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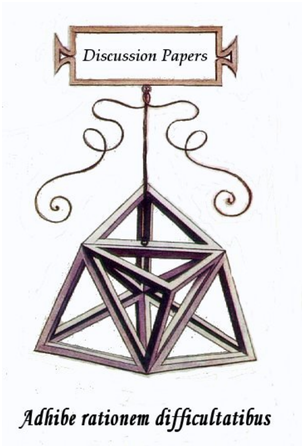

Virginia Cecchini Manara, Eleonora Ciscato,
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Back to the Future: an Experiment on Ecological Restoration

Discussion paper n. 307

2024

Discussion paper n. 307, presented: **May 2024**

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Please cite as:/Si prega di citare come:

Virginia Cecchini Manara, Eleonora Ciscato, Pietro Guarnieri, Lorenzo Spadoni (2024), "Back to the Future: an Experiment on Ecological Restoration", Discussion Papers, Department of Economics and Management – University of Pisa, n. 307 (http://www.ec.unipi.it/ricerca/discussion-papers).

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Discussion paper

n. 307

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Adhibe rationem difficultatibus

Virginia Cecchini Manara, Eleonora Ciscato, Pietro Guarnieri, Lorenzo Spadoni

Back to the Future: an Experiment on Ecological Restoration

Abstract

The urgency of climate, biodiversity, and pollution crises has prompted international and national institutions to move beyond the prevention and mitigation of damages and to design policies aimed at promoting ecological restoration. In this paper, we address this emerging policy challenge by presenting experimental evidence on individuals' propensity to contribute to restoration activities. Specifically, our design links a common pool resource game to a public good game to investigate how previous resource exploitation influences restoration decisions. We find that history matters since subjects who participate in resource depletion show a different behavior as compared to subjects who are only called to restore it. Specifically, while the former are subject to behavioral lock-ins that influence the success of restoration, the latter are more prompt to restore the more the resource is depleted.

Keywords: Ecological Restoration, Common-pool resource game, Public good game

JEL CLassification: C72; C99; Q48.

Back to the Future: an Experiment on Ecological Restoration

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Abstract

The urgency of climate, biodiversity, and pollution crises has prompted international and national institutions to move beyond the prevention and mitigation of damages and to design policies aimed at promoting ecological restoration. In this paper, we address this emerging policy challenge by presenting experimental evidence on individuals' propensity to contribute to restoration activities. Specifically, our design links a common pool resource game to a public good game to investigate how previous resource exploitation influences restoration decisions. We find that history matters since subjects who participate in resource depletion show a different behavior as compared to subjects who are only called to restore it. Specifically, while the former are subject to behavioral lock-ins that influence the success of restoration, the latter are more prompt to restore the more the resource is depleted.

Keywords: Ecological Restoration, Common-pool resource, Public goods, Behavioural Experiment

1. Introduction

Traditionally, environmental policies and regulations have mainly focused on preventing and mitigating damage to minimize the negative effects of human activities on the environment. However, the global and local threats posed by climate change, biodiversity loss, and pollution crises are soliciting a profound revision of environmental regulation and resource management. It is now evident that preservation alone is insufficient, and widespread restoration efforts are urgently needed on a global scale (Suding et al., 2015). According to the Society of Ecological Restoration, the practice can be defined as "the process of halting and reversing degradation, resulting in improved ecosystem services and recovered biodiversity" (Gann et al., 2019). Essentially, it involves returning a degraded ecosystem to its original functioning, structure, and diversity, making it more resilient to changing external conditions (Harris et al., 2006). Although nature has an extraordinary ability to recover its functions even after deep negative interferences, the engagement of human societies in restoration activities delivers a decisive boost and this is why such activities are increasingly studied and implemented. Not only is humanly-induced restoration more successful in most cases (Benayas et al., 2009), but social factors significantly influence the effectiveness of restoration projects (Löfqvist et al., 2022), and greater community participation enhances their long-term sustainability (Swart and Zevenberg, 2018).

At the policy level, significant initiatives have been developed in recent years, including the United Nations Decade on Ecosystem Restoration launched in 2021, aimed at stimulating community-led restoration practices worldwide (United Nations Environmental Programme, 2021). At the European level, the EU Commission proposed to establish a Regulation on Nature Restoration in 2022 as part of the implementation of the European Green Deal. This legislative measure aims to introduce obligations for the recovery of nature, the mitigation of climate change, and the adaptation to changing environmental scenarios. To achieve these objectives, the Regulation sets forth an overarching target of restoring 30% of its land and sea areas by 2030, along with a commitment to restore all degraded ecosystems by 2050. Additionally, the general target is supplemented with ecosystem-specific objectives, encompassing areas such as forests, urban ecosystems, agricultural lands, rivers, and marine areas. The obligations stemming from the Regulation fall directly on Member States, which are called upon to draft National Restoration Plans; public authorities are thus obliged to plan how they intend to achieve the specified restoration objectives, detailing the types of funds they plan to utilize and the administrative levels they intend to involve. Despite these ambitions statements, the difficulties in approving the law and implementing it at the local level, as well as the high costs required, necessitate an effort that far exceeds the abilities and resources of public entities. It is therefore crucial - as recognized in the text of the Regulation itself - to attract private investments, facilitate action among all stakeholders, and encourage grassroots voluntary participation by European citizens.

To this end, this study aims to experimentally investigate the behavioral and psychological drivers that influence individuals' willingness to participate in collective restoration efforts. Our focus is on analyzing the conditions that create incentives for restoration beyond legal mandates, providing deeper insight into its underlying dynamics for effective policy interventions. Therefore, we examine the combined impact of strategic interaction and ecosystem characteristics on both individual and collective motivations to restore depleted goods and resources.

We propose a novel design that connects a Common Pool Resource game to a Public Good game to represent the concatenation between an *exploitation* and a *restoration* phase involved in ecological restoration. In more detail, our *Restoration Game* requires subjects to face an exploitation decision - where they choose how much to extract from a common environmental resource - and a restoration decision - where they choose how much to invest in the regeneration of the same resource. The conditions differ based on subjects' participation in both decisions or only one of them. Accordingly, we have subjects making both decisions in sequence and subjects who make only the restoration decision, while inheriting the resource from other subjects who only made the extraction decision.

These design features are motivated by two fundamental aspects of ecological restoration crucial for understanding its behavioral drivers. Firstly, the decision to restore occurs within a specific time-frame: more precisely, the need to *re-store* inevitably follows resource exploitation. Therefore, we can assert that the intensity of prior degradation or the types of extraction choices made in the past can influence both individual and collective restoration decisions in the present - in other words, history matters. Secondly, ecological restoration involves a transformation in the perception and use of the resource itself. This transformation becomes apparent when we consider the rivalry in environmental goods consumption. Before restoration, the resource is subject to rivalry in consumption, leading to its gradual depletion.

This implies that if someone utilizes the good, then others are prevented from accessing it and its availability in absolute terms is reduced. A good example of this phenomenon is the rival exploitation of environmental resources for productive purposes, such as timber extraction. Restoration practices such as afforestation projects, in turn, reactivate ecological functions and produce non-rival benefits that are accessible to all.

Using common-pool resource games and public good games to explore environmental resource management is not new in behavioral ecological economics (Cardenas, 2000; Ostrom, 2008; Calzolari et al., 2018; Gächter et al., 2022). However, while both frameworks have been employed in repeated (Schill and Rocha, 2023) or inter-generational (Fischer et al., 2004) settings, the concatenation of the two represents an element of novelty. To our knowledge, only Boldrini et al. (2024) have applied a similar approach to investigate behavioral impacts of a restoration technology. However, while their main focus lies on the potential crowding out of motivation towards mitigation of environmental damages, we specifically address behavioral and psychological drivers of voluntary restoration activities. To this purpose, our between-subject design aims at disentangling the specific role played by subjects' participation in environmental resource degradation and their propensity towards restoration.

The paper is organised as follows: Section 2 describes the experimental design, illustrating the underlying model and the research questions; Section 3 presents the main results, discussing the treatment and condition effects as well as a first analysis of the behavioural traits in the restoration scheme. Section 4 concludes with the synthesis of the results and a discussion of the relevant insights for policy and practice.

2. Methods

2.1. The design

Our investigation of individual propensity to restore is based on a comparison between two main experimental conditions:[1] in the Baseline (BL)

[1]The experiment consists of four treatments preregistered on AsPredicted.org (#127629). The pre-registration, along with the screens, datasets, and replication files, can be accessed through an OSF repository. Data from the conditions where *a)* subjects who only made the exploitation decision in the CPG (Only Extraction condition), and *b)* subjects who made the extraction decision in the CPG and the restoration decision in the

condition our subjects perform in sequence the exploitation decision in the Common Pool Resource game (CPG) and the restoration decision in the Public Good game (PG); in the Only Restoration (OR) condition subjects only make the restoration decision.

To enhance the realism and emphasize the narrative of restoration, the decisions are framed in terms of the management of a forest: during the exploitation decision, participants choose the number of trees to cut and earn monetary payoffs from timber; in the restoration decision, they choose how much money to invest in the re-forestation. This approach imposes constraints on the generalizability of our findings, which may not accurately represent restoration decisions involving other types of environmental resource, as further discussed Section 4. However, within the online setting where our experiment was conducted, the framing is intended to enhance comprehension of the decision at hand while facilitating identification (Alekseev et al., 2017).

To motivate the main features of our design, we first describe the steps taken by subjects in the BL condition, and then outline the key distinctions of the OR condition.

In the exploitation phase (i.e., the CPG), participants are randomly and anonymously matched in groups of three and share a forest made of six trees. Each participant begins with an initial endowment of 40 points per person and is informed that these points are converted into GBP at the end of the experiment, with a conversion rate of 100 points per 1 GBP. The exploitation decision involves determining the number of trees to extract and convert into timber from a forest containing six trees. Each participant is presented with three extraction options: extracting 0, 1, or 2 trees. Cutting down a tree yields an individual benefit of 20 points. Participants make their decision privately by selecting the corresponding radio-button displayed in Figure 1. The counter instantaneously displays the points earned from timber associated with each option.

Following their extraction decision, subjects receive feedback about the state of the forest post-extraction. This feedback entails information about the behavior upheld by the other participants in their group, but does not detail individual extraction choices. Information is conveyed through a graphi-

PG (Strategy Method condition) are not discussed in this paper. As illustrated below, they were used to run the main treatments here discussed in detail.

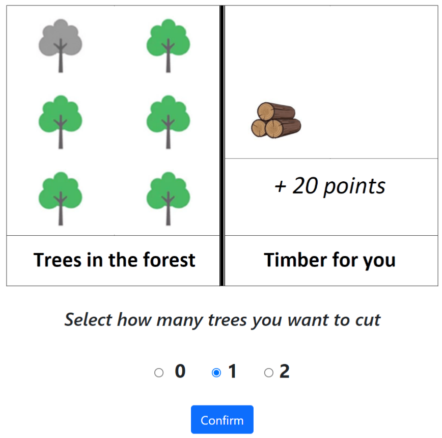

Figure 1: Example of screen for CPR decision

cal representation, as depicted in Figure 2. It is noteworthy that the graphical representation of the overall forest condition provides subjects with a stimulus that potentially activates subjects' considerations and feelings concerning the resource as a whole.

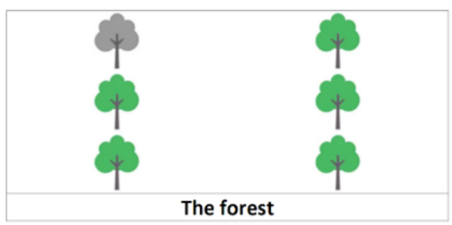

Figure 2: Feedback screen

In the restoration phase (i.e., the PG), the subjects' decision involves the option of replanting trees: they can choose to plant either 1 or 2 trees or decide not to plant any, with each tree costing 20 points.[2]

[2]Since simultaneous interactions are problematic in online experiments (Arechar et al., 2018; Zhou and Fishbach, 2016) primarily due to attrition, to provide subjects in the baseline with tangible feedback, we matched them with subjects playing the same game but using the Strategy Method for the PG decision. Specifically, subjects were tasked with deciding how much to restore conditional on every possible post-extraction state of the forest. Subjects in the BL were unaware of this matching strategy. However, we consider

The assumption that the cost of restoring one tree equals the earnings from extracting one tree in the CPG is admittedly bold. However, this parametrization is essential to ensure isomorphism between CPG and the PG decisions, thus keeping the same incentive to free-ride.

To manipulate the efficiency of restoration activities, we introduce two distinct treatments within each condition: replanting trees (H treatment) and replanting seedlings (L treatment). This implies that the returns from restoration benefiting the whole community (the marginal per capital returns *MPCR* of the PG, as explained below) are greater when mature trees are replanted compared to when seedlings are replanted. We account for this difference in terms of fresh air generated by the forest. These returns from the PG contribution are then paid off in points at the end of the experiment. Specifically, a tree planted in the H treatment generates 12 points in fresh air for each participant, whereas a seedling planted in the L treatment generates 9 points in fresh air for each group participant.

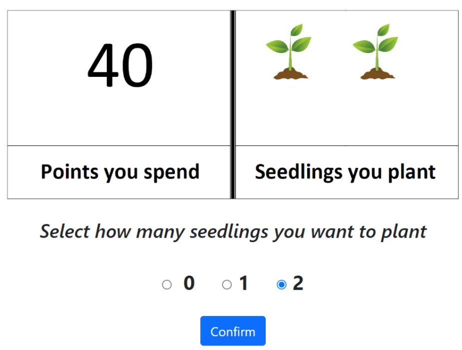

Figure 3: Example of screen for PG decision

In the OR condition, only the restoration phase is involved and subjects inherit the forest after it has been exploited by another group of subjects (in another condition named Only Extraction, OE). After receiving the information about the trees left in the forest, subjects are asked to determine the number of trees (or seedlings) they wish to replant. To ensure compatibility in payoffs with the BL, individuals are endowed with either 60, 80, or 100 points, representing all possible endowments individuals in the BL could

that this omission does not impact the outcomes in the BL, nor does it compromise the accuracy of our payment procedure, since the two conditions are identical payoffs-wise.

possess after exploiting the forest for their benefit.

In all conditions, we included a brief comprehension test before the decision task to ensure understanding. After the decision task, we elicited, only for exploratory purposes, social expectations (Bicchieri and Xiao, 2009; Bicchieri and Chavez, 2010). This encompassed subjects' expectations about the level of restoration by other individuals (*empirical expectations*) as well as subjects' expectations regarding the average belief within the group concerning how much one ought to restore (*normative expectations*). Moreover, at the end of the experiment, we administered two further questions to measure altruism and risk attitudes, following the methodology introduced and validated in Falk et al. (2023) and Dohmen et al. (2011), respectively.

2.2. The Restoration Game: model and theoretical predictions

We formulate the described problem using a two-stage model that we call the *Restoration Game* (RG). As anticipated, in the RG, n players interact in two stages: the CPR stage and the PG stage. In CPR, each player i decides how much to extract (e_i) from a common pool of size P, where each unit of resource extracted yields δ. In the second stage, PG, the choice concerns the voluntary contribution to restoring the common pool (c_i), with each unit of resource restored costing γ. We account for different public benefits generated by the common resource within the RG. Following extraction in the CPR, player i's individual benefit depends on the marginal per capita returns (*MPCR*) $\beta \in (0, 1)$. In the PG stage, two *MPCR* factors come to play: one pertains to what remains from the previous stage ($\alpha_{CPR} \in (0, 1)$), while the other concerns only what is restored ($\alpha_{PG} \in (0, 1)$).

Each player is additionally endowed with an amount Y_i. The payoff for each participant is positively influenced by the number of resources individually extracted but negatively impacted by the aggregate level of extraction, reflecting the negative externality of a degraded common resource. Furthermore, it is negatively affected by the individual contribution to restore but positively correlated with the quantity of restored resources, due to the positive externality of restoration.

In the BL version of the RG, the n players remain constant across both stages of the game. The payoff function for a generic i player in a group of n is:

$$\pi_i(BL) = Y_i + \delta e_i + \beta(P - \sum_{j=1}^{n} e_j) - \gamma c_i + \alpha_{CPR}(P - \sum_{j=1}^{n} e_j) + \alpha_{PG}(\sum_{j=1}^{n} c_j) \quad (1)$$

In the OR version, the n players make only the restoration decision, with other p players extracting from the common resource in the previous stage (this group of p players participated in the above-mentioned OE condition). The i payoff function in a group of n becomes:

$$\pi_i(OR) = Y_i + \beta(P - \sum_{k=n+1}^{n+p} e_k) - \gamma c_i + \alpha_{CPR}(P - \sum_{k=n+1}^{n+p} e_k) + \alpha_{PG}(\sum_{j=1}^{n} c_j) \quad (2)$$

Independently on the condition, everyone benefits from the returns of the common resource once it is restored in the PG, thus creating an incentive to free-ride in both stages of the RG. The theoretical predictions concerning both the BL and the OR are as follows: full extraction ($e_i = max$) whenever $\beta + \alpha_{CPR} < 1$ (and $e_i = 0$ otherwise), and full free riding ($c_i = 0$) whenever $\alpha_{PG} < 1$ (and $c_i = max$ otherwise). As we are interested in the social dilemma aspects of restoration, we impose $\beta + \alpha_{CPR} < 1$ and $\alpha_{PG} < 1$, in addition to $n \times (\alpha_{PCR} + \beta) > 1$ and $n \times \alpha_{PG} > 1$. Specifically, in our design $\beta = 0$ and $\alpha = 0.45$ in the L treatment and $\alpha = 0.6$ in the H treatment. Moreover, we recall that $Y = 60$, $\gamma = 20$, $e_i = \{0, 1, 2\}$, and $c_i = \{0, 1, 2\}$. To ensure comparability between treatments, we set groups of three in each condition, i.e., $n, p = 3$.[3]

2.3. Research questions and behavioral hypotheses

Our design enables us to investigate two main research questions. The first one explores the impact of participation in resource extraction on subsequent restoration behavior, while the second one focuses on the potential drivers of restoration within the BL condition. As for the first question, following a purely rational decision-making process, no differences should be observed. However, when comparing restoration decisions between the BL

[3]Payoff function and theoretical predictions for subjects in the OE treatment are provided in Appendix A.

and the OR behavioral and psychological factors could emerge. Indeed, participants in the BL have the opportunity to reconsider their initial choice, potentially influenced by sentiments such as guilt (Wyss, 2021) or a sense of loss for the depleted natural environment (Bartczak et al., 2015; Holland, 2015). In contrast, decisions in the OR condition are influenced by the extraction levels maintained by another group. Participants inheriting a forest previously utilized by others may choose to conform and mimic their behavior (Cialdini et al., 1990), or they may opt to deviate from the norm, particularly in cases of heavy extraction, driven by a desire to distinguish themselves as more responsible or pro-social (as described in social tipping dynamics initiated by pro-environmental behaviors of minorities, see Berger et al., 2023).

Moreover, the salience of the potential benefit of restoration differs between conditions. While subjects in the OR focus on restoration as their only decision, subjects in the BL view restoration as a future, second occasion. Boldrini et al. (2024) find that the possibility of restoring in the future negatively affects extraction decisions in their first stage. Contrarily, we investigate whether being involved in the first-stage decision conditions the restoration decision in the second stage by comparing the BL and the OR. In this regard, we consider that subjects in the BL could be focused on their first decision and be comparatively less concerned about all the implications involved in restoration, compared to subjects in the OR.

The second research question concerns the potential drivers of restoration behavior within the BL condition.Being exposed to both decisions and sharing them stably with the same group can condition restoration decisions in two ways. Firstly, subjects, based on the feedback on the group extraction decision, could respond to reciprocate or punish cooperative behavior upheld by others (Bowles and Gintis, 2011; Gächter et al., 2017), or they could decide to cooperate conditionally on others' behavior (Fischbacher et al., 2001; Fischbacher and Gächter, 2010; Ackermann and Murphy, 2019). Indeed, the feedback can update priors held by subjects, influencing their restoration behavior based on their expectations of others' behavior. Secondly, subjects' own extraction decision can condition their restoration decision (Gunnthorsdottir et al., 2007). For instance, they may tend to replicate the kind of behavior (more or less pro-social/pro-environmental) they adopted in the first stage without considering possible changes. Alternatively, a sense of consistency may drive them to reapply the same decision criteria without updating them to the new decision situation. We will discuss this hypothesis in terms of a behavioral lock-in binding subjects' decisions in the BL.

3. Results

The experimental sessions were coded using oTree (Chen et al., 2016) and conducted on Prolific, a crowdsourcing platform for online experiments (Palan and Schitter, 2017), throughout April 2023. We recruited an average of 135 subjects per condition. This sample size was computed using the software G*Power 3.1 (Faul et al., 2009) through an *ex ante* power analysis to detect effect sizes of 0.25 at a significance level of 5% with a power of at least 0.8. The experiment was restricted to participants located in the UK, aged between 18 and 40, who had previously completed at least 10 studies on Prolific with an approval rate of at least 90%. No sample restriction was applied *ex post* and only observations relative to subjects not concluding the experiment were excluded. On average, subjects took 6 minutes to complete the experiment. The participants had an average age of 31, with 49% identifying as female. Additionally, 62% reported having a full-time job at the time of the experiment, while 16% were students. They were paid a 0.50 GBP show-up fee to complete the experiment and received an average bonus of 0.56 GBP for the incentivized part. Therefore, on average, they received a total payment of 10.60 GBP per hour.

In this section, we analyze the evidence gathered in the experiment. In the first part, we focus on comparing extraction and restoration behaviors across the different conditions to which subjects are assigned. These conditions include the BL, where subjects make both decisions, and two other conditions where participants make only one decision (OE or OR). We also differentiate by restoration efficiency level, which is exogenously manipulated in our design.

Moving to the second part, our focus shifts to a detailed analysis of restoration behavior. Initially, we examine behavioral patterns in the BL, linking individual extraction decisions to restoration choices. Then, we investigate restoration behavior in relation to the state of integrity of the resource, considering the forest conditions in the BL and the OR treatment.

Finally, we ensure the robustness of our findings through regression analyses, controlling for the effects of demographics and self-assessed validated measures of altruism and proneness to risk.[4]

[4]In Appendix B, our analysis shows that, despite the low attrition levels in the on-

3.1. Treatment and conditions effects

In Figure 4 we present evidence from the extraction stage, corresponding to the CPR decision, where participants could choose to cut 0, 1 or 2 trees from the forest. This decision was made by participants in the BL, who later also participated in the PG decision on the same forest, and by participants in the OE condition, who only made this choice, and then left the forest to other groups who could, in turn, restore it. Overall, we do not observe any significant difference in results between the two groups. Specifically, while pooling conditions by *MPCR* value, extraction levels show no differences in subjects' behavior between the BL and the OE condition (Mann-Whitney test, p=0.127). The same holds when combining the two conditions and comparing the two *MPCR* levels (Mann-Whitney test, p=0.331). Moreover, we find no significant evidence when comparing the BL and the OE condition for the same level of *MPCR* (Mann-Whitney tests, with *high MPCR* p=0.435, with *low MPCR* p=0.174), or vice versa, when examining the effect of a change in the *MPCR* on extraction within the same condition (Mann-Whitney tests, BL p=0.373, OE p=0.673).

In Figure 5, we present findings from the restoration stage, corresponding to the PG decision, where participants could decide whether to plant 0, 1 or 2 trees (high *MPCR*) or seedlings (low *MPCR*). This decision was made by participants in the BL, who had already taken part also in the CPR decision on the same forest, and by participants in the OR condition, who only made this choice, receiving the forest from another group. Overall, once again, we do not observe significant differences between groups when considering our experimental manipulations. Specifically, while aggregating conditions by *MPCR* value, restoration levels show no differences in subjects' behavior between the BL and the OR condition (Mann-Whitney test, p=0.175). The same holds when pooling over the two conditions and assessing the effect of the *MPCR* (Mann-Whitney test, p=0.672). Additionally, no significant effect emerges when contrasting the BL and the OR condition for the

line experiment, some dropouts may be attributed to asymmetries between treatments in control questions presented to subjects, potentially leading to self-selection. However, we clarify that this issue is confined to the experiment's section related to control questions. Importantly, in the segment involving subjects' decisions, the attrition rate becomes negligible. We also establish that attrition has minimal impact on the composition of samples across the three conditions. Additionally, we confirm the robustness of our results by incorporating subjects' responses to control questions into our analysis.

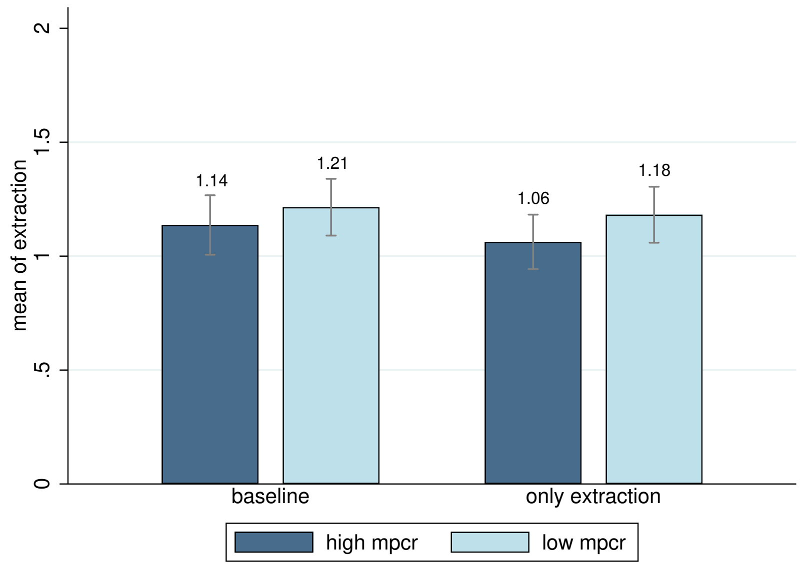

Figure 4: **Means of extraction by condition and over *mpcr***

same *MPCR* level (Mann-Whitney tests, with high *MPCR* p=0.115, with low *MPCR* p=0.746), or vice versa, when evaluating the impact of a change in the *MPCR* on restoration within the same condition (Mann-Whitney tests, BL p=0.345, OE p=0.702).

3.2. Exploring restoration behaviors

To examine how resource integrity and extraction choices affect restoration behaviors, we analyze data by pooling together evidence collected from both the BL and the OR condition. The average levels of restoration concerning forest conditions encountered by subjects upon entering stage 2 of the game are depicted in Figure 6. Forest condition is determined by the number of trees, ranging from 0 to 6, based on the decisions made by group participants in the CPR stage. Our observations indicate a significant impact stemming from involvement in resource exploitation during the first stage: in the BL, where participants took part in the extraction phase in CPR decision, we note a positive correlation between restoration levels and the number of trees remaining in the forest. Conversely, within the OR condition, a negative trend is observed. So, the history of the resource matters, despite theoretical predictions suggesting otherwise (namely, that nobody

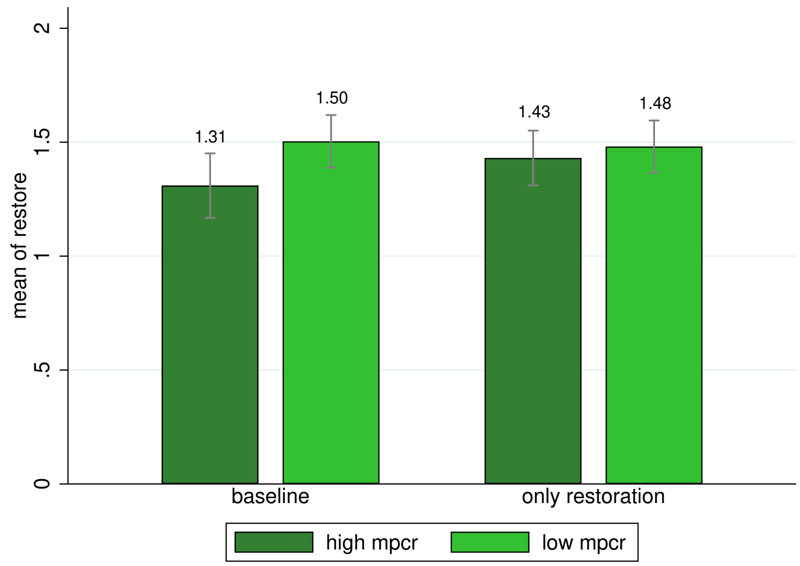

Figure 5: **Means of restoration by condition and over *mpcr***

should restore the forest regardless of who exploited it or how many trees are still there).

To test this, we conducted a regression analysis which is presented in Table 1. In Model 1, we consider as regressors the variables related to the impact of the MPCR, the difference between BL and OR, and the number of trees left in the forest after CPR decision, but with no interactions between them. We find that none of these variables has a significant impact on restoration behavior. However, significant effects emerge once we introduce interaction terms in subsequent models. Specifically, the positive (negative) trend displayed in Figure 6 is supported by the significant coefficient of the forest left regressor (interaction between forest left and only restoration). Moreover, the positive and significant coefficient regarding the OR indicates that in this condition subjects tend to restore more when the forest is in poor conditions compared to the BL.

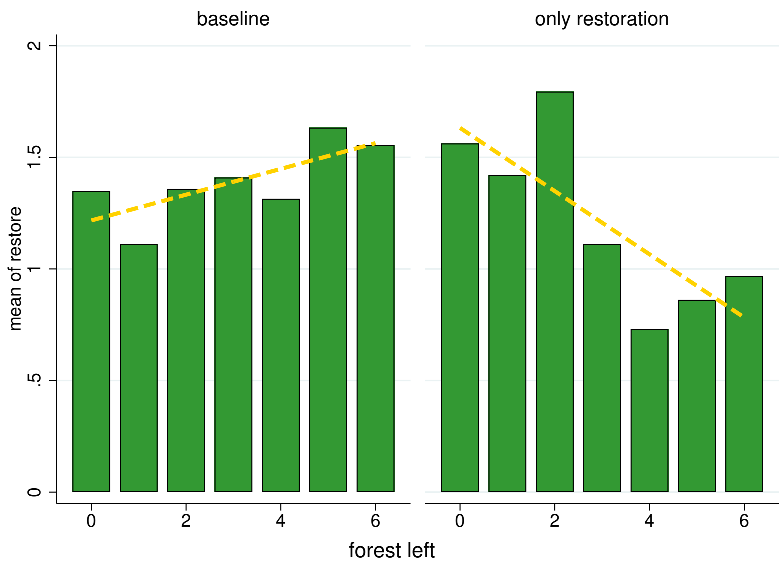

Figure 6: **Means of restoration by condition and over forest left**

DV: restore	(1) baseline + only restoration	(2) baseline + only restoration	(3) baseline + only restoration	(4) baseline + only restoration
low mpcr	0.153	0.166	0.210	0.184
	(0.232)	(0.230)	(0.227)	(0.227)
only restoration	0.128	1.656***	1.683***	1.638***
	(0.078)	(0.453)	(0.448)	(0.448)
forest left	-0.040	0.217**	0.217**	0.215**
	(0.063)	(0.101)	(0.100)	(0.100)
only restoration X forest left		-0.444***	-0.446***	-0.443***
		(0.131)	(0.129)	(0.130)
altruism			0.002**	0.002***
			(0.001)	(0.001)
self assessed risk			0.115**	0.133***
			(0.050)	(0.050)
controls				✓
N	543	543	543	540

Table 1: Tobit regressions with standard errors in parentheses.
$^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$.
Notes. *low mpcr*: 1 yes; 0 no. *only restoration*: 1 yes; 0 no. *forest left*: trees left from the extraction stage, ranging from 0 to 6. *fail*: 1 fail to answer control questions correctly at least once; 0 otherwise. *altruism*: self-assessed willingness to donate (Falk et al., 2023) ranging 0,100,...,1000. *self assessed risk*: self-assessed willingness to take risk (Dohmen et al., 2011).
A table with complete regressions is in Appendix C. Three subjects revoked consent on Prolific for the use of personal data, one in the BL and two in the OR.

Since participants in the BL are engaged in both stages of the game, the positive correlation between individual restoration contributions and the number of trees present in the forest (as shown in the left panel of Figure 6) could be associated with their extraction decisions and/or the behaviors of others regarding the exploitation of the common resource. To disentangle these two potential determinants of restoration decisions, our investigation now focuses on the significance of prior decisions in shaping restoration choices, specifically within the BL condition.

Figure 7 illustrates subjects' average levels of restoration contributions (trees or seedlings planted in the PG decision) in the BL as related to their choice during the extraction stage (trees cut in the CPR decision). Independently from the *MPCR* level, subjects' behavior is consistent across the two stages. This means that when they show stronger pro-environmental behavior in the first stage (extracting less), they tend to restore more in the second stage, and vice versa. To test this relationship and understand if others' extraction decisions influence restoration decisions in the BL, we conduct a regression analysis.

The results of this regression analysis, presented in Table 2, reveal a positive effect of subject's extraction decisions on restoration choices, confirming the pattern displayed in Figure 7, and a non-significant effect of the actions of other players in CPR decision. Additionally, we corroborate the non-parametric analysis findings regarding the negligible effect of the *MPCR* on restoration choices.

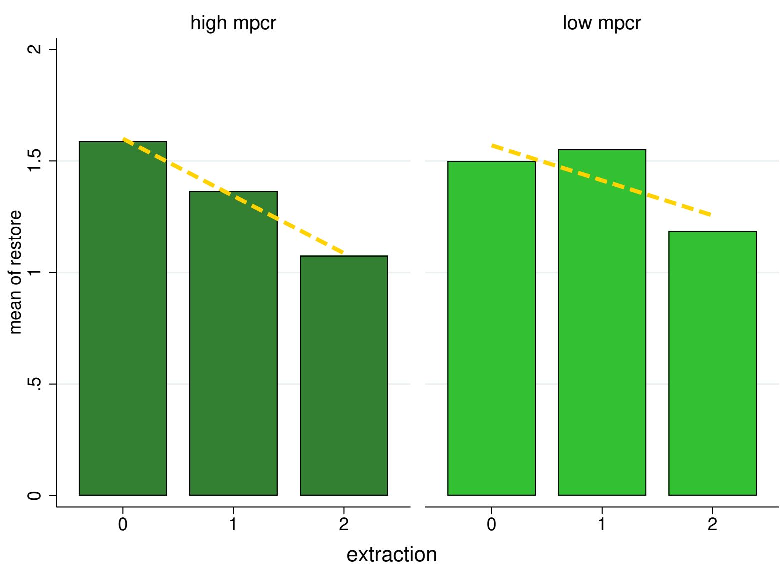

Figure 7: **Means of restoration by extraction in first stage and over *MPCR* (baseline)**

DV: restore	(1) baseline	(2) baseline	(3) baseline
low mpcr	0.374 (0.398)	0.389 (0.392)	0.365 (0.390)
own extraction	-0.957*** (0.279)	-0.978*** (0.271)	-1.021*** (0.281)
others extraction	-0.060 (0.141)	-0.054 (0.137)	-0.064 (0.137)
altruism		0.003** (0.001)	0.004** (0.002)
self assessed risk		0.135 (0.087)	0.136 (0.088)
controls			✓
N	283	283	282

Table 2: Tobit regressions with standard errors in parentheses.
$^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$.
Notes. *low mpcr*: 1 yes; 0 no. *own extraction*: subject's choice in CPR decision, ranging from 0 to 2. *oothers extraction*: sum of the other two group members' decisions, ranging from 0 to 4. *altruism*: self-assessed willingness to donate (Falk et al., 2023) ranging 0,100,...,1000. *self assessed risk*: self-assessed willingness to take risk (Dohmen et al., 2011).
A table with complete regressions is in Appendix C. One subject revoked consent on Prolific for the use of personal data.

Finally, in both sets of regressions presented in Table 1 and Table 2, we find a positive and significant impact of altruism on restoration, suggesting a correlation between pro-sociality and pro-environmental behaviors. Additionally, we observe a positive correlation between willingness to take risks and restoration levels, although this correlation is significant only in the specifications of Table 1.

4. Concluding remarks

We devised an experiment wherein subjects can restore a common pool resource after it has been exploited in a prior stage. In our Baseline, the group exploiting the resource and the group restoring it coincide, whereas in the Only Restoration treatment, the restoring group inherits the resource from another group. This setup enables us to explore to what extent previous exploitation of a resource influences restoration decisions. We find that subjects in the Only Restoration condition that received the resource fully depleted exhibited a higher propensity to restore. This behavior starkly contrasted with that of subjects in the Baseline condition, who restored after extracting the resource themselves. Notably, in the Only Restoration condition, the more depleted the received resource was, the more it was restored, while the opposite trend was observed in the Baseline condition. From our results, it appears that the history of resource exploitation burdens those who engaged in it, leading them to act less responsibly towards restoration compared to those who are free from this burden.

In exploring potential explanations for this behavioral difference, we observed that subjects in the Baseline were locked in the behavior they exhibited in the extraction phase. Those who were more aggressive in exploitation continued to opportunistically free-ride on others' contributions during the restoration phase, while those who initially displayed more pro-environmental behavior were more proactive in restoration. Furthermore, the two decisions appear to be taken independently of others' decisions, ruling out other *explanans* such as reciprocity or conditional cooperation (Fischbacher et al., 2001; Fischbacher and Gächter, 2010; Ackermann and Murphy, 2019), and confirming the behavioural lock-in hypothesis. Moreover, the statistical significance of our control for altruism does not rule out the behavioral lock-in hypothesis. The personal propensity towards pro-sociality does not eliminate the observed hysteresis effect in the Baseline.

Overall, these results suggest that targeting individuals who are not responsible for resource depletion or who do not have conflicts of interest in its exploitation may be more effective in motivating citizen participation in restoration initiatives. However, a few limitations of our experiment must be acknowledged to demarcate the scope of applicability of its results and to suggest possible avenues for further research.

The main limitation concerns external validity. Indeed, inferring insights from preferences and behavior expressed in experimental settings to real-world situations is a common issue in experimental and behavioral economics (Schram, 2005; Kessler and Vesterlund, 2015). In our case, the findings should be considered only as *stilized facts*, which are useful to highlight factors whose relevance in real-person decision processes should be further tested, for instance in the field. However, we believe that the online experiment we developed could potentially provide insights into citizens' behavioral attitudes, allowing to reach wider and more varied samples than standard lab experiments. Moreover, they could be devised to complement survey methodologies and link the collected experimental evidence to the elicitation of further individual characteristics, propensities, and habits. To this purpose, the very simple design we proposed can facilitate remote administrations and easily be adapted to collect more detailed and geolocalised data.

A second limitation concerns the framing used to provide subjects with a relatively familiar decision context. While grassroots initiatives pursuing reforestation are becoming increasingly popular, including through online crowdfunding, they represent only a specific case of possible restoration actions which include a broader range of ecosystems, such as rivers, meadows, peatlands, and others. The robustness of our results could be tested by simply substituting the forest framing to embrace a wider range of environments and relative exploitation and restoration initiatives. However, it must be acknowledged that these different environments may require both a different modelization of the choice and other experimental features.

Moreover, considering the current challenges that the development of legal obligations for ecological restoration faces at the institutional level, there is potential for further developing our experimental design to capture key features of the agreement-making process. Ultimately, such a design could offer valuable insights into how to design institutions more effectively to overcome existing interlocks and conflicts of interest and to pursue the common interest in ecological restoration.

Replication files

The preregistration document, the screens of the experiment and the data and code for replicating the results of this paper are available at https://osf.io/g82fs/. All files are licensed under a Creative Commons Attribution 4.0 International (CC BY 4.0) license.

Declaration of Competing Interest Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Use of Human Subjects

The authors declare that all procedures were performed in compliance with relevant laws and institutional guidelines. Informed consent was obtained from all subjects in the experiment.

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Appendix

Appendix A: Theoretical prediction for Only Extraction treatment

In the OE version, we consider that n players exclusively make the extraction decision, while additional m players restore the common resource in the subsequent stage. The i payoff function in a group of n is:

$$\pi_i(OE) = Y_i + \delta e_i + \beta(P - \sum_{j=1}^{n} e_j) + \alpha_{CPR}(P - \sum_{j=1}^{n} e_j) + \alpha_{PG}(\sum_{k=n+1}^{n+m} c_k) \quad (3)$$

Theoretical predictions for OE are consistent with full extraction ($e_i = max$) whenever $\beta + \alpha_{CPR} < 1$ (and $e_i = 0$ otherwise).

Appendix B: Dropouts analysis

In Table 3 we present attrition rates observed in the online experiment. We demonstrate that the number of subjects dropping out during the experiment is below 10%, with concentration in the initial phase when subjects engage with control questions. Only one subject dropped out afterward. Given that the attrition rate is significantly lower in the baseline than in the other two conditions (Kruskal-Wallis, $p = 0.042$), we direct our focus to a self-selection issue that may impact the composition of our sample and introduce bias into our analysis.

Table 3: Dropouts by experimental conditions

Condition	dropout during the experiment		total	dropout after control questions		total
	no drop	drop		no drop	drop	
baseline	283	17	300	283	0	283
only extraction	267	30	297	267	0	267
only restoration	260	33	293	260	1	261
total	810	80	890	810	1	811

We initially establish that attrition has minimal impact on the composition of samples across the three treatments. This assessment is based on two self-assessed variables queried at the end of the experiment—altruism and risk attitude—along with other demographic information (see Table 4). The only variable showing a discrepancy between conditions is subjects' age. Specifically, the average age in the baseline is lower than in only extraction (Mann-Whitney test, p = 0.011), whereas no significant difference emerges when comparing baseline and only restoration (Mann-Whitney test, p = 0.519).

Table 4: Differences across the 3 treatments of socio-demographic characteristics

Variable	*Test*	*p-value*
altruism	Kruskal-Wallis	0.899
self assessed risk	Kruskal-Wallis	0.443
female	χ^2	0.292
age	Kruskal-Wallis	0.026
left oriented	χ^2	0.122
env. concerned	Kruskal-Wallis	0.495

Notes. *altruism*: self-assessed willingness to donate (Falk et al., 2023) ranging 0,100,...,1000. *self assessed risk*: self-assessed willingness to take risk (Dohmen et al., 2011). *female*: 1 if female; 0 if male. *age*: age quartiles. *left oriented*: 1 yes; 0 no. *env. concerned*: concerned about the environment ranging 1 (Not at all concerned) - 5 (Very concerned).

To further validate the robustness of our results, we include a variable indicating whether subjects have not provided the correct answer at least once in the control questions. In Table 5, we demonstrate that all our results remain robust to the inclusion of this variable. Importantly, the variable does not achieve significance in any of the presented specifications, including when incorporating an interaction with *only restoration*.

Appendix C: Tables with Complete Regressions

DV: restore	(1) baseline + only restoration	(2) baseline + only restoration	(3) baseline + only restoration	(4) baseline + only restoration	(5) baseline + only restoration
low mpcr	0.132	0.142	0.193	0.174	0.179
	(0.231)	(0.229)	(0.226)	(0.226)	(0.226)
only restoration	0.120	1.637***	1.668***	1.630***	1.827***
	(0.078)	(0.451)	(0.446)	(0.447)	(0.469)
forest left	-0.0372	0.222**	0.221**	0.217**	0.226**
	(0.063)	(0.101)	(0.010)	(0.100)	(0.100)
only rest. X f. left		-0.447***	-0.448***	-0.444***	-0.456***
		(0.131)	(0.129)	(0.130)	(0.130)
fail	0.204	0.232	0.165	0.103	0.549
	(0.271)	(0.270)	(0.267)	(0.267)	(0.440)
only rest. X fail					-0.771
					(0.552)
altruism			0.002**	0.002***	0.002**
			(0.001)	(0.001)	(0.001)
self assessed risk			0.113**	0.131***	0.130***
			(0.049)	(0.050)	(0.050)
left oriented				0.261	0.252
				(0.239)	(0.238)
env. concerned				-0.245**	-0.236**
				(0.111)	(0.111)
female				0.584**	0.577**
				(0.231)	(0.231)
age				0.142	0.146
				(0.105)	(0.105)
N	543	543	543	540	540

Table 5: Tobit regressions with standard errors in parentheses.
$^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$.
Notes. *low mpcr*: 1 yes; 0 no. *only restoration*: 1 yes; 0 no. *forest left*: trees left from the extraction stage, ranging from 0 to 6. *fail*: 1 fail to answer control questions correctly at least once; 0 otherwise. *altruism*: self-assessed willingness to donate (Falk et al., 2023) ranging 0,100,...,1000. *self assessed risk*: self-assessed willingness to take risk (Dohmen et al., 2011). *female*: 1 if female; 0 if male. *age*: age quartiles *left oriented*: 1 yes; 0 no. *env. concerned*: concerned about the environment ranging from 1 (Not at all concerned) to 5 (Very concerned). Three subjects revoked consent on Prolific for the use of personal data, one in the baseline and two in the only restoration treatment.

DV: extraction	(1) baseline + only extraction	(2) baseline + only extraction	(3) baseline + only extraction
low mpcr	-0.132	-0.127	-0.189
	(0.148)	(0.148)	(0.143)
only extraction	0.228	0.214	0.172
	(0.148)	(0.148)	(0.143)
altruism		-0.0002	0.00001
		(0.0004)	(0.0004)
self risk		0.070^{**}	0.043
		(0.035)	(0.034)
left oriented			-0.181
			(0.154)
env. concerned			-0.282^{***}
			(0.081)
female			-0.540^{***}
			(0.146)
age			-0.068
			(0.063)
N	550	550	548

Table 6: Tobit regressions with standard errors in parentheses.
$^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$.
One subject revoked consent on Prolific for the use of personal data

DV: restore	(1)	(2)	(3)
	baseline	baseline	baseline
low mpcr	0.374	0.389	0.365
	(0.398)	(0.392)	(0.390)
own extraction	-0.957***	-0.978***	-1.021***
	(0.279)	(0.271)	(0.281)
other extraction	-0.060	-0.054	-0.064
	(0.141)	(0.137)	(0.137)
altruism		0.003**	0.004**
		(0.001)	(0.002)
self assessed risk		0.135	0.136
		(0.087)	(0.088)
left oriented			0.134
			(0.402)
env. concerned			-0.365*
			(0.198)
female			0.364
			(0.390)
age			-0.035
			(0.175)
N	283	283	282

Table 7: Tobit regressions with standard errors in parentheses.
$^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$.
One subject revoked consent on Prolific for the use of personal data

DV: restore	(1) baseline + only restoration	(2) baseline + only restoration	(3) baseline + only restoration	(4) baseline + only restoration
low mpcr	0.153	0.166	0.210	0.184
	(0.232)	(0.230)	(0.227)	(0.227)
only restoration	0.128	1.656***	1.683***	1.638***
	(0.078)	(0.453)	(0.448)	(0.448)
forest left	-0.040	0.217**	0.217**	0.215**
	(0.063)	(0.101)	(0.100)	(0.100)
only restoration X forest left		-0.444***	-0.446***	-0.443***
		(0.131)	(0.129)	(0.130)
altruism			0.002**	0.002***
			(0.001)	(0.001)
self assessed risk			0.115**	0.133***
			(0.050)	(0.050)
left oriented				0.257
				(0.239)
env. concerned				-0.246**
				(0.111)
female				0.587**
				(0.230)
age				0.140
				(0.105)
N	543	543	543	540

Table 8: Tobit regressions with standard errors in parentheses.
$^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$.
Three subjects revoked consent on Prolific for the use of personal data, one in the baseline and two in the only restoration treatment.