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1 Games as tools to address conservation conflicts

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24 **Keywords**

25 Conservation; conflicts; game theory; experimental games; constructivist games;
26 role-playing.

27 **Highlights** (two to four)

28 See conflict games highlights.doc

29 **Abstract** (100 - 120 words)

30 Conservation conflicts represent complex multi-layered problems which are
31 challenging to study. We explore the utility of theoretical, experimental and
32 constructivist approaches to games to help understand and manage these
33 challenges. We show how these approaches can help develop theory, understand
34 patterns in conflict and highlight potentially effective management solutions. The
35 choice of approach should be guided by the research question and whether the
36 focus is on testing hypotheses, predicting behaviour or engaging stakeholders.
37 Games provide an exciting opportunity to help unravel the complexity in conflicts,
38 whilst researchers need an awareness of the limitations and ethical constraints
39 involved. Given the opportunities, this field will benefit from greater investment and
40 development.

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50 **The conflict challenge**

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52 Conflicts are widespread within conservation and are damaging to both conservation
53 interests and to the livelihoods and well-being of people involved [1,2]. Such
54 conflicts are often complex, seemingly intractable and open-ended “wicked”
55 problems [3–5]. Whilst superficially they may appear to be about lions attacking
56 livestock, or the impact of superabundant geese in an agricultural landscape, in
57 reality they involve complex layers of multiple stakeholders with different interests,
58 values, goals, and life experiences in different political, cultural and historical
59 settings [2,6–9]. The complexity of conflicts challenges our ability to tease out critical
60 elements, understand the dynamics of conflict and stakeholder behaviour, design
61 effective interventions, understand how to promote engagement and build possible
62 solutions. Traditional approaches to studying such issues have often failed to meet
63 this challenge and in some cases have led to ineffective interventions which at worst
64 can exacerbate existing problems [10].

65

66 Games offer a potentially powerful means to disentangle this complexity and help
67 understand conflicts and their management. In everyday usage, a game is a
68 competitive activity defined by its rules, and is generally played for fun. However, a
69 more formal definition is offered by game theory, which regards a game as a model
70 of a strategic situation in which the outcome of an individual’s action also depends
71 on the actions chosen by others[11,12]. Viewed in this way, games provide both a
72 framework for formal analysis of conflicts and form the basis of a set of powerful
73 research tools which can be used to clarify the key elements of a conflict, investigate

74 the beliefs and behaviour of the participants, examine the effects of changes to the
75 system and engage stakeholders in productive discussion.

76

77 Various approaches to studying conflict and co-operation based on games have been
78 developed in fields related to conservation [13–17], but the games literature can
79 seem a bit overwhelming: the characteristics, strengths and weakness of alternative
80 approaches are not always clearly understood; they have different philosophical
81 underpinnings; and the terminology used to describe them can be confusing for non-
82 specialists. As a result, they have not yet been widely applied to the study of
83 conservation conflicts.

84

85 We cannot hope to be comprehensive in reviewing the diversity of games here, so
86 instead we focus on describing and differentiating between theoretical,
87 experimental and constructivist approaches to using games that are relevant to
88 those working in conservation. We explore how each one may contribute to our
89 understanding and management of conflict. We start by briefly describing and
90 illustrating the approaches with examples. We then consider the types of problems
91 that emerge in conflict situations and how they may be addressed by the different
92 approaches to games. From there we examine an on-going conflict to illustrate how
93 games may help to understand and manage it. Lastly, we consider some of the
94 general limitations and ethical issues involved in using games in conflicts and
95 propose promising directions for future work.

96

97 **Approaches to games**

98 **Theoretical games** are characterised by a formal mathematical analysis or simulation
99 of players, behaviours, outcomes and rules (see Box 1). They are useful for
100 understanding the nature of conflicts and identifying novel solutions to real-world
101 situations of strategic conflict. For example, a typical situation concerns the joint
102 goals of wildlife conservation and food production where protected animals have a
103 negative impact on farmers. Such a scenario could be simplified to consider two
104 possible strategies - for parties to cooperate, or to defect as when farmers illegally
105 hunt or conservationists exclude local people from the benefits of tourism income.
106 Game-theoretic analyses of such simple scenarios often seek analytic solutions [18].
107 For example, in the “tragedy of the commons” scenario [19], individuals seek to
108 maximise their own payoffs, leading to long term reductions in benefits for everyone
109 (all wild animals killed and no income from tourism). Because this problem is defined
110 by strategic interactions among rational players, a game-theoretic perspective can
111 be used to better understand such conflicts and potentially offer novel solutions for
112 promoting cooperation and sustainability [20,21], such as having an agreed level of
113 wild animals, agriculture and income from tourism.

114

115 In the related fields of common pool resources, land and water management and
116 fisheries, theoretical games have included more complex dynamic simulations, the
117 coupling of social-ecological systems and the uncertainty that is inherent in these
118 systems. The inclusion of both natural resource dynamics and human behaviour has
119 improved our conceptual understanding of conflict situations [22–24], broken down
120 the complexity of decision-making for individual stakeholder objectives [25], allowed

121 us to make qualitative or quantitative predictions of behaviour or other system
122 outcomes [26] and unified case studies through common theory [20,27]. Theoretical
123 games typically assume that simulated players follow a particular set of behaviour
124 patterns, such as being rational decision-makers, providing a baseline for comparison
125 with real-world behaviour [12]. However, behaviours deviating from classical
126 economic theory are also possible [28,29]. For a detailed discussion of the use of
127 game-theoretic approaches in conservation see [23].

128 *Strengths: Useful to probe theoretical understanding of a situation, examine the*
129 *logical conclusions of assumptions about a conflict, and make predictions about the*
130 *effects of changing aspects of a system.*

131 *Weaknesses: Necessarily simplified; they cut humans out of the loop, so the*
132 *complexity of real people in the process is lost.*

133

134 **Experimental games** are used to investigate participant behaviour in controlled
135 strategic situations, in either the laboratory or the field [30]. Experiments based on
136 games provide powerful tools for testing theoretical predictions about individual and
137 group behaviour [31] and for quantifying behavioural traits, such as levels of trust
138 and trustworthiness [32] and preferences for risk or fairness [33]. In this way,
139 experimental games enable the investigation of responses to conservation
140 interventions within the context of complex social dilemmas without the need to
141 rely on theoretical assumptions, or expensive full implementation studies. They are
142 well suited to investigations of possible conflict management strategies, enabling
143 researchers to study their relative effectiveness in a controlled setting prior to
144 implementation (See Box 2). This approach is particularly useful when participants in

145 a game are themselves stakeholders in the conflict the game seeks to model since
146 behaviour has been shown to vary with factors such as cultural and educational
147 background and familiarity with the situation being represented [34]. The application
148 of experimental game approaches with real stakeholders thus increases the
149 likelihood that results of experiments are applicable to real world resources,
150 institutions, and people [31].

151 *Strengths: Useful for testing theories and practical interventions that would be
152 difficult, expensive or unethical to test at 'reality scale' and to quantify behavioural
153 traits.*

154 *Weaknesses: Necessarily simplified, although not as much as theoretical games;
155 Design and implementation requires attention to detail so that a truly fair
156 comparison is made among treatments. Outcomes can be sensitive to small changes
157 in the experimental design.*

158

159 *The constructivist approach requires games to be designed and used in iterative
160 processes to understand conflict situations and to help stakeholders come up with
161 solutions [35]. These games can be card games, board games or role-playing games,
162 and they are used to foster dialogue and build trust among stakeholders [36]. As for
163 experimental games, constructivism integrates players inside the game – bringing in
164 their needs, desires, beliefs and intentions, allowing their behaviour in the game to
165 represent differences in knowledge and values. The difference from other
166 approaches, however, is that here the players are given freedom to explore a range
167 of possible outcomes in strategic situations, so they can reframe the problem and
168 the game, and create new options not initially contemplated by the research team*

169 [35](Box 3). As a result the capacity to learn and anticipate are integral to the
170 behaviour observed within a game [37]. In conservation conflict contexts, these
171 games often have a multi-agent system structure, with a landscape, resources, and
172 stakeholders, interactions within and among these components, and explicit
173 representation given to the cognitive capacities of the agents [38]. This approach is
174 exemplified by the work of the Companion Modelling community
175 (www.commod.org).

176 **Strengths:** *Flexible enough to allow for a wide range of human behaviour; useful to*
177 *establish dialogue, help people understand different viewpoints and agree a shared*
178 *understanding of a conflict.*

179 **Weaknesses:** *Documentation, analysis, replication and synthesis are all challenging.*

180

181 **How can games be used to address questions about conflicts?**

182 A number of issues that emerge from research on conflicts are pertinent to games

183 [2] (Table 1). First, there is a need to find generalities from the numerous case

184 studies and build relevant theory. For example, we might want to develop

185 hypotheses for how cooperation can develop in dynamic ecosystems that typically

186 have a high degree of uncertainty and significant fluctuations in resources [39].

187 When mapping conflicts, there is a need to explore the underlying patterns and

188 behaviour of conflicts – how they emerge and how they change over time, and when

189 they switch from conflict to cooperation [40,41]. In addition, understanding conflict

190 relies on mapping the underlying stakeholder values, emotions, interests and

191 positions and how these aspects affect behaviour in conflicts [42–46]. Moving into

192 conflict management, a widespread issue lies in understanding the impact of

193 different types of interventions on stakeholder behaviour and on the level of
194 conflict. Such interventions can include both specific technical measures such as
195 compensation schemes or lethal control, or interventions focused on trust and
196 relationships, dialogue processes, governance and institutions [47–55]. Lastly, a
197 critical issue lies in the importance of dialogue and engagement in promoting
198 listening, understanding and the development of solutions among stakeholders.

199

200 All three approaches to using games can provide useful insight into each of these
201 areas of conflict research (Table 1), and the choice between them should be guided
202 by the specific research question and context in which they will be applied. However,
203 some approaches tend to suit certain objectives. For example, experimental
204 approaches are well suited to exploring how an intervention might alter stakeholder
205 behaviour in a conflict, whilst constructivist approaches are useful when exploring
206 solutions with stakeholders. It is also worth pointing out that synergies can arise by
207 using combinations of games, such as experimental and constructivist approaches
208 [56].

209 To further guide the choice of approaches, it is useful to ask whether the main aim of
210 the game is to test specific hypotheses, predict behaviour or to engage stakeholders
211 (Figure 1).

212

213 **Approaching a live conflict – geese in agricultural landscapes**

214 To illustrate the utility of alternative approaches, we consider how games could be
215 used to illuminate different facets of the conflict over rapidly increasing geese

216 populations (Box 4). Most populations of geese in Europe (14 of 17 populations of 7
217 species) have grown from threatened to super-abundant over the last 60 years [68].
218 These geese often graze in intensively managed agricultural fields leading to conflict
219 with farming objectives [69,70]. Management strategies and policies have failed to
220 adapt to this increasing problem, causing frustration among stakeholders, and
221 reinforcing polarisation and conflicts [71]. Games can provide insight into the
222 understanding and management of this conflict in several ways.

223

224 **General limitations & ethics**

225 Games have enormous potential to provide insight, but they are not a panacea. One
226 of the main limitations is that, as for all models of reality, they simplify complex
227 situations and it is hard to choose which aspects of a situation can be safely ignored.
228 In addition, games can give the illusion of representing real-world outcomes, yet
229 they cannot predict with certainty what will happen when the stakes are real. A
230 particular concern about external validity arises in situations where the payoffs used
231 in a game are considerably lower than in real-life [31,72]. Similarly, there are issues
232 of internal validity - are the decisions being made by game participants the same as
233 those a researcher believes are being made? [72]. These questions need to be
234 considered throughout the process of developing, implementing and interpreting a
235 game. Debriefing sessions after experimental and constructivist games with the
236 participants are valuable in helping address these issues.

237

238 While games can seem innocuous fun, when played with stakeholders they can raise
239 serious ethical issues: from framing and game design through implementation and
240 publishing the results. For example, at the design stage, it is easy for researchers to
241 plan a game in such a way that the outcome of the game into a foregone conclusion.
242 To avoid this pitfall, the community of Companion Modelling has drafted a charter of
243 conduct [35]. In addition, early and thorough testing is essential. Game designers
244 need to consider how to capture and represent sensitive behaviours, such as
245 corruption, poaching or reprisals. Designs and tools are available to avoid revealing
246 individual information to other players, or even to the research team [73].
247 Stakeholders might also question whether games are serious enough to warrant the
248 interest of busy professionals with a reputation to lose [37].

249

250 Payments involving cash or other tangible goods are sometimes used in games
251 [73,74]. These approaches need to be thought through before implementation.

252 Payments linked to individual performance within games are supposed to give
253 players an incentive to focus harder, but also incentivise acting more selfishly,
254 potentially undermining the basis of collaboration [75]. In certain contexts, this
255 would improve understanding of the system. In others, it could be detrimental,
256 particularly if the incentives are trivial compared to the costs that stakeholders incur
257 in real life.

258

259 During certain games, the role of the participants will evolve, and researchers need
260 to reflect on how much power they are willing to give to participants and how to
261 deal with the power asymmetries among stakeholders and between stakeholders

262 and the research team [76]. In fact, even playing a game can affect the system, so
263 researchers need to exercise reflexivity to be aware of any potential unintended
264 outcomes of such interventions [67,77]. Games with participants can also spark
265 conflicts but these are generally inherent to the situation being explored. Games
266 simply bring these processes to light so that the conflict can be managed instead of
267 being suppressed by the power structure of the status quo [78]. Nevertheless, they
268 require careful facilitation to manage expectations and deal with emerging issues.

269

270 The ethical considerations of publishing games that involve stakeholders are also
271 important. Participants should be informed how data will be used, who will have
272 access to it, and in what form, particularly if it is identifiable to a particular player. As
273 with other empirical approaches to investigating sensitive behaviour, anonymising
274 individual behaviour might not, in itself, be sufficient to ensure that game
275 participants are protected from harm [79].

276

277 **Future Directions**

278 Games offer exciting opportunities to help guide the understanding and
279 management of conflicts over biodiversity and conservation. This field of conflict
280 research is focused on case studies with limited efforts to draw out the generalities
281 [80]. Games have the potential to help find and explore the generalities, such as the
282 consistent findings in ultimatum games of concern for others – as opposed to the
283 pure self-interest that is often assumed [11] and consider how they might fit in
284 different contexts. We consider a number of outstanding questions in Table 2.

285

286 **Concluding remarks**

287 Conflicts are ubiquitous, persistent and damaging. Their complexity and critical
288 human dimensions mean that they are challenging to study and manage. Games
289 have the potential to address these problems and provide genuine insight into a
290 wide range of issues around how we understand and manage conflicts. Moreover,
291 games also have the potential to be fun. There are different types of games available
292 to address different questions and situations – from theoretical games to ones
293 involving the active participation of stakeholders. Given their potential to help
294 develop theory, understand patterns in conflict and highlight potentially effective
295 management solutions, we suggest this field is ripe for development, given proper
296 awareness of the limitations and ethical constraints.

297

298

299 **Box 1** An example of a theoretical game developed to address a fisheries conflict and
300 the role of cooperation.

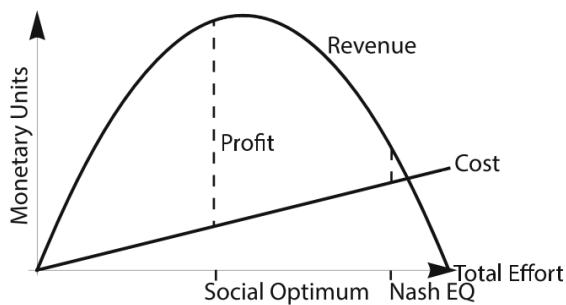


Figure 1 from [19] showing that cooperation and ultimately sustainability is best promoted at a higher total effort of harvest (Nash EQ) than would be optimal (Social Optimum) for maximising long-term profit (dashed lines). Figure reproduced with permission from the journal.

311
312 Tilman et al. [24] recently investigated conflict within a social-ecological fishery
313 system by constructing a mathematical model of the fishery as a common-pool
314 resource system. Fishers can increase their own profits by maximising their catch,
315 but the individual gain achieved by doing so contributes to long-term depletion of
316 total fisheries stock. The authors looked at this case study using game theory,
317 defining a 'socially-optimal' fishing strategy that could be enforced by allowing
318 fishers to ostracise one another when over-harvesting occurs. In the mathematical
319 model, fishers could either join a cooperative or they could harvest independently
320 which increased profit, but came at the cost of being ostracised by the cooperative.
321 Further, the punitive power of the cooperative increased with its size, and
322 ostracising independent harvesters also incurred a cost to the fishers in the
323 cooperative.

324
325 Tilman et al. [24] modelled the dynamics of fish biomass and the fraction of fishers
326 that joined the cooperative. Fishers were assumed to be rational agents who joined
327 or not based on whichever choice maximised their profit. They demonstrated the
328 conceptually general, counter-intuitive result that social ostracism can promote
329 cooperation and ultimately sustainability when individuals within a cooperative
330 harvest at a rate that is higher than what would otherwise be optimal for maximising
331 the long-term rate of resource harvest overall. This is because a higher harvest rate
332 for individuals within a cooperative can discourage independent harvesters from
333 invading, and ultimately leads to more sustainable long-term harvests. Hence, this
334 theoretical approach suggested a novel, generally applicable, way to address
335 conservation conflict.

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Box 2. An example of an experimental game developed to predict the outcomes of incentive-based interventions on illegal resource use in Cambodia.

Photos by H. Travers



In Cambodia, illegal resource use inside protected areas is common, with high rates of hunting and land clearance in particular leading to conflict between local people and conservation authorities. One solution that has been developed to mitigate this conflict is the introduction of incentive-based interventions to promote compliance with land use and resource access zones. To evaluate the potential behavioural impact of these interventions, Travers et al. [65] used an experimental game adapted from the common-pool resource game developed by Ostrom *et al.* [20]. To aid understanding, the game was framed around the harvesting of fish from a pond within the protected area. Each participant was given the option of harvesting fish from this pond or choosing to leave fish unharvested for future use. Payoffs were set such that harvested fish were worth considerably more to the individual harvesting than if they had been left in the pond. However, the collective value of fish left in the pond was greater than the payoff an individual received from harvesting. This set up a social dilemma in which the optimum strategy for players who wanted to maximise their own payoff was to harvest as many fish as they could, whereas the social optimum was to leave all fish in the pond.

A number of alternative management strategies were investigated, including fines if participants were caught harvesting too many fish and individual or collective rewards for keeping harvests within predefined thresholds. The most effective interventions at reducing fish harvest were those that encouraged participants to self-organise, through the use of incentives that were conditional on group behaviour or allocated to individuals by the group. Although the treatments considered in the game were stylised versions of those applied in reality, the findings provided valuable insight into the features of incentive initiatives predicted to have the greatest impact on encouraging sustainable use of resources and mitigating conflict between local people and conservation authorities. This has led to increased efforts to promote the development of local institutions and the provision of collective incentives to local communities.

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Box 3. An example of a role-playing game to explore the likely influence of policy change on an agro-forestry system in India

Photos by C.A.Garcia



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The landscape of Kodagu, in India's Western Ghats is a mosaic of rice fields, forest fragments and coffee farms. Coffee is produced under complex, multi-storied agroforestry systems, but farmers are replacing a diverse, native canopy cover with the fast growing, introduced Silver Oak *Grevillea robusta* [85,86]. Whereas the harvesting of native species is controlled, silver oak can be logged and traded [87]. For years, coffee farmers and their representatives have been demanding full ownership rights over trees on their land [85]. These demands have been opposed by the Forest Department for fear of the environmental impact. Farmer representatives have denied that the granting of rights would result in a loss of tree cover or conversion [88]. This polarized debate has led to a long-lasting standoff.

A role-playing game was developed with academics, representatives of the Central Coffee Board of India, local conservation organisations, private coffee trading companies, and community leaders in eight separate workshops across the district. Through workshops and interviews, the game was co-constructed and explored two scenarios. The business as usual scenario had rules for selling native trees mimicking the restrictions in place. The tree rights scenario saw these restrictions lifted. These game sessions were recorded and used as a basis for discussion.

The results suggested that farmers would increase their income were they to receive full rights. But we also observed that in such situations they decided to hasten, rather than reverse, the conversion to Silver Oak. This strategy was contrary to expectations that farmers would retain native forest, but instead, the faster rotation of Silver Oak trumped the multiple values of the native trees.

The lessons from this role-play game were bittersweet. The game revealed system components and processes that had been identified in none of the policy narratives of the concerned parties. These represented hidden pitfalls that would have plunged the system into a non-desired state had the current policy change been implemented as initially designed. However, these lessons could not be transferred to the policy process, in part because the findings undermined the initial position of our main partners, the coffee farmers themselves.

432 **Box 4. Examples of how three approaches to games could be used in a current**
433 **conflict over geese impacts on agricultural systems in Sweden.**

434
435 **Background.** Increasing numbers of
436 protected geese in Europe are causing
437 impacts on agricultural production [68]. In
438 Sweden, the government pays
439 compensation and supports the scaring of
440 most goose species, but as populations
441 increase, farmers are asking for more
442 lethal control.



Photo by Johan Månsson

443
444
445 **Theoretical game example.** Objective – *predict the impact of management*
446 *strategies on collaborations and goose populations.* First, map the time series of
447 goose numbers, management actions and players' interactions over time, to develop
448 a modelling framework within which game theory can be applied. Then simulate the
449 actions and players' interactions using mathematical or computational techniques to
450 find actions that reduce conflict. Such a game could enable predictions as to which
451 actions will lead to collaboration and a sustainable goose population under changing
452 conditions of governmental budget changes.

453
454 **Experimental game example.** Objective – *test a hypothesis that farmers are more*
455 *likely to cooperate in a goose management scheme, which uses a lethal rather than*
456 *non-lethal control method.* The game setting would be an idealised landscape in
457 which geese move among farms and damage crops. Players would be farmers who
458 choose between lethal or non-lethal measures using a cash endowment they receive
459 in each round. These measures would only be effective if the sum of investments
460 reached a predetermined threshold. If too few invest, no protection would be
461 achieved. Such an approach would allow researchers to test players' willingness to
462 participate in different measures and examine the effect of collective discussions on
463 individual decision-making. Post-game debriefing sessions would provide a greater
464 understanding of the factors influencing farmer behaviour.

465
466 **Constructivist games example.** Objective – *engage stakeholders to explore lethal vs.*
467 *non-lethal interventions under changing economic resources.* This game would be
468 played over a co-developed idealised landscape. Stakeholders would build and play
469 the game to explore the strategies they would employ under lethal and non-lethal
470 action scenarios, interacting with each other and the resources in the landscape. The
471 game would allow the compatibility and sustainability of actions over space and time
472 to be assessed. The design and gaming process and post-game reflections
473 would facilitate a shared understanding of the conflict among participants, enabling
474 an explorations of the outcomes and stakeholder acceptance for measures and
475 the development of innovative interventions.

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483

484

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Table 2. Outstanding questions**1) How to scale up to the management of a large scale conflict?**

Experimental and constructivist games are often played with a relatively small sample of the population of interest, we need to understand how best to scale-up.

One approach is to run games with decision-makers, to provide them with the insight into the system and its management. Alternatively, one could run games with trainers, so that they can then play the game more widely with key stakeholders.

Digital games also offer one way of extending the reach of these approaches [81,82].

2) How does one win a conservation conflict game?

All games define the winning conditions precisely: eg last man standing, or first one to achieve a certain amount of points. Given the complexity inherent to conservation conflicts, it is likely to be insufficient to only consider the monetary payoffs of different actions because the players may have conflicting interests that cannot be measured using the same unit of pay-off. For example, the value of a lion saved from being killed to conservationists in the USA cannot be easily compared to the value to a farmer of livestock lost to a lion. Other attributes, such as safety, reputation, and symbolic values are also important. To accommodate non-monetary attributes, we need to go beyond the ordinal rankings of pay-offs [22,23] and consider new approaches to determining pay-offs, such as integrating multi-criteria decision analysis and scenario planning analysis [25,83].

3) How to address uncertainty in pay-offs in conservation conflicts?

Predicting people's decision making under increasing uncertainty is paramount for future conservation and conflict management [84]. Game-theoretic approaches in conservation have mostly focused on the mathematical analysis and have so far ignored the dynamic nature of ecosystems (e.g. weather differences between years) and thus the uncertainty in pay-offs these dynamics create [23]. Yet games offer the potential to explore how people respond and change their behaviour according to implementation uncertainty, such as associated with conservation policies or incentives, or in situations of process uncertainty, such as a rapidly changing world. An important advantage of games is that these uncertainties are not tested for each person in isolation but in direct interaction with other players in the community. Games could be set up so that players experience challenges associated with agricultural food shortage or the international protection of species that provided traditional sources of wild meat, thereby mimicking situations of conservation conflict [59].

Figure 1. Decision tree highlighting the situations under which the different approaches to games are favoured. Experimental approaches are a good fit when addressing the objectives in Table 1 through testing hypotheses, and constructivist approaches are best suited when addressing the objectives through engagement. If the aim is to address the objectives through making predictions about future behaviour, then the most appropriate approach will depend on two things: first, whether or not there is a reasonable model of the players' decision-making process, and second, whether the main interest is in the system or the stakeholders. If there is knowledge of how people choose between a small set of actions then theoretical games will be most useful for predicting the behaviour of both systems and stakeholders. However, if there is no reasonable model of decision-making, then constructivist approaches are likely to be most helpful at predicting system behaviour, and experimental games are likely to be most helpful at predicting stakeholder behaviour.

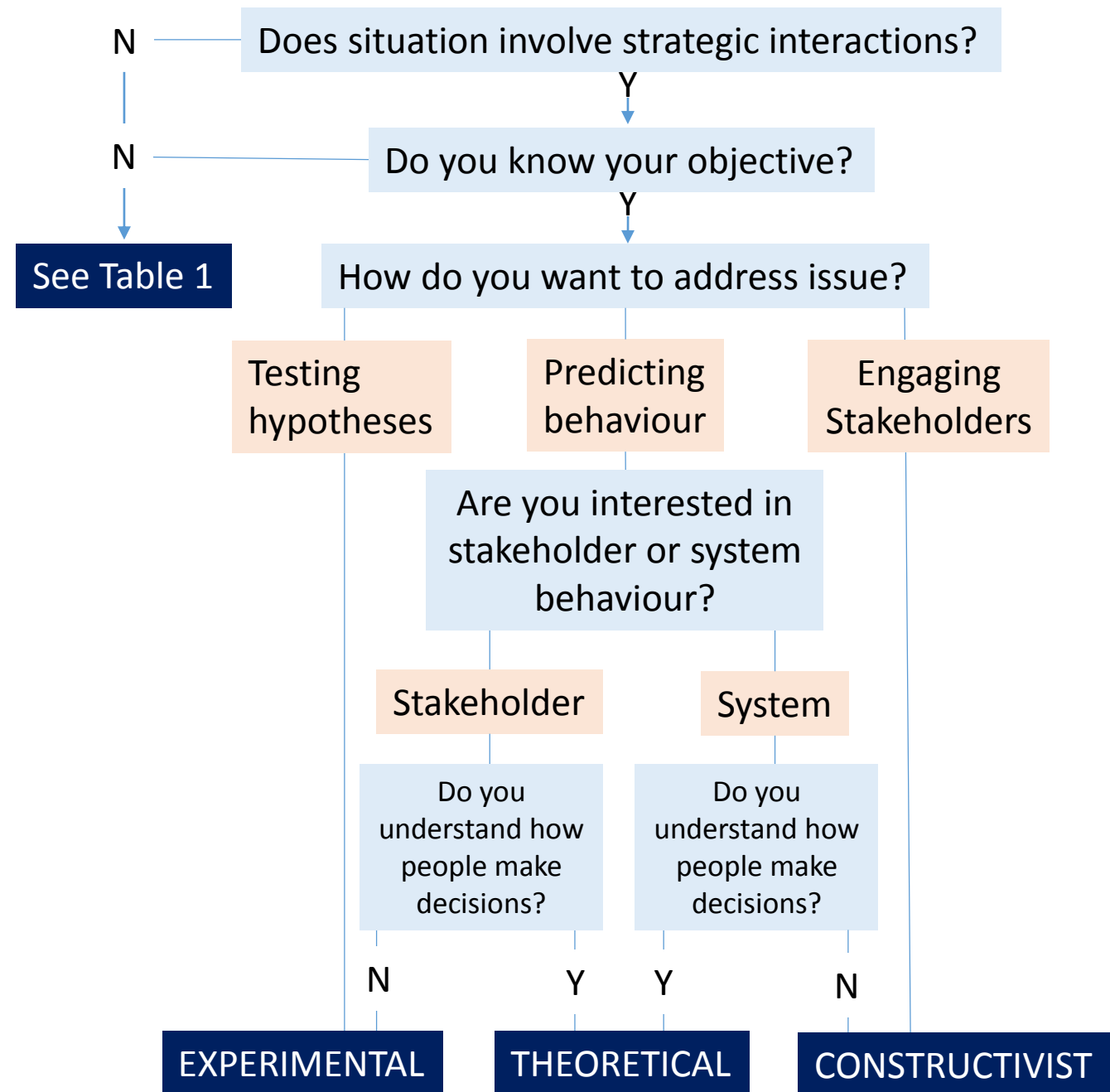


Table 1: Suggestions about how different approaches to games could be used to address objectives relevant to understanding and managing conservation conflicts. These suggestions are illustrative in nature and are not intended to be exhaustive or mutually exclusive. Each suggestion is accompanied by a reference to a study where this type of approach to games was used to address comparable objectives in a related field.

	Approach		
Objective	Theoretical e.g. game theoretic mathematical or computer simulation modelling	Experimental e.g. common pool resource and public goods games in lab and field	Constructivist e.g. role playing games and companion modelling in lab and field
Develop theory about conservation conflict in a changing environment	<p><i>Relevance of approach:</i> To explore the logical consequences of theories of conflict</p> <p><i>Comparable example:</i> Exploring whether social ostracism can promote cooperation and sustainability in fisheries harvesting, assuming rational agents [24] (Box 1).</p>	<p><i>Relevance of approach:</i> To test assumptions about behaviour in conflicts and look for generalities</p> <p><i>Comparable example:</i> Testing how environmental stochasticity and trust affect cooperation to mitigate climate-change [57].</p>	<p><i>Relevance of approach:</i> To elicit the insights of stakeholders about the nature of conflicts</p> <p><i>Comparable example:</i> Eliciting stakeholders' reported behavioural strategies in a natural resource management and conservation setting [36].</p>
Understand how conflicts emerge, evolve and resolve	<p><i>Relevance of approach:</i> To examine the conditions under which conflicts are likely and suggest how they might be changed to encourage cooperation.</p> <p><i>Comparable example:</i> Analysing the history of environmental conflict, identifying the structure and actions (e.g. enforcement) of the conflict and predicting possible solutions [58].</p>	<p><i>Relevance of approach:</i> To test the role of specific factors in promoting cooperation or conflict</p> <p><i>Comparable example:</i> Testing the effects of fear and environmental uncertainty on co-operation between nations with respect to climate change action [59].</p>	<p><i>Relevance of approach:</i> To support dialogue and shared learning to co-identify the roots of and solutions to conflict</p> <p><i>Comparable example:</i> Building a shared representation of farmers' interactions with a protected area to allow for the negotiation of uncertainties and risks [60].</p>
Understand how values, interests and positions affect stakeholder behaviour	<p><i>Relevance of approach:</i> To predict conflict from values and norms</p> <p><i>Comparable example:</i> Predicting the effect of a social norm of fairness on forest conservation [61].</p>	<p><i>Relevance of approach:</i> To test how individual and institutional characteristics affect behaviour in conflicts</p> <p><i>Comparable example:</i> Investigating how personal norms and other individual characteristics influence cooperative behaviour amongst fishermen [62].</p>	<p><i>Relevance of approach:</i> To facilitate understanding of behaviour and social learning in conflicts.</p> <p><i>Comparable example:</i> Revealing the processes leading to overgrazing and providing a platform for sharing stakeholder views, knowledge, and perceptions [63]</p>
Identify how interventions affect stakeholder behaviour and conflict	<p><i>Relevance of approach:</i> To predict behavioural responses to different interventions</p> <p><i>Comparable example:</i> Investigating effects of payments and sanctions on poaching and importance of individual-level heterogeneity</p>	<p><i>Relevance of approach:</i> To test behavioural responses to different interventions</p> <p><i>Comparable example:</i> Investigating the effect of incentive based payments on stakeholder behaviour amongst</p>	<p><i>Relevance of approach:</i> To explore behavioural responses to different interventions with stakeholders</p> <p><i>Comparable example:</i> Revealing the effect of policy change on stakeholder behaviour in coffee plantations (Box 3)</p>

	and strategic decision-making in design of interventions. [64]	fishermen in Cambodia. (Box 2) [65]	
Promote engagement amongst stakeholders to understand conflicts and develop solutions.	<p><i>Relevance of approach:</i> To explore possible outcomes of conflict under different scenarios</p> <p>Comparable example: Simulating fishery management in order to explore effectiveness of management options with stakeholders [66].</p>	<p><i>Relevance of approach:</i> To encourage reflection by participants, promote dialogue and test solutions</p> <p>Comparable example: Encouraging communities to reflect about the incentives and strategic interactions that can lead to conflict over resource use [67]</p>	<p><i>Relevance of approach:</i> To promote and support co-management</p> <p>Comparable example: Bringing local communities and protected area managers together to support the collaborative production of effective management plans. [60].</p>