**Methods**

*GMSE*

Simulations in GMSE are comprised of four submodels that govern the social-ecological system, each of which can be individually parameterised. The submodels are (1) the manager model which uses the genetic algorithm (GA, see below) to develop management policies that reduce deviation of the natural resource population from the target population size. The manager achieves this by dynamically altering the cost of actions for the users thereby increasing or decreasing the ability of the users to cull resources. (2) The user model, in which each user calls the GA to develop a strategy for that time step that maximises their utility (e.g. maximises their yield). Each user calls the GA after the manager has set the policy for a given time step. (3) The natural resource model which is used to mimic the population of a biological resource within the system. The natural resource model can simulate complex spatially explicit biological populations that have individual traits such as age, and population-level traits such as carrying capacity and related density-dependent mortality. Because individuals within the population have discrete traits there is inherent stochasticity within the population. (4) The observation model represents the observation process whereby the manager estimates the size of the natural resource population. The submodel has four methods available which mimic commonly used biological monitoring techniques.

the observation model, and the natural resource model (Fig. Sx – fig 1 Duthie et al 2018). For detailed explanations of the submodels, see Duthie et al (2018) and the documentation for the GMSE R package.

More general introduction to how the models work together. The objectives for the manager and the users, and how their budgets work together. How the different submodels link together.

*Genetic algorithm*

The GA is the core process by which the manager develops policy and users decide upon actions. The GA mimics the process of natural selection whereby each call to the GA results in several possible strategies being initialised. Multiple iterations then allow cross-over and mutation between the initialised strategies, ensuring that budgets are not exceeded. Each subsequent iteration of strategies is selected via a fitness function and a tournament. This process results in adaptive, but not necessarily optimal, strategies for the manager and the users. In each simulation time step the GA is called by the manager and each of the users to simulate decision-making. The GA first takes the manager’s budget constraints, user action histories, and the predicted consequences of each action on the resource population and develops a strategy for the manager to reduce deviation from the target resource population size. Once the manager’s policy is established users will individually call the GA to decide upon actions that maximise their utility, in this case agricultural yield. Users can either tend their crops or fell trees, both of which will increase their yield. Their ability to fell trees is governed by both the user budget, and the manager’s policy, in each time step.

*Parameterisation*

Define the landscape, and the scenarios – what are the resources, what are the objectives of the user and manager etc.