Using artificial intelligence to improve decision-making in conservation conflicts

Ten-week report

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1 Conservation conflicts

At the beginning of what could be a new mass extinction episode (LACKS REF), preserving the remaining Nature is a central concern for humanity. Many convictions can justify this statement, but the fact is we undeniably depend on the services ecosystems provide us. (no need for references, right?) Pollination, soil enrichment, water treatment, among many more, are essential for food production for example. However, the key for the permanence of ecosystems is diversity, as it assures a quick and dynamic response to change. Note that this variety is often an inspiration for innovation in any kind of technology. Thus, conservation of biodiversity have become a leading field of research and application.

1.1 Conservation

Definition of conservation. Conservation can be applied in many different policies. It can be preventive, by establishing protected area to preserve intact ecosystems from human impact (Wilgen and Biggs, 2011; **?**), or in direct reaction to a problem without preventing contact, *e.g.* culling control by monetary incentives (Mason et al., 2017; **?**). Another example is offsetting, meaning implementing elsewhere the natural features damaged somewhere by human activity (Gordon et al., 2011). Yet, completely successful implementation of conservation is scarce because of the numerous challenges it faces (**??**).

1.2 Problems faced in conservation

1.2.1 Complexity

Conservation problems are recognized as highly complex and densely interconnected systems, including ecology, sociology, agronomy and climatology simultaneously. Therefore, it is often impossible to isolate the causes of unexpected changes in the system.

1.2.2 Lack of data

These features make monitoring very expensive, time demanding, and often irrelevant, as the number of possible variables is too large. Thus, conservation policies often lack data to account for their effectiveness, or to understand failure.

1.2.3 Rigidity

Moreover, the inability to predict effectively the system's response to a change in the conservation policy results in some kind of reluctance to change.

Pas au bon endroit: Other limits in keith2011uncertainty about politics and self-serving. Unexpectedly, there is little evidence that bigger budgets make conservation easier or more effective (Ref: game2013conservation)

1.3 More generally, uncertainty

More generally, conservation faces uncertainty at many levels.

2 Adaptive management

2.1 Purpose

Adaptive management suggests to update the management policy dynamically according to the system response. This way, conservation can be better fitted to the system, and acting regularly allow to acquire informations, learning heuristically from its responses. Uncertainty is an irreducible aspect of conservation, so it seems more relevant to act embracing it rather than waiting and keep on with an inadequate policy. LACKS REF

2.2 Limits

critics from game2013.
other unresolved problems from above.

Even if a policy effectively protects a species from going extinct, mismanagement can lead populations to reach problematical numbers for human livelihood.

3 Conflicts

This is when conflicts arise, because people impacted by a protected population's growth are very likely to defect conservation policies, which can be threatening for the species persistence.
Definition of a conflict. Ref: Redpath's book.
Examples from ConFooBio. Ref: Redpath's book, redpath2013, mason2017. Elsewhere: behr2017, glynatsi2018.

3.1 Divergent interests between stakeholders

The inherent problem in conflicts is obviously the divergence of stakeholders interests. Farmers are usually way more interested in the yield they live on then the survival of the species that is part of its decreasing. The reaching of a consensus is therefore a unproductive process, moreover it can prevent the situation to change in a equitable way (Peterson et al., 2005).

3.2 MSE

A framework for conflict resolution. At four main levels: population dynamics, links between components of the ecosystems, type of estimation of the population, making the right decision without knowing precisely the outcomes, reaction of the users, politics, response of the system, ... Schema. All the problems it deals with.
First implemented in fisheries than applied on terrestrial animals conservation. Ref: bunnefeld2011, bunnefeld2013.

4 Modelling

need for it, because conservation complexity is usually beyond our direct understanding. Decision helping tools, capable of considering more features than we do simultaneously.

4.1 Different models used in literature

examples. Ref: schluter2012, rumpff2011 (dealt with uncertainty by implementing different scenarios), brainbridge2017.

For a proper implementation, need for human decision-making modelling, because one of the main reasons for failures. Ref: schluter2012.

High diversity, lack of common framework. Ref: schluter2012.

5 Decision-making modelling

Most successful approach is game theory, initiated by ??? in ??? in their book ??? economics.

5.1 Game theory

brief description. Ref: myerson1997.
Definition of the key concepts like utility. Ref: myerson1997.

5.2 Application to conservation conflicts

Ref: colyvan2011, Glynasti2018 (emphasize on the fact that it's recent).

Recently developed a model coupling all this.

6 GMSE

Ref: duthie2018gmse. emphasize on its novelty.

6.1 Formalisation of MSE framework

describe how it falls in MSE framework, how it deals with uncertainty at each level, consensus biases, long term foreseeing.
Explain clearly what it is meant for.

6.2 First IBM in conservation

"Individualbased models (IBMs; also known as agent-based models) are used to model the behaviour of a system at an individual level by specifying simple rules for agents and allowing them to interact. These models allow for complex behaviour to emerge from simple interactions, though this comes at some cost to interpretation and analysis." Ref: hamblin2012parctical.

6.3 Decision-making artificial intelligence

Genetic algorithm. Very accessible worded explanation. ref: hamblin2012practical
How is it suited to human decision-making?
Also used in solving game theoretical problems. Ref: Maynard Smith 1982.
An example of interaction between IBM and genetic algorithm was in hamblin2009, where the parameter governing the interaction rules in foraging ants where allowed to evolve through a GA.

6.4 limits

6.4.1 Theoretical

Agents act independently, which is very unlikely. REF???!!
Different types of conservation interests. Would be interesting to implement.
Does not consider the do nothing option which is sometimes interesting.
Measure of conflict intensity?

6.4.2 Computational

Computing time when the number of stakeholders increases.
Lacks machine learning to be a proper artificial intelligence.
Parallelism in general.

7 Research Questions

They have to be very closely related to conservation (to avoid making it a mere modelling project)

7.1 Case study: Geese

Description. Ref: mason2017, brainbridge2017. Its attributes (liked with the limits of GMSE).

from now on always speak about goose, state and farmers to settle the problem in the context of geese

7.2 Is waiting an interesting option for managers?

Recently introduced in iacona2017evolutionary: optimal delay before using funds.

7.2.1 Calculus of impact

Dr Ascelin Gordon: the difference in the variable of interest when manager acts or do nothing. Implementing the 'doing nothing' option in GMSE. Quantitatively assess the impact on repeated simulations. Mean deviation from conservation target at each time step.
According to duthie2018gmse. The number of extinctions over several simulations increases exponentially with the frequence of manager non-intervention. So, I suspect it is going to show that doing nothing is not sustainable as a policy in itself. Surprise! But is it necessary to act as each time step, "as soon as possible"?

7.2.2 Action threshold

Currently in GMSE, a parameter sets the number of the manager's interventions per time step. Rigid, insensible to the situation, action if pop > ou < target, regardless of the size of this difference. acting even if the population if only a few individuals from the target.
First, fixed deviation from manager's target as an action threshold. has to be relative the the population size though, if population size is 100, 50 individuals missing or extra is very concerning, yet it is less if population size is tens of thousands. For example I could test thresholds of 1, 5, 10, . . . % of target.
Quantitative assessment of the impact on the "quality" of the policy over repeated simulations for increasing threshold values: mean deviation from manager's target? Impact? Conflict reduction? number of extinctions? (Is there a chance that the result will be the same as the

manager intervention frequency?)
Dynamic threshold? A function of deviation from target, or conflict intensity, that would modify the action threshold.
Waiting could imply saving a certain amount of budget for next step. Something that could also concern the users, maybe highlighting a best time to act.

7.3 Including human values in adaptive management

All conservationists have different goals according to their values, it would be interesting to implement this. Using the framework from futureconservation.org, I could use quantitative measures of conservationists values and attribute utilities accordingly, and assess if it indeed produce the expected results. Users yields and population size according to the value on nature - people axis, and to conservation - capitalism one.

7.4 Standing alone: how to manage a conservation conflict with interacting users?

Possibly interaction among users, the information they perceive on their neighbours could influence their strategy.

8 Expected outputs

At least a paper on the action threshold, a talk in Newcastle, a poster in winter symposium, a participation at the Trondheim workshop. Updated version of GMSE. Field work for SNH, possibly in the policy team to which Aileen is close.

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