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 a market-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 the United Nations REDD+ program to refrain from harvesting from a local forest. The game explores topics including: payments for ecosystem services programs; climate change; tropical deforestation; cost-effectiveness; additionality; contract fraud 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, REDD+, market-based regulation

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

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Introduction

Payments for ecosystem services (PES) programs are market-based (i.e., 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). However, key concepts about them 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, and in trainings for policymakers and researchers.

Deforestation and forest degradation are extensive worldwide. 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). 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. The United Nations Framework Convention on Climate Change (UNFCCC) established the Reduced Emissions from Deforestation and Forest Degradation (REDD, which later became REDD+; we give some policy history in the Background section) Programme as framework to support a global program to fight deforestation and forest degradation using payments for ecosystem services. While in some cases large-scale conversion of forests to agriculture is the primary cause of deforestation, in other cases deforestation and forest

degradation happen as communities living in or near forests harvest firewood and other material, largely because of economic pressures. Our game depicts this more diffuse form of deforestation and forest degradation, and the potentials and pitfalls associated with REDD+ in such a context.

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 decide whether to enter into REDD+ 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, contract fraud, auditing, and enforcement; community governance and common pool resource management; and the challenges facing rural households in developing countries.[1] While we present the game in the context of REDD+, it could be adapted to other settings in which payments for ecosystem services programs interact with 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

[1] 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. Good games to explore common pool resource issues include Hazlett (1997) and Zetland (2017), and good games to study public good provision include Holt and Laury (1997) and Pickhardt (2005).

depending on which treatments and extensions you use. We also 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 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 training 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, REDD+, and Forest Conservation in Developing Countries

Globally, deforestation and forest degradation are significant issues. 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. The number of people in Africa using biomass for these purposes is projected to increase in the next decade from 793 million in 2014 to 823 million in 2030, after which it should start decreasing, but slowly: it is only projected to drop to 708 million by 2040 (Bluffstone, 2013; Chao, 2012; OECD, 2017).

The resulting deforestation and forest degradation has direct implications for climate change:[2] over the past 150 years, deforestation and forest degradation has caused an estimated 30% of the atmospheric build-up of CO_2 (Brown, 1998). Current deforestation and forest degradation accounts for 11–24% 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).[3] Further, fuelwood use and timber harvesting are unsustainable in many developing counties (Bailis et al., 2015; Damette and

[2] 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).

[3] Deforestation and forest degradation can be defined and measured in many ways, and estimates of their impacts on climate change vary widely. We choose the endpoints of our range from IPCC (2014), which estimates that forest degradation and deforestation directly cause 11% of greenhouse gas emissions, but attributes 24% of greenhouse gas emissions to the broader category of AFLU (agriculture, forestry, and land use).

Delacote, 2011).[4] 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 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."

What policies can leverage forests to fight climate change? REDD+ is a payments for ecosystem services (PES) system created under the United Nation's Framework Convention on Climate Change (UNFCCC) to reduce deforestation and forest degradation.[5] REDD+ seeks to increase investment in forest management by creating a market for ecosystem services that links providers of carbon sequestration (typically landowners and farmers in tropical countries) with beneficiaries and buyers in developed countries (Baker et al., 2019; Bluffstone, 2013; Bluffstone et al., 2013; Rakatama et al., 2017). Because REDD+ provides payments to those who provide forest-based ecosystem services, and those ecosystem service providers can voluntarily choose

[4] 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 reclassifed (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).

[5] REDD+ builds 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 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 REDD program, and REDD+.

whether to enter into REDD+ agreements, and further the program makes efforts to ensure that contracts are associated with meaningful reductions relative to reference levels, REDD+ functions as a payments for ecosystem services program.

The original program was called REDD, an acronym for Reduced Emissions from Deforestation and forest Degradation. It focused only on carbon sequestration and allowed no forest use. The program was revised to REDD+ (pronounced "REDD plus"), which allowed sustainable forest management and encouraged conservation of forests, with a goal of enhancement of carbon sinks. The "+" in REDD+ stands for other co-benefits added to the original REDD program to address potentially negative, unintended effects on non-carbon ecosystem services and mitigate the program's effects on the people who currently have claims to forests (Baker et al., 2019; Bluffstone, 2013; Bluffstone et al., 2013; Rakatama et al., 2017). A new iteration, REDD++, adds a focus on low-carbon but high-biodiversity land.

The program effectively provides financial incentives to release less, and sequester more, greenhouse gas emissions. By so doing, the program 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 (Bluffstone et al., 2013; Economist, 2010; 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).

Two common challenges faced by payments for ecosystem services programs in general, additionality and leakage, are notable concerns with regard to REDD+ (Engel et al., 2008; Joseph et al., 2013; 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; Salas et al., 2018). Additionality is a tricky concept to learn, but our game demonstrates it clearly.

Leakage occurs in this context when the protection of forests through REDD+ causes other forest areas that are not protected to be cut or degraded. For example, conserving one parcel in REDD+ 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 REDD+, 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 REDD+ and related programs is verifiability: because REDD+ 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 REDD+ contract may be secretly deforested or degraded, or a given parcel may be resold for offsets multiple times. New statistical techniques with detailed satellite monitoring data may improve enforcement; such use

is still largely theoretical (Alix-Garcia et al., 2012; Honey-Rosés et al., 2011; Olander et al., 2008; Sloan and Pelletier, 2012), but it is starting to enter forestry practice (Gonzales, 2019).

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 REDD+ in developing countries depends on the effectiveness of REDD+ 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, and REDD+. 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), deforestation and climate change (Angelsen, 2008; Bastin et al., 2019; Griscom et al., 2017; Popkin, 2019), programs like REDD+ that fight deforestation (Angelsen, 2009; Bluffstone, 2013; Bluffstone et al., 2013; Economist, 2010; Lubowski and Rose, 2013; Ostrom, 2010; 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 REDD+ program in 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 Engel (2016), Ostrom (1990), Balooni and Lund (2014), Bluffstone (2013), and Harrison and

Paoli (2012). On enforcement, you can use recent relevant studies like Honey-Rosés et al. (2009), 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 global warming, deforestation and forest degradation, general payments for ecosystem services programs, and REDD+ can highlight the relevance of these programs 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+ program (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 REDD+.

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 in households' garden plots (subsistence farming)[6] and by harvesting wood and non-timber forest products such

[6] It need not be subsistence farming; you can edit the game materials if you wish to represent another form of agriculture.

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 you 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.

The game generates variation in opportunity cost of 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 REDD+ payments that are offered from some external agent through the country's REDD+ Secretariat. As most public good or common pool resource issues are thus removed from the game, most 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 REDD+ contract, which would theoretically forbid forest harvest, although in some treatments it is possible to commit fraud by harvesting 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 take a REDD+ contract to prevent deforestation and is $50 in most treatments.[7] *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 engage in fraud 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

[7] Participants should consider this a net benefit from contract adoption that comprises both the money from REDD+ 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.

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 help students 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. 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 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 commit contract fraud, uncertainty in earnings, auction payment instead of flat payment, and community-level decision-making.

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.

No REDD+: 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 provides a good "test run" to ensure everyone understands how the game works, and it also provides a counterfactual against which additionality can be directly measured.

Baseline: In this treatment, participants choose between harvesting (and getting their harvest value) and taking the REDD+ contract for a flat $50 payment. Fraud is not possible. It provides a good baseline to establish understanding of the basics of payments for ecosystem services programs. If you run this treatment after the "No REDD+" treatment, you can identify contracts that are de facto non-additional. To be additional, a household must have harvested in "No REDD+" and taken a REDD+ contract in "Baseline." Therefore, a de facto non-additional contract is a contract made in "Baseline" with a household that did not harvest in "No REDD+;" that is, non-additional contracts are with ID's that harvest in neither treatment. If you do not run the "No REDD+" 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.

Baseline + Fraud: This treatment adds the option to harvest even if a participant has adopted a REDD+ contract. There is a probabilistic (25% likelihood) audit. Those caught committing fraud (taking a contract but harvesting) must give up their REDD+ 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 a plague of locusts, but you can change that if you change the setting) 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, REDD+ 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 REDD+ 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.[8] 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 taking a REDD+ contract. Some value variation within a group is desirable, though, to keep things interesting. We provide no rules for how groups should

[8] 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.)

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.

Community Contract + Fraud: 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 commit fraud by harvesting even when the community has a REDD+ contract. In this case, the probability of an audit is not exogenous as it is in the earlier Fraud treatment: rather, it becomes more likely as more people in the community commit fraud (as forest degradation becomes more obvious). Because of this possibility of cheating, and because any fraud 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 fraud 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 REDD+, 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.

The larger (and more talkative) your group, the longer each round will take. The simpler treatments (No REDD+, Baseline, and Baseline+Fraud), 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+Fraud) 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: REDD+ / Harvest?	CHOOSE: Fraud?	Audited?	A Farming Income	B PES Payment	C Forest Harvesting	D Policing, Fines, etc.	Earnings= A+B+C-D
0	No REDD+		Harvest No			$70		$		$
1	Baseline		REDD+ No			$70	$	$		$
2	Fraud		REDD+ No	Y N	Y N	$70	$	$	$	$
3	Uncertainty		REDD+ No			$70	$	$		$
4	Auction	$	REDD+ No			$70	$	$		$
5	Community		REDD+ No			$70	$	$		$
6	Comm + Fraud		REDD+ No	Y N	Y N	$70	$	$	$	$
								TOTAL	$	$

Figure 1: Participant Decision Recording Sheet

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).

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. In each round, 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 REDD+ and leave the cell blank for those not adopting.

	A	B	C	D	E	F	G	H	I	J
1	ID	Harv Val	REDD+?	Add'l	Harvest?	Farm Inc	PES Pmnt	Frst Hrvst	Earnings	Missed meal?
2	1	J	1	NOT	0	$70	$50	$0	$120	FALSE
3	2	2			1	$70	$0	$20	$90	FALSE
4	3	4	1	ADDL	0	$70	$50	$0	$120	FALSE
5	4	6			1	$70	$0	$60	$130	FALSE
6	5	9	1	ADDL	0	$70	$50	$0	$120	FALSE
7	6	2			1	$70	$0	$20	$90	FALSE
8	7	4	1	ADDL	0	$70	$50	$0	$120	FALSE
9	8	1			1	$70	$0	$10	$80	FALSE
10	9	Q	1	ADDL	0	$70	$50	$0	$120	FALSE
11	10	9			1	$70	$0	$90	$160	FALSE
12	11	4	1	ADDL	0	$70	$50	$0	$120	FALSE
13	12	7			1	$70	$0	$70	$140	FALSE
14	13	3	1	ADDL	0	$70	$50	$0	$120	FALSE

Figure 2: Excel Worksheet to Record Decisions (Baseline 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 REDD+ 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.

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-No REDD+	CP1-Baseline	CP2-Fraud	CP3-Uncertainty	CP4-Auction	CP5-Community	CP6-Comm+Fraud
2	Number of households	12	12	12	12	12	12	12
3	Number of hungry families	8	2	2	5	2	4	3
4	Minimum household income	$ 70.00	$ 70.00	$ 70.00	$ 70.00	$ 70.00	$ 70.00	$ -
5	Average household income	$ 80.83	$ 105.83	$ 117.50	$ 96.67	$ 110.00	$ 100.00	$ 87.50
6	Number of parcels harvested	6	6	9	6	6	6	9
7	Number of REDD+ contracts		6	6	6	6	6	6
8	Conservation expenditures		$300	$300	$300	$240	$300	$150
9	Average opportunity cost of conservation	$33	$33	$20	$33	$15	$45	$7
10	Number of fraudulent contracts			3				3
11	Number of non-additional contracts		2	2	2	2	0	4
12	Money wasted on non-add'l / fraud contracts		$100	$200	$100	$100	$0	$250
13	Number of additional, non-fraud contracts		4	2	4	4	6	1
14	Median bid					$35		
15	Auction REDD+ payment					$40		
16	Net social benefits (assuming $50 forest benefit)		$167	$80	$167	$185	$255	$43
17								
18		**ID**	**Earnings**					
19	**Person chosen for payment**	**7**	**$5.90**					
20	**Person chosen for payment**	**9**	**$6.30**					

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 will 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 will 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 "No REDD+" to get to "Baseline"), 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.

No REDD+: *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 might 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.

Baseline: *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 REDD+ 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 REDD+ 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 link the opportunity costs of forest preservation to the concept of abatement costs. 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 clarity. 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 REDD+; 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.

Baseline + Fraud: *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 committing fraud 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 commit fraud 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 commit fraud 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 committing fraud and not doing so, and those with $HV = 80$

are indifferent between a fraudulent contract and no contract. People who are averse to risk or to lying will need a higher minimum expected return to commit fraud.

Discussion: Verifiability is challengin in offset provision in general, and in forest-based offsets in particular, and this treatment easily tees up discussions about contract fraud and monitoring. The fraud 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 now for all forms of crime and response to regulation. 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 fraud 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 fraud treatments. Because cheating can be fun in a classroom context, participants may focus a great deal of energy and attention on fraud. 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 fraudsters. 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 fraud. At the same time, you will find that not everyone who has an incentive to commit fraud 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 for risk averse it is to become more likely to take the REDD+ contract.

Discussion: Risk and uncertainty are important features of this game and 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 Baseline treatment, except for some parcels at the margin if more or fewer than 50% of the bids are accepted, unless the realized value distribution 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 has no 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 kind of 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 upward. 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 Baseline 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.[9] 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 REDD+ contracts, they can be made unambiguously worse off if REDD+ payments are captured by elites. 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 + Fraud: *Theoretical Prediction:* Theoretical predictions in this treatment are complicated, so we derive them in Appendix IV. In short, the prediction depends

[9] 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.

on the composition of *HV* in the group as well as risk preferences and social preferences, but all outcomes (no contract, a REDD+ contract and policing, and a REDD+ contract and no policing with some people committing fraud 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 commit fraud, 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 a program like REDD+. 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 REDD+, 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. 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).[10]

First, when asked generally whether the game was a good use of class time and whether it helped their comprehension, as shown in Table 1, nearly all students responded affirmatively.

Table 1: 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.

[10] 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.

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 2, the majority of participants agreed that these concepts were reflected in their experience with the game, and some of the topics (like fraud, 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 2: 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", "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 fraud 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 fraud behavior as you change the likelihood that fraud 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 fraud, 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 REDD+ 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 REDD+ payments to explicitly provide insurance in the sense of being larger in years when farming income is lower. This feeds into a discussion about uncertainty, risk, crop-insurance, and climate change into the game.[11]

You could add variation in farming income 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 REDD+ 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 REDD+ would prevent piecemeal harvesting of the forest for firewood use, whereas in some other settings, like Brazil, REDD+ would prevent clearing of the forest for agriculture. This could be just a relabeling of the foregone forest harvest earnings as foregone 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.

[11] For example, if you want to show how the REDD+ payments can act as insurance, you can add uncertainty (a mean-preserving spread) to the return to farming. You can do this 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.

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 the United Nations REDD+ anti-deforestation 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!

References

Agrawal, A., Chhatre, A., Hardin, R., 2008. Changing governance of the world's forests. Science, 320(5882), 1460-1462.

Alix-Garcia, J.M., Shapiro, E.N., Sims, K.R.E., 2012. Forest conservation and slippage: Evidence from Mexico's national payments for ecosystem services program. Land Economics, 88(4), 613-638.

Andreoni, J., 1990. Impure Altruism and Donations to Public Goods: A Theory of Warm-Glow Giving. The Economic Journal, 100(401), 464-477.

Andreoni, J., 1995. Warm-Glow versus Cold-Prickle: The Effects of Positive and Negative Framing on Cooperation in Experiments. Quarterly Journal of Economics, 110(1), 1-21.

Angelsen, A., 2008, Moving ahead with REDD: issues, options and implications. Cifor.

Angelsen, A., 2009, Realising REDD+: National strategy and policy options. Cifor.

Bailis, R., Drigo, R., Ghilardi, A., Masera, O., 2015. The carbon footprint of traditional woodfuels. Nature Climate Change, 5(3), 266-272.

Baker, K., Baylis, K., Bull, G.Q., Barichello, R., 2019. Are non-market values important to smallholders' afforestation decisions? A psychometric segmentation and its implications for afforestation programs. Forest Policy and Economics, 100, 1-13.

Balooni, K., Lund, J.F., 2014. Forest rights: the hard currency of REDD+. Conservation Letters, 7(3), 278-284.

Bastin, J.-F., Finegold, Y., Garcia, C., Mollicone, D., Rezende, M., Routh, D., Zohner, C.M., Crowther, T.W., 2019. The global tree restoration potential. Science, 365(6448), 76-79.

Baylis, K., Honey-Rosés, J., Börner, J., Corbera, E., Ezzine-de-Blas, D., Ferraro, P.J., Lapeyre, R., Persson, U.M., Pfaff, A., Wunder, S., 2016. Mainstreaming impact evaluation in nature conservation. Conservation Letters, 9(1), 58-64.

Becker, G.S., 1968. Crime and Punishment: An Economic Approach. The Journal of Political Economy, 76(2), 169-217.

Bluffstone, R., 2013. Economics of REDD+ and community forestry. Journal of Forest and Livelihood.

Bluffstone, R., Robinson, E., Guthiga, P., 2013. REDD+ and community-controlled forests in low-income countries: Any hope for a linkage? Ecological economics, 87, 43-52.

Brauman, K.A., Daily, G.C., Duarte, T.K.e., Mooney, H.A., 2007. The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services. Annual Review of Environment and Resources, 32(1), 67-98.

Brown, P., 1998. Climate, biodiversity, and forests. World Resources Institute, Washington, DC.

Chao, S., 2012, Forest peoples: numbers across the world. Forest Peoples Programme Moreton-in-Marsh.

Chhatre, A., Agrawal, A., 2009. Trade-offs and synergies between carbon storage and livelihood benefits from forest commons. Proceedings of the national Academy of sciences, 106(42), 17667-17670.

Cummings, R.G., Holt, C.A., Laury, S.K., 2004. Using laboratory experiments for policymaking: An example from the Georgia irrigation reduction auction. Journal of Policy Analysis and Management, 23(2), 341-363.

Damette, O., Delacote, P., 2011. Unsustainable timber harvesting, deforestation and the role of certification. Ecological Economics, 70(6), 1211-1219.

Durham, Y., McKinnon, T., Schulman, C., 2007. Classroom experiments: Not just fun and games. Economic Inquiry, 45(1), 162-178.
Economist, 2010, Keeping it in the Community. The Economics.
Engel, S., 2016. The devil in the detail: A practical guide on designing payments for environmental services. International Review of Environmental and Resource Economics, 9(1–2), 131-177.
Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: An overview of the issues. Ecological economics, 65(4), 663-674.
Gneezy, U., Kajackaite, A., Sobel, J., 2018. Lying Aversion and the Size of the Lie. American Economic Review, 108(2), 419-453.
Gonzales, J., 2019, How a sheriff in Brazil is using satellites to stop deforestation. Mongabay.
Griscom, B.W., Adams, J., Ellis, P.W., Houghton, R.A., Lomax, G., Miteva, D.A., Schlesinger, W.H., Shoch, D., Siikamäki, J.V., Smith, P., 2017. Natural climate solutions. Proceedings of the national Academy of sciences, 114(44), 11645-11650.
Haddad, N.M., Brudvig, L.A., Clobert, J., Davies, K.F., Gonzalez, A., Holt, R.D., Lovejoy, T.E., Sexton, J.O., Austin, M.P., Collins, C.D., Cook, W.M., Damschen, E.I., Ewers, R.M., Foster, B.L., Jenkins, C.N., King, A.J., Laurance, W.F., Levey, D.J., Margules, C.R., Melbourne, B.A., Nicholls, A.O., Orrock, J.L., Xong, D.-X., Townshend, J.R., 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. Science Advances, 1(2), e1500052.
Hardin, G., 1968. The Tragedy of the Commons. Science, 162(3859), 1243-1248.
Harrison, M.E., Paoli, G.D., 2012. Managing the risk of biodiversity leakage from prioritising REDD+ in the most carbon-rich forests: the case study of peat-swamp forests in Kalimantan, Indonesia. Tropical Conservation Science, 5(4), 426-433.
Hazlett, D., 1997. A common property experiment with a renewable resource. Economic Inquiry, 35(4), 858-861.
Holt, C.A., 1999. Teaching Economics with Classroom Experiments: A Symposium. Southern Economic Journal, 65(3), 603-610.
Holt, C.A., Laury, S.K., 1997. Classroom games: Voluntary provision of a public good. Journal of Economic Perspectives, 11(4), 209-215.
Honey-Rosés, J., López-García, J., Rendón-Salinas, E., Peralta-Higuera, A., Galindo-Leal, C., 2009. To pay or not to pay? Monitoring performance and enforcing conditionality when paying for forest conservation in Mexico. Environmental Conservation, 36(2), 120-128.
Honey-Rosés, J., Baylis, K., Ramirez, M.I., 2011. A spatially explicit estimate of avoided forest loss. Conservation biology, 25(5), 1032-1043.
IPCC, 2014. IPCC, 2014: climate change 2014: synthesis report. Contribution of Working Groups I. II and III to the Fifth Assessment Report of the intergovernmental panel on Climate Change. IPCC, Geneva, Switzerland, 151.
Jayachandran, S., De Laat, J., Lambin, E.F., Stanton, C.Y., Audy, R., Thomas, N.E., 2017. Cash for carbon: A randomized trial of payments for ecosystem services to reduce deforestation. Science, 357(6348), 267-273.
Joseph, S., Herold, M., Sunderlin, W.D., Verchot, L.V., 2013. REDD+ readiness: early insights on monitoring, reporting and verification systems of project developers. Environmental Research Letters, 8(3), 034038.
Lubowski, R.N., Rose, S.K., 2013. The Potential for REDD+: Key Economic Modeling Insights and Issues. Review of Environmental Economics and Policy, 7(1), 67-90.

Lynch, J., Maslin, M., Balzter, H., Sweeting, M., 2013. Choose satellites to monitor deforestation. Nature, 496(7445), 293-294.
McKenney, D.W., Yemshanov, D., Fox, G., Ramlal, E., 2004. Cost estimates for carbon sequestration from fast growing poplar plantations in Canada. Forest Policy and Economics, 6(3-4), 345-358.
McKinsey & Company, 2009. Pathways to a low-carbon economy: Version 2 of the global greenhouse gas abatement cost curve.
Mildenberger, M., 2019, The Tragedy of *The Tragedy of the Commons*. Scientific American Voices Blog, https://blogs.scientificamerican.com/voices/the-tragedy-of-the-tragedy-of-the-commons/.
Millennium Ecosystem Assessment, 2005, Millennium Ecosystem Assessment General Synthesis Report: Ecosystems and Human Well-being. Millennium Ecosystem Assessment.
OECD, I.E.A., 2017. World Energy Outlook – Special Report on Energy Access. World Energy Outlook.
Olander, L.P., Gibbs, H.K., Steininger, M., Swenson, J.J., Murray, B.C., 2008. Reference scenarios for deforestation and forest degradation in support of REDD: a review of data and methods. Environmental Research Letters, 3(2), 025011.
Ostrom, E., 1990, Governing the commons: The evolution of institutions for collective action. Cambridge university press.
Ostrom, E., 2010. Beyond markets and states: polycentric governance of complex economic systems. American economic review, 100(3), 641-672.
Pan, Y., Birdsey, R.A., Fang, J., Houghton, R., Kauppi, P.E., Kurz, W.A., Phillips, O.L., Shvidenko, A., Lewis, S.L., Canadell, J.G., 2011. A large and persistent carbon sink in the world's forests. Science, 333(6045), 988-993.
Pattanayak, S.K., Wunder, S., Ferraro, P.J., 2010. Show Me the Money: Do Payments Supply Environmental Services in Developing Countries? Review of Environmental Economics and Policy, 4(2), 254-274.
Pearson, T.R., Brown, S., Murray, L., Sidman, G., 2017. Greenhouse gas emissions from tropical forest degradation: an underestimated source. Carbon balance and management, 12(1), 3.
Pickhardt, M., 2005. Teaching public goods theory with a classroom game. The Journal of Economic Education, 36(2), 145-159.
Popkin, G., 2019, How much can forests fight climate change. Nature, pp. 280-282.
R. Chazdon, P.B., 2019, Restoring forests as a means to many ends. Science, pp. 24-25.
Rakatama, A., Pandit, R., Ma, C., Iftekhar, S., 2017. The costs and benefits of REDD+: A review of the literature. Forest Policy and Economics, 75, 103-111.
Saatchi, S.S., Harris, N.L., Brown, S., Lefsky, M., Mitchard, E.T.A., Salas, W., Zutta, B.R., Buermann, W., Lewis, S.L., Hagen, S., 2011. Benchmark map of forest carbon stocks in tropical regions across three continents. Proceedings of the national Academy of sciences, 108(24), 9899-9904.
Salas, P.C., Roe, B.E., Sohngen, B., 2018. Additionality when redd contracts must be self-enforcing. Environmental and resource economics, 69(1), 195-215.
Schoene, D., Netto, M., 2005. The Kyoto Protocol: what does it mean for forests and forestry? UNASYLVA-FAO-, 56(3), 3.
Shah, P., Baylis, K., 2015. Evaluating heterogeneous conservation effects of forest protection in Indonesia. PloS one, 10(6), e0124872.

Sills, E.O., Atmadja, S.S., de Sassi, C., Duchelle, A.E., Kweka, D.L., Resosudarmo, I.A.P., Sunderlin, W.D., 2014, REDD+ on the ground: A case book of subnational initiatives across the globe. Cifor.

Sims, K.R.E., Alix-Garcia, J.M., 2017. Parks versus PES: Evaluating direct and incentive-based land conservation in Mexico. Journal of Environmental Economics and Management, 86, 8-28.

Sloan, S., Pelletier, J., 2012. How accurately may we project tropical forest-cover change? A validation of a forward-looking baseline for REDD. Global Environmental Change, 22(2), 440-453.

Song, L., 2019. An (Even More) Inconvenient Truth: Why Carbon Credits for Forest Preservation May Be Worse than Nothing, ProPublica.

Springate-Baginski, O., Wollenberg, E., 2010, REDD, forest governance and rural livelihoods: the emerging agenda. CIFOR.

Stavins, R.N., Richards, K.R., 2005. The cost of U. S. forest-based carbon sequestration. Pew Center on Global Climate Change. 52, 52.

Stern, 2006. Stern Review: The economics of climate change. London, England: HM Treasury.

Sukhdev, P., Wittmer, H., Schröter-Schlaack, C., Nesshöver, C., Bishop, J., ten Brink, P., Gundimeda, H., Kumar, P., Simmons, B., 2010, The economics of ecosystems and biodiversity: mainstreaming the economics of nature: a synthesis of the approach, conclusions and recommendations of TEEB. TEEB.

Toni, F., 2011. Decentralization and REDD+ in Brazil. Forests, 2(1), 66-85.

UN-REDD, 2015. Regions and Countries Overview, http://www.unredd.net/index.php?option=com_unregions&view=overview&Itemid=495#.

Van der Werf, G.R., Morton, D.C., DeFries, R.S., Olivier, J.G.J., Kasibhatla, P.S., Jackson, R.B., Collatz, G.J., Randerson, J.T., 2009. CO 2 emissions from forest loss. Nature geoscience, 2(11), 737.

Wunder, S., 2005. Payments for environmental services: some nuts and bolts.

Zetland, D., 2017. Teaching Common-Pool Resource Management. Available at SSRN 2906697.

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 the UN's REDD+ program. Local households and/or communities will make contracts with the country's REDD+ Secretariat. 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 REDD+ situations. In each period, you must make a decision: usually, whether to enter into a REDD+ 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 REDD+ contract, you get a PES (payments for ecosystem services) payment from the REDD+ market. Except when otherwise noted, this is $50. You can think of this as including both the money from REDD+ 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 REDD+ contract, you agree not to harvest wood from the forest. If you don't enter into a REDD+ 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 fraud is impossible. When fraud is possible, you may incur additional costs from fines or to finance policing.

Contract Period 0: No REDD+

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

Contract Period 1: Baseline

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

Contract Period 2: Baseline + Fraud

Everything is as in Baseline except that you can commit fraud by entering into a REDD+ contract and then harvesting wood anyway. Each parcel in a REDD+ contract will be audited with a 25% likelihood. If you are audited and found to be harvesting, you will not receive your REDD+ 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 plague of locusts this year, so the forest is very rich in some areas but terrible in others! 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 REDD+. Otherwise the period proceeds like Baseline.

Contract Period 4: Auction

Instead of declaring whether to enter into a REDD+ contract at a fixed price, you will instead declare the price at which you would be willing to enter into a REDD+ contract. The lowest 50% of the bids will be given REDD+ 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 REDD+ 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 REDD+ 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 REDD+ payments among yourselves. If a community enters into a REDD+ contract, *no-one* in the community can harvest wood from the forest.

Contract Period 6: Community Contract + Fraud

You will be in the same community as before and again decide collectively on whether to enter into a REDD+ contract and, if so, how to share REDD+ payments. But individual households in the group can now commit fraud: they can secretly harvest from the forest even though their community has entered into a REDD+ 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 fraudsters are totally deterred from entering the forest. If the community does not police itself, there is a chance it will be audited by the REDD+ Secretariat. The audit likelihood increases by 10% for each person in the community who commits fraud (starting from 0% if there is no fraud), 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* fraud is found, no-one in the community will get REDD+ 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 REDD+ or not?
2. If REDD+: Community decision: Engage in policing or not?
3. If no policing: Household decision: Conduct fraud or not?
4. Government action: each unpoliced REDD+ *community* audited with probability 10% times number of people committing fraud

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

(Reminder: if in some round you commit fraud, 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, PES, & REDD+

Over 50% of global forests have been converted to human use since the advent of modern agricultural practices (Millennium Ecosystem Assessment, 2005). 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; Millennium Ecosystem Assessment, 2005; Pan et al., 2011). Forest degradation accounts for 11–24% of annual greenhouse gas emissions (IPCC, 2014; Saatchi et al., 2011; Van der Werf et al., 2009).

Restoring forests and preventing forest degradation can be a vital part of reducing greenhouse gas emissions. The 2015 Paris climate accord committed to limit "the increase in the global average temperature to well below 2°C above preindustrial levels" and counted (toward emission reduction targets) countries' efforts to offset their emissions by planting or protecting forests (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." Curbing deforestation and forest degradation is also 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 UN's Reducing Emissions from Deforestation and forest Degradation (REDD+) program serves this purpose. REDD+ is a payment for ecosystem services (PES) system created under the UN's Framework Convention on Climate Change (UNFCCC, 2011). PES programs are market-based (a.k.a., incentive-based) approaches to environmental regulation and are 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).

Flavors of REDD

REDD:

- Focus only on carbon sequestration; allows no forest use

REDD+ (or REDD plus):

- Sustainable forest management
- Conservation of forests
- Enhancement of carbon sinks

REDD++:

- Low-carbon but high biodiversity lands

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. REDD+ creates a market for net reductions in greenhouse gas emissions by linking providers of carbon sequestration with countries that are required by the UNFCCC (or otherwise committing) to reduce emissions. The program provides 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). The '+' in REDD+ signifies other co-benefits that have been added to the original REDD program (which was focused solely on carbon) to address potentially negative, unintended effects on non-carbon ecosystem services and mitigate the program's effects on the people who currently have claims to forests (Bluffstone, 2013; Bluffstone et al., 2013; Sims and Alix-Garcia, 2017).

REDD+ is expected to 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 (Bluffstone et al., 2013; Economist, 2010; Sims and Alix-Garcia, 2017; Springate-Baginski and Wollenberg, 2010; Toni, 2011). As of 2014, about 64 counties were engaged in conducting about 300 pilot REDD+ projects (Sills et al., 2014; UN-REDD, 2015).

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 REDD+ in developing countries depends on the effectiveness of REDD+ 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.

References

Agrawal, A., Chhatre, A., Hardin, R., 2008. Changing governance of the world's forests. Science, 320(5882), 1460-1462.

Angelsen, A., 2009, Realising REDD+: National strategy and policy options. Cifor.

Baker, K., Baylis, K., Bull, G.Q., Barichello, R., 2019. Are non-market values important to smallholders' afforestation decisions? A psychometric segmentation and its implications for afforestation programs. Forest Policy and Economics, 100, 1-13.

Bastin, J.-F., Finegold, Y., Garcia, C., Mollicone, D., Rezende, M., Routh, D., Zohner, C.M., Crowther, T.W., 2019. The global tree restoration potential. Science, 365(6448), 76-79.

Bluffstone, R., 2013. Economics of REDD+ and community forestry. Journal of Forest and Livelihood.

Bluffstone, R., Robinson, E., Guthiga, P., 2013. REDD+ and community-controlled forests in low-income countries: Any hope for a linkage? Ecological economics, 87, 43-52.

Chhatre, A., Agrawal, A., 2009. Trade-offs and synergies between carbon storage and livelihood benefits from forest commons. Proceedings of the national Academy of sciences, 106(42), 17667-17670.

Economist, 2010, Keeping it in the Community. The Economics.

Engel, S., 2016. The devil in the detail: a practical guide on designing payments for environmental services. International Review of Environmental and Resource Economics, 9(1–2), 131-177.

Engel, S., Pagiola, S., Wunder, S., 2008. Designing payments for environmental services in theory and practice: An overview of the issues. Ecological economics, 65(4), 663-674.

Griscom, B.W., Adams, J., Ellis, P.W., Houghton, R.A., Lomax, G., Miteva, D.A., Schlesinger, W.H., Shoch, D., Siikamäki, J.V., Smith, P., 2017. Natural climate solutions. Proceedings of the national Academy of sciences, 114(44), 11645-11650.

IPCC, 2014. IPCC, 2014: climate change 2014: synthesis report. Contribution of Working Groups I. II and III to the Fifth Assessment Report of the intergovernmental panel on Climate Change. IPCC, Geneva, Switzerland, 151.

McKenney, D.W., Yemshanov, D., Fox, G., Ramlal, E., 2004. Cost estimates for carbon sequestration from fast growing poplar plantations in Canada. Forest Policy and Economics, 6(3-4), 345-358.

McKinsey & Company, 2009. Pathways to a low-carbon economy: Version 2 of the global greenhouse gas abatement cost curve.

Millennium Ecosystem Assessment, 2005, Millennium Ecosystem Assessment General Synthesis Report: Ecosystems and Human Well-being. Millennium Ecosystem Assessment.

Ostrom, E., 1990, Governing the commons: The evolution of institutions for collective action. Cambridge university press.

Ostrom, E., 2010. Beyond markets and states: polycentric governance of complex economic systems. American economic review, 100(3), 641-672.

Pan, Y., Birdsey, R.A., Fang, J., Houghton, R., Kauppi, P.E., Kurz, W.A., Phillips, O.L., Shvidenko, A., Lewis, S.L., Canadell, J.G., 2011. A large and persistent carbon sink in the world's forests. Science, 333(6045), 988-993.

Popkin, G., 2019, How much can forests fight climate change. Nature, pp. 280-282.

Rakatama, A., Pandit, R., Ma, C., Iftekhar, S., 2017. The costs and benefits of REDD+: A review of the literature. Forest Policy and Economics, 75, 103-111.

Saatchi, S.S., Harris, N.L., Brown, S., Lefsky, M., Mitchard, E.T.A., Salas, W., Zutta, B.R., Buermann, W., Lewis, S.L., Hagen, S., 2011. Benchmark map of forest carbon stocks in tropical regions across three continents. Proceedings of the national Academy of sciences, 108(24), 9899-9904.

Sills, E.O., Atmadja, S.S., de Sassi, C., Duchelle, A.E., Kweka, D.L., Resosudarmo, I.A.P., Sunderlin, W.D., 2014, REDD+ on the ground: A case book of subnational initiatives across the globe. Cifor.

Sims, K.R.E., Alix-Garcia, J.M., 2017. Parks versus PES: Evaluating direct and incentive-based land conservation in Mexico. Journal of Environmental Economics and Management, 86, 8-28.

Springate-Baginski, O., Wollenberg, E., 2010, REDD, forest governance and rural livelihoods: the emerging agenda. CIFOR.

Stavins, R.N., Richards, K.R., 2005. The cost of U. S. forest-based carbon sequestration. Pew Center on Global Climate Change. 52, 52.

Stern, 2006. Stern Review: The economics of climate change. London, England: HM Treasury.

Toni, F., 2011. Decentralization and REDD+ in Brazil. Forests, 2(1), 66-85.

UN-REDD, 2015. Regions and Countries Overview, http://www.unredd.net/index.php?option=com_unregions&view=overview&Itemid=495#.

UNFCCC, 2011. Fact Sheet: Reducing Emissions from Deforestation in Developing Countries.

Van der Werf, G.R., Morton, D.C., DeFries, R.S., Olivier, J.G.J., Kasibhatla, P.S., Jackson, R.B., Collatz, G.J., Randerson, J.T., 2009. CO 2 emissions from forest loss. Nature geoscience, 2(11), 737.

Wunder, S., 2005. Payments for environmental services: some nuts and bolts.

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.

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)

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[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.

- 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.
    - The UN has been working for a while on REDD+ to generate forest-based offsets.
        - Programs like REDD+ 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.
    - REDD+ is a PES system: 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).
- 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 REDD+ contract (usually $50).
        - (Policing or Fines) – in treatments where there can be fraud (cheating), 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: No REDD+
    - Write on the board: "No REDD+ 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: Baseline
    - Write on the board: $50 PES payment, no fraud
    - On their Recording Sheets, participants must circle their choice (REDD+ or No) and fill out the resulting earnings.
    - Go around and have each participant call out their REDD+ decision, and record them in the yellow "REDD+?" 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 REDD+ 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 REDD+ contract (which all should have) is non-additional
- Contract Period 2: Baseline + Fraud
    - Write on the board: $50 PES payment, fraud possible. 25% chance of audit. If caught, lose: REDD+ payment, harvest earnings, AND $70 fine
    - On their Recording Sheets, each participant must circle their choices: (REDD+ or No) and Fraud (Y or N). They cannot yet record their earnings until you announce the audit outcomes (unless they didn't commit fraud).
    - Go around and have each participant call out their REDD+ 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 REDD+ contract and harvest (commit fraud), 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 fraudsters 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 fraud; harvest value has 50% chance of being 20x card and 50% chance of 0
    - On their Recording Sheets, participants must circle their choice (REDD+ 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 REDD+ decision, and record them in the yellow "REDD+?" 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 REDD+ payment of 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 REDD+ 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 REDD+ 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 REDD+ contract
            - b) how to divide up payments if so
    - Emphasize that REDD+ 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 REDD+ contract and, if so, how to allocate the REDD+ payments across the members.
        - Let each community decide how the group is to make its decision.

        - They record their decision by circling REDD+ 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 REDD+ 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 REDD+ 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 + Fraud – 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 + fraud!
        - 1. Decide as community (3 minutes to talk):
            - a) whether to be in a REDD+ contract
            - b) how to divide up payments if so
        - 2. If they adopt REDD+, decide as a group whether to police themselves (at $5/household). If they do police themselves, fraud becomes impossible.
        - 3. If they adopt REDD+ and do not police themselves, each household privately decides whether to harvest.
        - 4. Government audits each REDD+ community that doesn't police itself with probability 10% times the number of people who commit fraud. If they detect any fraud, the REDD+ contract invalidated (everyone loses REDD+ payment and any harvest they got) plus the whole community is fined (at $70 per community member).
    - Note that participation in REDD+ is all or nothing within a community, but the fraud 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 fraud increases audit likelihood to be smaller or larger respectively. You can do this in the "params" worksheet; it's the parameter "community per-fraudster 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 REDD+ or No on their Recording Sheets, and by each writing the appropriate amount in the PES payment column. If they took a REDD+ 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 REDD+ contract or if they took a contract and policed themselves. Otherwise, wait.
    - Groups that took a REDD+ contract but did not police themselves should have everyone record their Fraud (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 REDD+ 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 committed fraud. 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 + Fraud Treatment

Let us define f_{oth} as the number of people other than one's-self who committed fraud

Then the sequence of actions is as follows:

- Group chooses:
  - REDD+ No → everyone CHANGE IN EARNINGS: HV
  - REDD+ Yes → Group chooses:
    - Police No → Individuals each choose:
      - Fraud No → Nature chooses
        - Prob $0.1f_{oth}$ → audited → CHANGE IN EARNINGS: -70
        - Prob $1-0.1f_{oth}$ → not audited → EARNINGS: 50
      - Fraud 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 REDD+ contract and not police, do they commit fraud? If we assume that people who are indifferent do not commit fraud, then a person only commits fraud if:

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

Simplifying:

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

Simplifying further:

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

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 committing fraud. 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 committing fraud. As another example, if a person thinks five people in their group are committing fraud, the threshold is 30. Therefore, the equilibrium prediction of the amount of fraud 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, fraud. The rate of fraud 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 commit fraud for a given *HV* and f_{oth}.

If we make a benchmark guess of 50% fraud, then the likelihood of audit in a six-person group is 30%, so REDD+ without policing yields an expected payoff for fraudsters:

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

And for those not committing fraud:

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

Now, given that, if a group chooses a REDD+ contract, will they choose to police? If they do, then everyone earns 45. If we take the same 30% audit rate (50% fraud rate) as given, then the expected payoff for any harvest value is never as high as the certain payoff from having a REDD+ 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 REDD+ contract? If they do, under the baseline inference that REDD+ 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 fraud except that people with harvest value of 50 will cease to be indifference and will prefer to not take the contract.