Using artificial intelligence to improve decision-making in conservation conflicts
Annotated readings

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Contents

Interesting sentences

When the actions of one party clashes with the objectives of another party, the objectives of one might be expressed at the expense of the other, causing conservation conflict (Duthie et al., 2018).

Currently, there is no standard way to measure conservation conflict in a social-ecological system where both the natural resource (e.g., animals, plants, or non-biological resources) and the people (e.g., stakeholders,managers, etc.) are modelled in a single system, and previous modelling approaches have not meaningfully separated agent objectives from agent actions. A starting point to developing a useful metric of conservation conflict is to quantify the deviation of an individual's actions from their objectives (i.e., of actual actions from desired actions) (Duthie et al., 2018).

GMSE does not currently distinguish female and male individuals (Duthie et al., 2018).

Conflict might persist around the appropriate target population size rather than what actions

are permitted for farmers; currently, this potential aspect of conflict is not modelled, but future versions of GMSE may attempt to incorporate such additional complexity in conflict scenarios (Duthie et al., 2018) = Negotiations around manager's targets and policy.

Future versions of GMSE will allow users to affect one another directly (representing, e.g., different groups of agents lobbying for different interests,among-user conflict, etc.) (Duthie et al., 2018).

"No player can do better without the other player being worse off". Solutions with this property are called Pareto optimal (Colyvan et al., 2011). It is a solution from where the system cannot move without at least one player being worse off (includes both players being worse off).

If no player would unilaterally change his or her action from a solution without loosing personal outcome, it is a Nash equilibrium (supposes that the player knows what the opponent strategy is).

Herein lies the real value of game theory: it provides a general and powerful framework for analysing environmental decisions, one that adopts a dynamical approach to decisions and naturally lends itself to an appreciation of the ongoing and far-reaching consequences of major environmental decisions. (Colyvan et al., 2011)

Early development of management strategy evaluation (MSE) models originated in fisheries (Polacheck et al.,1999; Smith et al.,1999; Sainsbury et al.,2000) (Duthie et al., 2018).

All models are wrong, but some are useful. George Box

Jeremy's talk (time series analyses in ConFooBio, budget optimisation and users compliance):

- Assessed the quality of a strategy with the (actual, not estimated) population deviation from the manager's target.

- The managers' impartiality does not influence the user compliance, they do whatever they want in the limit of their budget.

- Engagement (involving users in the policy) increases compliance way faster and higher than enforcement (force then into doing something through pressuring their budget).

- Genetic algorithm is a good candidate to model human thinking as it does not review every single possible strategies to select the best one, it selects the most fitted to its interests in a restrained population (along with discussion with Brad).

Moreover, the selection process through generations allows for stochasticity through mutation and crossing over. Hence the fittest strategy is not necessarily the optimal one, which could be interpreted as the fact that humans do not always chose the optimal option.

Holistic: characterized by the belief that the parts of something are intimately interconnected and explicable only by reference to the whole. (Google dictionary)

Median and average are means to reduce the information of a data set to a single value. 2D Linear regression reduces it to 2 values (slope and intercept). Several algorithms for linear regression: least sum of deviation (robust to outliers), least sum of squared errors (more sensible to outliers because the deviation is squared), maximum likelihood (error distribution given the data set and the parameters), ...

Ideas

Allow GMSE to build the world according to a GIS layer for landscape.

Include randomness into decision-making ? Already there, in the genetic algorithm: the decision is not optimal, it is just the best the agent could think of.

Use impact to assess the quality of a policy?

Use readings to justify the need of an adaptive model such as GMSE. Given which models have been used in previous studies.

How to justify the strength of the causality link between management actions and resource's response?

Try to formalize a ConFooBio case as a game.

Lit review has to present a very clear path from a large question (something like: "how modelling can help settling efficient management strategies in conservation conflicts ?") to a more specific question that will be the one I will be treating during the PhD, backed up by former studies.

Be strong on the definitions of **conservation**, **conflict**, **utility**, **game** in the theoretical sense, . . .

Emphasize on the fact that a sustainable conservation strategy is not to focus on nature only, but to find trade-offs between humans' interests and biodiversity.

WHY SEEKING CONSERVATION ?

Cognitive bias : anchor effect. We usually need a first guess to calibrate our judgement, but the utility associated with this guess strongly influences the way we estimate the alternative options' utility.

design a survey on how people perceive AI.

I could use EVPI to assess the most impacting interaction to implement. Would require a very precise question!

Be aware of a good trade of between over and under-fitting, or between too flexible and too rigid.

Brad meeting on 12th of October

Lands close to public areas suffer from a higher problematic population, because resources reproduce faster in public areas. Plus, the other landowners scare theirs away. There might be a need to adapt policies to public areas proximity.

GMSE is implemented well enough because, following rules based on real cases observations, it succeeds in finding policies that equitably conserve the species and maintain users yield. Even if it can not fit perfectly to all the possible situations (which is not its goal), the model can help to spot relevant aspects of the conflict that were neglected before. It is meant to be compared to actual cases, highlighting important factors, and to provide help for decision-making, giving an idea of the long term consequences of a policy in an idealistic situation.

Comparing to real case studies to asses the robustness of the model would not be relevant because of the myriad of uncontrollable factors that can influence population dynamics, spatial distribution and users choices. Plus, it's very costly. But would be a good way to show the flexibility of GMSE, showing that it could provide a suitable strategy without the need for full knowledge of the possible sources of variation in decision-making or population dynamics.

Implementing random factor to simulate unexpected events, the fact that agents are not game theory experts, and can sometimes not choose the best option, would require an actual justification, why would it be interesting? What question would it answer? Note that the genetic algorithm already introduces stochasticity in the decision-making.

GMSE is predicted to be used by managers, or research scientists, but it could also be a way

for "users" to understand why they are imposed quotas and interdiction. Nonetheless, it would require a more friendly interface.

The 80 stakeholders simulation took ca 12 hours, also because the population was very large. But it shows that the genetic algorithm could use parallelisation.

To show GMSE needs improvement, point at the situations where the four criteria of a successful strategy are not fulfilled. E.g : when the population is well managed but implying a broader income difference between the users. This could be a reason for the users (or the managers) to change the population target for example, should it be through negotiations. Brad's idea: use a measure of conflict as a threshold to initiate interactions (e.g: negotiations).

Implementing a estimation-type-dependent population variation (estimated population and population target difference) threshold under which managers would rather not intervene at this time step, and see what happens. Maybe allowing them to save some budget for next time step. Good training on C. The increase in budget must be coherent with what the budget represents. It could be a mix of money, time, energy, well-being.

Cognitive bias in negotiations: anchor effect.

ConSerVation / ConVerSation. When you turn the Versus over.

Dress a non-exhaustive list of the different models used in conservation management.

Poster's abstract

Conservation of biodiversity, and the ecosystem services it provides, is of vital concern for humanity. Yet, species mismanagement can lead populations to interfere with human livelihood, resulting in defection from the conservation policies. To keep protecting efficiently, a manager must durably tame such conflicts by implementing policies meeting all stakeholders' interests. But, in such complex and interconnected socio-ecological systems, management faces uncertainty at multiple levels. Adaptive Management suggests to deal with it by dynamically fitting the policy to the system's evolution. Here, computational models are useful decision-helping tools, as they inform on the system's possible responses through the exploration of a large number of scenarios. Generalized Management Strategy Evaluation (GMSE) is the first software that simulates over time managers' and users' decision-making in situations of conservation conflict using artificial intelligence, while accounting for uncertainty at the different stages of the policy-implementing process. I will use and develop it to explore the long-term consequences of different management strategies on actual cases from the ConFooBio project, a gathering of well monitored conflicts involving food security and conservation of biodiversity. The first focus of the thesis is the questioning of the relevance of the common management habit of intervening as soon as possible. Indeed, choosing the most relevant time to act could avoid the misuse of funds, and free time and energy to be spent in other more pressing matters. Yet, this strategy is only conceivable if it has no unwanted effect on the quality of both the conservation and conflict management. To test for this, I updated GMSE with a threshold in population density under which the manager will rather not change the policy, and save money, time, and energy for the next relevant time to act. Exploring the long-term consequences across a wide range of scenarios, I assessed whether, and under which conditions this management strategy is actually relevant.

1 Trondheim workshop 09/01-11/09/19

1.1 General bibliography

1.1.1 premier article lu, celui qui etait soporifique

Debate on the quotas for whale catching among IWC-involved countries. A moratorium was settled following the concerning decrease in certain populations of whales. Efficient since most of populations started recovering. Scientists from the "Green ****" argued against its ending in 1991, emphasizing on uncertainty linked with scientific measures of population, supposingly following ethical interests for whale protection, regardless of the economical interests in its exploitation. This resulted in the moratorium lasting longer than necessary. Discrediting scientific weight in the debate, main weight shifting to ethics, way more fragile and susceptible to fall under economical interests.

1.1.2 How sure are you? (Goodman, *Science* 2018)

Putting a value on the certainty about a scientific statement, as a "confidence index", an "estimate of the chance that the claim is true". Just like weather forecast, that narrows down a highly complex model into one clear value: "there is a 60% chance of rainfall tomorrow". Bayesian approach is "part-way down this path" as it estimates the probability of a hypothesis to be true. Reminder: p-value is the probability of being wrong rejecting the null hypothesis. HOW IS THAT DIFFERENT? Clearer for communication, not involving statistics directly, might drive scientists to aim at the rightest answer, rather than the more statistically significant (avoiding P-hacking, the process of trying every statistical analysis to select the one that produces the most significant statistic). Already used in stock-exchange. Suggestion to have scientist betting their own money in the righteousness of their answer.

1.1.3 The framing of decision and psychology of choice (Tversky, 2010)

Study of systematic changes in choices according to the framing of the same problem. "Preference reversal". Example: two situations with the exact same expected value. One option insure to get the expected value (secure choice), the second involves probabilities to get more but the expected value is the same (risk choice). WHAT PROPORTION IS EXPECTED HERE? If the problem is framed in terms of gain (certitude of people being saved), three quarters of the people interviewed chose the secure option. RISK AVERSE In terms of losses (certitude of people dying), 3/4 chose the risk option. RISK TAKING Yet the propositions are exactly equivalent, we would then expect the proportions not to change according to the framing. PSEUDOCERTAINTY effect, when applying a contingency to an alternative. "The preceding analysis suggests that insurance should appear more attractive when it is presented as the elimination of risk than when it is described as a reduction of risk."

Lizzy "positive outcome, decision maker is responsible for the positive outcome. Negative outcome, more likely to take risk because they won't be hold responsible (???)"

GMSE: an R package for generalised management strategy evaluation - Duthie, AB, et al. (2018).

Key words: Conservation, conflicts, adaptive management, genetic algorithm, spatially explicit population dynamics, goal-oriented behaviour.

According to GMSE framework, a satisfying management strategy implies (not in order of importance):

- Equitable spatial distribution of the resource on users lands.

- Focal species abundance stays close enough to the manager target.

- Users yield reaches a satisfactory percentage.

- Low differences between users yields.

Basic functioning of GMSE.

1. A population of discrete resources (e.g.,a managed species) with individual traits (e.g., location, age) is modelled on a spatially-explicit landscape and can simulate resource birth, movement, interaction with the landscape, and death; the discrete nature of resources causes demographic stochasticity, and therefore uncertainty.

2. Observation is modelled in one of four ways: resource counting on a subset of landscape cells (e.g., Nuno et al., 2013), marking and recapturing a fixed number of resources, and resource counting across the whole landscape either one linear transect or one rectangular block at a time (during which resources might move). Sampling error from all observation types generates a range of uncertainties that depend on monitoring effort.

3. Managers analyse data collected from observations to estimate resource abundance, then compare this estimate with their predefined target abundance. Policy is developed by calling the genetic algorithm, which works within a manager constraints to find costs for user actions on the resource (e.g., culling, scaring, etc.) that minimise deviation from the target abundance, as informed by the predicted consequences of each action on resource abundance and user action histories.

4. After a suitable policy is found, users perform actions that affect resources or landscape cells. Users respond to policy individually, each calling the genetic algorithm to find actions that maximise their own utilities (e.g., maximise resource use or landscape yield) within their imposed constraints. Once each user has found an adaptive strategy, user actions affect resources and landscape cells, feeding back into the resource sub-model.
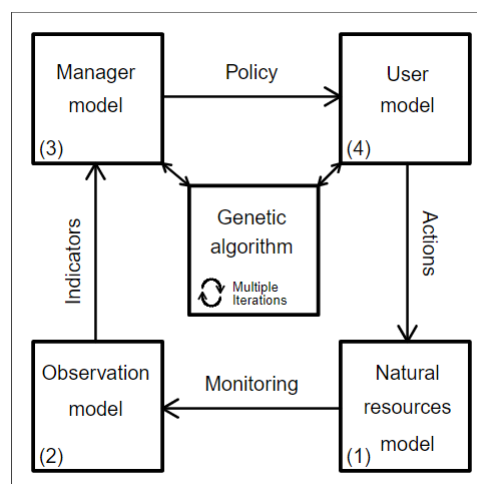
Genetic algorithm: called each time a manager or a user has to make a decision. Generates a unique population of strategies (e.g. for a manager, allow such budget to such change in the cost of actions) with an associated fitness. The algorithm allow them to "**cross-over and**

mutate" and re-evaluates their fitness. After burning some iterations, the decision is made when the fittest strategy fitness increase is below a chosen threshold.

SI1: Each run of the genetic algorithm mimics the evolution by natural selection of a population of potential manager or user strategies over multiple iterations.

Deeper in the code for ACTION arrays, the first column Act identifies the type of action being performed; a value of -2 defines a direct action to a resource (e.g., culling of the resource), and a value of -1 defines direct action to a landscape (e.g., increasing yield). Positive values are currently only meaningful for Manager_Actions, where a value of 1 defines an action setting a uniform cost of users' direct actions on resources (i.e., costs where Act = -2 for User_1_Actions and User_2_Actions). **It's a key value to add interactions between agents, e.g. a value of X is a direct action on user1 specifically)**

Adding a new type of stakeholder = a new layer in ACTION array

The fitness of each layer is evaluated based on how the layer is predicted to affect resources or landscape output to which the agent has assigned some utility.

Cross-over: each individual selects a partner, then exchanges corresponding array elements affecting agent actions (columns 8-13) with their partner at a fixed probability of ga_crossover.

Mutation: For each array element, a random uniform number $u \in [0,1]$ is sampled. If u is greater than 1 - (0.5 * ga_mutation), then the value of the array element is increased by 1. If u is less than 0.5 * ga_mutation, then the value of the array element is decreased by 1. Increase mutation if u is close to 1, decrease mutation if very close to 0, otherwise nothing.

fitness: Individual fitness is defined by a real number that increases with the degree to which an individual's actions are predicted to increase entities of positive utility and decrease entities of negative utility.

Land utility: When land_ownership = FALSE(default,modelling users that harvest resources),Uures$=-1$ and Uuland= 0, and when land_ownership = TRUE, Uures= 0 and Uuland= 100(modelling farmers trying to increase crop yield).

Genetic algorithm is well adapted to management strategies because it's a *I know it when I see it* approach. No prior knowledge of the best solution, but ability to judge the quality of a proposition and, compare it to previous ones.

Geese example (scare or cull): Only the estimates of population size from the observation model are available to the manager, so policy change at any time step is driven primarily by the deviation of the currently estimated population size from the manager's target and the actions of farmers in the previous time step. Hence, when the population size is estimated to be below (above) the manager's target, the manager increases (decreases) the cost of culling and decreases (increases) the cost of scaring. Because the manager does not know in advance how farmers will react to policy change, they assume a proportional response in total actions with respect to a change in cost (e.g., doubling the cost of culling will decrease stakeholder culling by1/2). Farmers responding to policy are interested only in minimising waterfowl's exploitation of their crops, so they will either cull or scare to remove the waterfowl from their land, depending on which option is more effective (i.e., cheaper).

Further improvement for the genetic algorithm: Future versions of GMSE might improve upon these heuristics to generate more accurate or more realistic models of human decision making. Such improvements could incorporate additional information such as memory of actions from multiple past time steps, or a continually updated estimate for how actions are predicted to affect resource abundance or landscape output in a simulation (e.g., through a dynamic manager_sense). Alternatively, future improvements could usefully incorporate knowledge of human decision making collected from empirical observation of human behaviour

during conservation conflicts.

`gmse_apply`: we can use it to study change in policy availability. E.g. what happens when scaring is suddenly introduced as a possible policy option. To see how manager or user power changes over time. If users' budgets increase by 100 every time step, with the manager's budget remaining the same. The consequence of this increasing user budget is higher rates of culling and decreased population size.
To avoid crashes, when an argument that changes the data structure is added, gmse_apply builds a new set of agents and a new world at each call.

The aim of GMSE is not only conservation or maximising human activity income, but to reduce the conflict in a equitable way.

SI6: GMSE might be used to assess the risk of extinction in a managed population, through repeated simulations varying in the frequency of managers intervenes. Possibility of extinction increases exponentially with this frequency.

2 Models in ecology

2.1 Theory and models in Ecology: a different perspective. (Caswell, 1988)

Key words: Theoretical approach, experimental approach, models, legitimacy, critique.

Fight the unjustified criticism towards mathematical models in ecology. Mathematical models allow the exploration of the possible patterns, which suggests "new ways of looking at problems". Theory in biology aims at exploring the range of possible patterns in order to identify the systems boundaries ("this can happen, this cannot"). One cannot expect theory to be infallible, as any knowledge accessible to us, including experimental one, it is **conjectural**. Experimental approach is compulsory when testing if a theory actually applies in nature, but it cannot answer questions on the theory itself while modelling approach can. For example, when searching for the least assumptions to predict a given phenomenon.

The following is a beginning of a list of types of theoretical problems:

(1) Exploring the consequences of a theory. To determine what is possible from a theoretical model can be a contribution to ecological knowledge, regardless of the eventual decision about the truth or falsity of the model in any specific case. This activity generates lots of papers exploring the dynamic consequences of particular equations. Rather than protesting that those papers do not contain empirical tests, it should be understood that most of them are adressing very different questions.

(2) Demonstrating the connection between apparently unrelated theories. For example, the demonstration that the bifurcation properties of several different discrete density-dependent models are generic to any smooth one-humped map of the interval (May, 1976) was a contribution to ecological knowledge, quite independent of the question of which (if any) discrete model gives the best fit to a stock–recruitment relationship.

(3) Evaluation of the robustness, or lack thereof, of theoretical results, by examining different models for the same phenomenon.

(4) Developing mathematical methods for the analysis of theoretical models.

(5) Finding the *simplest* model capable of generating an observed pattern.

(6) Designing empirical and/or experimental tests of the theory. Everybody admits that this is an important problem. As I will discuss in the next section, too many think it is the only important problem.

Which one is GMSE? Brad: it could pretty much be all of them. In general, it would be a (4), in the sense that it uses novel computational methods to model conflicts management, but it could be used for all the other possibilities. Basic use of GMSE is probably (1), it explores possible outcomes using the current situation as initial conditions. We could also argue that GMSE links decision-making theory to population dynamics, which would fit in (2).

Testing is not the only thing to do with theories. First, they need to be developed, and preventing people to develop theories without any backing-up data would result in slowing the discipline.

Refute a theory is not abandoning it, it is an encouragement for improvement.

"Does the model include such important factor (related to my field of study) ?". Irrelevant most of the time. Just as most experimental set-ups assessing one to two factors in relation to an other, the theoretical approach cannot take all the factors into account, and must also focus on the variables relevant to its research question.

"models are to theoretical problems as experiments are to empirical problems."

2.2 Individual-based modelling and ecological theory: synthesis of a workshop (Grimm 1999)

Key words: individual-based modelling, ecology, conservation, review, complexity.

3 main arguments against the use of IBMs in Ecology: " complex models are hard to develop, hard to communicate, and hard to understand."

The only way to communicate models is through verbal and mathematics description, but the core of the model is the code, which is incommunicable by definition. It is where all the errors and bugs can dwell, thus falsifying the information taken out of it. No one has the time to implement the model him/herself based on the verbal description. (ndlr - same for experiments

by the way! It's time costly to redo an experiment.) Beware of putting more effort in the coding than the the analysis, it could lead to a "WhatYouWantIsWhatYouGet" fallacy. Models has to be as simple as possible! Unnecessary complexity, although being an interesting challenge, would just result in the model being harder to communicate and analyse, thus reducing its scientific value.

Models can definitely help pointing at stuff that needs to be studied in order to understand a mechanism. It's even better to use **a suite of different model implementations** to prove that the way you code the model does not change the conclusion.

2.3 NEW HORIZONS FOR MANAGING THE ENVIRONMENT: A REVIEW OF COUPLED SOCIAL-ECOLOGICAL SYSTEMS MODELING (Schlüter, 2012)

Chapter 3.2.3. "One of the problems with many traditional decision-making tools in natural resource management is that their outcomes depend on humans behaving in a defined and predicable manner." "Unexpected responses of humans to management interventions have been identified as one of the key sources of uncertainty in fisheries management (Fulton et al. [2011]) and wildlife conservation (Keane et al. [2008]). Due to unforeseen behavioral responses of users or consumers or their non compliance with rules, a measure taken to enhance ecosystem services does not necessarily lead to the expected outcome or may even worsen the situation."

MSE "is also being introduced in a wildlife-management context (Chee and Wintle [2010]) and in catchment management (Turneret al. [2003])."

2.4 Ecologists should not use statistical significance tests to interpret simulation model results (White et al., 2013)

keywords:

Argues about the use of statistical methods applicable to experimental ecology in simulation results. "p-values are determined by statistical power (i.e. replication), which can be arbitrarily high in a simulation context, producing minuscule p-values regardless of the effect size." "Second, the null hypothesis of no difference between treatments (e.g. parameter values) is known a priori to be false, invalidating the premise of the test." Models does not test null versus alternative hypotheses like statistical tests, it explores the possible outcomes of a priori hypothesis. Yet ANOVA is ok, but only focusing on the explained variances, ignoring p-values.

3 Management strategy in conservation conflicts

3.1 Conservation and the Myth of Consensus (Peterson, 2005)

keywords: Argument-based, Consensus-based, Constructionist, Sustainable development, Democracy.

From a constructionist perspective, nothing is "real" for humans until they reach a consensus about it. Any idea stays "rhetorical" unless a community makes it "reality" by commonly agreeing on its meaning. Consensus is a unconditional step in the realisation of any idea. But very often, different consensus are reached in different communities, which -according to constructionist thinking- leads to the emergence of different realities.

Reaching a consensus on the fact that conservation can go alongside with economical growth is possible, but would require to ignore research work and personal experience that prove the

contrary. In this sense, the very notion of consensus of conservation in our growth-oriented societies faces a wall.

Management by consensus is risky because tying to meet every stakeholders expectations need agreement processes that can slow -sometimes eliminate- the impetus for a change. Moreover, such question usually arise within organised communities where some instance has the power to orientate the consensus in a way that does not threaten the current hierarchical positions.

Commonly accepted definition of sustainable development : "A development that meets the needs of the present without compromising the ability of future generations to meet their own needs". A definition based on which every "community" built its own reality, resulting in very different points of vue.

"The emphasis on win-win outcomes in consensus-based models for environmental decision making is problematic in part because we achieve the illusion of objectivity and universal reason only by bracketing or masking conflicts among participating groups and individuals. We thus treat as truth that which could just as easily be understood as hegemony. As Mouffe (2000) contends, the illusion of consensus is fatal to democracy because a healthy democratic process requires recognition of differing interests and the recognition that open conflict about differing interests is legitimate." To avoid conflict and to secure their position, "dominant elites generally prefer consensus-based approaches over those based on argumentation". Interesting for GMSE. Ivie (2004) specifies that, "democratic dissent in a period of war or crisis is as alarming to the purveyors of prevailing opinion as it is critical to a nation's political welfare." Consensus strengthen current political instances and their globalised, growth-oriented view of the world, thus produces nothing remotely sustainable.

"The hypothetico-deductive scientific method suggests reality only by methodically eliminating alternatives (Murphy & Noon 1991), not by proving truths." Thus, it cannot provide any answer for a policy question.

"Why focus our efforts on on achieving the improbable and possibly unwanted goals of monism in science and government, when an emphasis on negotiation (de Graaf et al. 1996) within democratic processes (Mouffe 2000) can explicate the implicit value judgments required for conservation to be successful, and simultaneously empower citizens to participate in the application of science to democracy? Within this argument-based model, environmental decision making reflects deliberation, debate, and conflict about both direct and indirect scientific observations of the physical world."

"Consensus-based approaches to environmental policy are necessary but insufficient to ensure the best decisions. An emphasis on argument legitimises and facilitates change, whereas an emphasis on consensus further legitimises continuity or stability."

3.2 Uncertainty and adaptive management for biodiversity conservation (Keith et al., 2011)

(Literature review)

Key words: Management quality, comparative studies, role of modelling, estimated value of perfect info.

Comparative study of different strategies on the field : " Its key elements include explicit definition of management goals, development of plausible alternative management strategies to achieve those goals, implementation of two or more strategies in a comparative experimental framework to spread risks of management failure and improve understanding of system responses to management, monitoring to evaluate the relative merits and limitations of alternate strategies, and iterative modification of management strategies to improve management out-

comes (Lindenmayer and Burgman, 2005)"

Since the response to a policy is lost into other responses from a myriad of uncontrollable external factors, monitoring the system's response to a policy over time seems not to be a good way to test and improve the policy. Also very costly! And the information gathered are most of the time estimations, that can mislead management if too far from real info. **Estimated Value of Perfect Information** can help targeting the most efficient commitment to monitoring and its scale of precision.

"Models are imprecise representations of complex ecological systems, and at best can typically only predict directions of change in response to management policies. Yet models can be extremely useful tools that help clarify management problems and identify important knowledge gaps that question faith in model predictions."

Some people implemented a way to compare different policy models in terms of learning and conservation efficiency.

Scientists "sometimes use policy demands to pursue discovery goals that may never be applied to decision making by testing their predictions. Managers often wilfully ignore scientific uncertainty to avoid complicating their message to stakeholders, and use it (or the pretence of certainty) later when policies fail in attempts to shift responsibility for failed policy implementation to the scientific community".

3.3 Which uncertainty? Using expert elicitation and expected value of information to design an adaptive program (Runge 2011)

Key words: Expected Value of Information, Expert Elicitation, Decision-making, Conservation, Adaptive Management, Workshop.

"Natural resource management is plagued with uncertainty of many kinds, but not all uncertainties are equally important to resolve."

"The promise of adaptive management is that learning in the short-term will improve management in the long-term."

Using the Expected Value of Perfect Information (EVPI) to anticipate the impact of the resolution of an uncertainty on the efficiency, or informativity, of a management strategy.

"several taxonomies of uncertainty (Morgan and Henrion, 1990; Regan et al.,2002)."

"by addressing epistemic uncertainty in the short term, we can improve management outcomes in the long-term. "

The utility for GMSE would be the level of conflict? The focal species population? Users income? The answer is that the "utility scale has to be relevant to the decision maker".

"The challenge with these value of information methods is that they require articulation of a set of models (hypotheses), a prior belief about the credibility of those models, and predictions of the outcomes under each model and action combination."

For prior knowledge, we can refer to expert elicitation using one of the many existing "Delphi" methods.

"The management problem was framed as a multi-criteria decision analysis under uncertainty: what management strategy should be undertaken at NNWR to benefit the EMP of whooping cranes, as expressed through four objectives, in the face of uncertainty about what is causing reproductive failure? This analysis involves manag ing tradeoffs among several objectives, as well as examining the im pact of several specific hypotheses for reproductive failure. To develop this framework, we needed to specify the objectives, artic ulate the hypotheses for reproductive failure, develop potential management strategies, and predict the outcomes of each strategy on each objective under the alternative hypotheses." Identify objectives, mea-

sures that can be associated with it, weight their relative importance, develop hypotheses on the reason why, attribute points for the relevance of each hypothesis to select a panel, and finally develop a management strategy to treat each hypothesis. Make predictions on the response of the objectives variables over a certain amount of time for each strategy under each hypothesis.

$$\text{EVPI} = E_s[\max_a U(a,s)] - \max_a E_s[U(a,s)]$$

EVPI is the utility gain associated to the fact of knowing *a priori* the best option. The first term is the utility of action a having the info about the best thing to do if the system behave a certain way *s*. The second term is the utility of the same action without having prior knowledge of the best thing to do. A positive EVPI traduces a information worth than investment. But only if "it is possible to reduce the uncertainty through monitoring, and whether the short-term costs of acquiring the information are off-set by the long-term benefits of the information".

3.4 A critical assessment of adaptive ecosystem management in a large savanna protected area in South Africa (Wilgen, 2011)

Keywords: National park conservation, Strategy building, Consensus on thresholds, multi-stakeholder conflict, feedback, protected area.

Interesting to-do-list for planning an adaptive management strategy. can be useful for GMSE?

"The goals of protected areas usually include the maintenance of their component species, communities, landscapes and ecological processes. [. . .] This approach integrates research, planning, management and monitoring in repeated cycles of learning about how to better define and achieve objectives." Users in the sense of MSE, are not taken into account in the cycle. Conservation motivations: preserve local habitats, avoid threat on local species by invasive alien species, control animal population, maintain the existing interactions. Different purpose, mainly ecology and tourism.

First, all the stakeholders talk through a list of objectives associated with a priority. Then agreeing on lower and upper thresholds to give any objective a range of satisfaction.

Active adaptive policy: implementing rapidly policies in order to acquire information on the outcomes, both expected and unexpected.

"In complex socilogical-ecological systems, the achievement of desired outcomes through management intervention cannot be guaranteed, and, in addition, the outcomes may be replaced with different ones that appear more desirable as understanding increases."

Example of difficulty of reaching a consensus: "A decade ago, conservation authorities and the government were unable, in the face of conflicting evidence, interpretations and opinions, to formulate an agreed policy on elephant management."

"Success may be complicated by the fact that ecosystems are often slow to respond to management interventions, or that the interventions could have unexpected consequences."
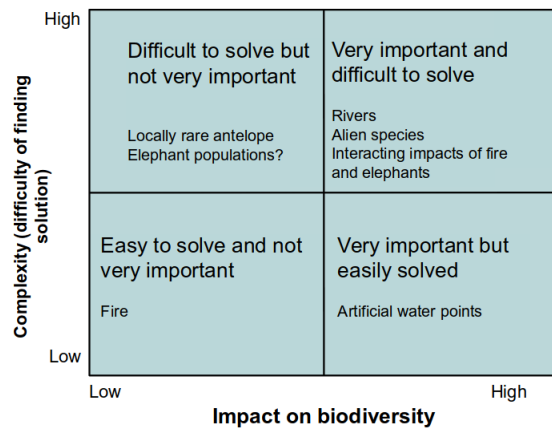
Fig. 1. Classification of management topics in the Kruger National Park in terms of: (1) their complexity, and therefore relative ease or difficulty of finding a solution; and (2) the relative impact of the topic on the overall goal of conserving biodiversity.
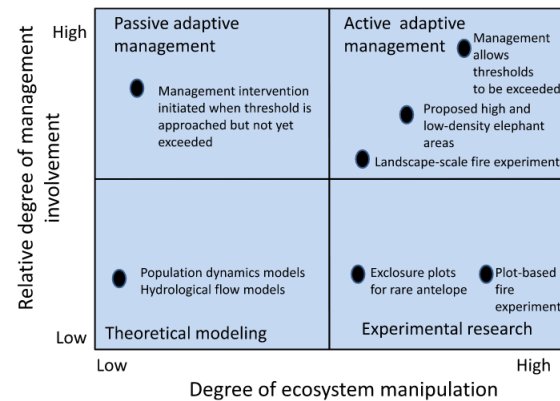
Fig. 2. Examples of ecosystem management interventions in the KNP along a continuum of ecosystem manipulation, showing the degree of involvement by management staff. Points indicate approaches that have been attempted or proposed in the Kruger National Park.

Management based on thresholds has proven to be quite difficult in terms of monitoring and accuracy. Too much time spent on revising thresholds and changing monitoring methods.

3.5 State-and-transition modelling for Adaptive Management of native woodlands (Rumpff, 2011)

Key words: Landscape management, state and transition model, Bayesian network, expert elicitation.

"Adaptive Management is a 'learning by doing' approach that acknowledges management action must proceed in the face of uncertainty, but facilitates iterative updating of knowledge and management strategies (Walters, 1986; Ringold et al., 1996). In this way, Adaptive Management ensures that future management decisions are socially, economically, and scientifically defensible."

"some of the problems [preventing AM to be implemented], such as complexity of natural systems and uncertainty and paucity of appropriate data about management effectiveness, are the very factors that recommend Adaptive Management and its promise of transparency and defensibility in management."

Most existing STM are said to "fail to meet three key requirements of a working model for Adaptive Management: (1) quantitative predictive capability; (2) representation of uncertainty in states and transitions; and (3) amenability to updating as new knowledge accumulates."

"Quantifying system response allows us to make predictions about the relative efficacy of management options and to identify and explore the 'critical uncertainties' that most impact on our ability to accurately predict responses to management and, therefore, choose the best course of action or the best investment strategy."

Everyone involved in conservation conflicts uses models all the time, but they are verbal (e.g. allowing geese-hunting will increase farmers income, planting these trees here will create habitat for birds and prevent weed development). When it comes to formalise them into something one can use for simulations (in order to predict systems response, identify uncertainties, or help decision-making), confidence in the model drops. Thus, it is believe to be something deeply scientific and invaluable in wildlife management.

The model complexity must be consistent with stakeholders expectations, and conservation goals.

"Transition = A change in state, caused by the crossing of a threshold value for one or more of the state variables". Thresholds, states, variables, and transitions have been determined with several workshop with ecologists and natural resources managers.

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All the states are not linked with transitions. A derived landscape can not shift to a reference state without going through the simple state. How do they justify it?

Differentiate biotic and abiotic factors that can be controlled by management actions (process) and the ones that management can not act on (independent).

They deal with uncertainty proposing to tweak thresholds, transitions, and states to compare results. I am not very satisfied with it.

Bayesian framework: simulate the transition probability given such and such management actions assuming prior knowledge on the likelihood of transitions under these particular management strategies; than monitoring and assessing actual transition probability; finally correct the model with actual prior knowledge on the likelihood. That way could spot which strategy was best and worse estimated. way of **learning** for the Bayes Net.

3.6 Management strategy evaluation: a powerful tool for conservation? (Bunnefeld, 2011)

Key words: MSE framework, management conflicts, multi-model approach, conservation.

"The management of natural resources is a complex process driven by interactions between the dynamics of the natural system, the decision-making and behavior of stakeholders, and uncertainty at various levels of the management process and the natural system. Traditional forms of natural resource management (e.g. fixed harvest quotas) do not respond to system dynamics and uncertainty, and so are prone to failure. Realization of the importance of learning about the dynamics of the system led to adaptive management, in which monitoring of the system allows updating of managers' models of system dynamics, which then produces alterations in the harvest in an iterative process."

"A key feature of the MSE approach is that an optimal strategy or solution is not pursued, but instead policies are sought that are feasible, robust to uncertainty, and which provide adequate management performance with respect to multiple criteria".

"MSEs can evaluate which data and how much of it should be collected and how often monitoring should be carried out to improve management performance."

Uncertainty occurs in each of the sub-models population dynamics, population estimation, institutional inertia and users compliance. Implementing them is also a way to quantify their relative importance.

"Management often works against the short-term economic interests of those who depend upon resources by decreasing the harvest or closing areas to protect its natural resources."

"[...] models on the line fishery of the Great Barrier Reef include how individual fishers [...] communicate information amongst each other." (with references!)

GMSE "has been criticized for: (i) having a longer development time (and thus increased costs) than traditional methods such as reference-based off-take rules; (ii) an upfront MSE can provide an overly rigid framework without room for decision-makers to change management in an adaptive way; and (iii) poor data inputs (e.g., gaps in monitoring or extremely low estimates of uncertainty) affect the performance of MSE, which needs to be recognized and explored within the MSE process." Incapacity to monitor the focal species can also be a highly problematic factor for the implementation of a MSE.

3.7 Conservation in a Wicked Complex World; Challenges and Solutions (Game et al, 2013)

Keywords: complexity, wicked problems, inspirations from external fields, adaptive management critique.

"the characteristics of "complex systems": numerous interacting elements lacking any central control, non-linear interactions between elements,constant change which is seldom reversible, and no clearly defined boundaries to the system (Rosser Jr 2001;Johnson 2007; Mitchell 2009)". In such wicked problem, it is very difficult, not to say impossible to isolate a feature from the other, as all characteristics are densely interconnected.

"There is no "right" solution to wicked problems in complex systems, only trade-offs that appear more or less favourable depending on your perspective. This ambiguity also means that there is rarely any need to declare conservation actions a failure".

Discussion about the relevance of AM in conservation. "Less frequently acknowledged is that AM is, at least in part, appealing because it reduces cognitive effort and resources invested in planning; changing the maxim "Ready, Aim,Fire" to "Ready, Fire, Aim" (Patton 2011) though per-haps "Ready, Fire, Aim, Fire" is more suitable." Change of strategies are rare in AM, because assessing the adequacy of a strategy is still very challenging. Another tricky problem is that implementing any decision will lead to a change in the system, thus learning from it can be misleading because the condition between the situations has already changed. All that could mean that AM is relevant only in simple, small-scale problems.

Authors recommend to use multiple-scenari approach.

"Although conservationists routinely bemoan the lack of funds for their activities (McCarthyet al. 2012), there is little evidence that bigger budgets make conservation easier or more effective."

3.8 Conflicts in conservation: navigating towards solutions. (Redpath et al., 2015)

Key words:

3.8.1 Phylosophy, conflict and conservation (Alan Holand)

Alan Holand emphasize in the second chapter that it is relevant to assess the impact of the policy (deviation from what would have happened if doing nothing).

Being aware of the consequences of a policy, because it can result in undesirable after effects (e.g. conservation of a certain gorilla species led it to be more vulnerable to human vectored diseases).

Questioning the statement that "more [biodiversity] is better", with a parallel with the tragedy of the commons.

About "commitment to nature", "conservation interest": "a highly complex and even puzzling concept". Examples of divergences: focus on individuals or on 'wholes' (populations, species, ecosystems, ...), degree of sentience of non-human living beings (**Sentience is the ability to feel, perceive, or experience subjectively.**(Linguee definition)), the tolerance to the intrusion of 'non-indigenous' species in a ecosystem.

Environmental philosophers: Katz (1987), Elliot (1992), McShane (2007).

The 'conservation interest' should not be related to any individual interest of the conservationist (e.g. I like hiking/climbing/diving like any other researcher, so I want to conserve mountains/seas/oceans to keep on enjoying it in the future) but to a highly intrinsic value of nature regardless of how the conservationist sees it. Plus, human interest and well-being is currently contingent with the welfare of the environment. Conservationists often behave (probably not being aware of it) as the voice of nature, standing for its interests. But 'nature's interests' does not really make sense, [ndlr] because **as far as we can tell, except limiting its increase of entropy, an ecosystem is not a goal-oriented entity, neither has any affection for the individuals that compose it**.

Stoicism critique Mill 1874.

"The 'conservation interest' is just an important aspect of 'human interest' in general" in the sense that our survival depends on the fragile balance of ecosystems.

"[...] ideals and values are precisely the kind of things that do not normally allow negotiations or compromises."

3.9   Goose management in Scotland: An overview (Bainbridge, 2017)

Keywords: adaptive management, conflict, geese conservation, SNH, politics, deterministic population dynamics modelling.

Geese endangered status (recognised during the 1940's) was caused by "a combination of hunting for food and sport, systematic persecution and the disruption of the Second World War".

Protection measures were really efficient as, in the 1980's, all geese species population numbers increased significantly. But this rise in population started a conflicts with farmers, as geese were grazing their crops. Especially for farmers owning culture in Special Protection Areas required by the European Bird Collective. The first arrangements between the state and these farmers concerning geese control were made in the early 1990's, in the form of payments from government for farmers to allow undisturbed grazing on certain areas, and scare them away in others areas.

Yet, some populations are still increasing nowadays, and farmers started to consider the financial compensation too low for the damages caused. Scottish government refused to increase them for financial reasons. Farmers then started to control the population by means unapproved by the government. Time had come to implement adaptive management of this conflict.

"In the absence of detailed population data, simple deterministic models were developed." Sometimes, the shooting target was beyond the capacities of local communities.

"To summarise, the current position of goose management in Scotland is that there are a limited number of winter schemes based on payments to allow feeding of geese on agricultural land. There is a limited shooting associated with these schemes (Islay only), and a general trend to decreasing levels of funding; with a resulting increase in farmer dissatisfaction and political activity."

3.10   Time series analysis reveals synchrony and asynchrony between conflict management effort and increasing large grazing bird populations in northern Europe (Cusack, 2017)

Keywords: time series, management, large grazing birds, synchronicity analysis, users compliance.

Synchronicity analysis on population, scaring counts, killing counts, and monetary compensations time series. Comparing the number of time steps where the time series were changing in the same direction, and compare it to a random distribution of the time steps.

Time series were sometimes synchronous and sometimes not. "inconsistent patterns of synchro- or asynchronicity".

"perceived randomness and inconsistent changes in management effort relative to wildlife impacts in the short and long terms have been shown to influence the level of trust stakeholders place on the decision-making process (Young et al., 2016), as well as their overall responsiveness to policy change (Olson et al., 2015)".

Encouraging managers to wait for proper information to act, so they can be synchroneous with changes in the system.

3.11 Social conflicts increase the risk of natural resource mismanagement (Cusack, in review, 2018)

Key words: management conflicts, lobbying, users compliance, illegal harvesting, GMSE.

"We find that in the absence of disagreement between manager, user and conservation objectives, natural resources are managed effectively regardless of manager impartiality and user compliance levels." Meaning all the stakeholders have the same population target? Budget?

When conservationists agree with the manager target but users want to harvest more than is permitted, management is only effective when user compliance with policy is high, thereby reducing illegal harvesting activities (Fig. 2a). A reduction in user compliance leads to over-exploitation regardless of conservation lobbying power. This finding is notable in highlighting the ineffectiveness of conservation lobbying pressure applied directly to managers of natural resources, and reflects the lack of success global conservation efforts have had in curbing biodiversity loss in the face of over-exploitation[25,29,30]. Similarly, effective management in the presence of conservationist disagreement is only possible at high levels of manager impartiality (Fig. 2b). As the manager becomes more susceptible to conservation demands for a higher harvesting cost, the natural resource population size is more likely to rise above the management target. This trend is enhanced by increases in user compliance, which prevents users from acting on their disagreement.

"[…] when users and conservationists show a symmetrical disagreement with the manager's target, the influence of illegal harvesting on management outcome is much stronger than that of conservation lobbying [because] user actions have a direct effect on the resource, whereas lobbying targets policy-setting by the manager, which does not directly affect the natural resource population. In other words, users have the "final say" on what harvest will be implemented […]". Increasing users compliance has a greater effect on policy's efficiency than any other increase in the stakeholders characteristics.
"the impact of conservation lobbying is constrained by the manager's budget"?
"User compliance reflects how effective the manager is at preventing illegal harvesting by the user. impartiality represents how susceptible the manager is to lobbying by conservationists for a change in policy."
Probability surfaces represent predicted values from a Poisson generalised additive model with a smooth tensor product representing the interaction between manager impartiality and user compliance"??? In this paper, conservation lobbyist are supposed to aim at a the stated conservation population target because they are species-driven only, but managers and users are

likely to aim at a lower target. "Lobbying can be broadly defined as any strategy that seeks to influence policy to benefit a specific interest." Lobbying intensity increases exponentially as the focal population approaches zero, and non-existent when it is above the conservation target. Is that consistent?

On the other hand, illegal harvesting intensity increases exponentially as focal population approaches K, and is non-existent if users target is above manager target. "The second would seek to obtain agreement amongst different parties on the management target prior to actions being carried out." Back to consensus?

GMSE = "stochastic growth of the population"?

"Management effectiveness was assessed as the mean resource population size at time step 10 across iterations."

SI. A major feature of MSE is to take into account uncertainty in all the key parts of conflict management: resource stochasticity, monitoring errors, (ndlr) and unoptimal decision-making. Jeremy tried to fill the gap of disagreement on manager's population target.

J emitted the idea that conservation lobbyists could influence the system by buying and protecting lands.

"management target can be achieved only for a subset of all manager and user budget combinati ons". Cf the 3D plot of J's seminar.

"To counter illegal harvesting, a manager may seek to increase user compliance, either through enforcement or user engagement."

3.12 When is a "wait and see" approach to invasive species justified? (Sims & Finnoff, 2013)

"Can a "wait and see" approach to invasive species be justified and if so under what circumstances? "Using temporal spread data for a number of well-known invasions, we find that most invasions are spreading too fast and unpredictably to do anything other than immediately respond." 'Wait and see' is only possible for the slow spreading invasions, for the management of which an optimal time of action is in question. "The policy maker must evaluate, at each instant in time, whether or not the policy should be implemented (t1) and if so at what stringency (r1) given all future policy cancelation T1, T2, . . . and implementation t2, . . . ; r2, ... decisions are made optimally." Mathematical model (equation resolution for optimal time of implementation and policy stringency). "Using data on eleven different biological invasions we formulate two general types of invasive species: those that spread slowly with little uncertainty and those that spread fast with large amounts of uncertainty. Applying the model to this data reveals that species in the latter category are simply spreading too fast and too unpredictably to do anything other than act immediately. Results indicate that a wait and see approach may be an optimal strategy for species spreading slowly with little uncertainty depending on the irreversibility of the policy decision. However, the optimality of a wait and see approach is fleeting with an immediate response required in all cases when invaded area reaches 1%"

4 Game theory

4.1 Game Theory, Analysis of Conflict (Myerson,1997)

Key words: games, utility, decision-making, cooperation, Nash equilibrium.

   "*Game theory can be defined as the study of mathematical models of conflict and cooperation between intelligent rational decision makers [which choices] affect one another welfare.*"

Origins in WWII, to help understanding the issue of the nuclear cold war.

Games are simplified vision of actual conflicts, the actual complexity being unreachable to us. But such complexity would prevent us from understanding the fundamental issues of conflict and cooperation. As any other scientific work, game models deliberately omit less relevant details of actual situation to allow the study of particular phenomenon in the scope of a particular question.

Players act in order to maximise the expected value of its outcome from the game = *utility*. Utility is not necessarily quantified as monetary pay-off, it can be time, effort saved, well-being, happiness, and even a mix of them.

Players are supposed to follow the expected utility maximising theorem. This theorem is consistent with the innumerable observations of evolutionary selection in biological system, doing whatever they can to survive and/or reproduce. It can go further in terms of entropy/order, all living being tends to consume order to slow the process of entropy increasing on their body (order being the expected utility to maximise).

The author refers to *intelligent* as players that has knowledge of the game theory framework, and is able to reach the same inferences as a game theorist. It is a questionable assumption but consistent with the fact that humans are able to learn from mistakes. (?)

Bayesian decision theory. Two models for utility function: probability model (objectives unknown) and state-variable model (subjective unknowns). Objective unknowns = you know the outcome possibilities and their probabilities (e.g. lotteries). Subjective unknowns = you do not know the probabilities (e.g. horse races). A decision making model can be descriptive (show why a decision was the best for a player), or prescriptive (this is what you should do in this situation according to the model).

Several cases in which expected utility maximising is usually not respected.

4.1.1 Models

A model of too simple structure may miss key aspects of understanding, but a too complicated one can obscure fundamental issues.

4.2 The conservation game (Colyvan et al., 2011)

Key words: game theory, conservation conflicts, cooperation, top-down regulation, adaptive management.

Management strategy usually focuses on a single outcome, assuming a consensus on its utility among the stakeholders. In the context of conflict, such an approach is unproductive. It can be symptomatic of a certain partiality in conservation. Sustainable solution need to take all stakeholders interests into account (nature itself being also eligible as a stakeholder). Game theory framework is a better approach as it is designed to find each stakeholders actions that can lead to the best outcome for everyone.

Plus "game-theoretic perspective provides insights about: the strategies different stakeholders will likely adopt given their objectives when consensus, compromise, or cooperation are feasible; what types of cooperation best reflect stakeholder interests and achieve their objectives; which stakeholders are likely to form coalitions; the range of possible outcomes under non-cooperative and cooperative decision-making dynamics; and, whether an optimal or satisfactory solution for all stakeholders can be reached simultaneously".

Four main game theory examples (numbers represent gains) :

Tendency to defect can be discouraged by applying political penalties. WE WANT TO CHANGE THE UTILITIES SO THAT COOPERATION IS A PARETO OPTIMAL NASH

P1

	C	D
C	**2,2**	1,1
D	1,1	0,0

P2

Table 1: *Simple* game = No costs for actions. E.g : two bordering countries cooperate for the management of a species at no cost. Both countries choosing to conserve is the highest personal gain both players can get. If one of the countries chose not to participate, personal gain is lower for both, which makes [C,C] Pareto optimal. There is no way that a player can be better off than the other by moving from [C,C], for any of the opponent strategies, the best option is always cooperation; making it also a **Nash equilibrium**.

P1

	C	D
C	1,1	**1,2**
D	**2,1**	0,0

P2

Table 2: *Chicken* game = action have a cost. E.g : two bordering countries face the problem of the management of a shared species implying costs (-1 in gain). Hence, if a party conserves and the other defects, the later enjoys some of the benefits from conservation without paying its cost, but the management is **as** efficient. Here, the system can always find a situation to move in so at least one party is better off, meaning there is no Pareto optimal situation. Knowing the other party strategy, the best outcome for a country would be [D,C], and if the situation stayed the same this country would have no reason to move away from its position. Since each party would have the same thinking, the system has two **uncorrelated Nash equilibria**.

EQUILIBRIUM.

Game theory can help foreseeing the impacts of a given policy, as long as "agents [can] be explicit about goals, strategies about the best ways to achieve those goals, monitor strategy success, and modify strategies given the impact of other agents on those goals." "Being "self-interested" in game theory only requires that all such considerations are fully reflected in the agent's preference ordering."

The challenging part in game theory applied to conservation is to determine which type of game is being played. The various games we are uncertain about can be represented as states of the world in a decision problem. "Probabilities should be assessed for each game (i.e. the probability that a particular game is being played) and expected utilities of actions are calculated by weighing outcome utilities with their respective probabilities. If there is no chance the conservation goal can be achieved without cooperation, three policy regime options are available: transform chicken to a simple cooperative game, transform stag hunt to a simple cooperative game, or do nothing. The payoffs for each regime are the summed payoffs of the relevant games less the costs associated with the regime transformations". It takes advantages of both game and decision making theory.

Tragedy of the commons : each individual of a commons aims at maximizing its gain of the pool-resources. In this case, an individual associate a positive utility at resources assimilated, while the negative utility associated with the consummation of the pool-resources is shared upon all the commons. That way, the utility of assimilating resources is almost always greater than the negative utility of resources consummation. Therefore, if each individual acts that way, the outcome is the pool-resources depletion. Solution : third party imposes limits to individuals, implementing sanctions with negative utility compensating the utility of individual pool-resources over-consumption (**top down regulation**).

$$
\begin{array}{c}
\text{P1}\\
\begin{array}{cc|c}
 & \text{C} & \text{D}\\
\end{array}
\end{array}
$$

		P1	
		C	D
P2	C	**2,2**	0,1
	D	1,0	**1,1**

Table 3: *Stag* game. E.g : bordering countries face the problem of the management of a shared species implying costs. The management is efficient only if all countries apply it, but countries can chose cheaper and less efficient unilateral policies. The best outcome is cooperation, which is a situation from which moving would be disadvantageous for at least one party (Pareto optimal situation). If one party cooperate, the other's best option is to cooperate as well, so (C,C) is also a Nash equilibrium. If one party defects, other's best option is to defect as well, so (D,D) is also a Nash equilibrium. Note that if countries have no information on the neighbours' policy, the best option is to defect. Also, "whether the game is chicken or a stag hunt depends on how many countries must cooperate to achieve the conservation goal. All countries having to cooperate (i.e. stag hunt) or only some countries must cooperate (i.e. chicken)"

		P1	
		C	D
P2	C	3,3	0,5
	D	5,0	**1,1**

Table 4: *Prisoner* game. E.g : two bordering countries share the costs of management of a species. If one country defects, its gains increase because the species is conserved at no cost while the other pays more for the same conservation outcome. If they both defect, no money for the management and it fails, but at least no one is paying for the other's gains. Again, there is no situation from which moving would not imply one of the parties to be better off, so no Pareto optimal situation. But defecting is the best choice for any of the other country strategy, so [D,D] is a Nash equilibrium.

"Empirical studies show that in many conservation contexts cooperation is more likely to emerge from bottom-up community-based programs than top-down enforced regulation".

"The extant incentive structure only targets individual hunters through punishment rather than benefits, while non-hunters reap tangible rewards from a successful wildlife management program—the consequence is that hunters reject the management regime."

"no self-monitoring agreement can be sustainable without a payment to each individual that exceeds the opportunity cost of monitoring — even if no one is poaching" (Mesterton-Gibbons and Milner-Gulland, 1998).

"i) fines proportional to the number of trophies in a poacher's possession are more effective than fixed fines, (ii) increasing the effort devoted to detecting and prosecuting poachers is more effective than increasing the severity of punishment to poachers" and (iii) the success of bans on international ivory trade is ambiguous, depending on the assumptions in the model. The fact that banning ivory could increase elephant poaching is particularly interesting. It could be caused, at least in part, by an expected rise in ivory prices that would enhance incentives to poach elephants (from review by Keane et al., 2008). Also, trade bans can accelerate species toward extinction if speculators bet on future price increases by **stockpiling**, with the intention of cashing in on their stock once the species becomes extinct.

"oversimplification is assuming that nature's response is straightforward and easily predictable following conservation actions such as monitoring or managing species." (marking bias as an example). Indeed, how to justify the strength of the causality link between management actions and resource's response. "representing nature as part of the fixed background structure of the conservation problem is inaccurate. Rather, it should be treated as another player in the

game."
Other assumptions in games : "they are perfectly rational expected utility maximisers (ndlr. - is it the case for nature as a player ?) [...] [which] require players be expert game theorists: they must know not only what their strategy should be, but also what other players' strategies should be." It is already a questionable assumption for human, but for "nature", which is not supposed to be conscious nor rational -**IS IT ?**-, it is even more "implausible".
But you could model "nature" as a player like : "In hydrology, for example, nature can be represented as an agent that prefers liquids to attain their lowest level of energy and it schemes to make this happen. Humans attempting to increase water tables or construct artificial lakes are players with different intentions and they must play against nature."
"It is useful to distinguish between nature as a player in a game and nature as a rule maker. There will be structural features of the game — such as, which moves are available to a player — that are immutable and non-negotiable." It can also play both roles, just as a government that sets costs (rule-maker, manager), but is open to negotiations (player).
"a core conservation concern: ensuring species (and environmental resources more generally) never reach irreversible thresholds below which population decline and ultimate extinction are inevitable." Such a concept was argued for a lack of empirical validation, and uncertainty in prediction. But it also does not include insights of the economical value a resource can have to humans.

"How the game is represented significantly affects what conservation actions are defensible and/or whether a compelling rationale for conservation exists."
"Herein lies the real value of game theory: it provides a general and powerful framework for analysing environmental decisions, one that adopts a dynamical approach to decisions and naturally lends itself to an appreciation of the ongoing and far-reaching consequences of major environmental decisions."

4.3   Evolutionary games and population dynamics: maintenance of cooperation in public goods games (Hauert et al., 2013)

Keywords: mathematical model, common pool game, dynpop, cooperators defectors coexistence, stability analysis, group size effect

"In order to combine game dynamics and population dynamics in a replicator equation, we assume that x denotes the fraction of cooperators, y the fraction of defectors and $z = 1 - x - y$ the fraction of empty space. Thus, $x + y$ denotes a normalized population density, such that 0 corresponds to extinction and 1 is the maximal population density. The fractions x and y determine the average payoffs of cooperators, fC, and of defectors, fD, at any given point in time, as detailed below. To determine the dynamics of x, y and z, we assume that cooperators and defectors die at a constant rate d and give birth at a rate proportional to their average payoffs. We also assume that reproduction can only occur into empty space, so that birth rates are proportional to z." Population is randomly scattered in different subgroups of interacting individuals of size S. "Interestingly, population dynamics enables cooperators to survive even when facing exploitation by defectors. In order to analyse this scenario, we introduce the new variable $f = x/(x + y)$, i.e. the relative proportion of cooperators". Cooperators are outsmarted when the multiplying factor is lesser than the population size ($r < N$), because defectors receive a higher pay off (cooperators receive the same pay off minus the cost they invested first). But, on the other hand a population of defectors only results in a decrease of the population, leading inevitably towards extinction. "Cooperation can be maintained because decreasing population densities can reduce the effective interaction group size S to a point where $r > S$. In these groups, the social dilemma is relaxed and cooperation is favoured.

Conversely, high population densities generate large effective interaction group sizes S, in which $r < N$, so that defection is favoured. Thus, if populations are large and defection is favoured, average fitness is low and populations decrease, while if populations are small a high frequency of cooperation leads to high average fitness and triggers an increase in population density."
"The main result of this paper is that this eco-evolutionary feedback can stabilize cooperation at intermediate frequencies. At equilibrium, the population density is such that the expected size of the interaction groups is exactly equal to the multiplication factor r, so that cooperators and defectors have equal payoffs."

4.4 Evolution of cooperation in stochastic games (Hilbe2018cooperation)

Keywords:

"The tragedy of the commons leads to the question of how to manage and conserve public resources. Any solution to this problem requires an understanding of which processes drive human cooperation and how institutions, norms and other feedback mechanisms can be used to reinforce positive behaviours."
in previous cooperative games studies, the resources player were 'competing' for was fiwed. When resources vary according to the players strategies, cooperation between them is much more likely.
"One-shot models assume that players consider only their present pay-off when making strategic choices. In stochastic games, players take a long-term perspective instead. To find optimal strategies, they need to consider how their actions affect the response of their opponents and the future state of the environment. As we show, this interplay between reciprocity and pay-off feedback can be crucial for cooperation. [. . .] We introduce an evolutionary perspective to stochastic games. Players do not need to act rationally, but instead they experiment with available strategies and imitate others depending on success" "In the n-player public goods game, aggregated costs are multiplied by a factor ri (with $1 < ri < n$ depending on state i), and redistributed among all players."
"The condition in equation (1) (condition on the benefit value of cooperation in each game to the cost of cooperation) highlights the fact the that the stability of cooperation depends on how the states change given the players' decisions." "We explore cases in which cooperation leads to a more valuable game next round and defection to a less valuable one. Surprisingly, we find that this setting boosts cooperation markedly. In the resulting stochastic game, cooperation can prevail even if it is unsuccessful in all individual repeated games. Our observations suggest how naturally occurring or designed feedback can promote cooperation. A tragedy of the commons can be avoided if the environment deteriorates (rapidly) as a consequence of defection. Likewise, cooperation is boosted if there is the prospect of playing for higher gains should the current cooperation succeed. The evolutionary analysis of stochastic games represents a new tool for understanding and influencing human decision-making in social dilemmas."
CHECK SUPPLEMENTARY INFORMATION FOR FORMULATION, IT'S BRILLIANT!

4.5 Maintaining cooperation in social-ecological systems:Effective bottom-up management often requires sub-optimal resource use (Tilman, 2016)

How self-setted norms and social ostracism can maintain cooperation in bottom-up regulation of fisheries when political enforcement is not accessible.
"we consider an evolutionary game-theoretic approach, where resource users — fishers — shift toward strategies that give higher individual utility, taking into account economic pay-offs as well as the social and economic costs of both norm violation and enforcement. [. . .] incorpo-

rating a cost to punishment and by assessing how a cooperative can best choose a harvesting norm, achieving a balance between optimal harvesting and robustness to invasion by selfish, independent fishers."

5 Artificial intelligence

5.1 Decision-making

5.1.1 Waiting can be an optimal conservation strategy, even in a crisis discipline (Iacona, 2017)

Key words: investment choices, optimal delay, forest conservation, restoration, deterministic ODE modelling, numerical optimisation process.

Optimal growth in finances, or plant, sometimes include doing nothing, more precisely to invest less resources than usual in buying (balance between consumption and capital investment) or reproduction (less investment in seeds or flowers and more in root stock or growth, waiting for a less unsuitable or competitive time) for a certain amount of time.

Since the problems conservation is dealing with are often irreversible, managers are used to invest resources in acting as soon as they get them. Optimal growth concept applied to management strategy shows that 'doing nothing' is sometimes more profitable for conservation goals. By doing nothing, authors mean invest in other domains than policy application, such as research, monitoring, or even other lucrative placements. But only if the possible outcome outweigh the increase in threat in the meantime.

The complexity of conservation problems (involve many different dynamics) results in temporal heterogeneity. Therefore, acting can be more efficient at certain moments than others. Just as conservation outcomes can be improved by "identifying the most efficient locations to act in space", finding the best time to act could lead to more efficient management strategies.

"[...] model the general trade-off between the benefit of waiting and the cost of delay" with a system of differential equations linking conservation actions with a biodiversity conservation goal (through habitat restoration). They chose not to consider any stochasticity nor uncontrollable factors, to ensure a focus on this trade-off.

An extinction debt appears after the destruction of a habitat, but the extinction goes effective gradually, at a (non-linear) rate. Extinction debt is modelled as the difference between the number of occuring species and the number of species the landscape could contain (considered as species richness when all habitat is intact).
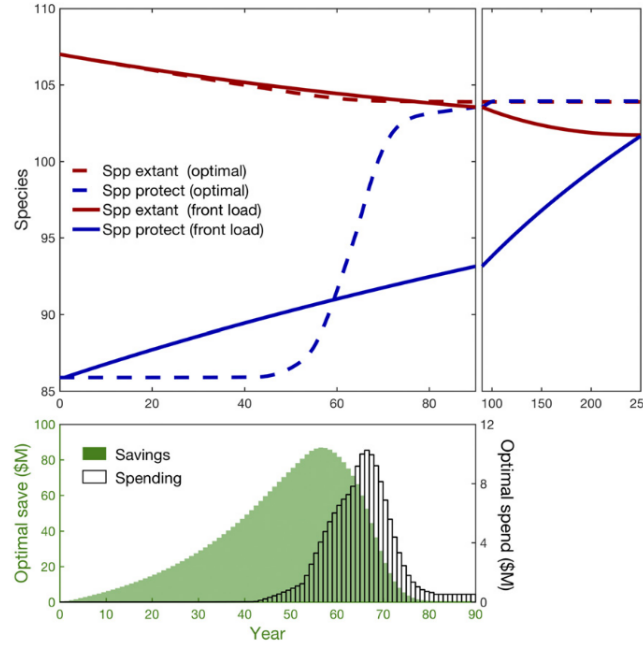
Fig. S4. Mount Lofty Ranges—Treasury bond interest rates. This figure shows the optimal schedule for the Mount Lofty Ranges, Australia, case study when the interest rate is set to 4% to represent the more conservative returns available from 25-y average Australian Treasury bond rates. Top panels show extant (red lines) and protected (blue lines) species under the optimal (dashed lines) and front-loading strategy (solid lines). The distance between the blue and red lines reflects the size of the extinction debt. Note the different timescales of the plots. *Bottom* shows the amount of funding available to the manager over time (green), and the amount spent (bars) in yearly increments under the optimal strategy.

Numerical Optimization Process. Operationally, we calculated the optimal disbursement solution using FMINCON, a constrained numerical optimization routine in Matlab. We discretize the control function $u(t)$ into a vector of 51 different control variables $0 \leq u_i \leq 1$, which we distribute evenly across the project of total duration T. Thus, u_1 is the proportion of the funds spend on direct conservation actions between $0 \leq t < T/50$, u_2 is the proportion of the funds spent between $T/50 \leq t < 2T/50$, and so on. We choose a value of T with increasing length, until the all funds have been expended well before the end of the simulation. We then allow the numerical optimization routine to choose values for u_i that maximize the number of extant species at T. We initialize each u_i at a random value between 0 and 1. To increase the probability that the algorithm is finding the global optimum, we repeatedly ran the algorithm from multiple initial conditions. For both case studies, the algorithm found the same optimal

5.1.2 Antagonistic Crowd Simulation model with Emotional contagion and Evolutionary game

Keywords: antagonistic crowd mouvement IBM, game theory, deterrent force- driven, weird vocabulary, questionable assumptions, emotional transmission, user perception study.

Crowd motion model involving different types of protagonists, and different emotions. They stress that the emotional state you are in can influence the way you choose strategies in games. Model tested against videos of actual cases of antagonistic crowd behaviour. Involves a user perception study. SIR: Susceptible, Infected, Recovered disease dynamics model. External (perceived from the surroundings) VS mental (subjective) emotions.

5.1.3 Emotions, Implicit Information that allows the Conscious Phenomenon (laureano-Cruces et al., 2018)

Keywords:

Emotions in reaction to events in the environment rearrange the order of priority of the possible actions. Based on chimps behaviour, quite rigid map of possible reactions to an external event, according to the desirability of the outcome, or the proximity of the event. 2 finalities of this map are 'wellfare' and 'death'. Spatially explicit hierarchical and gregarious IBM of an chimp-inspired 'animats' population, with interaction between them, and with predators. Intrinsic characteristics: strength, speed, personality. Variable characteristics: hunger, energy level, social rank, age, belonging to a group. *Unity 5*: a customised game engine (most likely impose a certain data or modelling structure!).

Critique: Interesting methodology but rigid schema, don't understand how emotions affected the priority order, conclusions are a bit rough, don't really understand how they tested their hypothesis, what was their prediction, and how they drew conclusions on 'emergent' behaviours.

5.1.4 Policy Learning for Continuous Space Security Games using Neural Networks

keywords:

Continuous strategies games, where strategies are defined by values on different continuous action scales (e.g. here the position and angle of a agent on a map). As opposed to traditional games (e.g. here like rock paper scissors), where the possible actions are discrete objects in a defined ensemble. Forest Security Game: a circular map of a forest with randomly distributed trees from a forest center. Starring forest defenders, protecting a forest from opponents wanting to log it. Defenders policy is a set of radius and angle couples for forest guardians with a fixed visual range. Opponents policy is a set of distances and angles, determining where the lumberjack will stop (along a line going from the boundary position they appeared at, towards the forest center) and log. If the lumberjack trajectory crossed the visual range of a guardian, they will loose their wood and be fined. Reward for the opponent is the number of logged trees minus the fines. The reward for the defender is minus the opponent's reward. Each player updates its strategy according to an estimation of the other's. Defender deploys the policy first, guessing the opponent's. The opponent deploys a policy after observing the defender's.
Strategy:"Conventionally, a player's mixed strategy is a probability distribution over the player's actions given the game state (s)." Meaning the probabilities of each ACTION to be undertaken by the player change according to the game state s. A player's strategy is the set of probability functions (here weight parameters?) associated with each action, given a game state. **Action**: something that can be undertaken by players. Here, a SET of angles and a distances to place the agents. **Policy**: "A player's policy is a mapping from game states to mixed strategies". It is the fact of choosing a strategy given a state s. "Since this is a stateless game [continuous actions], there is no distinction between policy and mixed strategy."
Purpose: given a state s, find the weight parameters that maximizes a player's reward, and minimizes the opponent's = Best Response policy. Two methods proposed. **Gradient optimization:** each episode, a replay-memory of previous actions is created and available for both players. (Weight parameters are initialized randomly. Actions are drawn from each player's strategies at the state s, and for these weight parameters. What is available are combinations of state s and both players actions.) A player samples state-actions combinations from the replay memory, fixes its action and compute the rewards for each of the opponent's other actions. What we obtain is some kind of 3D space of x a player's actions, y the opponent's action, and z the player's reward. Gradient optimization then compute how to modify the weights param-

eters to reach the optimal reward. **Convolutional Neural Network:** model reads in the forest map, identify it as a state and outputs the parameters of the logit-normal distribution of the actions for defender and opponent.

5.2 Genetic algorithms

5.2.1 On the practical usage of genetic algorithms in ecology and evolution (Hamblin, 2012)

"Genetic algorithms are a heuristic global optimisation technique mimicking the action of natural selection to solve hard optimisation problems."

"particularly troublesome when solving problems in evolutionary game theory, when the optimal strategy is a function of not only an individual's choice but also the choices of the other players in the game."

Initialization. Generates a population of individuals having different "representations", a group of values associated to different characteristics that describe it. It is referred to, in genomic terms, to a 'population' of 'individuals' characterized by a 'chromosome', or 'genotype', containing different 'loci', at which one can find different 'alleles' depending on the individuals. **Fitness assignation.** Each individual is assigned a relevant 'fitness' value depending on how well it solves the problem considered. In GMSE, the fitness for managers depends on the expected outcome from the implementation of the strategy, *i.e.* the distance of the expected population count to the conservation target, the smallest the fittest. For users, fitness is the sum of utility from the resource variation and from the land productivity variation. the highest the fittest. **Selection.** The individuals reproduce according to different possible rules. In GMSE, the non-parametric 'tournament' method has been chosen: some individuals are randomly sampled with replacement from the population and the fittest is chosen for staying at the next time step. The process ends when the number of selected individuals reach the chosen population size. **Crossing-over.** An individual's alleles are swapped with another reproductive individual with certain probability. **Mutation.** Some allele is modified with a certain probability. **Replacement.** Reorganisation of the population according to the reproductive individuals. Different scenarios can be considered. In GMSE, the whole population is replaced by the winners of the tournament.

"Exploration refers to (often random) movement around the search space, while exploitation refers to movement along a fitness gradient. Genetic algorithms combine exploration (mutation and crossover) with exploitation (selection/replacement) to test new solutions while increasing the representation of good solutions within the population." The user must find the good trade-off between these two features by tweaking the stochasticity-inducing parameters.

"Luke (2009 p.7) neatly summarises the best problems for genetic algorithms and othermetaheuristics: Metaheuristics are applied to I know it when I see it problems. They're algorithms used to find answers to problems when you have very little to help you: you don't know what the optimal solution looks like, you don't know how to go about finding it in a principled way, you have very little heuristic information to go on, and brute-force search is out of the question because the space is too large. But if you're given a candidate solution to your problem, you can test it and assess how good it is. That is, you know a good one when you see it."

Interesting use of GAs in co-evolution models, with two GA running in parallel, or allowing interaction parameters in foraging ants to evolve through a GA. Also important in approching EES in game theory problems.

Careful, genetic algorithms can not find EES because by definition, an ESS is a population fixated on the proposed ESS solution that has been exposed to every other potential strategy (chromosome) by mutation and/or crossover (this follows directly from the definition of an ESS in Maynard Smith (1982), which makes stability contingent on comparison to 'all possible

mutants')" and did not changed. Plus, it's very likely that the GA did not explored all the possible stable states, or identified mixed stable states.

6 Why do we want to conserve? (From an evolutionary point of view?)

Caution! Use more conditional mode.
Does conservation make sense? Why do we want it?
The scientific/ecological reasons:

- Biodiversity is necessary for the maintain of the ecological balance (we depend on).

- It fuels evolution.

- We strongly depend on environmental services (pollination, CO_2 absorption, maintain of soil, bio-degradation, soil maintenance, and many more), that might be affected by losses of biodiversity.

- Biodiversity insure a quick and adapted response to change. Some of which are useful to us (lots of cure molecules were discovered thank to species that already used it).

- Source of inspiration through biomimetism.

- . . .

The ("non-scientific") non-ecology-related reasons:

- We like the way nature looks, **we do not want it to change**, we want it to stay the way we used to know it. Or we know it works kind of fine this way, and letting it change uncontrollably could lead to a less suitable habitat for us.

- We want to leave a beautiful world to our offspring, at least as beautiful as ours. **Beautiful or just suitable?.** Interestingly, this could be interpreted as an evolutionary-driven behaviour; we were successful in that environment, we assume that our descendants are more likely to be as successful in the same environment. The chances are lower if the environment changes too much, or faster than they can adapt to.

- It might be a simple intent to indirectly conserve our species, because we rely on a healthy environment.

- We like having some species around, because they are cute or directly useful to us.

- It gives us an ethical purpose. We feel better trying to act on it, a sort of compensation for us being at the origin of the problem. Would any other species do that?

- Could also be a simple scientific curiosity for the topic. Which would be more understandable than any other reason to me.

- Being in control of one's environment seems satisfying to us, it is a feel of power.

- Having a socially accepted/recognized life goal, because in our society we are mostly defined by our occupation.

- Researcher are often further needed to justify their intellectual work, putting "conservation" on it makes consensus on its social "utility".

Luc after someone's response at the lab drink: "Is that a satisfactory answer to your question? We conserve because we want to." From the game-theoretic point of view, most people value (associate a positive utility to) the fact of having access to nature. They also value certain "sexy species". But most of them also despise some aspects of the biodiversity that goes with it (insects, weed plants), and would rather not have them around (negative utility).

We might also be preventing species from evolving by maintaining their environment in a relatively steady state, thus slowing the adaptation process, getting on "its" way.

Being a pro-conservation has became the norm in "developed" countries, and anyone that would think otherwise might be ostracised. (Same with feminism, I believe going against it, or not being aware of the problem, will significantly reduce chances to seduce a girl.) It became a must-have to be part of a "northern modern society". Being aware of it, seeing it as a concern, is seen as a positive signal by the community.

If it was actually/strictly environmentally-driven, it would be quite paradoxical because we are, very likely, the source of unprecedented perturbations in the ecosystem(s). Through conservation, we extend our time spent on Earth, and delay our population drop/the natural control of our population. (Are we living above our carrying capacity? Probably, because it's a known fact that one planet is not enough to sustain 7 billions people living the northern way of life.) But does it makes sense for species to embrace its own population control? We could avoid extinction, just by conserving ourselves the way we do with other species. It is controversial, we don't mind letting farmers shoot geese when managers judge it necessary, but would we let that happen on our own species? **Are we legitimate to act on the conservation of any species, knowing that we are not willing to deal with the initial issue which is our life style?**

A typical answer would be "it would be worse if we do nothing", but is that a correct thinking? The dynamic and complexity of ecosystems are unreachable for our minds, or machines, who knows what could be the actual outcome of such species going extinct. Extinctions and emergence of new species is a well established cycle, it would be interesting to see at which rate species are disappearing and emerging, and to investigate the link with human activity. It would also be interesting to see in which group has which rate and if it changed since our "development". Seems very tough, given that our methods have and are evolving. Would it make sense in the way that general, overall biodiversity is not the goal of conservation, but biodiversity inside all the different "functional" groups.

Biodiversity, as the net between ecosystems, species and genetic diversities, is the key for environment to respond to change, and subsist. Losses in any kind of theses bio-diversities, or the links between them, will result in a environment much more sensible/weaker to changes. WHY IS THAT SO CONCERNING? It is for us, because it makes our survival less likely in the future! As species that spawn and fray at the same exact location, we assume, in a evolutionary way that the place we are successful in is the best bet we have. Same when it fells weird to leave your home-town to settle elsewhere. We are afraid of change, of uncertainty, because we want to persist in the environment we are successful in? **Which might cause divergences when someone involved in a conservation process is less successful in his environment, maybe he wants it to change!**

7/11/18 Challenge Debate: Do we have a moral responsibility to save the planet? Tom said that we have limited empathy for what goes beyond our close circle of relationships, which can explain why we care so few about others, or our environment. **Do conservationists have a higher empathy ability?** Holland, in Redpath et al. (2015) second chapter emphasise on the distinction we make between our relatives and our environment.
Sam said that there are other problems more important to resolve, like hunger, homelessness, war, ... Alistair answered that most of these problems rise from a unequal repartition, and

misuse of resources. He believe that these problems are highly interconnected, and that a better management of the environment would participate to the attenuation of these. I think that as he chose a scientific career, it is probably a good thing he can do to involve in the resolution of these problems.

Post on Sti-CS website: What kind of conservationist are you? Cf futureconservation.org. A questionnaire supposed to identify which kind between New Conservationist (conservation is about human well-being rather than nature's sake. Emphasise on the role of biodiversity in economic growth. More generally, including nature in the economic system so people care more.), Market Biocentrist (promote free market to let more sustainable markets to develop thus reducing our resources consumption), Critical Social Scientist (see below - Growth and market sceptic, understanding that conservation has to include people's life and well-being), Traditional Conservationist (Mainly nature-driven, with human well-being in mind but not a actual goal, promote protected areas, mainly in yet untransformed landscaped as preventive measures). Some trouble hesitating to answer "aspirationally (this is how it should be) or more realistically (this is how it should be, given the circumstances)".

My answers to the questions:

Advancing the well-being of all people should be a goal of conservation. Disagree - The goal of conservation is to manage our impact on wildlife, by being aware of the consequences of our actions so we can choose them wisely. If it result in better well-being it's great but it is not a goal *per se* to me.

Non-native species offer little conservation value. Disagree - The value we attribute species should be adaptive, they now belong to the "previous" ecosystem and are thus part of its balance. They should enter in the scope of conservation as well.

Conservation goals should be based on science. Slightly disagree - Conservation should be based on both sciences and empirical knowledge on inhabitants expectations. Sustainable management strategy can only emerge when every party is happy with it.

Human affection for nature grows in line with income. Disagree - Sometimes the poorest people rely a lot on what we call "ecological services" for "survival" so they might care a lot for nature. But very rich people tend to not care that much in comparison to fortune. But as soon as something "natural" is an income resource, they might be very focused on it and forget about nature in a broader sense. There might be a difference to make between people using ecological services as source of monetary income and those needing them to survive. Among the first kind, it might be a sort of Gaussian relationship, *might be interesting to check*.

Protecting nature for its own sake does not work. Strongly agree - It has to include human interests so it can be efficient and sustainable.

There is a risk that economic rationales for conservation will displace other motivations for conservation. Agree - And it could lead to species interesting to humans to get more attention and feed what I would call the "monoculture" effect.

Conservation messages that emphasise the value of nature for nature's own sake are more effective than those that promote the benefits of nature to humans. Agree - the masses seem more sensible to the extinction of species than the loss of income of farmers.

Conservation should work with, not against, capitalism. Disagree - Capitalism is kind of antinomian to conservation to me, but it can use its semantic/logos to make stakeholders agree on the fact that unlimited exploitation is not a sustainable solution.

Conserving nature for nature's sake should be a goal of conservation. Slightly disagree - I like the way nature is right now, would be glad to continue seeing it that way, but it should not be a goal of conservation. It should focus on reducing and avoiding conflict with humans.

To achieve conservation goals, human population growth must be reduced. Slightly disagree - It would be a very efficient solution but not doable, what is more feasible is changing

northern consumerism.

Conservation goals should be based on ethical values. Disagree - Ethics are rooted in culture too much, and differs greatly to one another.

Strict protected areas are required to achieve most conservation goals. Neutral - If the area has been specifically dedicated to it, yes. But one could also think of these places as a haven of human non-interference.

Giving a voice to those affected by conservation actions improves conservation outcomes. Strongly agree - Involvement is more efficient than enforcement.

To achieve its goals, conservation should seek to reform global trade. Disagree - If the exploitation were meant to provide for local populations only, I suspect they would be smaller, and would be less likely to enter in complex conflict with wildlife.

Economic arguments for conservation are risky because they can lead to unintended negative conservation outcomes. Slightly agree - Could lead to more "monoculture".

The best way for conservation to contribute to human well-being is by promoting economic growth. Strongly disagree - Economic growth is a irrational concept that is absolutely not sustainable, and should not be promoted by anything.

Conservation must benefit poor people because to do so is an ethical imperative. Disagree - It does not have to benefit anyone, it has to trade-off.

Pristine nature, untouched by human influences, does not exist. Slightly disagree - Even thought you can find plastic shreds pretty much everywhere, I believe there are still places where human influence is anecdotic. **Maintaining biological diversity should be a goal of conservation.** Agree - It is a necessary condition for the well-being of an ecosystem.

There is no significant conservation value in highly modified landscapes. - Slightly disagree - Even if there is not much left to conserve, highly modified landscapes can still use ecological services, and they can help reducing energy consumption.

Nature often recovers from even severe perturbations. Strongly agree - Yet it might be in a very unpredictable way and might never resemble what we knew before, nor being suitable for humans or many other contemporary species.

Having multiple rationales for conservation weakens the conservation movement. Disagree - Even if it makes it more complex, it makes it more adapted, adaptive and sustainable.

Conservation actions should primarily be informed by evidence from biological science. Agree - But also by any kind of other tangible evidence.

To achieve conservation goals, the environmental impact of the world's rich must be reduced. Agree - Them first, but much better if every one could do the same. **Working with corporations is not just pragmatic; they can be a positive force for conservation.** Slightly agree - It can be a marketing force, but I would be surprised if it was not productivity driven.

Humans are separate from nature, not part of it. Slightly agree - They have means of resources assimilation that put them aside from the rest of the species, but they interact with nature just as much as every other and impact them in a much greater way, so they are still part of it. They just suffer less natural selection *(is there a way to assess the intensity of selection in population genetics?)*.

Conservation communications are more effective when they use negative 'doom and gloom' messages rather than positive messages. Slightly agree - people are more sensible to their own threat, or to the suffering of charismatic animals.

When communities manage their own resources, their efforts are more effective than top-down approaches. Agree - Involvement is stronger than enforcement.

Conservation should seek to reduce the emotional separation of people from nature. Slightly agree - It goes with being conscious of the consequences of its loss, but not

necessary. People just has to understand the consequences and agree with the solution.

Conservation will only be a durable success if it has the support of corporations. Disagree - No one needs their support, conservation is also about gaining confidence on our individual value and consequences of our actions. *Corporations are deflective shield, we go through them so we don't face the consequences of our consumerism.* Yet, they can help spreading a way of thinking.

Giving a voice to those affected by conservation action is an ethical imperative. Slightly disagree - It is just the most efficient way.
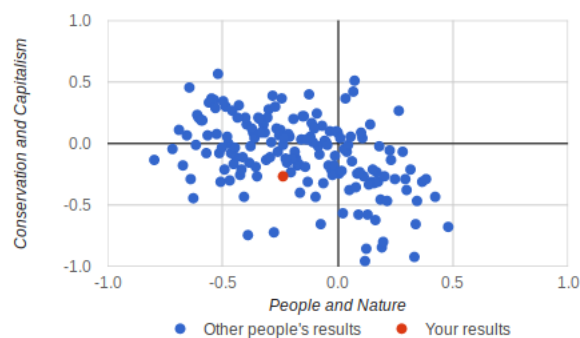
Maintaining ecosystem processes should be a goal of conservation. Agree - They are the key of balance.

How to interpret your results

Your position is weakly negative along the people & nature axis and weakly negative along the conservation & capitalism axis.

Your position on the two axes above reflects your survey answers. A move from left to right along the horizontal axis (people/nature) implies a shift from seeing conservation as a means of improving human welfare to conservation for nature's own sake.

The vertical axis (capitalism & conservation) indicates a spectrum of willingness to embrace markets and capitalism as conservation tools: the higher up the graph your score is, the more pro-markets it is. This places you in the bottom left quadrant of the graph – a position suggesting your views on these particular dimensions of the debate are most closely related to those of what we call 'critical social science'.

## Your thinking most closely aligns with: Critical Social Science

According to critical social scientists, the impacts of conservation on human wellbeing should be at the forefront of the conservation debate. This entails both being critical of negative side-effects that conservation activities might have on people who are economically poor and/or politically marginalised, and also employing conservation initiatives as a means of improving human welfare.

However, critical social scientists tend to be sceptical of the ability of markets and capitalism to deliver benefits for both nature and people. For example, the economic valuation of nature might be perceived as a corporate strategy to open up avenues for its exploitation, whilst concealing the negative impacts of such activities by manipulating the way in which these activities are presented to the public.

This position is sometimes critiqued by others for offering a strong diagnosis of what is wrong with conservation practice, whilst failing to offer practical alternatives.

All four positions represented by these particular dimensions of the debate are shown in the figure below.

Find out more about your position and the others.
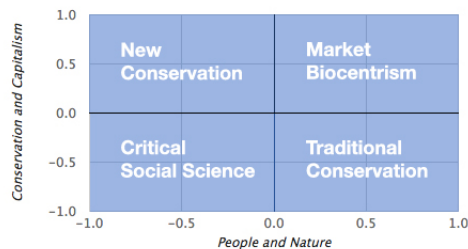
7   AI ethics

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