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Supplement E from Aureli et al., “Fission-Fusion Dynamics”

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Examples of Spatially Explicit Agent-Based Simulations

In a simulation model, the key parameters of interest can be defined precisely and the effects of varying those parameters explored in a systematic fashion. For example, simulated agents in a model environment can be presented with resources in explicitly defined patches (e.g., circular spaces on the landscape containing discrete numbers of “fruits”) or a defined patch density (fig. E1, *A*, *B*). Similarly, the spatial relationships among multiple simulated agents can be easily tracked and monitored (fig. E1, *C*, *D*), something that cannot be easily achieved with real animals in a complex, natural environment.

Some of the best examples of the use of spatially explicit agent-based simulation models in primatology have focused on higher-FF taxa and demonstrated that some very simple social and foraging rules can yield complex fission-fusion dynamics. For example, in te Boekhorst and Hogeweg’s (1994) pioneering use of agent-based simulations, a set of male and female “chimp” agents was allowed to search randomly for fruit and conspecifics in a forest composed of a lattice with “fruiting trees” of varying size. Upon encountering a fruiting tree, the “chimps” stayed there until there was no more food; upon encountering conspecific agents, males followed females in estrus, while females ignored other individuals. In their simulations, “parties” (or aggregations of agents) arose as a result of the tendency of “chimps” to meet at fruiting trees, and males traveled in larger parties as a result of their tendency to follow estrus females. The resulting party-size frequency distribution and differences in average party size and travel distance between females and males were similar to those observed in real chimpanzees.

More recently, Ramos-Fernandez, Boyer, and Gómez (2006) used agent-based simulations to model the travel paths and fission-fusion dynamics of spider monkeys. Instead of assuming that animals search for food at random, the authors assumed that “spider monkey” agents have a sophisticated knowledge of the location and size of available food sources and that they choose among potential food patches, which maximizes the ratio between the size of the next-visited patch and the distance traveled to it, ignoring patches already visited. Agents in this model “fuse” into “parties” by the general mechanism described above when they meet at the same preferred food patches. However, “party fissions” also occur because agents have different histories of previous visits and therefore make different decisions about where to go next. Despite the fact that there is absolutely no rule that specifies anything about the social interactions between agents, “spider monkey” agents regularly formed “parties” and split from others as a result of their interactions with the environment. Moreover, these grouping tendencies produced nonrandom association patterns, including weak and strong bonds among particular sets of agents that appear very similar to those found in animal societies.

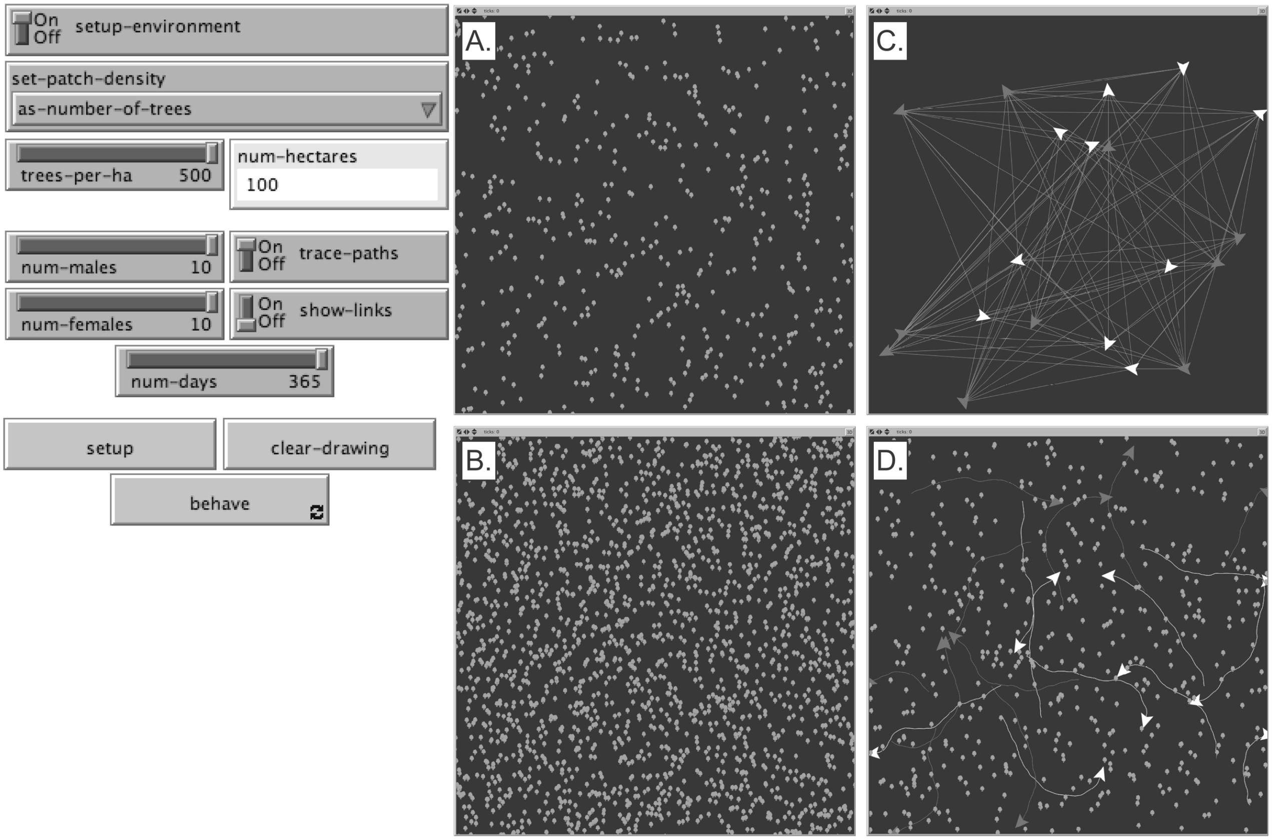

Figure E1. Example landscape windows for an agent-based simulation being developed for spider monkeys (A. Di Fiore, unpublished data). *A* and *B* show two alternative landscapes of 100 ha in size, each containing the same amount of resources (1,000,000 “fruits”) that differ in distribution. *A* contains 500 patches (*gray circles*), each with 2,000 fruits. *B* comprises 2,000 patches, each with 500 fruits. In each case, the patch radius is proportional to the cube root of the number of fruits per patch. *C* shows 20 “spider monkey” agents—10 “males” (*gray arrowheads*) and 10 “females” (*white arrowheads*)—initially placed at random in the landscape and shows the links defining the spatial associations between all male-female agent pairs. For clarity, the locations of food patches are not shown. As agents move around the landscape, features of the links among agents (e.g., the distance between pair members) can be recorded and stored by the program. *D* shows a view of the agents (all indicated as white arrowheads for clarity) in a landscape comparable to *A* after several random movement steps.