GMSE: an R package for generalised management strategy evaluation

Supporting Information 2

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Extended introduction to the genetic algorithm applied in GMSE

Thanks for the clarification regarding the equation. I'll try to answer as best as I can – apologies if this has been unclear. At the broadest scale, the equation for user fitness would be on L367 in the strategy_fitness function (https://github.com/bradduthie/gmse/blob/master/src/game.c#L376). Here's what's going on: Users are predicting how their actions will change the quantities of things in the model (either resources or landscape output), and these changes are individually multiplied by the users' utilities for that thing. The change multiplied by utility for each thing is summed across all things to get a value for fitness. Note that positive change times positive utility, and negative change times negative utility, will increase fitness (i.e., increasing the thing users want more of and decreasing the things they want less of). Hence, an equation describing user fitness would be the below,

$$F_{user} = \sum_{i=1}^{N} \Delta A_i \times U_i$$

.

Where F_{user} is user fitness, N is the total number of things that might be of interest (at the moment $N = 2$ in GMSE, one resource and, potentially, one landscape value), ΔA_i is the change in the abundance of thing i, and U_i is the utility of thing i from the perspective of the user (apologies for the LaTeX code – attached a PNG of the conversion). I want to stress though that I would not consider this equation to be central to the GMSE framework – if someone else has a better approach for defining fitness, or defining any of the terms listed above, or wants to expand upon it to include new things, then that would be awesome! The above just works well as a heuristic tool to get users to act in such a way as to maximise their interests in harvesting or getting more crop yield (as is my intent), but it's not based on first principles and I don't claim it to be particularly special.

The values of ΔA_i are calculated for resources and the landscape in the functions res_to_counts and land_to_counts, respectively (and U_i is specified a priori in the model depending on other parameters – namely land_ownership). Again, a bit of heuristic is needed here because there cannot be any perfect way of exactly predicting how a users actions will increase or decrease resources – there are too many complex factors (e.g., behaviour of other stakeholders, demographic stochasticity, movement of resources on the landscape, and interactions between resources and the landscape). Even if we could include all of these things somehow, it would be a bit unrealistic in that real stakeholders would never have this much information. The predicted direct effect of actions on resources is shown in lines 268-272 (https://github.com/bradduthie/gmse/blob/master/src/game.c#L268), and the array 'jaco' (a sort of Jacobian matrix) accounts for interactions between landscape and resources on line 286. Something similar happens in the land_to_counts function. The manager's genetic algorithm works in a similar way (the above equation applies), but with the need to dynamically update utility values based on current resource abundance, and to account for the predicted actions of users in finding ΔA_i.