unambiguous way that can be answered with just the word "yes" or the word "no," and ask it in such a way that their "yes" always corresponds to you typing "1" – this will make recording much faster.

  - After you have collected all decisions, let people check their earnings against the "Earnings" column in the spreadsheet (you may have to zoom and scroll).
  - If desired, after a round you can navigate to the "summaries" worksheet to show the summary table. Alternatively, you can wait to do this at the end of the game.
  - We recommend you keep the spreadsheet projected at all times throughout the game (except when you are showing slides if you choose to do so). Each contract period has its own worksheet that you'll be working in and projecting.
- Contract Period 0: Baseline
  - Write on the board: "No PES payment; decision: harvest or no"
  - On their Recording Sheets, participants must circle their choice (Harvest or No) and fill out the resulting earnings.
  - Go around the room and have each participant call out their harvest decision, and record them in the yellow "Harvest?" column.
  - Key things to discuss:
    - Each household's marginal abatement cost in this context is an opportunity cost: the foregone benefits from forest exploitation.
    - Likely, almost everyone, except people with jokers and face cards, chose to harvest because they have positive abatement costs; this establishes a baseline amount of conservation.
    - If anyone diverges from this, you can interrogate that deviation; it might be a result of confusion (which gives you the opportunity to clear that up) or of something like a desire to conserve (which is fruitful to discuss).
- Contract Period 1: Payments for Ecosystem Services (PES)
  - Write on the board: $50 PES payment, no illegal harvest
  - On their Recording Sheets, participants must circle their choice (PES or No) and fill out the resulting earnings.
  - Go around and have each participant call out their decision (to adopt PES or not), and record them in the yellow "PES?" column. Note the "Yes" in this round has an inverse meaning compared to the last round ("Yes" in CP0 means "yes, I will harvest" and in CP1 means "no, I won't harvest, I will take a PES contract").
  - Key things to discuss after round is complete:
    - Same as those listed under Contract Period 0, plus…
    - Cost effective conservation minimizes costs of reaching a given amount of conservation.
    - If the regulator knew everyone's costs, they could choose parcels to conserve to minimize costs. Since they don't, but households know their own costs, this system lets households opt in based on private information.
    - Additionality:
      - De facto: if you ran CP0, anyone who did not harvest in CP0 but took a contract in CP1 is non-additional

        - Theoretical: any household with a joker or face card that took a PES contract (which all should have) is non-additional
- Contract Period 2: PES + Illegal Harvest
    - Write on the board: $50 PES payment, illegal harvest possible. 25% chance of audit. If caught, lose: PES payment, harvest earnings, AND $70 fine
    - On their Recording Sheets, each participant must circle their choices: (PES or No) and Illegal Harvest (Y or N). They cannot yet record their earnings until you announce the audit outcomes (unless they didn't harvest illegally).
    - Go around and have each participant call out their contract adoption decision, and record them in the yellow "REDD+?" column; if they took a contract they must also tell you whether they harvest. If they take a PES contract and harvest (illegally), type "1" in the yellow "Harvest?" column to override the formula.
    - Once you have recorded all of the decisions, determine who is audited. The randomizer re-runs each time you type anywhere in the worksheet; you can just use the audits that were determined when you typed the last decision, but we like to run it one more time to add drama (e.g., double-click in a cell then hit enter).
        - To make it stop re-randomizing, select the "Audit?" column, copy it, and paste its *values* (using Paste Special) on top of the existing cells.
    - When you show the outcomes, explicitly identify which illegal harvesters were audited.
    - Key things to discuss:
        - Verifiability: explain why it's hard to verify forest-based offsets and how that can undermine an offset system.
        - Rational crime theories: back to Becker (1968), economists have not used complicated psychology to explain why people commit crimes, but have just assumed people weigh the costs and benefits of so doing.
- Conservation Period 3: Harvest Uncertainty
    - Write on the board: $50 PES payment, no illegal harvest; harvest value has 50% chance of being 20x card and 50% chance of 0
    - On their Recording Sheets, participants must circle their choice (PES or No). If they harvest, they can't write their earnings yet because they don't know if they will have a shock.
    - Go around and have each participant call out their PES decision, and record them in the yellow "PES?" column.
    - Once you have recorded the decisions, determine who will receive shocks. The randomizer re-runs each time you type in the worksheet; you can just use the set of shocks that were determined when you typed the last decision, but we like to run it one more time to add drama (e.g., double-click in a cell then hit enter).
        - To make it stop re-randomizing, select the "Shock?" column, copy it, and paste its *values* (using Paste Special) on top of the existing cells.

    - When you show the outcomes, explicitly identify who got shocks.
    - Key things to discuss:
        - How did people make their decisions? Was it just based on expected value? Did anyone change their decision versus the baseline round?
- Conservation Period 4: Auction
    - Write on board: auction! Write down dollar bid. Lowest 50% of bids are accepted and receive a PES payment equal to the lowest not-accepted bid
        - This is hard to understand, so use a picture: write a vertical list of (an even number of) bids, ordered from highest to lowest.
        - Draw a line at the median.
        - All bids below the median line are accepted ("win").
        - The bid just above the median is the *lowest bid not accepted*; the amount of this bid is the PES payment for everyone who won the auction.
    - On their Recording Sheets, participants must write down their bids. They can't yet fill out the resulting earnings because they don't know if they won the auction.
    - Go around and have each participant call out their bid, and record them in the yellow "Bid" column.
    - Go to the "summaries" worksheet, where the summary block shows, in the column for the auction treatment, the median bid and the auction payment. Remind participants that everyone who bid BELOW the median bid wins the auction and thus has a PES contract, and everyone else harvests.
    - Key things to discuss:
        - If we know all the opportunity costs, we can design a flat payment and an auction to conserve the same amount of land. Both will be cost effective.
        - But if don't know the distribution of opportunity costs, the auction should reveal those values and thus achieve the desired conservation target.
        - Auction theory: second price auctions are incentive compatible. This is because if your bid determines both *whether you win* and *what you pay*, you shade your bid down; in this kind of auction, your bid just determines *whether* you win so you have an incentive to bid your true value.
- Contract Period 5: Community
    - Write on board: Community
        - 1. Decide as community (5 minutes to talk):
            - a) whether to be in a PES contract
            - b) how to divide up payments if so
    - Emphasize that PES participation is "all or nothing" within a community: all community members are in a contract, or none are.
    - Defining communities:
        - The blue "Comm #" column has community numbers in it.

        - You can use the pre-populated community numbers, which create 6-person communities, though the last community will be a residual so may be much smaller. Alternatively, you can change community numbers by typing new numbers or formulae in the blue column: count people off (count 1-2-3… etc. and then tell all the 1's to get together, all the 2's, etc.), use a different random number generator (with "rand()" or "randbetween()"), or whatever you choose.
        - The default structure may create groups of people who are mostly already sitting near each other because they are adjacent ID's; it might be more fun to mix it up a bit.
        - If you change the community numbers, sort the spreadsheet by community number (the blue column) to make it easier to enter group decisions.
    - Once communities are defined, people need to gather with their communities.
    - Give them up to 5 minutes with their groups to decide whether to take a PES contract and, if so, how to allocate the PES payments across the members.
        - Let each community decide how the group is to make its decision.
        - They record their decision by circling PES or No on their Recording Sheets, and by each writing the appropriate amount in the PES payment column. They can calculate their final payments right away.
    - Go around and have each group call out their contract adoption decision (record in the "REDD+?" column) and, if they took a contract, how they decided to divide up payments (if the payments are not equal, override the automatically populated "PES Pmnt" column amount by typing the amount each household is to receive).
    - Key things to discuss:
        - Often, individual contracts between the PES authorities and households are not feasible because of high transaction costs or because many forests are community owned or managed, so this configuration is more realistic.
        - The literature on community governance (e.g., Ostrom), shows that sometimes it works well and sometimes not! Why might that be?
        - Equity and power within community can determine whether these contracts are taken and who benefits and loses out.
- Contract Period 6: Community + Illegal Harvest – this is the most complicated treatment, and takes the longest to run. You should run CP5 first so they get the hang of working with their groups. You might want to play this treatment at least twice if you have time!
    - Write on board: community + illegal harvest!
        - 1. Decide as community (3 minutes to talk):
            - a) whether to be in a PES contract
            - b) how to divide up payments if so

        - 2. If they adopt PES, decide as a group whether to police themselves (at $5/household). If they do police themselves, illegal harvest becomes impossible.
        - 3. If they adopt PES and do not police themselves, each household privately decides whether to harvest.
        - 4. Government audits each community that accepted a PES contract and that doesn't police itself with probability 10% times the number of people who harvest illegally. If they detect any illegal harvest, the PES contract invalidated (everyone loses the PES payment and any harvest they got) plus the whole community is fined (at $70 per community member).
    - Note that participation in PES is all or nothing within a community, but the illegal harvest decision is at the household level.
        - If your groups are going to be particularly large or small, you might want to change that 10% value by which illegal harvest increases audit likelihood to be smaller or larger respectively. You can do this in the "params" worksheet; it's the parameter "community per-illegal harvester audit probability increment"
    - Use the same communities as you used in CP5.
        - If you have more than 20 communities, go to the "params" worksheet to add higher "Comm #" values to the block there to get audit outcomes.
    - Give participants up to 3 minutes with their groups to discuss and make decisions.
        - Let each community decide how the group is to make its decision.
        - They record their decision by circling PES or No on their Recording Sheets, and by each writing the appropriate amount in the PES payment column. If they took a PES contract and decided to police themselves, they can write $5 in the "Policing, Fines, etc." cell.
        - They can calculate final earnings right away if they did not take a PES contract or if they took a contract and policed themselves. Otherwise, wait.
        - Groups that took a PES contract but did not police themselves should have everyone record their Illegal Harvest (Y or N) decision in private (e.g., walk away from the group to decide, then fold the paper to hide their decision).
    - Go around and have each group call out:
        - Their PES decision (record in the "REDD+?" column)
        - If they took a contract
            - How they decided to divide up payments (if the payments are not equal, override the automatically populated "PES Pmnt" column amount by typing the amount each household is to receive)
            - Whether they policed themselves

            - If they did not police themselves, ask each community member whether they harvested illegally. This part can get fun.
    - Once you have recorded all of the decisions, determine who is audited. The randomizer re-runs each time you type anywhere in the worksheet; you can just use the audits that were determined when you typed the last decision, but we like to run it one more time to add drama (e.g., double-click in a cell then hit enter).
        - To make it stop re-randomizing, select the "Audit?" column, copy it, and paste its *values* (using Paste Special) on top of the existing cells.
    - Key things to discuss:
        - Community and peer enforcement: people may have motives for and against enforcing rules in their own neighborhoods.
- Pick participants for payment
    - Go to the "summaries" worksheet, and find the orange block for payments.
    - Two IDs will already have been selected randomly as the randomizer reruns each time anything is typed in the workbook.
        - Again, you can use the last-generated random values, or build suspense by typing elsewhere in the sheet.
        - To make it stop re-randomizing, select the "ID" cells in the orange block, copy, and paste *values* (using Paste Special) on top of the existing cells.
        - If you want to pay more than two people or teams, you can copy and paste the cells we have provided as many times as you like.
- Review the summary table and graphs, and discuss further!

**Appendix IV: Theoretical Predictions for Community Contract + Illegal Harvest Treatment**

Let us define $f_{oth}$ as the number of people other than one's-self who engage in illegal harvest

Then the sequence of actions is as follows:

- Group chooses:
  - PES No → everyone CHANGE IN EARNINGS: HV
  - PES Yes → Group chooses:
    - Police No → Individuals each choose:
      - Illegal Harvest No → Nature chooses
        - Prob $0.1f_{oth}$ → audited → CHANGE IN EARNINGS: -70
        - Prob $1-0.1f_{oth}$ → not audited → EARNINGS: 50
      - Illegal Harvest Yes
        - Prob $0.1(f_{oth}+1)$ → audited → CHANGE IN EARNINGS: -70
        - Prob $1-0.1(f_{oth}+1)$ → not audited → EARNINGS: 50 + HV
    - Police Yes → everyone CHANGE IN EARNINGS: 50-5 = 45

We will now backwards induct from the perspective of a risk neutral person.

If the group chooses to take a PES contract and not police, do they engage in illegal harvest? If we assume that people who are indifferent do not harvest illegally, then a person only engages in illegal harvest if:

$$0.1(f_{oth}+1)(-70)+\left(1-0.1(f_{oth}+1)\right)(50+HV)>0.1f_{oth}(-70)+(1-0.1f_{oth})50$$

Simplifying:

$$0.1(-70)+(-0.1)(50)+\left(1-0.1(f_{oth}+1)\right)HV>0$$

Simplifying further:

$$\left(1-0.1(f_{oth}+1)\right)HV>7+5$$

Which we can solve to: $HV>\dfrac{12}{1-0.1(f_{oth}+1)}$

The greater is $f_{oth}$, the smaller the denominator and thus the higher the threshold harvest value for engaging in illegal harvest. If $f_{oth} = 0$, this value is 12/0.9 = 13.33. In other words, in the range 0-100, only people with harvest values of 0 or 10 would uphold the contract if they thought no-one else was illegally harvesting. As another example, if a person thinks five people in their group are illegally harvesting, the threshold is 30. Therefore, the equilibrium prediction of the number of people engaging in illegal harvest depends on the distribution of harvest values in the group. If a group of six participants has a random draw of values ranging from 0-100 (but discretely constructed as integers times ten), then we expect a 2/3 chance of each "tens" value appearing; thus it's overwhelmingly likely that there will be some, and in fact quite a bit of, illegal harvest. The rate of illegal harvest can be solved for, but we refrain from doing so because it is not deeply predictive: any given group's set of *HV* draws may vary quite a bit, and, further, risk averse and pro-social people will be less inclined to engage in illegal harvest for a given *HV* and $f_{oth}$.

If we make a benchmark guess of 50% illegal harvest, then the likelihood of audit in a six-person group is 30%, so a PES contract without policing yields an expected payoff for illegal harvesters of:

$$0.3(-70) + 0.7(50 + HV) = 14 + 0.7HV$$

And for those not engaging in illegal harvest of:

$$0.3(-70) + 0.7(50) = 14$$

Now, given that, if a group chooses a PES contract, will they choose to police? If they do, then everyone earns 45. If we take the same 30% audit rate (50% illegal harvest rate) as given, then the expected payoff for any harvest value is never as high as the certain payoff from having a PES contract and policing it. Thus, in this case, everyone should opt for policing the contract.

They will be less likely to do so if they trust each other more, and more likely to do so if they are risk averse.

Given that, will groups choose to accept a PES contract? If they do, under the baseline inference that PES contracts will be policed, everyone earns 45. If they do not, everyone earns their harvest value. Thus, group decisions should be the same as in the Community Contract treatment without illegal harvest except that people with harvest value of 50 will cease to be indifference and will prefer to not take the contract.