We open this response by thanking the reviewers for their thoughtful comments and suggested. In fact, we have fully taken their comments on board and made what we hope will be considered the major modifications.

The main modification has been to the utility model itself: upon reflection we have included another component of the poaching process to the utility model. By considering the time it takes to kill a rhino this ensures a heightened risk to indiscriminate poachers as they will kill all rhinos they see they will spend more time in the park at risk of being caught. This has en immediate effect of modifying the conclusions of our first submission: all strategies can be evolutionarily stable.

Given this major modification we will now respond to each comment/suggestion below:

1 Reviewer 1

Ln 20 40, pg 6, the variables talk about "proportion of horn gained" but I think a more general way to think of the variable is "proportion of value gained from the horn". For example, de-horning clearly leads to proportion of horn, but for other management interventions such as dye it may be a proportion of devaluing rather than quantity. Think it would be useful to say something like this model holds for any management action that proportionally devalues or removes a quantity of horn from the market, we will use the word "horn gained" because we are thinking about "dehorning" but the model is more general, or something to that effect.

This has been addressed by making the suggested substitution and including the opening comment but also ensuring that unless dehorning is specifically intended that the term devaluing is used.

Eqn 5, There are many mathematically valid choices for how to write this equation, including yours, but I think this way of expressing it is less clear than some alternatives. I think it would be clearer to write this equation in one of the following ways, (1-r) + (1-x)(1- r + r sigma_r) or 1 r + r sigma_r (1-x) to me your choice of expression obfuscates the meaning and creates an awkward nested parenthesis. Of the two expressions above, the first one starts from the point of view of the proportion of poachers, the alternative equation starts from the point of view of the rhino (i.e. whole horns are harvested from both types (1-r) and r sigma_r (1-x) is the additional value harvested by the indiscriminate poachers. The second is the simplest expression in my opinion, but I can see reasons for why you might prefer the former one.

Thank you to the reviewer for pointing this out: we have made the suggested change.

>> Ln 55-56 pg 6, can you avoid introducing the variable capital x. Simply say as you basically do in the following line, that x uniquely determines the proportion of both types and therefore describes the state of the population of poachers. The added variable is unnecessary unless you are going to use it heavily later.

>> Similar to the capital X comment this sentence is also confusing. Just introduce s.

We have made this suggested change.

>> Eqn 6 is confusing as to how it should exactly be thought of and how it relates to supply and demand relationships. It is not clear how fig.2 shows how "fig 2 verifies that the gain curve corresponds to a demand curve". How exactly does it do this?

Eqn 6 attempts to capture that by devaluing raw rhino horn (increasing r) its scarcity in the market increases which in turn increases its 'price'. We have attempted to clarify this further in the text.

>> Eqn 9, this is a bit strange to me, why is this an exponent? Consider that each rhino dehorned caused a unit of money that could go to security, then dollars to security is directly proportional to (1 r) so why not a constant multiple? Presumably if beta < 1 this could denote a diminishing return on police efficacy

>> Eqn 8, I do not understand this equation. What is this the cost of? Searching for rhinos? Presumably this could be measured in the amount of time it took to find a rhino comparatively if you were passing on rhinos that have been devalued. If we were assuming poachers encountered rhinos randomly via laws of mass action for every time unit it took for indiscriminate poachers to find a rhino it would take 1/(1-r) units of time for an indiscriminate poacher to find a rhino that hasn't been devalued. Is this how equation 8 is being calculated? If so I do not follow the derivation. Im also concerned with double counting. Your benefit function includes the added benefit from poaching rhinos indiscriminately by getting more rhinos. Please walk the reader through this equation. Is it search cost? Is this the same cost for an individual of both strategies? Im not really sure what you are assuming here.

>> Eqn 5 11, Handling time of killing and processing a rhinos and the increased risk of being caught due to killing more rhinos (dehorned rhinos) do not appear to be factored into the model. As a result I question whether the main result is an artefact of this model set-up. Im not sure I follow how an discriminant poacher gets any benefit from their actions in this model (with the exception of H). I don't think supply and demand is the main reason managers argue for this strategy, so the effect of H is less important to explore than handling time and risk to poachers, in my opinion. From a game theoretic sense, unless I am missing something, it is obvious that increases in H with r wouldn't affect the stable strategies because all individuals are affected by the price of the value of horn equally. So only through risk of exposure and added costs through handling time of killing less valuable rhinos can one argue for dehorning, which this paper doesn't explore.

>> Eqn 11 confuses me as I thought time would be the unit of cost of searching for rhinos, as can be seen from my comment above I thought something like these equations would be the costs. Basically I was expecting equation 11 to be the costs. It seems like we have similar thoughts. Psi actually seems to just be proportional to the number of rhinos being poached, but you call it the cost, which is confusing to me. Am I missing something here?

We have reflected on these raised points extensively and have explicitly addressed the points raised. Indeed, as was the model did not account for the time related to killing and processing rhinos which in the

case of the indiscriminate poachers would correlate with an augmented risk.

This has now been modelled using a stochastic walk, this has been explained in the text and a diagram has also been included.

The reviewer was completely correct in their insight about the conclusions and a new theoretic result has been obtained that describes the conditions for which devaluation will lead to selective poachers.

We thank the reviewer for very helpfully pointing this out and feel that this has greatly improved the paper including the conclusions that detail the factors that influence selective behaviour.

```
>> When introducing H I think you need a reference for its choice. Below are
some modelling papers where supply and demand affecting poaching

- [Economics of Antipoaching Enforcement and the Ivory Trade
Ban](https://www.jstor.org/stable/1244594?seq=1#page_scan_tab_contents) -
[Protecting the African elephant: A dynamic bioeconomic model of ivory
trade](http://www.unece.lsu.edu/responsible_trade/documents/2008/rt08_33.pdf)


>> There are many papers modelling poaching in the rhino trade system. You
might want to consider going through them a bit more systematically and
describing how your work sits within the broader rhino horn modelling
literature (possibly in the discussion).  Here are some examples (but there
are many more) to seed your search

- [Debunking the myth that a legal trade will solve the rhino horn crisis: A
system dynamics model for market
demand](http://www.saeon.ac.za/enewsletter/archives/2015/october2015/images/0300.pdf)
- [Identification of policies for a sustainable legal trade in rhinoceros
horn based on population projection and socioeconomic
models.](https://www.ncbi.nlm.nih.gov/pubmed/25331485) - [Trading on
extinction: An open-access deterrence model for the South African abalone
fishery](http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0038-23532016000200019)
- [How many to dehorn? A model for decision-making by rhino
managers](https://www.cambridge.org/core/journals/animal-conservation-forum/article/how-many-to-deho


>> It would be good to cite the anthropogenic Allee effect in either line 42
of the intro or in the discussion as this is one of the main hypothesised
drivers in the mathematical modelling literature on what causes rhino horn
to be so valuable.  The theory is mathematically described in

- [High prices for rare species can drive large populations extinct: the
anthropogenic Allee effect
revisited.](https://www.ncbi.nlm.nih.gov/pubmed/28669883)

>> and first biologically hypothesized here

- [Rarity Value and Species Extinction: The Anthropogenic Allee
Effect](http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.0040415)

>> Ln 20  43 pg 3. The issue of opportunistic exploitation is highly
relevant to the game you present. In fact I think it may be the logic behind
a lot of what's driving your results. It's not exactly the same because the
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authors think of opportunistic exploitation as a multi-species problem, but
it is very similar because you could think of dehorned and horned rhino as
two species. The basic idea is that while hunting for one type you will kill
the other if it's there and easy to kill without much added cost.  Ln 20 -43
seems like a natural place to talk about this, but it could be talked about
later in the discussion

- [Opportunistic exploitation: an overlooked pathway to
extinction](https://www.sciencedirect.com/science/article/pii/S0169534713000712)
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Thank you for these suggestions we have included the above citations.

2 Reviewer 2

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>> I think the most problematic assumption is that rhino population dynamics
is assumed to be stable through time. Obviously, this won't be the case and
that could change everything because the increasing rarity of rhino could
increase the price of horn, devalued or not, and therefore the relationship
between costs and benefits that would be challenging to predict. I think
addressing this question could definitely increase dramatically the novelty
of this study, which will be beneficial from an ecological and a modelling
point of views.
```

Whilst the rhino population dynamics are not modelled explicitly we agree this would be an interesting avenue to consider, we have included this in the discussion. However, we feel that for the purpose of analysis considered at this stage assuming the dynamics of the rhino population and thus the cost/benefit to the poachers is sufficiently captured by the supply/demand model: whilst not considered specifically the rarity of rhino is consider by the $(1 - r)$ term and the behaviour of the poachers. This can also be seen in some of the new scenarios that have been included.

```
>> The authors have also identified some situations were selective strategy
could be more beneficial than indiscriminate. I think it could be
interesting to look at the literature in which kind of situations we really
are, and if these conditions found theoretically can be really encountered
on the field.
```

We have not addressed this as a lot of these details are purposely kept confidential ...

```
>> Regarding the length of the paper, I am not 100% sure that the analysis
for situations where everyone has selective or indiscriminate strategy
really brings something.  This highlight that this study is maybe not deep
enough, because classically, these analyses would be moved in supplementary
materials. I understand the point of showing the difference with mixed
strategies, which won't be stable, but I still think these analyses on pure
strategies are not very insightful.
```

Thank you for this comment which encouraged us to reflect on the length of the paper, as a result we have modified the model to only consider a disincentive and furthermore only a single theoretic result is presented. This specifically offers insight regarding the conditions required for selective poachers to subsist.

```
>> Finally, from a presentation point of view, I think that figure 1 is not
needed
```

We have removed this figure.

```
>> Figure 2 and 3 could be merged.
```

```
>> Legends and axes names need to be improved to make the figures readable
without going back to the text.
```

Figure 3 has been replaced with another Figure relevant to the new model and the axes and legends are now hopefully clear.

```
>> I think that a summary figure of the selected strategies
(without discentive) could be also an interesting addition.
```

We have included a figure that describes the strategies as requested.