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Research

The role of incentive-based instruments and social equity in conservation conflict interventions

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ABSTRACT. Conflicts between biodiversity conservation and other human activities are multifaceted. Understanding farmer preferences for various conflict mitigation strategies is therefore critical. We developed a novel interactive game around farmer land management decisions across 18 villages in Gabon to examine responses to three elephant conflict mitigation options: use of elephant deterrent methods, flat-rate subsidy, and agglomeration payments rewarding coordinated action for setting land aside for elephants. We found that all three policies significantly reduced participants' inclinations to engage in lethal control. Use of deterrents and agglomeration payments were also more likely to reduce decisions to kill elephants in situations where levels of social equity were higher. Only the two monetary incentives increased farmers' predisposition to provide habitats for elephants, suggesting that incentive-based instruments were conducive to pro-conservation behavior; different subsidy levels did not affect responses. Likewise, neither participants' socioeconomic characteristics nor their real-life experiences of crop damage by elephants affected game decisions. Killing behavior in the games was 64% lower in villages influenced by protected areas than in villages surrounded by logging concessions, highlighting the need to address conservation conflicts beyond protected areas. Our study shows the importance of addressing underlying social conflicts, specifically equity attitudes, prior to, or alongside addressing material losses.

Key Words: *conservation conflict; human behavior; human–elephant conflict; human–wildlife conflict; interactive game; monetary incentives; stakeholder engagement*

INTRODUCTION

Conflicts over conservation endeavors (or "conservation conflicts") not only undermine effective conservation, but also hamper sustainable development (Redpath et al. 2013). Many such conflicts involve species of conservation concern that damage crops or prey on livestock, and are often killed in retaliation by affected farmers. Such problems are commonly framed as human–wildlife conflicts (Woodroffe et al. 2005). However, beneath the material manifestations of these impacts lie deeper and more complex social conflicts between different social groups (Dickman 2010, Peterson et al. 2010, Madden and McQuinn 2015, Hill et al. 2017). At the core of these conflicts is the involvement of multiple stakeholders with conflicting values and agendas (Redpath et al. 2013). If the non-material needs of affected stakeholders (e.g., farmers) are not also adequately considered, interventions to address wildlife impacts might fail to mitigate conservation conflicts through lack of engagement, uptake, and follow-through by farmers (Hill et al. 2017). For instance, increased concern over social equity among stakeholders has been associated with a decreased likelihood of finding solutions to biodiversity-related conflicts (Young et al. 2013, 2016*a*). For our purposes, equity may relate to: (1) recognition, i.e., the equitability of cost allocation across national conservation and development strategies; (2) procedural equity, which refers to participation in decision-making processes; and (3) distributive equity, which addresses the distribution of benefits and costs (McDermott et al. 2013). Given the complex nature of conservation conflicts, devising the best interventions to mitigate conflicts is a growing priority for policy makers (e.g., Young et al. 2016*b,* Mason et al. 2018).

We developed a highly interactive game to understand how farmers respond to alternative conflict intervention strategies in Gabon (Rakotonarivo et al. 2021*b*). Games have emerged as an effective means to engage stakeholders and enable player responses, mimicking real-world reactions through immersion (Redpath et al. 2018). They have been used in a wide range of contexts such as irrigation (Meinzen-Dick et al. 2016), fisheries and forests (Cardenas et al. 2013), and agriculture (Bell et al. 2016). Games can help to develop decision-making theory, to understand patterns in conflict, and to elucidate possible solutions for environmental issues (Redpath et al. 2018). Games have been used to foster more sustainable practices or transformative changes (e.g., Mayer et al. 2014, Rodela et al. 2019), as well as to test theoretical predictions of human behavior in various natural resource dilemmas (e.g., Cardenas et al. 2013, Janssen et al. 2010, Travers et al. 2011, Andersson et al. 2018, Rakotonarivo et al. 2021*b*). Here, we used a game as a low-cost and low-risk tool to engage farmers and investigate how they react to potential management strategies in a setting where real-life experiments would be impractical. Unlike many behavioral experiments, which commonly involve high levels of abstraction and simplified visual representation (Janssen et al. 2014, List and

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Price 2016), our game modeled ecologically relevant temporal and spatial dynamics at the landscape level using tablet computers and the Netlogo interface (Wilensky 1999).

Our game was framed around farmers' land management decisions and crop-damaging elephants, a keystone and charismatic flagship species that symbolizes wildlife conservation in Asia and Africa. As iconic species, elephants attract tourists who contribute significantly to some range state economies (Naidoo et al. 2016). However, elephants can impose considerable social and financial costs on farmers by damaging crops, food stores, and water sources, thus impairing local farmers' well-being (Mackenzie and Ahabyona 2012, Barua et al. 2013). In addition to poaching (Poulsen et al. 2017), land-use change, and habitat loss (Chartier et al. 2011), retaliatory killing of elephants poses a serious threat to the species' survival. The increasing intensity of elephant-related conflicts highlights the pressing need to develop a better understanding of farmers' decision-making and its underpinnings (Evans and Adams 2018, Shaffer et al. 2019).

Technical interventions to reduce agricultural damage by elephants at a local level tend to focus on physical and biological barriers such as fencing, guarding, and the use of repellents (Nyhus 2016, Pooley et al. 2017, Pozo et al. 2019). Economic instruments, either through compensation mechanisms for crop losses (Ravenelle and Nyhus 2017) or financial incentives that reward a specific conservation outcome, have also been suggested as effective solutions to conservation conflicts (White and Hanley 2016, Wilson et al. 2017). Incentive-based instruments also include agglomeration payments, which encourage spatial coordination of land set aside for conservation by offering additional payments to farmers enroling adjacent parcels in agri-environment schemes (Parkhurst and Shogren 2007). Little is known about the acceptability of various mitigation strategies to affected farmers or their effect on farmers' decision-making about wildlife and land management.

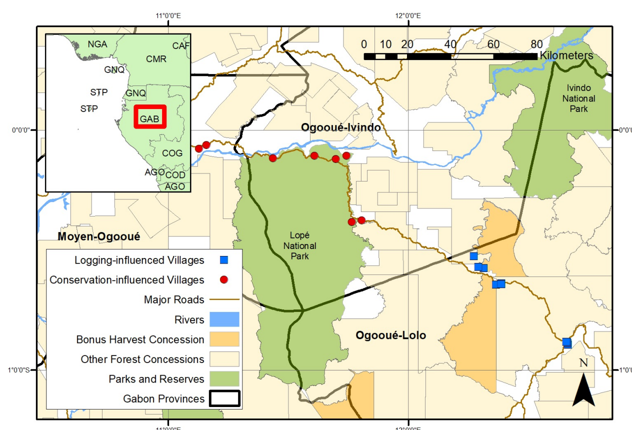
Our aim was to examine the effects of three mitigation approaches on local farmers' propensity to use lethal control or to support conservation interests through the provision of habitat for elephants: (1) support for elephant-deterrent techniques designed to offset costs constraining their adoption; (2) monetary incentives, a flat subsidy for pro-conservation land uses through the provision of elephant habitats; and (3) agglomeration bonuses, designed to encourage spatial coordination in the adoption of pro-conservation land uses. We explore the relationship between game outcomes and key socioeconomic and attitudinal factors, collected using accompanying household surveys. We expected participants who had stronger preferences for equity, those with positive perceptions of the well-being effects of elephants, and those who experienced lower levels of crop damage by elephants to be less likely to kill elephants and more likely to provide elephant habitats in the game. We also explored farmer motives using in-depth debriefing interviews with a subsample of participants and discuss how interactive games can help in addressing conservation conflicts across a wide range of settings.

METHODS

Study area

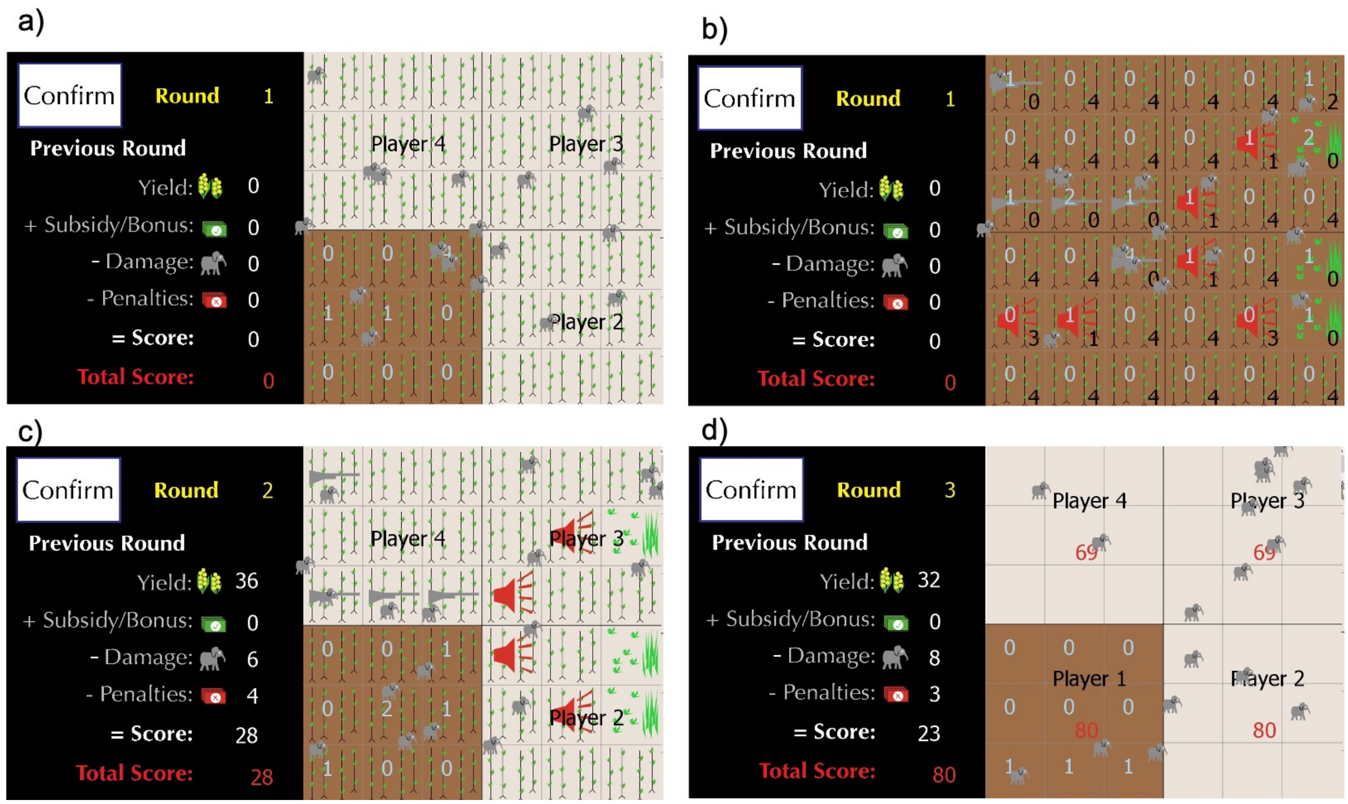
We conducted games in two rural areas of Gabon. These areas included all eight villages near Lopé National Park and within the World Heritage site associated with the park, which we refer to as "conservation-influenced villages", and ten villages within production forests, which are referred to as "logging-influenced villages" (Fig. 1, Appendix 1). The two regions were chosen to cover a range of both exposure to crop damage and reliance on agriculture. Negative interactions between local farmers and forest elephants, *Loxodonta cyclotis,* are widespread at both sites. However, the protected area adjacent to the conservation villages might offer better protection for elephants, and more elephants in adjacent forests might lead to increased crop damage in these villages (Graham et al. 2010). The availability of alternative income from logging might also reduce reliance on agriculture in logging villages and hence lead to reduced capacity to protect fields from elephants. Elephants in Gabon, as in other African countries, are known to destroy an entire year's worth of crops in a single visit and thus cause serious hardship to subsistence farmers (Fairet 2012). The rapid expansion of rural employment in logging concessions across Gabon (Laurance et al. 2006), compounded by high rural exodus (Fairet et al. 2014) and extremely low rural population density (0.2 inhabitants/km²; Laurance et al. 2006) have further led to a reduced capacity to protect fields.

Fig. 1. Map showing the locations of the study villages in Gabon. Eight conservation-influenced villages were located near a national park, and 10 logging-influenced villages were located away from protected areas.



To protect crops from elephants, local farmers use a range of traditional methods such as scarecrows, barriers, and cleared field perimeters (Fairet 2012, Walker 2012, Ngama et al. 2016). Shooting of problem elephants outside protected areas is implemented by the government if the village submits evidence of extensive crop damage (Fairet 2012). The legislation also includes the possibility of compensation for crop damage, but records are not available for the number of claims and compensations paid. Recently, the Gabonese government has provided funding to build electric fences around village farmlands near National Parks to deter elephants (Poole 2016). Only one village in the study area had benefited from community electric fencing at the time of the study, and a further three of the study villages have since received electric fencing.

Fig. 2. Images of the game screen (English version) showing how the game proceeds. See Fig. 3 for game parameters. (A) The bottom left corner of the landscape is the active player at round 1; elephants are randomly distributed across the landscape, and the white number on each cell indicates the number of elephants. (B) Game screen of the active player after all four players have made decisions. (C) Game screen at the start of round 2; actions taken by other players in the previous turn are visible to all. The score of the active player in the previous round is shown on the left side of the panel. (D) Game screen showing the total score for each player at the end of practice rounds.



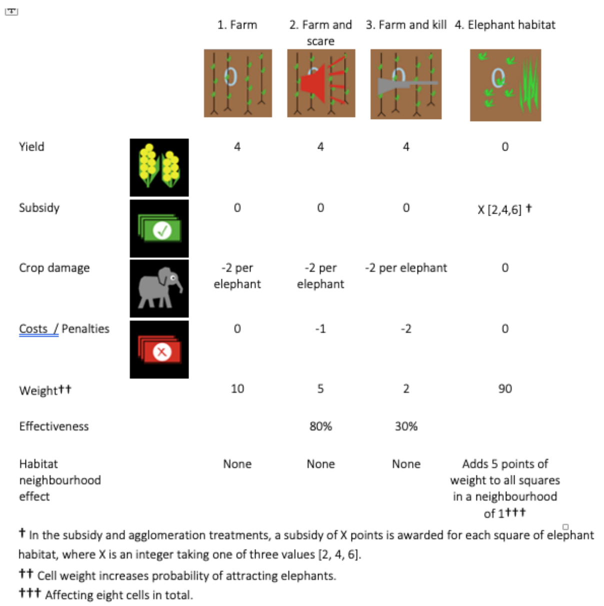
Game design

We developed an interactive game played in groups of four participants using tablet computers linked via a mobile hotspot. The game was designed within Netlogo (Wilensky 1999), a multi-agent modeling environment, and adapted from NonCropshare, a coordination game for insect-based ecosystem services (Bell et al. 2013, 2016; Appendix 2). We incorporated both temporal and spatial dynamics: (1) resource availability at a given time t is dependent on decisions made previously (e.g., animal number decreases with killing effort), and (2) crop damage depends on the location or proximity of cropland to other land uses as well as neighboring farmers' decisions (e.g., elephants are moving across the landscape, and intensive scaring in one farm might displace the problem elsewhere). These spatial and temporal dynamics positively influenced the game's realism.

Game-play involves four participants (each representing one household) who make decisions on a digital farming landscape. Each participant acts on nine cells arranged in 3 × 3 contiguous square blocks (Fig. 2). Each game session consisted of six to eight rounds, intended to represent agricultural years. Communication between participants was permitted in all the sessions to mirror the conditions in which real-life incentive schemes operate. In each round, there were four options available to participants in each cell: (1) farm, (2) farm and scare elephants off the cell using non-lethal methods (e.g., physical or biological barriers, noise), (3) farm and shoot elephants in the cell (lethal control), or (4) lease the cell for elephant conservation (i.e., provide habitat for elephants). Each option had different costs and benefits and was assigned different parameter settings (Fig. 3).

At the start of each round, the default option on all 36 grid cells is farmland. Eighteen elephants are randomly distributed across the landscape cells with equal probability. Multiple elephants per cell are permitted. In each round, players select an option by tapping repeatedly on the cell and end their turn by "confirming" their choices when they are ready (Fig. 2). Damage occurs immediately on a cell if an elephant is present in a cell and is neither scared nor killed. If elephants are scared from a given cell, they reorient to other cells probabilistically based on cell weights. Elephant habitat cells have the highest weight and are nine times more likely to accommodate elephants chased from other cells than are farmed cells (Fig. 3). These habitats were described as buffer resources providing alternative food sources for elephants. However, providing elephant habitat means foregoing private yield for benefits shared by all four players, creating a public good dilemma. Scaring and killing have an immediate effect in the same round (e.g., if an elephant is killed, no damage is incurred) as well as a future effect because there are fewer elephants in future rounds (Fig. 3).

Fig. 3. Game parameters.



The minimum value score per cell is set to zero to avoid unrealistic negative values. Elephants left on any given cell decrease yield by 2 points. A habitat neighborhood effect is added to the game settings to reflect the likely increase in crop damage in farmlands that surround elephant habitats (Fig. 3). Similarly, non-lethal and lethal control methods are not equally effective: scaring displaces elephants with a probability of 0.8, and lethal shooting immediately removes elephants from the landscape with a probability of 0.3. Shooting costs much more than scaring to reflect the higher risks and dangers involved in killing elephants, as well as the costs of cartridges and guns. Killing systematically results in a lower payoff for any player given its lower cost-effectiveness ratio (0.3/2 vs. 0.8/1 for scaring; see Fig. 3), thus making it a dominated strategy in a one-shot game (i.e., shooting earns a player a smaller payoff than some other strategy, regardless of what others do; see Appendix 3 which provides a detailed explanation of the theory underlying the game design).

Participants' overall score on their set of $n = 9$ squares each round is calculated as:

$$Score = \sum_{n=1}^{9} (Yield_n + Subsidies_n - Damage_n - Costs_n) . \qquad (1)$$

The parameter values (Fig. 3) were chosen to reflect the local social-ecological systems underpinning human–elephant interactions in Gabon, and their plausibility was carefully pre-tested with local farmers. For instance, losing 50% of the crop yield value to elephant damage was observed in similar contexts (Mackenzie and Ahabyona 2012).

Data collection

Each game session began with a short practice session of three rounds followed by four randomly ordered treatments of six to eight rounds each (Table 1). We thus used a within-subjects design with 65 groups (260 participants) per treatment. The number of rounds was randomized to prevent participants from anticipating the conclusion of the treatment.

Table 1. Treatment conditions for the game sessions.

Treatments	Subsidy for elephant habitat	Cost or penalty of scaring elephants off farmlands	Cost or penalty for shooting elephants	Agglomeration bonus
Control: no external intervention	None	1	2	0
Support for deterrent	0	0	0	0
Flat-rate subsidy	2, 4, or 6†	1	2	0
Agglomeration payment	2, 4, or 6†	1	2	1 for every elephant habitat that is contiguous to another habitat, excluding diagonal cells

†Subsidy values were randomly selected at the start of the game and kept constant for the remainder of the experimental session.

We conducted 65 game sessions with 260 household farmers, of which 140 households were in conservation-influenced villages ($N = 8$), and 120 households were in logging-influenced villages ($N = 10$). Because of the low number of households within each village in the two study areas (2–30 households per village), we did not randomly select participants but instead invited all willing participants present in each village to participate in our study. Only one representative per household was invited to participate in the games and was preferably the person responsible for most agricultural activities; in most cases, this person was female.

Games were facilitated in April and May 2018 by two teams of two people each (including the lead author), randomly assigned to groups of four participants. The game instruction protocol (in French) was extensively piloted in nearby villages in February and March 2018 (Appendix 4). The research ethics committee of the University of Stirling approved this study. We told participants that results would be presented in aggregate form and would not be linked to their identity or the individual villages. We gained verbal informed consent from all participants before implementing the games. We dedicated sufficient time to the practice rounds before starting the treatments to ensure sufficient comprehension and to gain participants' trust. The use of images and verbal explanations allowed accessibility to illiterate or innumerate participants (< 5% of participants; see Table A.1.2 in Appendix 1). The practice rounds lasted 30–60 min, and the whole game lasted 1.5–2.5 h. We offered gift items (e.g., a torch, food containers, and cutlery, amounting to $8 USD in total) to compensate participants for their time. Daily wages in the area were approximately $6 USD.

We also administered a questionnaire survey to all participants (*N* = 260) after the games to collect information on demographics, farming practices, losses to wildlife, and attitudinal variables on trust and equity (see Rakotonarivo et al. 2021*a* for the full survey and anonymized data). To understand motivations for broad decision strategies in the game, we further conducted unstructured individual debriefing interviews with 30 participants immediately upon completion of the game sessions and questionnaire survey. Interviewees were selected purposively, based on our observations of behavior in the game. We continued surveys until we believed that we had interviewed participants that had used the full spectrum of participant strategies in the games, i.e., those who engaged frequently in lethal control, those who mostly resorted to using non-lethal deterrents, and those who exhibited varying levels of willingness to provide elephant habitats. The interviews lasted 20–40 min and were not audio-recorded given the sensitive nature of the data (particularly crop losses to elephants and retaliatory killing by villagers, which is illegal). Instead, we took notes and direct quotes where appropriate to aid the contextualization of the game outcomes and provide additional insights into the participants' stated motivations (Anderies et al. 2011).

Data analysis

We examined two main game outcomes measured at the individual household level (i.e., household unit): use of lethal control (i.e., kill decisions), and provision of elephant habitats. These outcomes draw from a larger number of actions (farm, kill, scare, provide habitat) and represent two diametrically opposed strategies in mitigating elephant crop damage. They are thus particularly relevant to the exploration of responses to conflict interventions.

We modeled these outcome variables as proportion data (proportion of cells with kill decisions or with habitat provided, respectively) using binomial generalized linear mixed-effect models with logit link function implemented within the lme4 statistical package (Bolker et al. 2009). Household identity was included as a nested random effect within group identity to account for household-specific and group-specific effects. We controlled for learning by including four game conditions: (1) rounds in the game, (2) rounds into session, (3) sum of kill decisions of the three other participants in the previous round (lagged kill decisions), and (4) sum of habitat decisions of the three other participants in the previous round (lagged habitat decisions).

To relate behavior in the game to the trust and equity attitudes, we included three explanatory variables in addition to the treatments and game conditions: (1) one aggregated measure of interpersonal trust among local communities, (2) one aggregated measure of institutional trust (trust toward conservation and government authorities), and (3) one aggregated measure of equity indices. Each of these aggregated measures is the weighted factor scores of three variables generated from exploratory factor analyses with the psych statistical package using *oblimin* rotation (Revelle 2018; Tables A1.1a–c in Appendix 1). The Chronbach's alpha (Tables S1a–S1c) indicated strong internal consistency and showed that these aggregated measures were valid indicators of a single underlying factor. We also included participants' perceptions of the positive and negative effects of elephants on their well-being.

To explore the associations between game outcomes and real-life farming practices and regions, we included as explanatory variables households' reported experiences of crop losses (whether any of their fields had been damaged by elephants in the previous agricultural year) and the study location. In addition, we controlled for other socioeconomic variables such as participant age, gender, education, and two principal component vectors of a range of household wealth indicators extracted from a principal component analysis (PCA) using the psych package and *promax* rotation (Revelle 2018; Fig. A1.1 in Appendix 1). We also considered two-level interactions between the treatments and other household-related variables such as reported experiences of crop losses, and participant-related variables such as perceptions of elephants, trust, and equity indices. Table A1.2 (Appendix 1) provides a detailed summary of the explanatory variables included in our models.

To avoid multicollinearity, we checked for correlations between predictor variables. Model selection was then carried out using backward stepwise selection of fixed effects based on the corrected Akaike Information Criterion (AICc) value. We conducted all analyses in R version 3.5.1 (R Core Team 2018).

RESULTS

Household socioeconomic and participant attitudinal characteristics

On average, 47% of the surveyed households relied on agriculture as the primary source of income in both study sites (Table A1.2 in Appendix 1). Of the 140 and 120 households sampled in conservation-influenced villages and logging-influenced villages, respectively, 69% and 55% had received at least one visit by elephants in the previous agricultural year and experienced crop damage (Table A1.3 in Appendix 1). Of the affected households, 68% and 54% reported significant crop losses (> 60% of annual crops; Table A1.3 in Appendix 1). On average, participants had six years of schooling, and 95% were literate. Food security, as measured by the mean number of months per year for which families reported having enough to eat, was 7.6 (standard deviation [SD] = 3.6) and 8.5 (SD = 3.3) in the conservation-influenced and logging-influenced villages, respectively. The PCA of 10 measures of wealth resulted in two axes that explained 46% of the variation and revealed no systematic differences between the two groups of villages in terms of wealth (Table A1.3 and Fig. A1.1 in Appendix 1). These two axes were used as covariates in the statistical analyses using generalized linear mixed-effect models along with other key socioeconomic characteristics (Table 2).

Participants generally reported negative attitudes on key equity indices. The share of participants who felt able to influence decision-making regarding land use and wildlife management was < 13% in both village groups (Fig. 4). Most participants (> 88%) in both regions also perceived inequitable distribution of benefits among community members, as well as unbalanced conservation and development policy (Fig. 4). More than one-half of participants reported little trust toward governmental organizations such as the National Agency for National Parks and the Ministry for Water and Forests (Fig. 4).

Table 2. Odds ratio estimates from the reduced generalized linear mixed model showing the effect of treatments and other fixed effects on farmers' propensity to kill elephants in the games. Individuals and groups were included as random effects.

Predictor	Proportion of kill decisions	
	Odds ratio	95% confidence interval
Intercept	0.04***	0.03–0.07
Support for deterrents	0.83***	0.75–0.92
Subsidy	0.73***	0.66–0.81
Agglomeration	0.58***	0.51–0.65
Rounds into session	0.99***	0.98–0.99
Total number of elephants in the landscape	1.03***	1.02–1.05
Region ID (conservation-influenced villages)	0.36***	0.22–0.60
Lagged kill decisions of other participants	1.06***	1.04–1.08
Equity index	0.74**	0.59–0.93
Positive well-being effects of elephants	0.88**	0.80–0.96
Support for deterrents × equity index	1.19**	1.05–1.36
Subsidy × equity index	1.10	0.96–1.26
Agglomeration × equity index	1.26**	1.10–1.44
Random effects (τ_{00})	$1.36_{\text{Individual ID:Group ID}}$ $0.65_{\text{Group ID}}$	
Observations	5156	
Marginal R^2/conditional R^2	0.071/0.423	

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

The interviews revealed that although local farmers in the study areas have faced crop damage for generations, crop losses to elephants are perceived by some to have escalated after the former Wildlife Reserve (created in 1946) became a National Park in 2002. Nine of thirty interviewees believed this escalation was because of increased enforcement of the protected status of elephants. Five interviewees in the logging-influenced villages also blamed logging concessions for the increasing crop damage incidents in the region. Logging activities were perceived to disturb forest and push elephants to the periphery where farmers farm. These feelings have fueled resentment toward the park and other government entities. The interviews also uncovered that the park agency role was perceived by some participants as strictly repressive. Two interviewees articulated that the park agency's only purpose was to tighten control over wildlife. Nevertheless, 41% and 39% of surveyed households in conservation-influenced and logging-influenced villages, respectively, had positive trust attitudes toward the park agency (Fig. 4), mostly because of their dedication to protect elephants, which are considered Gabon's national pride.

> *If it were not for the park agency's actions, Gabon's elephants would have gone extinct, and we appreciate their efforts.* (ID04, 31-year-old female, park village).

Proxies for community trust were high (> 55%) in both study sites (Fig. 4). Approximately 40% of surveyed farmers (41% and 39% in conservation-influenced and logging-influenced villages, respectively) perceived positive effects of elephants on their well-being (Fig. 4). These benefits were mostly described as pertaining to the roles of elephants in ecosystems, as well as their cultural importance. The share of participants who perceived negative effects of elephants on their well-being was 79% in both village groups, mostly because of crop losses.

Effect of game treatments and household characteristics on farmers' predisposition to kill elephants

All three treatments significantly decreased farmer propensity to engage in killing compared to the control in the game (Figure A1.2 in Appendix 1); the agglomeration treatment had the greatest effect, reducing the odds for killing by 42% compared to the control in the main-effect- only model (Table A1.4 in Appendix 1). Participants with a higher equity index were significantly less likely to engage in killing; for a one-unit increase in equity index, the model suggested a 21% decrease in the odds of kill decisions (odds ratio 0.79, 0.95 confidence interval [CI]: 0.63–0.98; Table A1.4 in Appendix 1).

In the final model (Table 2), we observed a significant interaction between the treatments and equity indices; higher equity values significantly weakened the effects of the deterrent and agglomeration treatments in reducing farmers' decisions to kill. Kill decisions were significantly higher in the logging villages than in the conservation villages (the odds for the former were 64% higher; Table 2). Likewise, positive perceptions of the well-being effects of elephants decreased participants' propensity to engage in killing (odds ratio 0.89, 0.95 CI: 0.80–0.98). Trust indices did not affect participants' decisions in the game (Table A1.4 in Appendix 1). Similarly, neither farmers' experiences of crop losses (as measured by whether their farms had been damaged at least once by elephants) nor the perceived negative effects of elephants on their well-being affected game decisions (Table A1.4 in Appendix 1). These results were insensitive to alternative model specifications testing for the effect of elephant visit frequency or whether affected households have experienced high damage.

At lower equity levels, The effect of treatments on farmers' propensity to kill were much more pronounced at lower than at higher equity levels, as were the differences between the conservation-influenced and logging-influenced villages (Fig. 5). The predicted mean proportion of kill decisions in the baseline treatment was almost two times higher in logging-influenced villages than in conservation-influenced villages at the low equity level (7.6%, 0.95 CI: 5.2–10.8 vs. 3.1%, 0.95 CI: 2.2–4.1, respectively). However, at the higher equity level, discrepancies among treatments became negligible, and the effect of conservation vs. logging villages was also much smaller (Fig. 5).

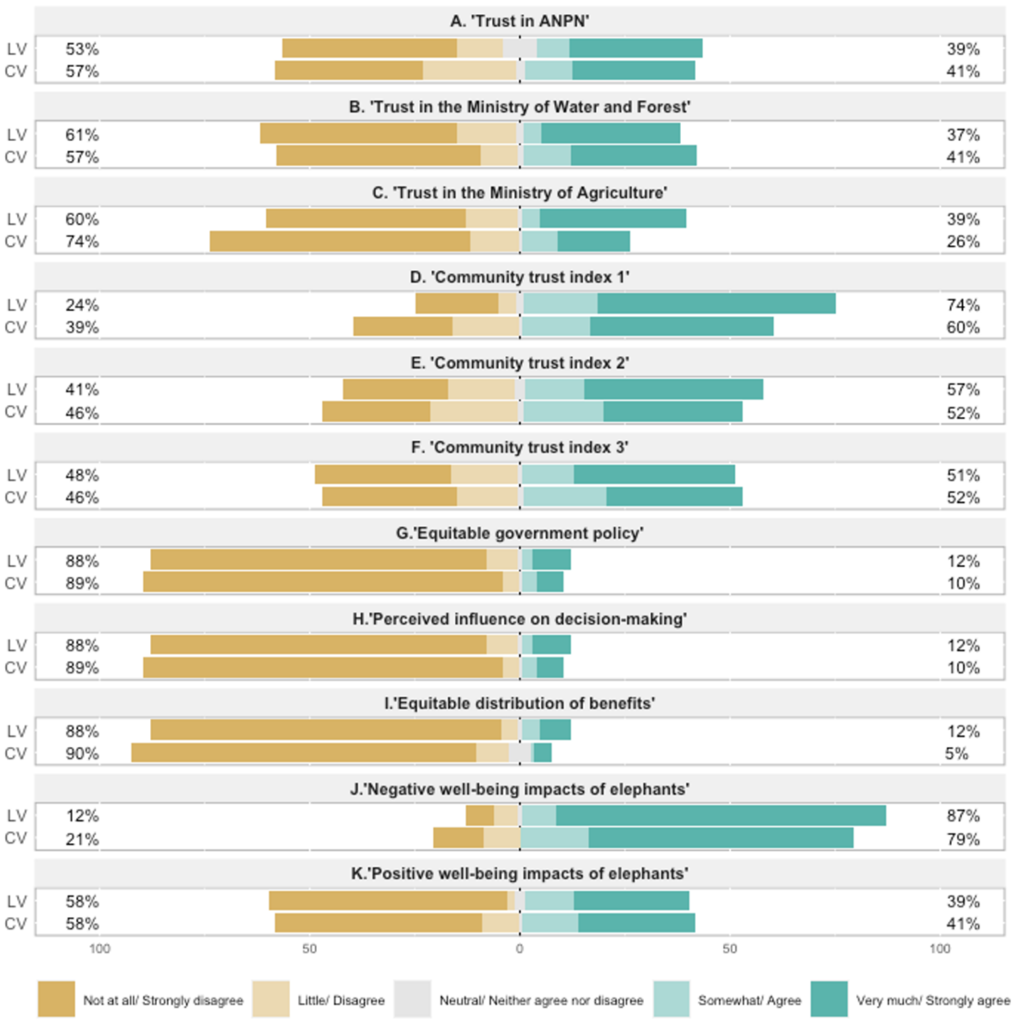
The qualitative interviews highlighted that most participants (23 of 30) felt they had very little opportunity to voice their views and concerns (Fig. 4). Their predisposition to killing in the game was as much to express their discontent as about protecting crops.

> *The authorities are not clearly interested in listening to our needs. If we are aggressive towards elephants, it is because we feel abandoned, we are angry.* (ID56, 56-year-old male, logging village).

Nevertheless, farmers recognized the value of elephants and anchored their killing behavior in the game on the need to control their number, not to eradicate them altogether. Such rationale was also evidenced by the negative association between kill decisions and farmers' perceptions about the positive effects of elephants on their lives (Table 2).

To test the robustness of our inferences, we fitted additional models testing each variable of interest one at a time. These models suggest that the magnitude and statistical significance of three key variables (equity index, region, and perceptions of the

Fig. 4. Diverging stacked-bar charts of attitudinal trust and equity. (A–C) Statements were based on "Not at all" to "Very much" Likert scales. (D–K) Statements were based on "Strongly disagree" to "Strongly agree". CP = conservation-influenced villages, LV = logging-influenced villages.



Institutional trust indices

A. Trust in the National Agency for National Parks (ANPN)

B. Trust in the Ministry of Water and Forest

C. Trust in the Ministry of Agriculture

Community trust indices

D. "Most of the time, people in my community are mostly trying to help each other"

E. "Generally speaking, most people in my community are honest and can be trusted"

F. "In general, people in my community lend money to each other when needed, and get the money they have lent back"

Equity indices

G. "The current government strategy fairly balances local livelihoods and conservation interests"

H. "We feel able to influence decision-making related to elephant conservation and local livelihoods (through effective participation)"

I. "The government strategy on conservation and development equally benefits my community"

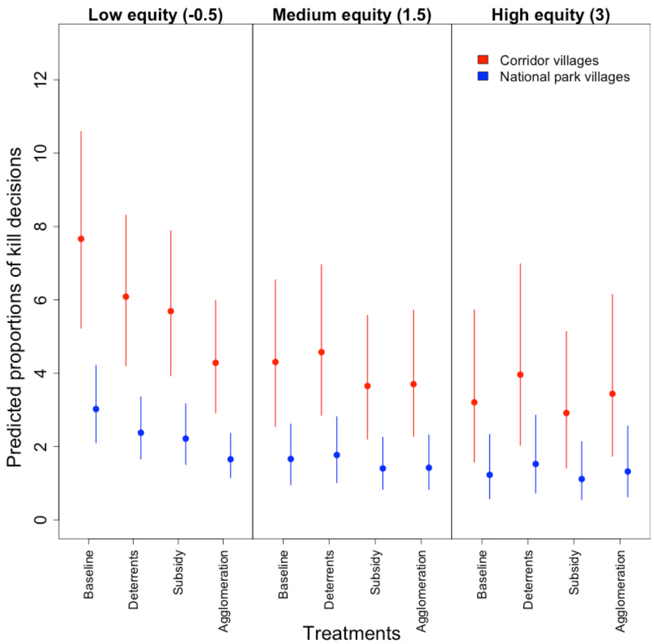
Perceptions of elephants

J. "Elephants negatively affect my well-being (i.e. cultural heritage, health, livelihoods)."

K. "Elephants are beneficial to my well-being (i.e. cultural heritage, health, livelihoods)."

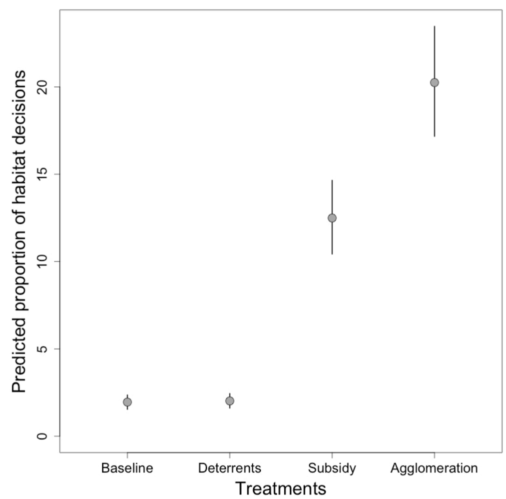
positive effects of elephants on well-being) were robust to alternative specifications (Table A1.7 in Appendix 1).

Fig. 5. Predicted proportions (%) of farmers' decisions to kill elephants in the conservation and logging villages under three levels of equity. Predicted values computed from the reduced model (Table 2) are shown for the average household and group. Error bars are 0.95 quantiles of the bootstrapped distributions.



The maintenance costs of the community fences and a fair sharing of these costs among village members if government funds are ever withdrawn were also concerns for these interviewees. In the logging villages, participants foresaw space and soil fertility as major limitations of the fences.

Fig. 6. Predicted proportion (%) of farmers' decisions to provide habitats in each treatment. Predicted values computed from the reduced model (Table 3) are shown for the average household and group. Error bars are 0.95 quantiles of the bootstrapped distributions.



Effect of game treatments and household characteristics on farmers' predisposition to provide habitats for elephants

Only the two monetary treatments generated a substantial increase in decisions to create elephant habitat across rounds compared to the baseline treatment. The percentage of habitat decisions was the highest under the agglomeration treatment (Figure A1.2 in Appendix 1). Agglomeration had the greatest effect on habitat decisions (with an odds ratio of 12.97, 1.8 times greater than that of subsidy, 0.95 CI: 11.18–15.05; Table 3). The predicted percentages of habitat decisions in the agglomeration and subsidy treatments were 21% (0.95 CI: 16–23) and 12% (0.95 CI: 11–14), respectively (Fig. 6).

The deterrent treatment had no significant effect on farmers' willingness to provide habitats (Table 5). The interviews suggested a nuanced account of farmers' motives for these results. The erection of electric fences was used as an illustration of external support for deterrents in the game instructions. Although participants were generally positive about the potential effect of such technology in reducing elephant crop damage, fencing around parks or designated conservation areas was perceived by 10 interviewees as more effective than fencing farmlands.

> *Hungry elephants will inevitably breach the fences; if not, they will come around our houses and feed on our fruit trees and gardens. The only solution is to keep them far away.* (ID32, 34-year-old female, conservation village).

Table 3. Odds ratio estimates from the reduced generalized linear mixed model showing the effect of treatments and other fixed effects on farmers' propensity to provide habitats in the games. Individuals and groups were included as random effects.

Predictor	Proportion of habitat decisions: Odds Ratio	Proportion of habitat decisions: 95% confidence interval
Intercept	0.00***	0.00–0.01
Deterrents	1.04	0.89–1.20
Subsidy	7.17***	6.28–8.17
Agglomeration	12.75***	11.04–14.71
Rounds into session	1.03***	1.02–1.03
Total number of elephants in the landscape	1.07***	1.05–1.08
Lagged habitat decisions of other participants	1.07***	1.06–1.08
Random effects (τ_{00})	$1.85_{\text{Individual ID:Group ID}}$ $0.17_{\text{Group ID}}$	
Observations	5156	
Marginal R^2/conditional R^2	0.293/0.562	

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

Varying subsidy levels had no significant effects on the percentages of kill decisions made or habitats provided (Table A1.6, Fig. A1.3 in Appendix 1). The interviews corroborated such findings; eight interviewees felt that they could use any help with their livelihoods.

> *You cannot say no to money; the amount does not really matter when you do not have many choices. Anyway, we have already started giving up on farming because we can no longer fight elephants; entire villages are disappearing here, we are left on our own.* (ID16, 62-year-old female, conservation village).

None of the socioeconomic or attitudinal covariates significantly affected decisions to provide habitats (Table A1.5 in Appendix 1).

Effect of other game conditions on game outcomes

At the treatment level, we did not observe any significant learning effect for both outcomes (as shown by the odds ratios of the "round in the game" variable in Tables 2 and 3). However, as participants played more rounds into the entire game session, they were less likely to kill and more likely to provide habitats for elephants (although the effect size was relatively small, odds ratio = 0.99, 0.95 CI: 0.98–0.99 and 1.02, 0.95CI: 1.02–1.03 for decisions to kill and provide habitats, respectively). Also, the decisions of other participants in previous rounds significantly affected the two outcomes, leading to higher kill and habitat decisions, other things being equal. This result indicates that participants took cues from the previous round and were more likely to use a strategy that others used. Higher numbers of elephants in the landscape also led to higher percentages of kill and habitat decisions.

DISCUSSION

Predictors of farmer land-use decisions

We examined the effects of deterrent support and financial incentives on farmer decisions using a temporally and spatially dynamic game. We found that monetary payments significantly increased local farmers' decisions to provide designated areas for elephants and decreased their propensity to use lethal methods. The agglomeration treatment that pays individual households for the provision of contiguous habitats had the greatest effect on farmers' behavior. Our results differ from those of Liu et al. (2019), who reported mixed findings on the performance of an agglomeration bonus in an auction setting among forest landowners in rural China.

Our study provides robust quantitative evidence that directly links equity issues (e.g., the degree to which local people perceive that they are involved in decision-making processes) with their behavior in the game. We found that farmers' propensity to engage in killing is significantly reduced by more positive perceptions of equity indicators. Another key finding is that killing behavior is also strongly predicted by whether local people perceive positive effects of elephants on their well-being (such as the critical role of elephants in ecological processes). Neither material losses that farmers had incurred from elephant crop damage nor their socioeconomic characteristics affected their game decisions. In addition, the odds of killing behavior (in the games) were 64% higher in the logging villages than in villages influenced by conservation management policies (i.e., close to National Parks), although the rates of elephant encounters and crop damage were lower in the former (55% have experienced crop damage in previous agricultural year in logging villages compared to 69% in conservation villages). These results highlight the need to extend conflict interventions beyond protected areas. Because there were no significant differences in trust and equity perceptions between the two groups, these results could be explained by lower environmental law enforcement further from national parks or more positive attitudes toward conservation among participants in the conservation-influenced villages.

Unlike previous studies (e.g., Gneezy and Rustichini 2000, Handberg and Angelsen 2019), we found that increasing subsidy levels in the monetary treatments did not generate a positive response in habitat provision. The interviews suggested that some farmers felt unable to negotiate compensations or to participate effectively in decision-making processes. There seems to be an urgent need for any forms of recognition of the considerable costs that farmers incur from elephant crop damage, as documented elsewhere in Africa (Noga et al. 2018).

Games as tools to predict and manage conservation conflicts

The results presented here are from a game rather than pilot or real-world interventions, and despite our efforts to encourage participants to state their true preferences, we cannot guarantee that they are accurate reflections of the complexity of human–elephant interactions. Thus, our findings might not correspond with how participants would behave in real life (Roe and Just 2009, Jackson 2012). In particular, the value parameters (Fig. 3) used in the games, such as the relative weight of different land uses and the scale of crop damage by elephants, might not perfectly mirror elephant behavior (Mumby and Plotnik 2018). However, although our game settings were necessarily simplified, they were perceived by participants as a safe and realistic decision-support tool to voice their preferences and needs. The incorporation of the temporal dimension and animal movements also enhanced motivation and plausibility. Studying such a sensitive topic with conventional methods is often difficult (Nuno and St. John 2015), but the game provided a relaxed atmosphere to explore local farmers' propensity to engage in lethal control.

Although our incentive structure differed from common practices in experimental economics (rewarding players based on their scores), there is precedence in the experimental literature for being flexible with the incentive structure to ensure compatibility with local concerns (e.g., Bell et al. 2015, Meinzen-Dick et al. 2016, Rakotonarivo et al. 2021*b*). Our priority was to create a safe sphere for participants to engage fully and state their preferences for various interventions. We also wanted to avoid participants' fixation on the rewards (Hur and Nordgren 2016) and were careful not to introduce monetary rewards in a sensitive and emotionally charged context such as human–elephant conflicts.

We also draw upon qualitative data to validate and contextualize our results; the discussions that followed the games gave critical insights into the game behavior and suggested that the game was salient to participants. A follow-up question asking participants about their main goal in the games further suggested that 180 participants (69%) aimed to maximize their utility by playing as in real life (Fig. A1.4 in Appendix 1). By better understanding how farmers, and not a perfectly rational *Homo economicus,* make decisions when facing different options, we are better able to understand what drives people's decisions and uncover novel solutions invisible to conventional tools such as questionnaire surveys (Murnighan and Wang 2016).

Implications for managing conservation conflicts

There is increasing evidence that incentive-based instruments that are directly linked to conservation objectives can be valuable tools for encouraging human–wildlife coexistence (Dickman et al.

2011, Nyhus 2016). Our findings suggest that incentive-based instruments are conducive to pro-conservation behavior. Performance payments for habitat provision can be made contingent on wildlife populations by rewarding farmers for wildlife species inventoried in these habitats. Such a mechanism has been successfully trialed in other countries such as Scotland, where farmers are paid to maintain and feed protected geese on their lands (McKenzie and Shaw 2017). Likewise, in Sweden, farmers are paid for each certified lynx and wolverine in village grazing lands (Zabel and Holm-Müller 2008). Incentive-based instruments might also outperform the damage compensation approach by reducing issues of "moral hazards" prevalent in compensation schemes whereby farmers increase the likelihood of crop losses (Ravenelle and Nyhus 2017).

Nevertheless, monetary incentives might suffer from many of the same problems faced by compensation schemes, such as the timing of payments and determining the appropriate payment level (Hanley et al. 2012). Monitoring might also be challenging where there is an issue of scale and mobility, especially when schemes involve large mammals. Real-time monitoring technology such as GPS collars and drones that provide near-instantaneous observation of animals can help to address these challenges (Wall et al. 2014, but see Shrestha and Lapeyre 2018, who discuss the drawbacks of using modern technologies).

In the context of Gabon, where rural exodus and low rural population density have considerably weakened agricultural production (Fairet et al. 2014) and where wildlife habitat availability is not a concern, incentivising the allocation of more lands to elephants might not be appropriate. Instead, because our findings show that positive perceptions of the well-being effects of elephants can reduce farmers' propensity to kill, redistributing financial incomes from national parks to local development might help to increase local support for conservation and have a greater effect on pro-conservation behavior (McDermott et al. 2013). National government strategies such as the Gabonese National Park Agency management plan include the provision of benefits to surrounding communities through tourism revenues and direct financial aid leveraged from conservation funding (Leduc et al. 2016). Interviewed participants, however, felt that the effectiveness of these revenues is limited.

Our study further shows that conflict interventions in rural Gabon are more likely to succeed where levels of social equity are higher. Our findings imply that conflict interventions might also be more effective if they seek ways and means of addressing social equity. For instance, beyond the current focus on reducing elephant crop damage, greater involvement of communities in decision-making processes would help to build trust toward conservation agencies and build genuine receptivity to, and ownership of, conflict interventions (Madden and McQuinn 2014, Hill et al. 2017, Noga et al. 2018). Such ownership, in turn, can help to foster community commitment to maintain technological deterrents such as electric fences in the long term. Stakeholder engagement that leads to genuine participation can be achieved by developing dialogue (Redpath et al. 2017), by building local people's capacity and abilities to negotiate their needs (McDermott et al. 2013), or by empowering local people in leadership roles during decision-making and implementation processes (Madden and McQuinn 2014). Because equity concerns are complex and evolving (Dawson et al. 2018), efforts to engage local stakeholders will also need to be adaptive and sustained over time.

Conclusion

We used a dynamic interactive game framed around farmer land-use decisions to examine farmer responses to conflict interventions such as support for elephant deterrent techniques and innovative economic instruments. Our findings suggest that incentive-based payments are conducive to pro-conservation behavior, and agglomeration schemes will achieve the greatest conservation outcomes. Our study also shows that positive perceptions of social equity can advance the acceptability of conflict mitigation strategies. Our findings imply that addressing the material manifestations of such conflicts might not tackle underlying social conflicts; conflict interventions might be more effective if they also address social equity. The strong regional differences in elephant killing behavior further highlight the need to extend conflict interventions beyond protected areas. Interactive games such as the one we describe here offer a low-risk tool for testing novel approaches to understanding, managing, and, where possible, preventing conservation conflicts.

Responses to this article can be read online at:
https://www.ecologyandsociety.org/issues/responses.php/12306

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Data Availability:

The data are available at http://reshare.ukdataservice.ac.uk/854068/.

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Appendix 1. SUPPLEMENTARY FIGURES AND TABLES

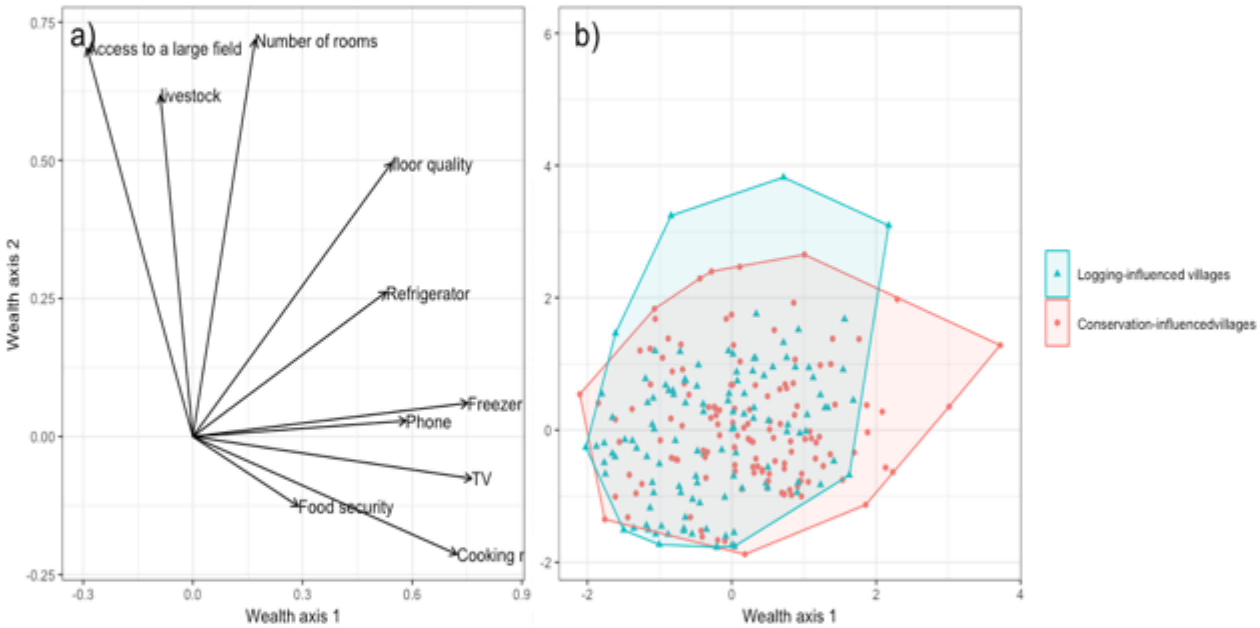


Figure A1.1: Indicators of wealth. Principal Component Analysis plots showing a) loadings of measures of wealth and b) individual scores with a convex hull for each study area. Wealth axis 1 represents consumer gods such as freezer, phone TV and cooking materials while wealth axis 2 distinguishes between households with more rooms, more livestock and those who have access to a large field (as opposed to gardens)

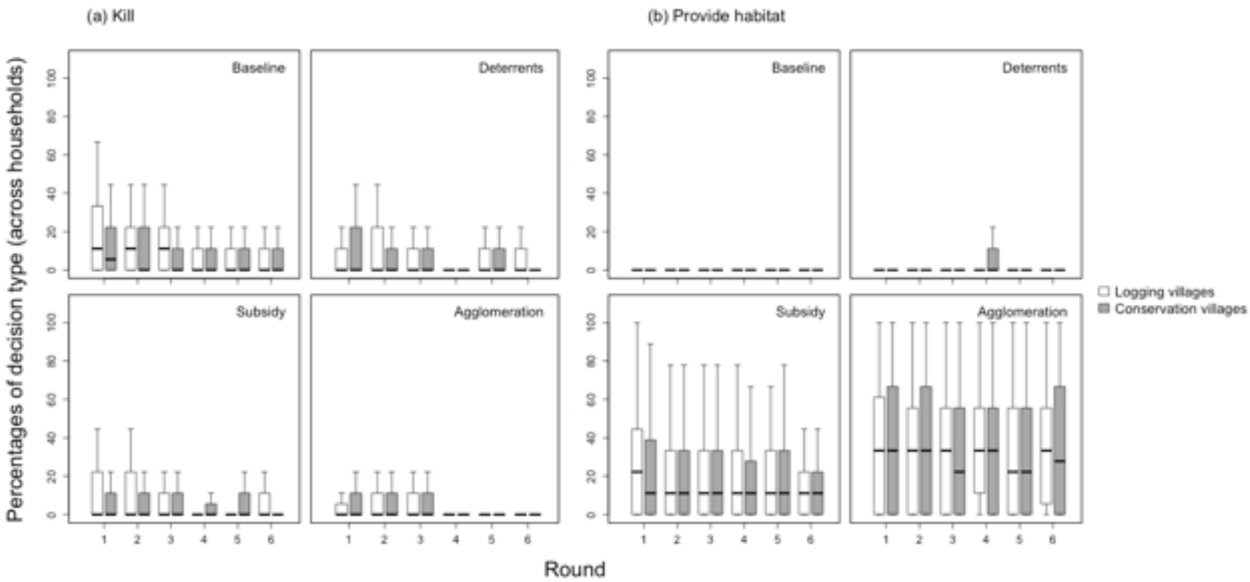


Figure A1.2: Distribution of observed percentages of decisions to kill and to provide habitats in each treatment and round, across households and groups. Solid black bars represent the median proportion, boxes the interquartile range and error bars extend to 1.5 times the IQR limits.

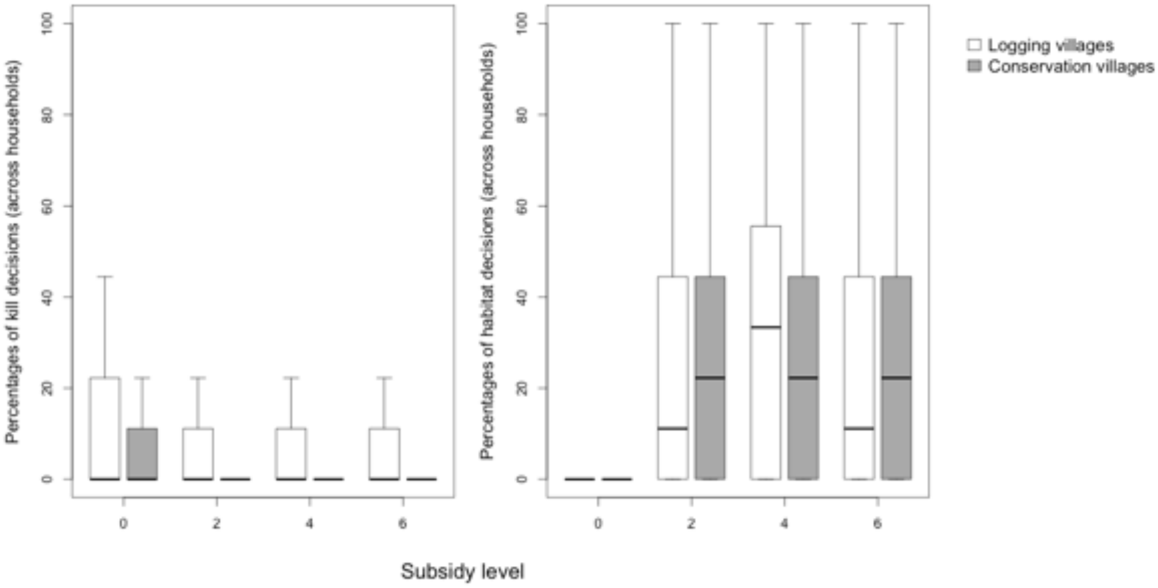


Figure A1.3: Distribution of observed percentages of decisions to kill and to provide habitats per subsidy level across households and groups. Solid black bars represent the median proportion, boxes the interquartile range and error bars extend to 1.5 times the IQR limits.

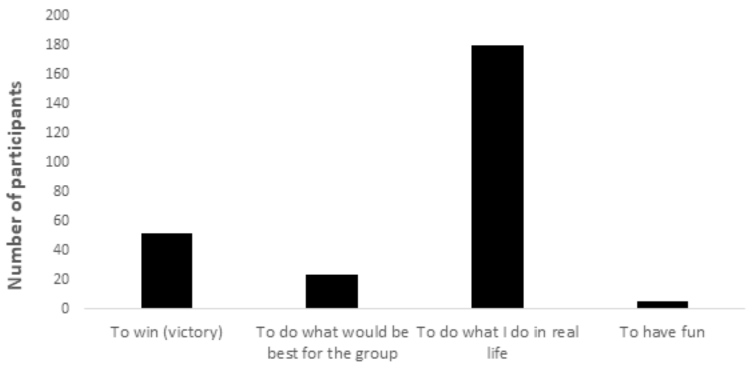


Figure A1.4: Follow-up question asking participants about their main goal in the game

Table A1.1a: Factor loading of the interpersonal community trust indices

	One-factor solution
"Most of the time, people in my community are mostly trying to help each other"	0.76
"Generally speaking, most people in my community are honest and can be trusted"	0.61
"In general, people in my community lend money to each other when needed, and get the money they have lent back"	0.61
Proportion of variance explained = 0.44, Cronbach's alpha = 0.70	
SS loadings = 1.32, Correlation of (regression) scores with factors = 0.85, Root mean square of the residuals = 0	

Table A1.1b: Factor loading of the institutional trust indices

	One-factor solution
Trust in the National Park Agency	0.81
Trust in the Ministry of Water and Forests	0.88
Trust in the Ministry of Agriculture	0.70
Proportion of variance explained = 0.64, Cronbach's alpha = 0.84	
SS loadings = 1.92, Correlation of (regression) scores with factors 0.93, Root mean square of residuals (RMSE) = 0	

Table A1.1c: Factor loading of the equity indices

	One-factor solution
"The current government strategy fairly balances local livelihoods and conservation interests"	0.81
"We feel able to influence decision-making related to elephant conservation and local livelihoods (through effective participation)"	0.67
"The government strategy on conservation and development equally benefits my community"	0.60
Proportion of variance explained = 0.45, Cronbach's alpha* = 0.70	
SS loadings = 1.34, Correlation of (regression) scores with factors = 0.87, Root mean square of residuals (RMSE) = 0	

Table A1.2: Socio-economic and attitudinal variables included in the models

Variables	Description	Summary statistics (N=260)	
Region ID	Binary variable indicating whether a household was surveyed in the conservation-influenced or logging-influenced villages	National park villages	140 (54%)
Institutional Trust Index	Numeric variable representing the weighted factor scores from three measures of institutional trust (trust towards the Park agency, the Ministry of Water and Forests and the Ministry of Agriculture; figure S1; Cronbach's alpha* = 0.84, the one-factor solution explained 64% of the total variance)	Min Max Median	-0.9 1.4 -0.3
Community trust index	Numeric variable representing the weighted factor scores from three measures of trust among local communities; figure S1; Cronbach's alpha* = 0.70, the one-factor solution explained 44% of the total variance)	Min Max Median	-1.4 1.0 0.2
Equity	Numeric variable representing the weighted factor scores from three measures of equity among local communities (Equitable government policy, perceived influence on decision-making and equitable distribution of benefits; figure S1; Cronbach's alpha* = 0.70, the one-factor solution explained 46% of the total variance)	Min Max Median	-0.5 3 -0.4
Positive well-being impacts of elephants	Numeric variable indicating the households' perceptions of the positive impacts of elephants on well-being (figure S1)	Mean Std. dev. Mean	-2 2 1.2
Negative well-being impacts of elephants	Numeric variable indicating the households' perceptions of the positive impacts of elephants on well-being (measured on a Likert scale of -2 to +2) (figure S1)	Mean Std. dev. Median	-2 2 -0.4
Experienced crop damage	Binary variable indicating whether a household has experienced crop damage (0=No, 1=Yes) (figure S1)	Yes	161 (62%)
Primary occupation: Agriculture	Binary variable indicating whether a household's primary occupation is agriculture	Yes	117 (47%)
Age	Numeric variable indicating the age of the participant	Mean Std. dev. Median	42.6 15 42
Gender	Categorical variable (two categories in our data, so treated as binary) indicating the gender of the participant	Male	96 (36%)
Education	Numeric variable indicating the years of official schooling of the participant	Mean Std. dev. Median	6.1 3 6

* Cronbach's alpha is a measure of internal consistency or scale reliability, i.e. how closely related a set of items are as a group, coefficient of .70 or higher is considered acceptable in most social science research (Cronbach 1951).

Table A1.3: Socio-economic characteristics of surveyed households

Variables	Description	Summary statistics: Conservation-influenced villages (CV) (N=120)	Summary statistics: Logging-influenced villages (LV) (N=140)	Coding used in combined wealth indices
Crop damage	Whether the household has experienced any damage by elephant for the past 12 months (in any of their fields)	69.2 % Yes	55 % Yes	NA
Magnitude of crop damage	Whether crop losses by elephant were high (damage > 60%) (for households who have experienced crop damage)	68% Yes	54.5% Yes	NA
Frequency of elephant visit	Numeric variable indicating the number of crop-raiding incidents by elephants for the past 12 months	Median: 2.0 Mean: 3.0 Std. dev.: 3.3	Median: 1.0 Mean: 2.5 Std. dev.: 3.8	NA
Food security	Number of months for which HH has enough to eat	Median: 9.0 Mean: 7.6 Std. dev.: 3.6	Median: 10 Mean: 8.5 Std. dev.: 3.3	Continuous variable (0-12 months)
Tropical livestock	Numeric variable indicating total livestock owned by the household in tropical livestock unit (Chilonda and Otte 2006)	Median: 0.01 Mean: 0.16 Std. dev.: 0.28	Median: 0.00 Mean: 0.16 Std. dev.: 0.41	Continuous variable (0–1.3)
Cooking materials	Materials used by the household for cooking	21%: Fuelwood 45%: Fuelwood and stove, 18%: Stove, 16%: Four-flame oven	33%: Fuelwood 41% Fuelwood and stove, 15% = Stove, 11%: Four-flame oven	Cooking materials (Fuelwood = 1, Fuelwood and stove = 2, Stove=3, Four-flame oven = 4)
Number of rooms	Total number of rooms	Median: 4, Mean: 5.5, Std. dev.: 4.0	Median: 4, Mean: 4.7, Std. dev.: 3.4	Continuous variable
Floor quality	Type of floor in the primary dwelling	78.5 % Concrete	59.1 % Concrete	Floor type (0= Soil, 1=Concrete
Large Field (>0.7 ha)	Whether households have access to a large field	50% Yes	63% Yes	Access to a large field (0=No, 1=Yes)
Refrigerator	Number of refrigerators owned by the household	Median: 0.0 Mean: 0.17 Std. dev.: 0.41	Median: 0.0 Mean: 0.12 Std. dev.: 0.35	Continuous variable
Freezer	Number of freezers owned by the household	Median: 1.0 Mean: 0.87 Std. dev.: 0.66	Median: 1.0 Mean: 0.68 Std. dev.: 0.76	Continuous variable
Television	Number of televisions owned by the household	Median: 1.0 Mean: 0.87 Std. dev.: 0.65	Median: 1.0 Mean: 0.64 Std. dev.: 0.57	Continuous variable

Mobile phone	Number of mobile phones owned by the household	Median: 1.0 Mean: 1.27 Std. dev.: 0.74	Median: 1.0 Mean: 1.07 Std. dev.: 0.48	Continuous variable

Table A1.4: Odds ratio estimates from the full GLMM model showing the effect of treatments and other households' characteristics on farmers' propensity to kill elephants in the games. Random effects included in the model were individuals and groups.

	Proportion of kill decisions	
Predictors	*Odds Ratios*	*95 % CI*
(Intercept)	**0.09** ***	**0.03 – 0.24**
Deterrents	**0.81** ***	**0.73 – 0.90**
Subsidy	**0.72** ***	**0.64 – 0.80**
Agglomeration	**0.57** ***	**0.50 – 0.64**
Rounds in the game	0.97	0.93 – 1.00
Rounds into session	**0.99** ***	**0.98 – 0.99**
Lagged kill decisions of other participants	**1.05** ***	**1.03 – 1.08**
Total number of elephants in the landscape	1.02 *	1.00 – 1.04
Region ID (conservation-influenced villages)	**0.36** ***	**0.22 – 0.59**
Equity index	**0.73** **	**0.58 – 0.93**
Community trust index	1.13	0.91 – 1.41
Institutional Trust index	1.04	0.85 – 1.27
Positive well-being impacts of elephants	**0.88** *	**0.79 – 0.97**
Negative well-being impacts of elephants	1.01	0.87 – 1.16
Experienced crop damage	0.76	0.51 – 1.13
Primary occupation: Agriculture	1.03	0.68 – 1.53
Wealth axis 1	1.20	0.97 – 1.48
Wealth axis 2	1.07	0.87 – 1.31
Age	0.99	0.98 – 1.01
Gender	0.98	0.66 – 1.46
Education	1.01	0.94 – 1.08
Support for deterrents * Equity index	**1.18** *	**1.03 – 1.35**
Subsidy * Equity index	1.04	0.90 – 1.20
Agglomeration * Equity index	**1.25** **	**1.08 – 1.44**
τ_{00}	$1.29_{\text{HHID:GameID}}$	
	0.51_{GameID}	
Observations	4976	
Marginal R^2 / Conditional R^2	0.082 / 0.406	

Table A1.5: Odds ratio estimates from the full GLMM model showing the effect of treatments and other households' characteristics on farmers' propensity to provide habitats in the games. Random effects included in the model were individuals and groups.

	Proportion of habitat decisions	
Predictors	*Odds Ratios*	*95% CI*
(Intercept)	**0.00** ***	**0.00 – 0.01**
Deterrents	1.00	0.85 – 1.17
Subsidy	**7.29** ***	**6.37 – 8.35**
Agglomeration	**12.97** ***	**11.18 – 15.05**
Rounds in the game	0.98	0.96 – 1.01
Rounds into session	**1.03** ***	**1.02 – 1.03**

Lagged habitat decisions of other participants	**1.07** ***	**1.06 – 1.07**
Total number of elephants in the landscape	**1.07** ***	**1.04 – 1.09**
Region ID (conservation-influenced villages)	0.85	0.55 – 1.30
Equity index	1.01	0.81 – 1.26
Community trust index	0.92	0.73 – 1.16
Institutional Trust index	1.06	0.86 – 1.32
Positive well-being impacts of elephants	1.00	0.90 – 1.12
Negative well-being impacts of elephants	0.99	0.85 – 1.15
Experienced crop damage	1.11	0.74 – 1.65
Primary occupation: Agriculture	0.91	0.60 – 1.38
Wealth axis 1	0.96	0.78 – 1.18
Wealth axis 2	0.86	0.70 – 1.06
Age	1.00	0.98 – 1.01
Gender	1.45	0.97 – 2.17
Education	1.03	0.96 – 1.10
τ_{00}	1.84 $_{HHID:GameID}$	
	0.15 $_{GameID}$	
Observations	4976	
Marginal R^2 / Conditional R^2	0.302 / 0.568	

Table A1.6: Effects of subsidy levels and other game conditions on kill and habitat decisions (only the monetary treatments were included in the model). For categorical variables the level that is represented by the intercept term is shown in parentheses.

	Proportion of kill decisions		**Proportion of habitat decisions**	
Predictors	***Odds Ratios***	***95% CI***	***Odds Ratios***	***95% CI***
(Intercept)	**0.02** ***	**0.01 – 0.04**	**0.03** ***	**0.02 – 0.06**
Treatments (Subsidy)				
Agglomeration	**0.78** ***	**0.69 – 0.88**	**1.93** ***	**1.78 – 2.10**
Subsidy level (2)				
Subsidy level 4	0.87	0.54 – 1.43	0.83	0.55 – 1.27
Subsidy level 6	0.94	0.48 – 1.84	1.09	0.63 – 1.86
Rounds in the game	0.98	0.93 – 1.04	0.98	0.95 – 1.01
Rounds into session	**0.99** *	**0.98 – 1.00**	**1.04** ***	**1.03 – 1.05**
Lagged kill decisions of other participants	**1.07** ***	**1.03 – 1.10**		
Lagged habitat decisions of other participants			**1.06** ***	**1.04 – 1.07**
Total number of elephants in the landscape	**1.05** **	**1.02 – 1.09**	**1.06** ***	**1.03 – 1.08**
Random Effects				
Variance	1.61 $_{HHID:GameID}$		2.42 $_{HHID:GameID}$	
	0.96 $_{GameID}$		0.43 $_{GameID}$	
Observations	2580		2580	
Marginal R^2 / Conditional R^2	0.009 / 0.444		0.076 / 0.505	
***** $p<0.05$ ** $p<0.01$ *** $p<0.001$***				

Table A1.7: Robustness tests: Odds ratio estimates from three GLMM models showing the effect of treatments and three variables of interest (1: Equity, 2: Region ID, 3: positive well-being impacts of elephants) on farmers' propensity to kill elephants in the games. Random effects included in the model were individuals and groups.

	Proportion of kill decisions (1)		Proportion of kill decisions (2)		Proportion of kill decisions (3)	
Predictors	*Odds Ratios*	*CI*	*Odds Ratios*	*CI*	*Odds Ratios*	*CI*
(Intercept)	0.04 ***	0.02 – 0.06	0.06 ***	0.04 – 0.10	0.03 ***	0.02 – 0.05
Deterrents	0.84 **	0.76 – 0.94	0.83 ***	0.75 – 0.93	0.83 ***	0.75 – 0.93
Subsidy	0.75 ***	0.67 – 0.83	0.74 ***	0.66 – 0.83	0.74 ***	0.66 – 0.83
Agglomeration	0.59 ***	0.52 – 0.67	0.58 ***	0.52 – 0.66	0.58 ***	0.52 – 0.66
Equity index	0.73 **	0.58 – 0.92				
Rounds	0.97	0.93 – 1.00	0.97	0.93 – 1.01	0.97	0.93 – 1.01
Rounds into the session	0.99 ***	0.98 – 0.99	0.99 ***	0.98 – 0.99	0.99 ***	0.98 – 0.99
Lagged kill decisions of other participants	1.05 ***	1.03 – 1.08	1.05 ***	1.03 – 1.07	1.05 ***	1.03 – 1.07
Total number of elephants in the landscape	1.02 *	1.00 – 1.04	1.02 *	1.00 – 1.04	1.02 *	1.00 – 1.04
Support for deterrents * Equity index	1.19 **	1.05 – 1.36				
Subsidy * Equity index	1.10	0.96 – 1.26				
Agglomeration * Equity index	1.26 ***	1.10 – 1.45				
Region ID (conservation-influenced villages)			0.36 ***	0.22 – 0.60		
Positive well-being impacts of elephants					0.86 **	0.79 – 0.95
Random Effects						
τ_{00}	1.45 $_{HHID:GameID}$		1.46 $_{HHID:GameID}$		1.40 $_{HHID:GameID}$	
	0.88 $_{GameID}$		0.61 $_{GameID}$		0.87 $_{GameID}$	
Observations	5156		5156		5156	
Marginal R^2 / Conditional R^2	0.016 / 0.424		0.057 / 0.421		0.023 / 0.422	
						* p<0.05 ** p<0.01 *** p<0.001

Appendix 2. NOTES ON THE NETLOGO FRAMEWORK

Netlogo is a coding language that specialises in agent-based-modelling but can also be successfully used to implement field experiments, as we demonstrated. Its interface was very user-friendly, and it readily allowed the incorporation of the spatial and temporal dynamics. The NetLogo framework also allowed us to create a mobile lab in the field – giving us the benefits of a computational framework (capturing nonlinear outcomes in the landscape) without introducing the selection bias inherent in bringing people to a computer lab (those that can give up more time and drive out to join you). As well, the structure of NetLogo and HubNet mean that it was easy to get tablets to send signals to each other reliably in field conditions, change languages easily, and sub in visual cues in place of text. Plea see Bell (2013) and Bell and Zhang (2016) for more information.

Bell, A., & Zhang, W. (2016). Payments discourage coordination in ecosystem services provision: evidence from behavioral experiments in Southeast Asia. Environmental Research Letters, 11(11), 114024. Retrieved from http://stacks.iop.org/1748-9326/11/i=11/a=114024

Bell, A., Zhang, W., Bianchi, F., & vander Werf, W. (2013). NonCropShare - a coordination game for provision of insect-based ecosystem services. (http://ifpri.org/ publication/noncropshare-coordination-game) (Accessed: 19 June 2016).

Appendix 3 - THEORY UNDERLYING THE GAME DESIGN

Introduction

Game theory provides the foundation for predicting the decisions of rational agents in strategic situations. For simple games, it is often possible to find strategic solutions in which no agent can benefit by changing their strategy (i.e., Nash equilibria). But where the possible strategy space of a game is very large (e.g. if optimal play is contingent upon dynamic local conditions such as resource distribution or game history), analytical solutions are often intractable (Hamblin 2013). To ensure sufficient realism and motivations for play, our treatments model many elephants moving independently and stochastically among spatially explicit landscape cells, and we allow for the decisions of current rounds to potentially affect payoffs in future rounds (e.g. shooting elephants subsequently reduces their number). While this critical game realism precludes us from deriving analytical solutions for optimal play, it is possible to derive analytical solutions for simplified conditions (e.g. a single round of game play and expected elephant distribution), and to explore the consequences of dominant (though not necessarily optimal) strategies (such as "always scare when elephants are on a cell, else farm") that might be used in game play.

Stakeholders in our games needed to consider the discrete movement of elephants on a spatially explicit landscape, while simultaneously considering how current decisions might affect future payoffs. Under such complex conditions, considering the full range of possible strategies available to players is not tractable, nor would it be particularly useful for understanding actual stakeholder decision making in our behavioural games. Nevertheless, it is worthwhile to relate the behavioural games being played back to first principles of game theory. In this supplementary material, we analyse a simplified version of the behavioural game from the main text and demonstrate that while farming all landscape cells is a Nash equilibrium, cooperative play to build elephant habitats can ultimately lead to higher payoffs if the temptation to defect can be avoided. We also show the payoffs associated with heuristic strategies played when elephant distributions are discrete across the landscape, and when shooting elephants can have long-term consequences on accrued payoffs in late rounds of the behavioural game. Finally, we show all R code used to analyse Nash equilibria. This supplementary material is organised as follows.

1. Nash equilibria for simplified game
2. Issues arising from elephant distributions
3. Issues arising from sequential rounds
4. Supporting code: Annotated functions

In the first section, we consider a game played for a single round, and given expected (i.e., probabilistic) rather than realised elephant distributions.

Nash equilibria for simplified game

A Nash equilibrium is a stable state of strategies for a game, from which no invading strategy can outperform the resident strategy, hence any individual player performs best by adopting the resident strategy. Below, we have developed code that allows the user to place three identical resident strategies on the simulated game landscape for any set of game parameter combinations. The test_fitness function then iterates *every possible* invading strategy and checks its fitness against the fitnesses of the resident strategy. It does this by simulating the player in the upper right corner of the game landscape (note that due to landscape symmetry, choice of landscape quadrant does not matter). In the elephant games, players can choose from four possible options for each of their nine cells:

1. Farm
2. Scare

3. Cull

4. Habitat

Each option is associated with points, a cost, and a weight that affects the cell's attractiveness to geese (and those of neighbouring cells). There are $4^9 = 262144$ possible combinations of farm, scare, cull, and habitat choice on the nine cells. Hence, to test whether or not a resident strategy can be invaded by a different strategy, we cycle through all 262144 possible land use choice combinations that could possibly invade the resident strategy . If none of these combinations results in a higher payoff than the resident strategy (i.e., if the best invading strategy *is* the resident strategy), then we have proved through exhaustive search that the resident strategy is a Nash equilibrium for the chosen game conditions.

The key simplifying assumption we make in assessing Nash equilibria is that payoffs are calculated from the expected distributions of elephants (based on landscape cell weights) rather than realised distributions of individual elephants. For example, on a landscape in which all cells are being farmed and therefore of equal weight and probability of elephant occurrence , each cell is assumed to have $18/36 = 0.5$ elephants. Where different land-use decisions are made, expected elephant numbers are adjusted accordingly by cell weights. This simplification preserves the general structure of the game and allows us to investigate it from first principles using game theory. Allowing instead for realised elephant distributions would make calculation of Nash equilibria using our method intractable, as there are $36^{18} \approx 1.03 \times 10^{28}$ possible ways that 18 elephants can be distributed across the landscape (although this number could be reduced somewhat by identifying symmetries on the landscape). It would also likely result in complex strategies, conditional upon realised elephant distributions; we explore such strategies in the following section.

The test_fitness function works by iterating through all possible invading strategies and calculating the payoff of each. If the background strategy is a Nash equilibrium, then the highest payoff score will also be the background strategy. All parameter values are included as arguments, which are listed in Table 1 of the main text, recreated below. In this simplified game, we assume no elephant habitat subsidy.

	Farm	Farm and scare	Farm and kill	Elephant habitat
Yield	4	4	4	0
Subsidy	0	0	0	X [2, 4, 6]
Crop damage (per elephant)	-2	-2	-2	0
Costs	0	-1	-2	0
Weight	10	5	2	90
Effectiveness	–	30%	80%	–
Habitat neighbourhood effect	None	None	None	+5 weight to neighbour cells

The parameter values in the table above are set as default arguments in the function test_fitness() function, which is shown below.

```
test_fitness <-  function(land,
                   farm_points     = 4,
                   scare_points    = 4,
                   cull_points     = 4,
                   habitat_points  = 0,
```

```
                farm_cost       = 0,
                scare_cost      = 1,
                cull_cost       = 2,
                habitat_cost    = 0,
                farm_weight     = 10,
                scare_weight    = 5,
                cull_weight     = 2,
                habitat_weight  = 90,
                bump            = 5,
                habitat_neigh   = 1,
                eleph_count     = 18,
                damage          = 2,
                scare_prob      = 0.8,
                cull_prob       = 0.3,
                shoot_to_kill   = TRUE,
                replace_living  = FALSE
){
  parameters <- c(farm_points, scare_points, cull_points, habitat_points,
                  farm_cost, scare_cost, cull_cost, habitat_cost,
                  farm_weight, scare_weight, cull_weight, habitat_weight,
                  bump, habitat_neigh, eleph_count, damage,
                  scare_prob, cull_prob, shoot_to_kill, replace_living);
  perms      <- expand.grid( c1 = 1:4, c2 = 1:4, c3 = 1:4, c4 = 1:4, c5 = 1:4,
                        c6 = 1:4, c7 = 1:4, c8 = 1:4, c9 = 1:4);
  tot_perms  <- dim(perms)[1];
  fit_vector <- rep(0, tot_perms);

  time_elapsed <- proc.time();
  for( strat in 1:tot_perms ){
    temp_l          <- land;
    temp_l[1,4]      <- perms[strat,1];
    temp_l[1,5]      <- perms[strat,2];
    temp_l[1,6]      <- perms[strat,3];
    temp_l[2,4]      <- perms[strat,4];
    temp_l[2,5]      <- perms[strat,5];
    temp_l[2,6]      <- perms[strat,6];
    temp_l[3,4]      <- perms[strat,7];
    temp_l[3,5]      <- perms[strat,8];
    temp_l[3,6]      <- perms[strat,9];
    temp_l          <- unlist(temp_l);
    land            <- matrix(data = temp_l, nrow = 6, ncol = 6);
    land_pay         <- calc_payoff(land, parameters);
    strat_fitness    <- sum(land_pay[1:3, 4:6]);
    fit_vector[strat] <- strat_fitness;
    time_check       <- proc.time();
    time_print       <- time_check - time_elapsed;
    if(time_print[3] > 30){
      pct_complete <- round(strat / tot_perms * 100);
      print(paste("Progress: ", pct_complete, "%", sep = ""));
      time_elapsed <- proc.time();
    }
```

```
  }

  output <- list(strategy = perms, fitness = fit_vector, land = land);

  return( output );
}
```

Note that the test_fitness function relies on the custom function calc_payoff to calculate the payoff of a focal strategy (i.e., the payoff of a focal set of land-use decisions, as played in the upper right corner of the landscape), which in turn calls several other custom functions. These custom functions are explained in detail below, but here it is only important that calc_payoff calculates the payoff of a focal invading strategy against a selected resident strategy. The loop in the above cycles through every possible invading strategy to calculate all possible payoffs. In the output of test_fitness, the list of strategies is returned (strategy), along with the fitness of each strategy (fitness; vector elements correspond to rows of strategy), and the original landscape (land).

Resident farming strategy: To show that farming on all cells is a Nash equilibrium, it is first necessary to define a landscape as a six by six matrix in which the background strategy land-use choices are being played. For farming, cell land use choice takes a value of 1, so the appropriate land is simply a matrix of 1s.

```
proposed_NE <- matrix(data = 1, nrow = 6, ncol = 6);

##      [,1] [,2] [,3] [,4] [,5] [,6]
## [1,]    1    1    1    1    1    1
## [2,]    1    1    1    1    1    1
## [3,]    1    1    1    1    1    1
## [4,]    1    1    1    1    1    1
## [5,]    1    1    1    1    1    1
## [6,]    1    1    1    1    1    1
```

The land matrix is then used in the test_fitness function, where all the payoffs of all possible invading strategies are compared to the payoffs of the resident strategy.

```
fitness_results <- test_fitness(land = proposed_NE);
```

These results are then summarised with the following function fitness_summary.

```
fitness_summary <- function(results, background = NULL, plot = FALSE){
  if(is.null(background) == TRUE){
    background <- matrix(data = 1, nrow = 3, ncol = 3);
    warning("No resident strategy selected: assuming all farming");
  }
  fitness   <- results$fitness;
  strategy  <- results$strategy;
  land      <- results$land;
  fit_order <- order(fitness, decreasing = TRUE);
  top_ten   <- fit_order[1:10];
  payoff    <- fitness[top_ten];
  most_str  <- strategy[top_ten,];
  res_tabl  <- cbind(payoff, most_str);
  bgstrat   <- unlist(t(background)[1:9]);
  permpos   <- 1;
  checkstr  <- 0;
  time_elapsed <- proc.time();
  while(checkstr == 0 & permpos < dim(strategy)[1]){
```

```
        sqrdev <- (bgstrat - strategy[permpos,])*(bgstrat - strategy[permpos,]);
        if( sum(sqrdev) == 0 ){
           checkstr <- 1;
        }else{
           permpos <- permpos + 1;
        }
        time_check       <- proc.time();
        time_print       <- time_check - time_elapsed;
        if(time_print[3] > 10){
           pct_complete <- round(permpos / dim(strategy)[1] * 100);
           print(paste("Checked: ", pct_complete, "%", sep = ""));
           time_elapsed <- proc.time();
        }
     }
     last_row <- c(fitness[permpos], bgstrat);
     res_tabl <- rbind(res_tabl, last_row);
     rownames(res_tabl) <- c("Strategy 1", "Strategy 2", "Strategy 3",
                             "Strategy 4", "Strategy 5", "Strategy 6",
                             "Strategy 7", "Strategy 8", "Strategy 9",
                             "Strategy 10", "Resident Strategy");
     if(plot == TRUE){
        par(mar = c(5, 5, 1, 1), lwd = 2);
        hist(fitness, xlab = "Strategy Fitness", ylab = "Frequency",
             main = "", cex = 1.5, cex.lab = 1.5, cex.axis = 1.5, col = "grey");
     }
     return(res_tabl);
}
```

The function fitness_summary organises the results from test_fitness and generates an ordered list of invading strategies by fitness. If the highest fitness strategy is the resident strategy, then it will be the first listed in the table and the resident strategy will be a Nash equilibrium. The fitness_summary argument background is for the user to set what the equivalent 'resident' strategy looks like for the invader. The reason that the background strategy is not just assumed to be identical to the other three players is because an 'identical' strategy might actually rely on symmetry in land orientation – e.g., if everyone farms all their squares *except* the square in the middle of the board.

```
inv_bgd <- matrix(data = 1, nrow = 3, ncol = 3);
results <- fitness_summary(results    = fitness_results,
                           background =  inv_bgd);
```

Results for a resident strategy of farming all landscape cells are shown below.

	payoff	c1	c2	c3	c4	c5	c6	c7	c8	c9
Strategy 1	27.00000	1	1	1	1	1	1	1	1	1
Strategy 2	26.68879	2	1	1	1	1	1	1	1	1
Strategy 3	26.68879	1	2	1	1	1	1	1	1	1
Strategy 4	26.68879	1	1	2	1	1	1	1	1	1

Strategy 5	26.68879	1 1 1 2 1 1 1 1 1
Strategy 6	26.68879	1 1 1 1 2 1 1 1 1
Strategy 7	26.68879	1 1 1 1 1 2 1 1 1
Strategy 8	26.68879	1 1 1 1 1 1 2 1 1
Strategy 9	26.68879	1 1 1 1 1 1 1 2 1
Strategy 10	26.68879	1 1 1 1 1 1 1 1 2
Resident Strategy	27.00000	1 1 1 1 1 1 1 1 1

The payoff is indicated in the second column, while c1 through c9 refer to the invading strategy's landscape cells ordered by row as below in table form.

```
##      [,1] [,2] [,3]
## [1,]    1    2    3
## [2,]    4    5    6
## [3,]    7    8    9
```

Given that the highest fitness strategy is the resident strategy of farming on all cells, with a total payoff of 27, we can say that farming on all cells is a Nash equilibrium strategy; if all neighbours are farming all of their cells, then the best strategy a focal player can have is to also farm all cells.

It is important to note that just because farming on all cells is a Nash equilibrium, this does not mean that farming on all cells also yields the highest payoff per player. Indeed, we can show using the same method that a cooperative strategy replacing farming with elephant habitat in each player's centre-most landscape cell yields a higher payoff for each player. Consider the landscape below, and recall that 4 indicates the choice of elephant habitat.

```
##      [,1] [,2] [,3] [,4] [,5] [,6]
## [1,]    1    1    1    1    1    1
## [2,]    1    1    1    1    1    1
## [3,]    1    1    4    4    1    1
## [4,]    1    1    4    4    1    1
## [5,]    1    1    1    1    1    1
## [6,]    1    1    1    1    1    1
```

The above cooperative resident strategy yields more than 27 points, but is not a Nash equilibrium. To demonstrate this, the below code is run as before.

```
proposed_NE_coop         <- matrix(data = 1, nrow = 6, ncol = 6);
proposed_NE_coop[3:4, 3:4] <- 4;
fitness_results_coop     <- test_fitness(land = proposed_NE_coop);
inv_bgd_coop             <- matrix(data = 1, nrow = 3, ncol = 3);
inv_bgd_coop[3, 1]       <- 4; # Habitat in the lower left corner
results_coop             <- fitness_summary(results    = fitness_results_coop,
                                            background = inv_bgd_coop);
```

The below table shows the results.

	payoff	c1	c2	c3	c4	c5	c6	c7	c8	c9
Strategy 1	30.25000	1	1	1	1	1	1	1	1	1
Strategy 2	30.14320	1	1	1	1	1	1	2	1	1
Strategy 3	29.80237	1	1	1	2	1	1	1	1	1
Strategy 4	29.80237	1	1	1	1	1	1	1	2	1
Strategy 5	29.72078	1	1	1	2	1	1	2	1	1
Strategy 6	29.72078	1	1	1	1	1	1	2	2	1
Strategy 7	29.63195	2	1	1	1	1	1	1	1	1
Strategy 8	29.63195	1	2	1	1	1	1	1	1	1
Strategy 9	29.63195	1	1	2	1	1	1	1	1	1
Strategy 10	29.63195	1	1	1	1	2	1	1	1	1
Resident Strategy	27.50000	1	1	1	1	1	1	4	1	1

While the total payoff of the resident strategy has increased slightly to 27.5 from 27 when all players were farming, this cooperative use of elephant habitat is not a Nash equilibrium because the highest payoff strategy is still farming, which now yields an even higher payoff of 30.25. Hence, when the game is analysed for a single round of play given payoffs of expected elephant distributions, it entails a classic Prisoner's dilemma situation in which rational play by all agents leads to a lower payoff than would be possible through cooperation.

Resident scaring strategy: Interestingly, if the resident strategy is such that all farmers scare elephants on all cells, then the most successful invading strategy is one that scares on every cell except one, in which elephant habitat is instead provided. Using the same techniques as above, the following strategies payoffs accrue.

	payoff	c1	c2	c3	c4	c5	c6	c7	c8	c9
Strategy 1	18.71382	2	2	2	2	2	2	4	2	2
Strategy 2	18.69544	4	2	2	2	2	2	2	2	2
Strategy 3	18.54265	2	2	2	2	2	2	2	2	4

Strategy 4	18.48862	2	2	4	2	2	2	2	2	2
Strategy 5	18.47838	2	2	1	2	2	2	4	2	2
Strategy 6	18.47838	2	1	2	2	2	2	4	2	2
Strategy 7	18.47838	1	2	2	2	2	2	4	2	2
Strategy 8	18.45241	2	2	2	2	2	1	4	2	2
Strategy 9	18.42327	2	2	2	2	2	2	4	2	1
Strategy 10	18.40228	4	2	1	2	2	2	2	2	2
Resident Strategy	16.16820	2	2	2	2	2	2	2	2	2

As noted above, the top scoring strategy yields a payoff of 18.7138156, which is higher than the resident strategy of 16.1681998, meaning that scaring on all cells is not a Nash equilibrium, and can be invaded by a player who opts to set one landscape cell aside for elephant habitat. Interestingly, this strategy of scaring on all landscape cells, except for a centre-most cell, is also not a Nash equilibrium, but can itself be invaded by a strategy of scaring on only one cell and farming on the rest. The total payoff accrued to each player increases, and it is worth noting that most of the highest payoff strategies listed below are farming-centred.

	payoff	c1	c2	c3	c4	c5	c6	c7	c8	c9
Strategy 1	27.29826	1	1	1	1	1	1	2	1	1
Strategy 2	27.18349	1	1	1	1	1	1	1	1	1
Strategy 3	27.04452	1	1	1	1	1	1	2	2	1
Strategy 4	27.03048	1	1	1	2	1	1	2	1	1
Strategy 5	26.88839	1	1	1	1	1	1	1	2	1
Strategy 6	26.87459	1	1	1	2	1	1	1	1	1
Strategy 7	26.82997	1	1	1	1	1	1	2	1	2
Strategy 8	26.82295	1	1	1	1	2	1	2	1	1
Strategy 9	26.82295	1	1	1	1	1	2	2	1	1

Strategy 10	26.81441	2	1	1	1	1	1	2	1	1
Resident Strategy	22.33192	2	2	2	2	2	2	4	2	2

In the above, the background and highest fitness strategy has a payoff of 27.2982609, slightly higher than the payoff accrued to one player when all players farm. Nevertheless, this highest fitness strategy in the example above is also vulnerable to invasion, this time from our originally considered Nash equilibrium strategy of farming all cells, as is shown by the highest payoff strategy below.

	payoff	c1	c2	c3	c4	c5	c6	c7	c8	c9
Strategy 1	26.27824	1	1	1	1	1	1	1	1	1
Strategy 2	25.99745	1	1	1	1	1	1	2	1	1
Strategy 3	25.99745	1	1	1	1	1	1	1	2	1
Strategy 4	25.99745	1	1	1	1	1	1	1	1	2
Strategy 5	25.99247	2	1	1	1	1	1	1	1	1
Strategy 6	25.99247	1	2	1	1	1	1	1	1	1
Strategy 7	25.99247	1	1	2	1	1	1	1	1	1
Strategy 8	25.99247	1	1	1	2	1	1	1	1	1
Strategy 9	25.99247	1	1	1	1	2	1	1	1	1
Strategy 10	25.99247	1	1	1	1	1	2	1	1	1
Resident Strategy	25.99745	1	1	1	1	1	1	2	1	1

Hence, by induction, it is clear that a community of players who scare elephants on all cells is prone to eventual replacement by a community of farmers. A strategy in which all players scare on all cells will be invaded by a strategy in which one player scares on all but one cell (leaving elephant habitat in their centre-most cell), which in turn will be invaded by a strategy of farming all but one cell (scaring elephants in their centre-most cell), which will finally be invaded by a strategy of farming on all cells. The same occurs for a community of players who shoot elephants on all cells, which (like uniform scaring) can also be invaded by a strategy of scaring on all but one cell.

Resident shooting strategy: When the resident strategy is to shoot on all landscape cells, the highest payoff invading strategy is to scare on all cells except one where a single landscape cell of habitat is instead placed.

	payoff	c 1	c 2	c 3	c 4	c 5	c 6	c 7	c 8	c 9
Strategy 1	20.96820	2	2	2	2	2	2	4	2	2
Strategy 2	20.64253	4	2	2	2	2	2	2	2	2
Strategy 3	20.64253	2	2	2	2	2	2	2	2	4
Strategy 4	20.56269	2	2	2	2	2	1	4	2	2
Strategy 5	20.56269	2	2	2	2	2	2	4	2	1
Strategy 6	20.56269	2	2	1	2	2	2	4	2	2
Strategy 7	20.56269	2	1	2	2	2	2	4	2	2
Strategy 8	20.56269	1	2	2	2	2	2	4	2	2
Strategy 9	20.38758	2	2	4	2	2	2	2	2	2
Strategy 10	20.25904	2	2	2	2	2	1	4	2	1
Resident Strategy	11.70000	3	3	3	3	3	3	3	3	3

Hence shooting on all cells is not a Nash equilibrium, while the strategy of providing habitat on one (central) cell and scaring on all of the rest is surprisingly robust.

Summary: We have proven through exhaustive search that farming all landscape cells is a Nash equilibrium in a single round of the game described in the text given expected elephant distributions (i.e., where the cost of an elephant on each cell is determined by the expected number of elephants on the cell). We have also demonstrated that a cooperative strategy allocating at least one landscape cell to elephant habitat yields a higher payoff for each player, but that this cooperative strategy can be invaded by a selfish strategy that only farms. Finally, we have shown that strategies of scaring or shooting elephants on all landscape cells are vulnerable to invasion by strategies that are more farming-focused. The important outcome of this exercise is to show that the theoretical foundation of the complex elephant game played among stakeholders in the main text is grounded by the classic situation in which rationally acting agents will play a selfish strategy despite cooperative play yielding a higher total payoff.

Using the functions test_fitness and fitness_summary, it can additionally be shown that scaring, killing, or placing elephant habitat on all cells are not Nash equilibria, with all being invaded by a 'farm all cells' strategy. Hence, for the simplified game structure, it is always best for a rational agent to farm all of their cells. It is important to emphasise that such a strategy is not necessarily rational once the assumption of expected elephant distribution is relaxed and elephants are allowed to vary stochastically across the landscape. In this case, due to chance, discrete elephants will appear on some cells and not others, and with a probability that is proportional to cell weights. Players will therefore need to decide what to do when they are faced with one or more elephants on specific cells but not others. In this case, the number of possible ways that 18 elephants can be distributed across 36 landscape cells makes calculating the payoff consequences of different strategies for each possible elephant distribution intractable. Further, given this level of game complexity, it is highly unlikely that real human players will play completely rationally, so it is more useful to consider the consequences of heuristic strategies that yield high payoffs. We do this in the next section.

Issues arising from elephant distributions

When elephants are placed discretely on the landscape, and therefore have discrete by-cell effects on crop loss rather than expected effects proportional to their probability of occurring on a given landscape cell, game players must decide what to do with elephants found on specific cells. Rational strategies in this case will likely not correspond to specific land-use choices on landscape cells, but rather decisions about what to do upon observing ϵ elephants on a given landscape cell; this decision might be affected by the strategies of other players and the distribution of elephants on other players' lands.

Recall that the minimum cell payoff is 0, elephants are randomly and uniformly distributed across landscape cells, and multiple elephants per cell is permitted. In a single round of game play, scaring and shooting actions take immediate effect. There are two heuristic strategies that are especially worth considering, which we define as 'scare-on-cells' and 'shoot-on-cells'. In the scare-on-cells strategy, players scare on any cell containing at least one elephant, but otherwise farm. In the shoot-on-cells strategy, players shoot on any cell containing at least one elephant, but otherwise farm. Below, we discuss the consequences of each strategy for a single round of game play.

The scare-on-cells strategy. The scare-on-cells strategy is likely a useful heuristic for playing the elephant game. Elephants on a landscape cell reduce the payoff yielded from the cell by 2 (Δ). Scaring elephants comes with a cost (C_{scare}) of 1 and has a 0.8 probability of success. It therefore comes with a potential increase in payoff of 1 if there is one elephant on the cell and 3 if there are two or more elephants on the cell. In the case of a single elephant, all else being equal, the probability that the elephant will be scared onto one of the focal player's remaining 8 cells (thereby negating the benefit of the action) is roughly 0.23. Using this value, the probability of scaring to a cell of a neighbouring player is therefore $Pr(scared) \approx 0.8 \times (1 - 0.23) \approx 0.616$. In other words, this is the probability that by scaring on a cell, the elephant leaves the cell and does not return to a different cell on the focal player's landscape. All else being equal, the expected number of points accrued from scaring on a cell with ϵ elephants is as follows,

$$E_{scare}(\epsilon) = Y - C_{scare} - \Delta\epsilon(1 - Pr(scared)).$$

In the above, Y is the yield from farming on the cell. Verbally, the above therefore describes the payoff yield from farming, minus the cost of scaring, minus the damage of elephants after scaring. Scaring damage is calculated as the damage per elephant (Δ), times the number of elephants (ϵ), times the probability that an elephant is not scared successfully ($1 - Pr(scared)$). For a landscape cell containing a single elephant, expected yield is as follows,

$$E[scare_{\epsilon=1}] = 4 - 1 - 2(1)(1 - 0.616) = 2.232.$$

Note that $E[scare_{\epsilon=1}] = Yield - Cost_{scare} = 3$ when $\epsilon = 0$, but as ϵ increases, the expected number of points accrued from scaring can actually become negative. Consider the instructive though highly unlikely case in which $\epsilon = 18$ (i.e., all elephants are on a single cell). Because the minimum possible cell yield is 0, in such a situation it would be a better strategy to simply farm the cell or turn it into elephant habitat (both have a cost of 0) because scaring elephants on the cell risks dispersing all 18 of them to other cells and spreading the damage. The focal player is simply better off accepting the loss of the 3 potential yield from farming on a single cell (4 minus 1 for the cost of scaring) to ensure a yield of 4 on all of the remaining 8 cells, regardless of what other players are doing.

For illustrative purposes, now assume that there exist ϵ elephants on a particular landscape cell of interest. Further assume that all other landscape cells are farmed, and that any other elephants on the landscape can be ignored for the purpose of predicting payoffs. We can consider how low ϵ needs to be for scaring them to be beneficial for a focal player when all elephants are on a single cell. First, note that to expect to gain any points at all from the cell on which elephants are located (even ignoring $Cost_{scare}$, and the possibility of elephants being displaced to a focal player's other cells), it must be the case that $\epsilon < 10$. When $\epsilon = 10$, the number of elephants remaining on the cell is expected to be 2 ($\epsilon(1 - 0.8)$), which would still result in the minimum possible crop yield of zero. When accounting for the cost of scaring and probability that scared elephants will return to one of the focal player's own landscape cells, with the above equation, scaring is only expected to increase payoff when $\epsilon < 4$. Values of $\epsilon \geq 4$ result in a negative $E[scare]$, meaning the action should not be taken (a higher payoff would be possible by farming the cell, or by turning it into elephant habitat). Nevertheless, it should be noted that $\epsilon \geq 4$ is highly unlikely, and that this situation was very rarely observed during behavioural games.

Given that the realised number of elephants per landscape cell is rarely more than three, the heuristic strategy of scare-on-cells is generally a good one. In this case, all else being equal, scaring increases a focal player's total payoff. Next, we will investigate the shoot-on-cells heuristic strategy in more detail.

The shoot-on-cells strategy

Shooting elephants potentially removes them from the entire landscape, thereby decreasing the total number of elephants that can subsequently decrease crop yield on a focal player's landscape cells. But unlike scare-on-cells, a shoot-on-cells strategy is not very beneficial for a single round of play. The probability of successfully shooting an elephant is low ($Pr(shot) = 0.3$), and from a focal player's payoff perspective, completely removing the elephant from the landscape gives no more benefit than scaring it onto a neighbouring player's cell. Because elephants are not displaced upon shooting, calculating the expected payoff for shooting an elephant on a landscape cell is relatively straightforward,

$$E[shoot] = Y - C_{shoot} - \Delta\epsilon(1 - Pr(shot))$$

In the above, C_{shoot} is the cost of shooting. For a landscape cell containing a single elephant, expected yield is as follows,

$$E[shoot_{\epsilon=1}] = 4 - 2 - 2(1)(1 - 0.3) = 0.6.$$

In this case, the expected payoff of shooting the elephant is actually lower than simply farming the landscape cell; the cost of shooting is too high, and the probability of success is too low, for shooting to be worthwhile. When $\epsilon > 1$, $E[shoot] = 0$ regardless of whether farming or shooting is chosen (if farming, then elephant damage reduces crop yield to zero; if shooting, elephant damage is expected to reduce crop yield to 1.2, but the cost of shooting is an additional 2). Hence, shooting elephants is never beneficial in a single round of the game. In the next section, we will look at how the shoot-on-cells strategy can affect points accrued over the course of 6-8 rounds of play in behavioural games.

Issues arising from sequential rounds

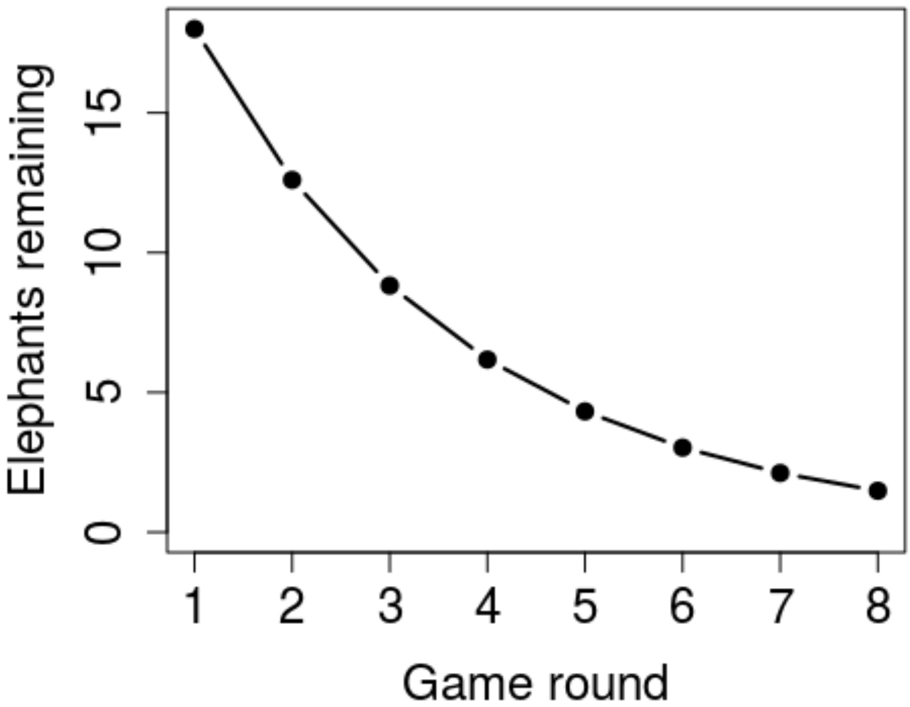
In previous sections, we examined simplified versions of the behavioural game in the main text, either by using expected rather than realised spatial distributions of elephants, or by considering payoff consequences for a single round of game play. When players interact over multiple rounds of game play, the parameter space of possible strategies increases exponentially to include strategies that are conditional upon game history. These strategies could be dependent upon the actions of, and payoffs accrued by, one or more players over the course of previous game rounds (e.g., a strategy might be to act one way if some number of other players did something within the previous 3 rounds, but act a different way if not). The complexity permitted in such strategies, and the consequent challenge of assessing their costs and benefits, is illustrated by the considerable amount of literature surrounding iterative strategies for the simple Prisoner's dilemma game (Darwen and Yao 1995; Adami and Hintze 2013; Rapoport et al. 2015). We therefore cannot attempt a detailed assessment of even a fraction of the possible strategies of the behavioural games played in the main text. Instead, here we consider only the most obvious, and likely most influential, effect of game history on player strategies; when an elephant is shot, there is one fewer elephant to cause crop damage on the landscape for all subsequent rounds of play.

Long-term gains of shooting of elephants

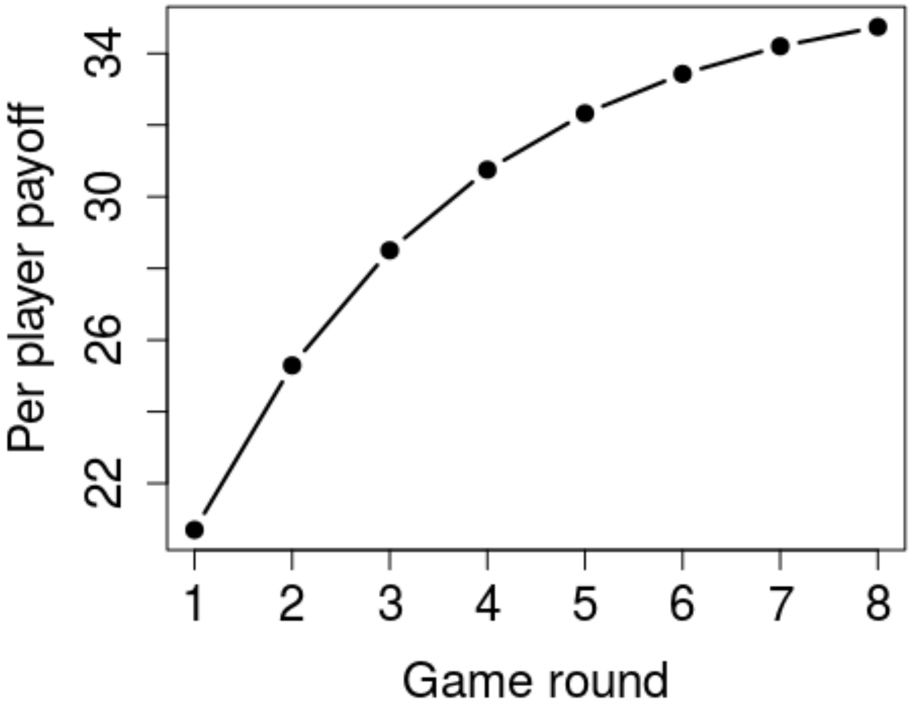
Behavioural games are played over the course of 6-8 rounds. Given this constraint, we can predict how elephant number is expected to decrease if all players shoot elephants when elephants are observed on their landscape cells. The expected number of elephants in round $r + 1$ is as follows,

$$E[\epsilon_{r+1}] = \epsilon_r(1 - Pr(shot))$$

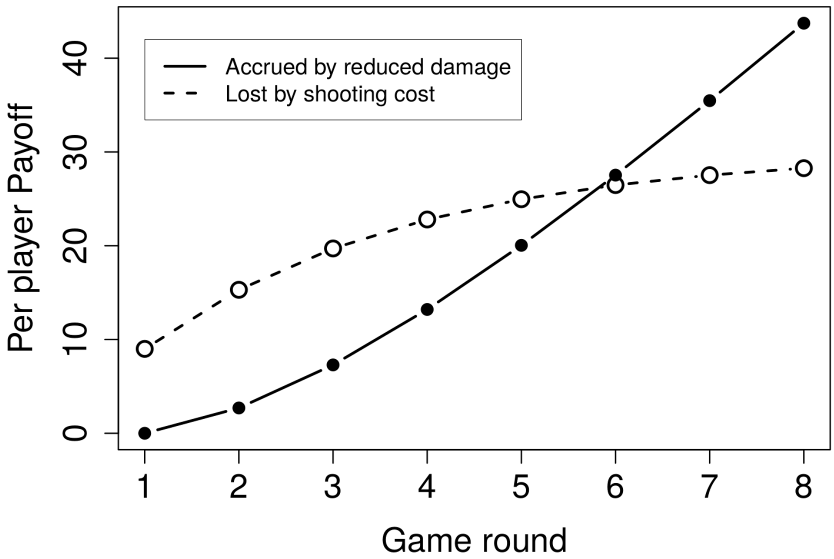
In the behavioural games, $Pr(shot) = 0.3$, and we can plot $E[\epsilon_{r+1}]$ over rounds assuming that all players attempt to shoot elephants.



Overall, we see an exponential decrease in elephant number. By round six (in which some games terminate), the combined efforts of four players reduce expected elephant number to 3.02526. An additional two rounds brings expected elephant number down to 1.4823774. This greatly reduces the potential for elephant damage on the landscape for later rounds, but the cost of shooting in each round also needs to be considered. In each round, the expected total cost of shooting across all players will be equal to twice the number of expected elephants ($C_{shoot} = 2$), while the expected cost for a single focal player will be equal to half the number of expected elephants (assuming the expected distribution of elephants is uniform). If we restrict potential strategies to farming and shooting, we can calculate the expected payoff per player over time as elephant number decreases.



To look at the benefit of shooting over rounds, we can compare the marginal benefit accrued from shooting (i.e., the increased payoff per player above the baseline expected if no shooting had taken place) to the accrued cost of shooting (i.e., the total amount spent over rounds on shooting).



As indicated by the plot above, when all players are shooting elephants on their cells, the benefit of shooting will have outweighed the cost of shooting by round six. Any subsequent rounds 7-8 will lead to an even higher payoff associated with lower elephant number. The accrued benefit begins to outweigh the cost of shooting because with each passing round, more farmed cell yields accumulate that would not have accumulated if elephants had not already been shot, and the cost of shooting also begins to drop as fewer elephants occupy landscape cells. In other words, the early decision by players to shoot elephants can payoff in later rounds because once elephants have been eliminated, yield can be collected in higher numbers with each passing round with less need to spend costs on shooting. Were games to continue for an indefinite number of rounds with this strategy, eventually all elephants would be eliminated, thereby increasing farm yield to its maximum per cell payoff for each cell, and eliminating the cost of shooting altogether (by eliminating the need to shoot). Hence, when round history is considered, long-term cooperative strategies of shooting can be beneficial.

Note that the above estimate for when determining when sustained shooting becomes more beneficial than costly is conservative because sometimes more than one elephant will occupy a single cell. When this happens, the cost of shooting will be reduced by two times the additional number of elephants on the cell because the cost of shooting is accrued on a per cell basis, not a per elephant basis. Also note that the same long-term rationale for shooting applies to individual players, assuming that elephants are not scared onto focal player's land. The expected per-player costs and benefits accrued over rounds will not change in this case because each player is expected to start with 4.5 elephants on their land. Relaxing this assumption, players that start with more elephants on their landscape will also accrue the long-term payoff benefits of shooting more rapidly than players that start with fewer elephants on their landscape cells.

Supporting code: Annotated functions

Here we list and explain all functions called by calc_payoff in the test_fitness function above, starting with calc_payoff itself. All functions are publicly available on GitHub. The calc_payoff function above refers to a function that calls other functions to calculate the payoff of an invading strategy.

```
calc_payoff <- function(land, parameters){
   farm_points    <- parameters[1];
   scare_points   <- parameters[2];
   cull_points    <- parameters[3];
   habitat_points <- parameters[4];
   farm_cost      <- parameters[5];
   scare_cost     <- parameters[6];
   cull_cost      <- parameters[7];
   habitat_cost   <- parameters[8];
   damage         <- parameters[16];
   eleps_distr    <- place_eleps(land, parameters); # Expected eleph number
   eleps_distr    <- disturb_eleps(land, parameters, eleps_distr);
   pay_mat        <- matrix(data = 0, nrow = dim(land)[1], ncol = dim(land));
   # Assign points to each landscape type
   pay_mat[land < 4]    <- pay_mat[land < 4] - eleps_distr[land < 4] * damage;
   pay_mat[pay_mat < 0] <- 0;
   pay_mat[land == 1]   <- pay_mat[land == 1] + farm_points
   pay_mat[land == 2]   <- pay_mat[land == 2] + scare_points
   pay_mat[land == 3]   <- pay_mat[land == 3] + cull_points
   pay_mat[land == 4]   <- pay_mat[land == 4] + habitat_points
   pay_mat[land < 4]    <- pay_mat[land < 4]  - eleps_distr[land < 4] * damage;
   pay_mat[pay_mat < 0] <- 0;
   pay_mat[land == 1]   <- pay_mat[land == 1] - farm_cost;
   pay_mat[land == 2]   <- pay_mat[land == 2] - scare_cost;
   pay_mat[land == 3]   <- pay_mat[land == 3] - cull_cost;
   pay_mat[land == 4]   <- pay_mat[land == 4] - habitat_cost;
   return(pay_mat);
}
```

This calc_payoff() function reads in the relevant parameters and the places the elephants with the place_eleps function, disturbs them (for scaring and shooting strategies), then calculates the payoffs for the landscape given the expected distribution of elephants. Note that as in the actual behavioural game, effects of scaring or shooting take effect immediately, so an elephant on a cell at the beginning of a round might not cause crop damage to that cell if successfully scared or shot. Weights of the cells map linearly to the probability of an elephant landing on a cell, so the probability of an elephant landing on a cell is simply the cell's weight divided by the total of all cell weights. This is seen in the place_eleps function.

```
place_eleps <- function(land, parameters){
  eleph_count <- parameters[15];
  weight_mat  <- assign_cell_weight(land, parameters);
  weight_pr   <- weight_mat / sum(weight_mat);
  exp_eleps   <- eleph_count * weight_pr;
  return(exp_eleps);
}
```

The above function places elphants based on cell weight, which is assigned using the assign_cell_weight function below.

```
assign_cell_weight <- function(land, parameters){
  bump       <- parameters[13];
  rows       <- as.numeric(dim(land)[1]);
  cols       <- as.numeric(dim(land)[2]);
  weight_mat <- matrix(data = 0, nrow = rows, ncol = cols);
  weight_mat[land == 1] <- parameters[9];
  weight_mat[land == 2] <- parameters[10];
  weight_mat[land == 3] <- parameters[11];
  weight_mat[land == 4] <- parameters[12];
  weight_mat            <- habitat_bump(land, bump, weight_mat);
  return(weight_mat);
}
```

Note that each landscape option 1-4 is assigned its weight as defined in the parameters vector, then the habitat_bump function adjusts weights based on neighbourhood effects (i.e., if land == 4 indicating elephant habitat, the weight of neighbouring cells increases).

```
habitat_bump <- function(land, bump, weight_mat){
  # Early return if there's no reason to go through the ifs
  habitats <- sum(land == 4);
  if( habitats == 0 ){
    return(weight_mat);
  }
  rows        <- dim(land)[1];
  cols        <- dim(land)[2];
  for(row in 1:rows){
    for(col in 1:cols){
      if(land[row, col] == 4){
        neighbours <- get_neighbours(land, row, col);
        neighbours[neighbours == 1] <- bump;
        weight_mat <- weight_mat + neighbours;
      }
    }
  }
  return(weight_mat);
}
```

The bump is added whenever a landscape cell equals 4 indicating elephant habitat, and this bump is added to all neighbours. The neighbours of a particular cell land[row, col] is found using the get_neighbours function.

```
get_neighbours <- function(land, row, col){
   rows         <- dim(land)[1];
   cols         <- dim(land)[2];
   neighbour_mat <- matrix(data = 0, nrow = dim(land)[1], ncol = dim(land));
   if(row == 1){
      if(col == 1){
         neighbour_mat[1, 2] <- 1;
         neighbour_mat[2, 1] <- 1;
         neighbour_mat[2, 2] <- 1;
      }
      if(col == cols){
         neighbour_mat[1, col - 1] <- 1;
         neighbour_mat[2, col]     <- 1;
         neighbour_mat[2, col - 1] <- 1;
      }
      if(col > 1 & col < cols){
         neighbour_mat[1, col - 1] <- 1;
         neighbour_mat[1, col + 1] <- 1;
         neighbour_mat[2, col - 1] <- 1;
         neighbour_mat[2, col]     <- 1;
         neighbour_mat[2, col + 1] <- 1;
      }
   }
   if(row == rows){
      if(col == 1){
         neighbour_mat[rows - 1, 1] <- 1;
         neighbour_mat[rows - 1, 2] <- 1;
         neighbour_mat[rows, 2]     <- 1;
      }
      if(col == cols){
         neighbour_mat[rows - 1, col]     <- 1;
         neighbour_mat[rows - 1, col - 1] <- 1;
         neighbour_mat[rows, col - 1]     <- 1;
      }
      if(col > 1 & col < cols){
         neighbour_mat[rows, col - 1] <- 1;
         neighbour_mat[rows, col + 1] <- 1;
         neighbour_mat[rows - 1, col - 1] <- 1;
         neighbour_mat[rows - 1, col]     <- 1;
         neighbour_mat[rows - 1, col + 1] <- 1;
      }
   }
   if(row > 1 & row < rows){
      if(col == 1){
         neighbour_mat[row - 1, 1] <- 1;
         neighbour_mat[row + 1, 1] <- 1;
         neighbour_mat[row - 1, 2] <- 1;
         neighbour_mat[row, 2]     <- 1;
```

```
      neighbour_mat[row + 1, 2] <- 1;
    }
    if(col == cols){
      neighbour_mat[row - 1, col]     <- 1;
      neighbour_mat[row + 1, col]     <- 1;
      neighbour_mat[row - 1, col - 1] <- 1;
      neighbour_mat[row, col - 1]     <- 1;
      neighbour_mat[row + 1, col - 1] <- 1;
    }
    if(col > 1 & col < cols){
      neighbour_mat[row - 1, col - 1] <- 1;
      neighbour_mat[row - 1, col]     <- 1;
      neighbour_mat[row - 1, col + 1] <- 1;
      neighbour_mat[row, col - 1]     <- 1;
      neighbour_mat[row, col + 1]     <- 1;
      neighbour_mat[row + 1, col - 1] <- 1;
      neighbour_mat[row + 1, col]     <- 1;
      neighbour_mat[row + 1, col + 1] <- 1;
    }
  }
  return(neighbour_mat);
}
```

Loops are avoided in the above function to increase computational efficiency. An additional call to the place_eleps() function is used whenever elephants are scared or culled off of a cell to redistribute those displaced elephants

```
disturb_eleps <- function(land, parameters, eleps_distr){
  starting_eleps <- parameters[15];
  scare_prob     <- parameters[17];
  cull_prob      <- parameters[18];
  replace_living <- parameters[20];
  rows           <- dim(land)[1];
  cols           <- dim(land)[2];
  for(row in 1:rows){
    for(col in 1:cols){
      if(land[row, col] == 2){
        eleps_on_cell        <- eleps_distr[row, col];
        stay_prob            <- (1 - scare_prob);
        eleps_distr[row, col] <- eleps_on_cell * stay_prob;
        parameters[15]       <- eleps_on_cell * scare_prob;
        added_eleps          <- place_eleps(land, parameters);
        eleps_distr          <- eleps_distr + added_eleps;
      }
      if(land[row, col] == 3 & parameters[19] == FALSE){
        eleps_on_cell        <- eleps_distr[row, col];
        stay_prob            <- (1 - cull_prob);
        eleps_distr[row, col] <- eleps_on_cell * stay_prob;
        parameters[15]       <- eleps_on_cell * cull_prob;
        added_eleps          <- place_eleps(land, parameters);
        eleps_distr          <- eleps_distr + added_eleps;
      }
      if(land[row, col] == 3 & parameters[19] == TRUE){
```

```
            eleps_on_cell        <- eleps_distr[row, col];
            stay_prob           <- (1 - cull_prob);
            eleps_distr[row, col] <- eleps_on_cell * stay_prob;
            culled              <- eleps_on_cell * cull_prob
            parameters[15]       <- parameters[15] - culled;
            starting_eleps       <- starting_eleps - culled;
         }
      }
   }
   parameters[15] <- starting_eleps;
   if(replace_living == TRUE){
      eleps_distr <- place_eleps(land, parameters);
   }
   return(eleps_distr);
}
```

References

Adami, C., and A. Hintze. 2013. Evolutionary instability of zero-determinant strategies demonstrates that winning is not everything. Nature communications 4:2193. Nature Publishing Group.

Darwen, P. J., and X. Yao. 1995. On evolving robust strategies for iterated prisoner's dilemma. Pp. 276–292 *in* Progress in evolutionary computation.

Rapoport, A., D. A. Seale, and A. M. Colman. 2015. Is tit-for-tat the answer? on the conclusions drawn from axelrod's tournaments. PLoS ONE 10:1–11.

Appendix 4. GAME PROTOCOL (TRANSLATED FROM FRENCH)

[first set up the seating, preferably forming a circle, read consent form, record player names write their identifier codes on the score recording sheet, set up tablets, and put in player identifier]

Hello, and thank you for being here today.

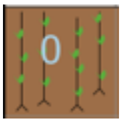
Today we are going to play a game about land use decision making. You'll play in groups of four, and each player will have an equal share of the land in the game, a total of 9 squares. Your participation is voluntary but we would really appreciate if you stay for the full session as the game can't run without all four participants.

We are offering some gift items to thank you for your participation in today's experiment which should take about 90-120 minutes. In addition, the content of the gift items will depend on your management decisions in the game, which we will explain in a moment.

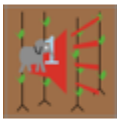
Do you consent to continue? If at any time you find that this is something that you do not wish to participate in for any reason, you are of course free to leave whether we have started the game or not.

In each of those squares, you can do one of four things:

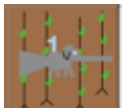
1



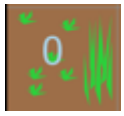
2



3



4



1. Farm the square for your private business

2. Farm the square for your private business and use non-lethal deterrent methods to scare elephants away

3. Farm the square for your private business and kill elephants found marauding on your farmlands

4. Lease your farm plot for elephant conservation (zones dedicated to elephant conservation or" elephant habitat").

Each of the you will take responsibility for land use decisions on a 3x3 grid-cell section (farm) of a 6 x 6 grid-cell agricultural landscape as shown in the following figure.

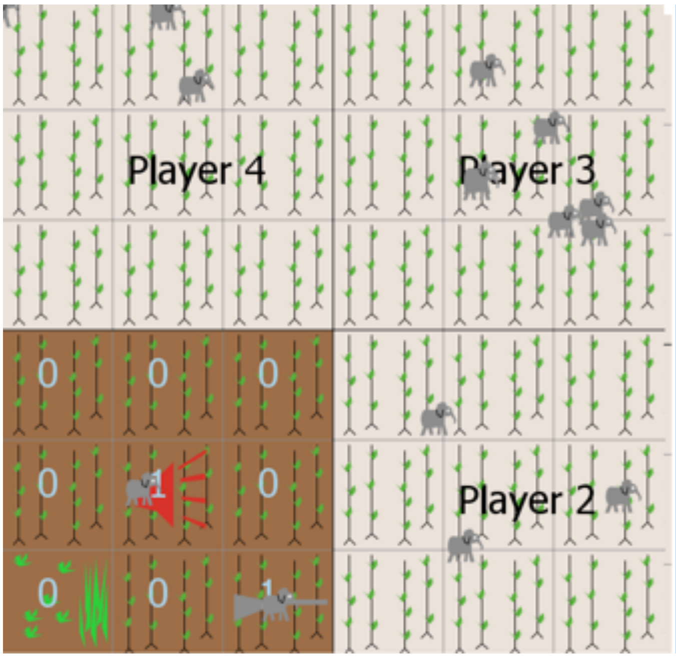


Figure: Bottom left corner of the landscape is active player

Each of these four options has different benefits and costs. Let me introduce each of them in turn.

Farming the square (options 1, 2 and 3) brings a yield of +4. Providing elephant habitats brings no yield. Non-lethal scaring brings a cost of -1 while lethal scaring costs -2. These costs reflect both the materials, efforts, and also the risk associated with the illegal nature of these activities.

We are going to play a few rounds per game session – rounds can be analogous to years. In each round, there are a certain number of elephants in the landscape. When elephants land on farmed cells (options 1, 2, 3), they cause damages and decrease your farm yield. This is described in the second line in the above figure ("elephant damage"), the amount of elephant damage on each farmed square depends on the number of elephants in that square.

You don't need to memorize this – you can use this sheet as a reference while you play the game [hand out sheet now].

At the start of each round, the default land use options on all 36 grid cells are farmlands (option 1). Elephants are randomly distributed across the landscape with an equal chance. If you decide to scare elephants on a given cell, then some will leave the cell and reorient in other cells based on the attractiveness of the three options. Elephant habitats (the forth option) is the most attractive option, that is elephants are much more likely to be drawn to an elephant square (option 1) than on your farmlands (options 1, 2, 3). These habitats contain some palatable crops and can therefore reduce agricultural damages across the landscape by drawing elephants from other places. However, elephant habitats may slightly increase the amount of elephant damage in farmlands that immediately surround them by bringing more elephants close to them in the landscape. However, rest assured that the neighbourhood effect of the habitat is small enough and may only marginally significantly affect the yield of adjacent farmlands. Put simply, elephant habitats may make things significantly better for some farms by keeping elephants at bay.

The number of elephants at the start of each round equals 18 and decreases with lethal scaring efforts (the more you shoot, the less elephants there are left). Please note that non-lethal and lethal scaring techniques are not 100 % effective, just like in real life, so you may try to deter elephants, but they might still raid your farm, likewise, you may attempt to kill them, but some will survive. We have set the games so you will success at killing an elephant 8 out of 10 times, using deterrent techniques however only works 3 out of 10 attempts.

In some of the game sessions that we are going to play today, a subsidy and/or bonus is given for every elephant habitat in the landscape. In another game session, the subsidy will offset the cost of the non-lethal deterrent method, i.e. the cost of the non-lethal deterrent option (option 2) becomes zero.

You can cycle through the choices for each square by clicking on the square itself, and we'll practice that in a minute. When you've decided, you can click 'Confirm' and wait for the other players to confirm. Once everyone has confirmed, the round is over and the "score" (i.e., the total points earned) is calculated for each cell based on your choices in and around the cell, and the process is repeated in the next round.

You will be permitted a period of discussion (one minute) before you make your individual decisions at the beginning of each round. You will make decisions simultaneously on your land squares and will see at the end of each round what has happened across the whole landscape, what yields are achieved in each square, and what scores are earned by each player. Although you can observe individual players' decisions, you won't be able to match decisions to the individual.
One other note – you can change any of the 9 squares to any of the two land use choices you like, in each round.

So just to review, farming brings a yield of +4. Scaring techniques bring a cost of -1 or -2. Elephant habitats bring no yield but they may decrease elephant damage across the landscape by keeping elephants away from farmlands.

Let's look now at the game screen and see how this all fits together.

This is a screen shot from the first turn for Player 1, in the bottom left quadrant. The identifiers of the other three players are shown over their quadrants, which are lighter in colour, and can't be modified by Player 1. The white coloured number on each square is the number of elephants.

Figure 2: Bottom left corner of the landscape is active player, actions taken by other players in previous turn are visible.

[Note, we don't show a sample here as we don't wish to suggest any strategies]

After I have finished the explanation we will play a short practice game to help you to understand the process.

Practice

We'll just play a few short rounds now so that you get comfortable with the rules of the game. I'll walk you through the first turn so you can see how it goes, and you can ask me questions during your turn or between rounds. I encourage you to use the practice session as an opportunity to explore different options and see what happens. Feel free to discuss with others, but please do keep your screen to yourself.

[walk through a 4-round practice game]

Got it? *[answer any follow-up questions]*

Ok, let's move on to the experiment.

We are going to play four different games, each one of which will differ a little bit, and might change a bit from what we've done in the practice.

Now, as you make your decisions, we'd like you to maximize your utility (or "do well") by trying to earn points, and that's where the gift items come in. At the end of the session, we'll record the score for each player on the paper and pick one of the four games that you played randomly and look at the highest score. The gift items (content and number) that you will each receive equally will be based on that highest score.

Please remember that there are different ways to earn points, either by playing individually or as a team working together. Most importantly, we want your decisions to reflect what you would do in real life.

Ok, let's begin.

[Each game group will play 4 treatments; the order are randomised across groups. Thus, the four treatments can be introduced in a way that does not depend on other treatments having been played first.

G1: Baseline treatment:

In this game, the settings are just like they were in the practice. There is no subsidy from providing elephant habitats. You are allowed to discuss the game with the other players at the beginning of each round, but please keep your screen to yourself. This game will last at least 6 rounds.

G2: Flat Rate Subsidy: A subsidy from *X* points (drawn randomly at the beginning of the game and held constant during the game)

In this game, you are being offered a subsidy for each square of land that you lease as elephant habitats. You'll receive a subsidy which will add to your total score. You are free to discuss the game with other players at the beginning of each round, but keep your screen to yourself. This game will last at least 6 rounds.

G3: Support for deterrents

In this game, the settings are just like they were in the practice. There is no subsidy from leasing plots for elephants. However, you will get some support for deterring elephants from your farmlands, the support will offset the cost of non-lethal deterrent methods. You are allowed to discuss the game with the other players at the beginning of each round, but please keep your screen to yourself. This game will last at least 6 rounds.

G4: Agglomeration payment

In this game, you are being offered a subsidy for each square of elephant habitat in your land. You'll receive a subsidy worth X points which will add to your total score. In addition, you will also get an additional bonus of 1 point for every elephant square that has at least one elephant square next to it. You are free to discuss the game with other players at the beginning of each round, but keep your screen to yourself. This game will last at least 6 rounds.

[redacted]

Household questionnaire survey - GABON

Survey Information

Activity/Task	Date	Start	End	Person(s) Responsible
Survey administration				
Data entry		[redacted]	[redacted]	
Data cleaning		[redacted]	[redacted]	
Data validation		[redacted]	[redacted]	

A. Identification: Explain that this is for us to conduct spatial analyses, for example examining how distance from goose roosting sites affects them and their farming – or for us to contact them again for feed-back, follow-up surveys or experimental games if they agree to. Note that 2. and 3. can be filled prior to the survey.

1	Household Name & Code	*(name)*		*(HHID)*
2	Village name & code	*(name)*		*(VID)*
3	GPS location of the HH			
4	Distance of HH from nearest market			
5	Game ID			

[BLANK PAGE HERE]

[redacted] **Household Questionnaire Survey** **HHID: ________**

B. Information about the Respondent(s) - whoever is available to answer the survey on behalf of the whole household)

1	Is the respondent the head of the household? (1=Yes, 0= No), If No, ask question 2, if Yes, go to question 3	(code)
2	What is your relationship with the household head?	(code)
	1=Souse (se), 2=Son / Daugther, 3=Grand child, 4=Parent, 5=Siblings, 6=Others (Specify)	
3	What is your year of birth? (e.g. 1956)	_______ year
4	Gender (1=Female, 2=Male)	(code)
5	How many years of formal education do you have?	_______ years
6	How long have you lived in this village?	_______ years
7	How long have you farmed here? (in the village)	_______ years
8	What is the size of your current household? Including only those who live 6 months or more in the household)	_______
9	How many of your household members do not reside here for six months or more? (i.e. have moved elsewhere)	_______
10	What are they doing away? (1=Study, 2=Work, 3=Others (specify))	(code)
11	Do they contribute to the hosuehold's income or expenditure? (1=Income, 2=Expenditure, 3=Both, 4=Neither)	
12	Household income: What is the primary source of income of your household?	(code)
	Source of income 1=Agriculture; 2=Oil industry; 3=Government job (e.g. civil servant); 4=Private job (e.g. small business, NGO, ecotourism); 5=Wild product harvester (or hunter); 6=Other (specify)	
13	Household income: What is the secondary source of income of your household?	(code)
	Source of income 1=Agriculture; 2=Oil industry; 3=Government job (e.g. civil servant); 4=Private job (e.g. small business, NGO, ecotourism); 5=Wild product harvester (or hunter); 6=Other (specify)	
14	Has you househopld beenfited from any livelihood or development project for the past five years? (1=Yes, 0=No)	(code)

C. Farming practices: Land ownership, land use and wildlife damage

1 *Please provide information about the land that you have access to and those you cultivated during the last agricultural year (2016/2017). How many plots did you farm? How far are they from the centre of the village? What's the size? How did you get access to these plots?*

[Note: Ask here about ALL the plots that the HH has access to and can cultivate. For the plots that were cultivated during the most recent agricultural year), ask and record the (estimated) area, either in ha (m^2) OR in quantity of seeds used with units]

[(Non-)response codes: -98=respondent DOES NOT KNOW; -99=respondent DOES NOT WANT TO ANSWER; -100=interviewer DID NOT ASK (specify why)]

Plot	Distance from the village	Ownership/Access	Cultivated Size and crop		Index of wildlife damage			
	(In kilometre or minutes walk)	*(1=inherited; 2= rented; 3=bought; 4=borrowed; 5=cleared by the household; 6=other (specify))*	*(area cultivated during 2016/2017)* ***[ha or m^2]***	*Crops planted (if more there is more than one crop per plot, just list them here and separate by a comma)*	*Has this plot been devasted by elephants fopr the past 12 months? (1+yes, 0-=No, if no, move to next plot)*	*How many times has it been damaged by elephants fpor the past 12 months?*	*Area of damage by elephants (1=<25%, 2=25-50%, 3=>50-75%, 4=>75% of the plot under cultivation)*	*Intensity of damage (1=slight, 2=moderate, and 3=severe)*
a								
b								
c								
d								
e								

2	Which one describes best the food consumed by your household for the past 12 months? (1= Enough food (both in quantity and variety, 2= Enough but not always the type of food we want to eat, 3= Not enough both in terms of quantity and variety, 4= Not at all enough)	(code)
3	How many months did your household have enough to eat for the past year?	________ mois
4	Apart from crop damage, has your household also exp[erienced other wildlife impacts? *(1=Yes, 0=No, if yes, go to question 5)*	(code)
5	Types of other impacts: 1= Proprieties (e.g. house), 2= Injuries, 3= Death, 4= Others (Specify)	
6	In your village, are there any elephants that have been killed to protect crops? How many?	(Number)

D. Wealth indicators: Livestock, assets

1	Please tell us how many of these livestock does your household currently own	
a	Cattle	_______
b	Pork	_______
a	Fish tanks	_______
b	Beehives	_______
a	Poultry	_______
b	Other (specify)	_______
a	Other (specify)	_______

2	*Could you please tell us more about your house(s)? How many there are? What are they made of? What kind of roof have they got? Whether they are your permanent or temporary dwelling?*				
		House 1	**House 2**	**House 3**	
	Number of storey (main house)				
	Number of rooms (main house)				
	Roof type (main house)				

3	Does any member of your household own the fopllowing iutems (please indicate the total number)	
a	Television	_______
b	Fridge	_______
c	Freezer	_______
d	Mobile phones	_______
e	Generator	_______

E. Norms, perceptions, beliefs: We will make some statements, please tell me on a scale of 1 to 4 to what degree you agree with each of them (1=Not at all, 2=Little, 3=Somewhat, 4=Very much, -98=Don't know, -99=Don't want to answer)

1	Elephants harm my well-being.	_______
2	Elephants are beneficial to my well-being	_______
	Please provide examples of these benefits	_______
3	Elephant conservation is important for future generations.	_______
4	in my view, ANPN should be entirely responsible for the protection of farmers' livelihoods from elephant crop damage.	_______
5	Farmers with neighbouring lands need to coordinate the provision of elephant habitats to minimize elephant crop damage	_______
6	Farmers with neighbouring lands need to coordinate scaring techniques to minimize elephant crop damage	_______
7	The risk of being fined would prevent me from being involved in killing elephants.	_______
8	The risk of social disapproval would prevent me from killing elephants.	_______
9	In my view, crop damage by elephant has encouraged more elephant killings in your village.	_______
10	In my view, crop damage by elephant has caused people to move away from our village.	_______

F. Trust index 1: How much trust do you have in the following organisation to make balanced decisions about land and wildlife management: (1=Not at all, 2=Little, 3=Somewhat, 4=Very much, -98=Don't know, -99=Don't want to answer)

1	ANPN	_______
2	Ministry de Environnement et des forets	_______
3	Ministry of Agriculture	_______

G. Trust index 2: Trust in other community members (1=Not at all, 2=Little, 3=Somewhat, 4=Very much, -98=Don't know, -99=Don't want to answer)

1	Would you say that most of the time, people in your community are mostly trying to help each other? (1=Not at all, 2=Little, 3=Somewhat, 4= Very much)	_______
2	Generally speaking, would you say that most people in your community are honest and can be trusted? (1=Not at all, 2=Little, 3=Somewhat, 4= Very much)	_______
3	Do you think that most people would try to take advantage of you if they got a chance? (1=Not at all, 2=Little, 3=Somewhat, 4= Very much)	_______

H. Attitudes towards management options: In your opinion, to what extent do the options listed below answer questions a, b and c with regard to mitigating elephant-human conflict ? (1=Not al all, 2=to a certain extent, 3= Definitely Yes)

		a. "…is acceptable."	**b. "…is effective."**	**c. "…is sustainable."**
1	Local non-Lethal Scaring techniques		_______	_______
2	Electric fences	_______	_______	_______
3	Killing	_______	_______	_______
4	Alternative feeding areas ("habitat")	_______	_______	_______
5	Subsidy / Compensations	_______	_______	_______
6	Ecotourism	_______	_______	_______

I. Equity index

1	Would you say that the government fairly balances agricultural and conservation interests? (1=Not at all, 2=Little, 3=Somewhat, 4= Very much)	_______
2	Do you feel able to influence decision-making related to wildlife management and farming? (1=Not at all, 2=Little, 3=Somewhat, 4= Very much)	_______
3	Would you say that the government strategy (wrt conservation and development) equally benefits your community? (1=Not at all, 2=Little, 3=Somewhat, 4= Very much)	_______
4	Do you feel that the current government strategy respects your local cultures and and traditions with regard to wildlife manage-ment? (1=Not at all, 2=Little, 3=Somewhat, 4= Very much)	_______

J. Familiarity

	Can you rate your familiarity with other participants? (from 1 to 4, 1= very limited , participant hardly meets up with the person, 2=limited , rarely meets up with the person, 3=Good , meets up with the person quite often, and 4= Very good , meets up frequently with the person)			
1	Participant 1 - HHID	_______	Familiarity	_______
2	Participant 2 - HHID	_______	Familiarity	_______
3	Participant 3 - HHID	_______	Familiarity	_______

K. About the games

1	What was your main goal in the games?	(code)
	1= To win (victory), 2= To do what would be best for the group, 3= To do what I do in real life, 4= To have fun, 5= Autres (specifier)	(code)
2	Did your choices in the games depend on what others did? (1=Not at all, 2=Little, 3=Somewhat, 4= Very much)	(code)
3	Did you consider the effect of your choices on other participants? (1=Not at all, 2=Little, 3=Somewhat, 4= Very much)	(code)
4	Did you consider the effect of your choices on the next generation? (1=Not at all, 2=Little, 3=Somewhat, 4= Very much)	(code)
5	Knowing how the game was played, with the benefit of hindsight, do wish you had made different decisions? (1=Not at all, 2=Little, 3=Somewhat, 4= Very much)	(code)

Notes

Notes

[redacted]

Questionnaire

Information sur l'enquete

Activites	Date	Debut	Fins	Personne responsable	Remarques
Enquete					
Verification du questionnaire					
Saisie des donnees					
Verification de la saisie					

A. Identification: Expliquer que les donnees suivantes nous seront utiles pour des etudes spatiales, par exemple pour analyser l'impact de la distance au parc sur leurs moyens de subsistence. A noter que 2. 3. et 5. peuvent etre remplis avant l'enquete.

1	Nom du menage et Code	*(nom)*	*(code))*
2	Nom du village et code	*(nom)*	*(code))*
3	Location GPS		
4	Distance du menage du marche le plus proche	*(km)*	
5	Code du jeu	*(GID)*	

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		Enquete menage HHID: ________
B. Information sur le menage		
1	Le répondant est-il le chef de foyer? (1=Oui, 2=Non) Si non, posez question 2	(code)
2	Quelle est la relation entre le répondant et le chef du foyer?	(code)
	1=Epoux (se), 2=Fils / Fille, 3=Petit Fils/Petite Fille, 4=Mere/Pere, 5=Frere / Soeur, 6=Autres (Specifier)	
3	Quel age avez-vous?	_______ ans
4	Genre (1=Feminin, 2=Masculin)	(code)
5	Quel est votre niveau scolaire final?	_______ ans
6	Combien d'annees avez-vous vecu dans ce village?	_______ ans
7	Combien d'annees cultivez-vous ici?	_______ ans
8	Combien de personnes vivent sous le meme toit? [Inclure seulement les membres du foyer qui vivent 6 mois ou plus sous le meme toit]	_______
9	Combien de membres de votre foyer ne vivent pas ici pendant six mois ou plus? [si c'est 0, passez a question 12]	_______
10	Pour quelles raisons ces membres de votre foyer vivent ailleurs? *(code 1=Etudier, 2=Travailler, 3=Autres [specifiez])*	
11	Est-ce que que ces membres vivant ailleurs contribuent-ils a votre revenu ou a vos depenses *(code 1=revenu, 2=depenses)*	
12	Quelle est la principale source de revenu de votre foyer?	(code)
	1=Agriculture; 2=Fonctionnaire d'Etat; 3=Emploi privé (commerce, artisanat, motel, ANPN); 4=Peche, 5=Chasse et recolte des produits sauvanges; 6=Autres (specifier)	
13	Quelle est la source secondaire de revenu de votre foyer?	(code)
	1=Agriculture; 2=Fonctionnaire d'Etat; 3=Emploi privé (commerce, artisanat, motel, ANPN); 4=Peche, 5=Chasse et recolte des produits sauvanges; 6=Autres (specifier)	
14	Votre foyer a-t-il bénéficié des projets de developpement (agriculture, elevage, ou autre projets de formation) au cours des 12 derniers mois? (1=Oui, 2=Non)	(code)

C. Pratiques agricoles: Acquisition et utilisation des terres et devastations causées par la faune

1 [Commencer par demander combien de champs avez-vous cultivés au cours de l'annee derniere? Puis commencer par le premier champ et poser les questions suivantes pour chaque champ: À quelle distance sont-elles du centre du village? Quelle est la taille? etc.]

[Codes de réponse (non): -98 = le répondant NE SAIT PAS; -99 = le répondant NE VEUT PAS RÉPONDRE; -100 = interviewer N'A PAS DEMANDÉ (précisez pourquoi)]

Champs	Distance du village	Acquisition des terres	Superficies cultivees et types de cultures		Indicateurs de devastations			
	(En kilomètre ou minutes de marche)	*(1 = hérité, 2 = loué, 3 = emprunté, 4=Acheté, 5 = autre (préciser))*	*Superficie cultivee l'annee derniere **[m2]** - si le menage ne peut pas estimer les m2 ou ha, choisissez parmi: 1=Petit, 2=Moyen, 3=Grand*	*Cultures plantées [listez-les ici et séparez-les par une virgule]*	*Ce champ a-t-il été devasté par les elephants? (1=Oui, 2=non) Si non, passer a C.2*	*Fréquence des dévastations au cours de l'année derniere*	*Dégâts causés par les éléphants (1=petit degat (0-30%), 2=degat moyen (30%-60%), 3=grand degat (>60%)*	*Techniques de dissuasion des éléphants utilisées*
a								
b								
c								

2	Lequel décrit le mieux la nourriture consommée dans votre ménage au cours des 12 derniers mois? (1=assez de nourriture que nous voulons manger, 2=Assez mais pas toujours le type de nourriture que nous voulons manger, 3= Pas assez a manger aussi bien en quantite qu'en variete; 4=Pas du tout assez a manger)	(code)
3	Combien de mois votre menage a t-il eu assez a manger au cours des 12 dernier mois?	_____ mois
4	A part les cultures, avez-vous aussi subis d'autres types de degats a cause des élephants au cours des 12 derniers mois? *(1=Oui, 2=Non) - Si oui, poser question 5, sinon, passer a question 6)*	(code)
5	*Types de degats: 1=Proprietes (maison, cours d'eau), 2=Blessure, 3=Mort, 4=utres (precisez)*	(code)
6	Dans votre village, y a-t-il eu des éléphants qui ont été tués par des membres de la communauté au cours des 12 derniers mois dans le but de protéger les cultures? Si oui Combien? (si non, mettez 0)	(Nombre)

D. Indicateurs de richesse: élevage, maison, biens

1	Pouvez-vous nous dire combien de ces animaux votre ménage possède-t-il actuellement?	
a	Moutons	_______
b	Chevres	_______
c	Volailles	_______
d	Betail	_______
e	Autres (specifier)	_______

2	Pourriez-vous nous en dire plus sur votre (vos) maison (s)? Combien y en a-t-il? De quoi sont-ils faits? Quel genre de toit ont-ils? [Commencer par le logement permanent]			
		a.Maison 1 (permanent)	**b.Maison 2**	**c.Maison 3**
	Matiere de la maison			
	Nombre de chambres			
	Type de toit			
	Type de sol			

3	Votre menage possede t-il les biens suivants? [notez le nombre de biens pour chaque type]	Nombre
a	Frigo / congelateur	
b	Tele	
c	Telephone portable	

4	Lequel de ces outils utilisez-vous pour cuire votre nourriture? [*code: 1=Four, 2=Rechaud, 3=Feux a bois, 4=Autres [Precisez)*		*(code)*

E. Normes, perceptions, croyances: [Noter dans quelle mesure le repondant est d'accord avec les questions suivantes]

[Si le repondant NE SAIT PAS, mettez "-98"; si le répondant NE VEUT PAS RÉPONDRE, mettez -99]

1	Les éléphants nuisent-ils a votre bien-etre? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
2	Les elephants contribuent-ils a votre bien-etre? [Citez par exemple, fertilisation, ecotourisme, etc.] (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
3	Pensez-vous que la conservation des elephants est importante pour votre generation future)? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
4	Pensez-vous que l'ANPN devrait etre entierement responsable de la protection de vos cultures contre les elephants? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
5	Selon vous, les gens de votre communauté devraient-ils coopérer dans les techniques de protection de cultures? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
6	Est-ce que le risque de se voir emprisonner vous empêcherait d'abattre un éléphant? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
7	Est-ce que le risque d'etre condamné par votre communaute vous empêcherait d'abattre un éléphant? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
8	Est-ce que les dégats causes par les élephants sur vos champs a poussé notre communautea a faire plus de chasse? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
9	Est-ce que les dégats causes par les élephants sur vos champs ont poussé votre communautea a quitter votre village? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)

F. Indice de confiance 1: Quelle confiance avez-vous dans l'organisation suivante pour prendre ou suggerer des décisions équilibrées concernant la gestion des terres agricoles et la conservation des elephants: (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)

1	ANPN (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
2	Ministere des Eaux et Forets (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
3	Ministere de l'agriculture (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)

G. Indice de confiance 2: Confiance envers les autres membres de la communauté

[Si le repondant NE SAIT PAS, mettez "-98"; si le répondant NE VEUT PAS RÉPONDRE, mettez -99]

1	Diriez-vous que la plupart du temps les gens dans votre communauté essayent de s'entraider? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
2	Avez-vous confiance a la plupart des gens dans votre communauté? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
3	En général, est-ce que les gens de votre communauté prêtent de l'argent les uns aux autres en cas de besoin, et récupèrent l'argent qu'ils ont prêté? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)

H. Attitudes à l'égard des options de gestion: Dans quelle mesure les strategies de gestion des conflits citées ci-dessous re-pondent-elles aux questions a, b et c? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)

		a. "…est acceptable."	**b. "….est efficace dans l'attenuation des degats."**	**c. "…est viable a long terme."**
1	Techniques locales	NA	_______ (code)	_______ (code)
2	Barrieres eletriques	_______ (code)	_______ (code)	_______ (code)
3	Abattage	_______ (code)	_______ (code)	_______ (code)
4	Zones pour elephants	_______ (code)	_______ (code)	_______ (code)
5	Subventions / compensations	_______ (code)	_______ (code)	_______ (code)
6	Ecotourisme	_______ (code)	_______ (code)	_______ (code)

I. indice d'équité

1	Diriez-vous le gouvernment protége equitablement vos intérêts agricoles et les objectifs de conservation? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
2	Est-ce que le gouvernment ecoute votre point de vue en matiere de conservation et de developpement? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
3	Est-ce que la politique actuelle du gouvernement en matiere de conservation et developpement presente les memes avantages pour tout le monde? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
4	Selon vous, est-ce que les barrieres electriques sont compatibles avec votre tradition locale et cultures en matiere de plan-tations? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)

J. Sur le jeu

1	Quel etait votre objectif dans le jeu? (code: 1= Gagner (victoire), 2=Faire ce qui serait le mieux pour le groupe, 3= Prendre des decisions comme dans la vie reelle, 4= S'amuser, 5= Autres (specifier)	(code)
2	Vos decisions dans les jeux dépendent-elles de ce que les autres feraient? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
3	Aviez-vous considéré les effets de vos décisions sur les autres participants (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)
4	Aviez-vous considéré les effets de vos decisions sur votre generation future? (1=pas du tout, 2= un peu, 3=dans une certaine mesure, 4=Tout a fait)	(code)

K. Relation

1	Laquelle de options suivantes indique votre relation avec les autres participants du jeu? (de 1 a 4, 1=Pas d'affinite, personne frequentée tres rare-ment, 2=Affinite assez limitée, personne frequentée rarement, 3=Bonne affinite, personne frequentée assez souvent, 4=Tres bonne affinite/entente, personne frequentée tres souvent) [ajouter seulement le code du menage apres l'enquete]			
a	Realtion avec	_______ (nom et code)	Indice de relation	_______
b	Relation avec	_______ (nom et code)	Indice de relation	_______
c	Realtion avec	_______ (nom et code)	Indice de relation	_______