Runs with FEARLUS-SPOMM

| ***Things to define*** | ***Ideas for definition*** |
| --- | --- |
| **The language used to describe**   * **Land Use** * **Climate** * **Economy** * **Biophysical Characteristics**   This language is quite simple – it requires, for each of the above four items J, a specification of one or more dimensions that J has; and then for each of the dimensions DJ, a specification of one or more discrete (finite) set of values (as strings) VDJ that DJ may have.  A specific Land Use, Climate, Economy or Biophysical Characteristics *state*, S is then a #DJ-tuple the entries of which a single member of VDJ. | More Land Use options means more for farmer agents to choose among, and hence more for them to know about.  Faster change of Climate or Economy to new states means that existing knowledge of farmer agents becomes less relevant.  More spatial variation in Biophysical Characteristics means knowledge of neighbouring farmer agents becomes less relevant. |
| **Lookup tables that specify the yield and economic return for all possible situations**  The yield lookup table has one column for each of the dimensions of Land Use, Climate and Biophysical Characteristics, and another column specifying the yield returned for the row entry of values of each dimension. One row will be needed for each combination of values of all the dimensions, so the table can become very large. (Its size is for J in Land Use, Climate and Biophysical Characteristics.)  The income lookup table has one column for each of the dimensions of Land Use and Economy, in a similar way to the yield lookup table. | See the rows immediately above and below. |
| **Climate and Economy time series**  Sequences of Climate and Economy *States* as #DJ-tuples for J in Climate and Economy (obviously). These should be specified in advance, and need to cover the duration of the run. | The lookup table structure effectively allows yields and incomes to be defined one year at a time. Existing work with FEARLUS-SPOMM has only used highly stylised time series for Economy (the Climate not having been varied): one where there was no change; another where there is cyclical change.  Autocorrelated time series with different variances, cycles and trends could be defined in advance. Climate and Economy being in and out of phase, incomes for different Land Uses being in and out of phase all add to the challenges for the agents to learn how to maintain their survivability. |
| **Species and their parameters**  Species have parameters determining their dispersal kernel size (alpha), mortality (mu), habitat preferences, and competition with other parameters. Higher values of alpha lead to smaller dispersal kernels; higher values of mu lead to higher chances of local extinction (i.e. on a single patch), all other things being equal. The SPOMM part of FEARLUS-SPOMM has other parameters that determine species dynamics, but these are the main ones we have played with so far. | A variety of species can be defined, but because of the computational complexity of calculating occupancy (which depends on landscape fragmentation), large numbers (e.g. 50 or more) are not recommended.  More species do not necessarily add to the complexity of the environment per se, but adjusting alpha, mu and the habitat can make the species more or less difficult to maintain (high alpha (>1.5 or so), high mu (>0.2 or so), and few land use options providing habitat will lead to a more challenging situation for the species).  More complexity can be added by having the species out-compete each other. In certain habitats, one species can be ‘dominant’ (the species will out-compete certain other species if it has been on the patch for long enough). There is also the option (not mentioned during the workshop discussion) to create ‘sink’ habitats for species – these are habitats the species can migrate to, but from which it cannot disperse. |
| **Land use/habitat matrix**  For each Land Use, we need to know how much of each Habitat it provides. (Numbers in the range [0-1].) | See above. |
| **Other parameters**  There are various other parameters that need to be defined:   * Environment size (we have used 25x25 in runs so far, but have also seen that there can be qualitatively different results – in FEARLUS alone – if the environment becomes bigger and bigger[[1]](#footnote-1)) * Land purchase price – cost of a parcel of land. Work with Dawn Parker also included an endogenised land market in FEARLUS – see Polhill, Parker & Gotts (2008) and Polhill et al. (2008). We have not added this in to FEARLUS-SPOMM, but it would create potentially additional complexity. * Break-even threshold * Farm-scale fixed costs * Government parameters   + What they will reward for, and how much. Code exists to allow Governments to reward for specific Land Uses, and/or the presence of a Species on a Patch.   + Where the reward will happen. Optionally, governments can be configured only to issue rewards in specific patches. * Decision-making parameters   + Aspiration (can be a uniform distribution allowing population level adaptation as circumstances change)   + Case base size (ditto)   + Change delay (ditto) – how many consecutive years of being dissatisfied before using decision-making algorithm to make a change to Land Uses.   + Probability of using case based reasoning rather than a heuristic algorithm when dissatisfied (ditto)   + Bids offered by in-migrant land managers   + Land offer threshold (amount of money they must have before offering money for a neighbouring patch).   + Parameters determining whether and if so whom to approach for ‘advice’ (cases when none exist in your own memory), and whether to give it if asked. * I think there may be an option to reintroduce species (once) where they can exist in the model. This tends to be used after the agents have done some learning. | Government parameters will determine the goal(s) it has (i.e. what it ‘wants’ to have persist – food security, viable farm businesses, species biodiversity, or the conservation of specific species).  Aspirations form the goals of the farmer agents. With some (minor) modifications, farmer agents could also have goals to undertake specific activities (i.e. there are only some Land Uses they will select).  Additional social complexity can be introduced through imitative heuristic strategies, advice giving, more realistic land markets. Satisficing (not making a change when aspirations achieved) was found to be challenging for a control-theory-based government agent to manage (Polhill et al. 2010). |
| **Initial state**  The initial state of the model needs to be specified. This tends to involve specifying an initial landscape of land uses, and which agents own which parcels. The species just initially occupy every patch offering suitable habitat. The biophysical characteristics will also need to be given as part of the ‘initial state’ (but the inverted commas in this are to indicate that the biophysical characteristics don’t change). | Spatial variation in the biophysical characteristics add to the ‘challenge’ as stated above.  The initial allocation of land uses will influence what the initial farmers can learn from and whether they can make a living straight away.  The initial estate size also affects what land managers can learn and potentially affect their ability to survive. |
| **Outputs required**  Very important! FEARLUS and SPOMM both have various outputs that can be collected. | Number of time steps for which agents’ goals have been achieved, and/or number of time steps for which agents have been able to re-establish their goals if they have not been achieved (if they have). |

# References

Gimona, A. and Polhill, J. G. (2011) Exploring robustness of biodiversity policy with a coupled metacommunity and agent-based model. *Journal of Land Use Science* **6** (2-3), 175-193. (doi:10.1080/1747423X.2011.558601)

Gimona, A., Polhill, G. and Davies, B. (2011) Sinks, sustainability and conservation incentives. In Liu, J., Hull, V., Morzillo, A. and Wiens, J. (eds.) *Sources, Sinks and Sustainability*. Cambridge University Press. pp. 155-178.

Gotts, N. M. and Polhill, J. G. (2010) Size matters: large-scale replications of experiments with FEARLUS. *Advances in Complex Systems* **13** (4), 453-467. (doi:10.1142/S0219525910002670)

Polhill, J. G., Gimona, A. and Gotts, N. M. (2013) Nonlinearities in biodiversity incentive schemes: A study using an integrated agent-based and metacommunity model. *Environmental Modelling and Software* **45**, 74-91. (doi:10.1016/j.envsoft.2012.11.011)

Polhill, J. G., Gotts, N. M. and Law, A. N. R. (2001) Imitative versus nonimitative strategies in a land-use simulation. *Cybernetics and Systems* **32** (1-2), 285-307. (doi:10.1080/019697201300001885)

Polhill, J. G., Jarvis, A., Gimona, A. and Gotts, N. M. (2010) Towards adaptive control of landscape biodiversity. In Swayne, D. A., Yang, W., Voinov, A. A., Rizzoli, A. and Filatova, T. (eds.) *Modelling for Environment’s Sake: 2010 International Congress on Environmental Modelling and Software, Ottawa, Ontario, Canada, 5-8 July 2010*. http://www.iemss.org/iemss2010/papers/S07/S.07.08.Towards%20adaptive%20control%20of%20landscape%20biodiversity%02-%20GARY%02POLHILL.pdf

Polhill, J. G., Parker, D. C., Brown, D. G. and Grimm, V. (2008) Using the ODD protocol for describing three agent-based social simulation models of land use change. *Journal of Artificial Societies and Social Simulation* **11** (2), 3. http://jasss.soc.surrey.ac.uk/11/2/3.html

Polhill, J. G., Parker, D. C. and Gotts, N. M. (2008) Effects of land markets on competition between innovators and imitators in land use: Results from FEARLUS-ELMM. In Edmonds, B., Hernandez Iglesias, C. and Troitzsch, K. G. (eds.) *Social Simulation: Technologies, Advances and New Discoveries*. pp. 81-97. (doi:10.4018/978-1-59904-522-1.ch007)

1. See Gotts & Polhill (2010). Essentially original results in FEARLUS used 7x7 environments, but with larger environments (I think we went up to 100x100) some of the results we had reported in Polhill, Gotts & Law (2001) didn’t happen. [↑](#footnote-ref-1)