Rock, Paper and Scissors in Space:

A Demonstration of R2DToo [1]

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Paradigm Shift

- Wrong = Me presenting to you
- Right = Me picking your brains

Should present topic that I need feedback on.

Working on problem of whether migration can account for power-law extinction times, but data not ready. Have been developing simulation tool to collect data.

Need feedback on how simulation tool can be made more useful for population biology.

Q for you to keep in mind: “How could this tool be improved so that it could help me?”

R2DToo [3]

Simulation tool for MS-Windows.

Designed for fixed, discrete networks (eg. spatial grid), not continuous space.

Users write & compile simulations and load them into R2DToo.

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[3] http://rikblok.cjb.net/software/r2dtoo

Sample Problem

E. coli has 3 competing, non-transitive strains (no strain dominates).

Kerr *et al.* (2002) demonstrate spatial structure allows coexistence.

Q was raised in Sept. 6 EDG, “How big does space have to be?”

Will try to solve via R2DToo simulation.

Comments on Simulation

- advantages: repeatable, control
- disadvantage: need to simplify model (could “throw the baby out with the bath water”)

But simplification can be useful:

- equivalent in complexity science to reductionism in traditional science
- reveals minimum properties needed to produce a given phenomenon
- can always add detail as necessary

Model: Roshambo

(Not named after “South Park” game.)

Example of non-transitive interaction.

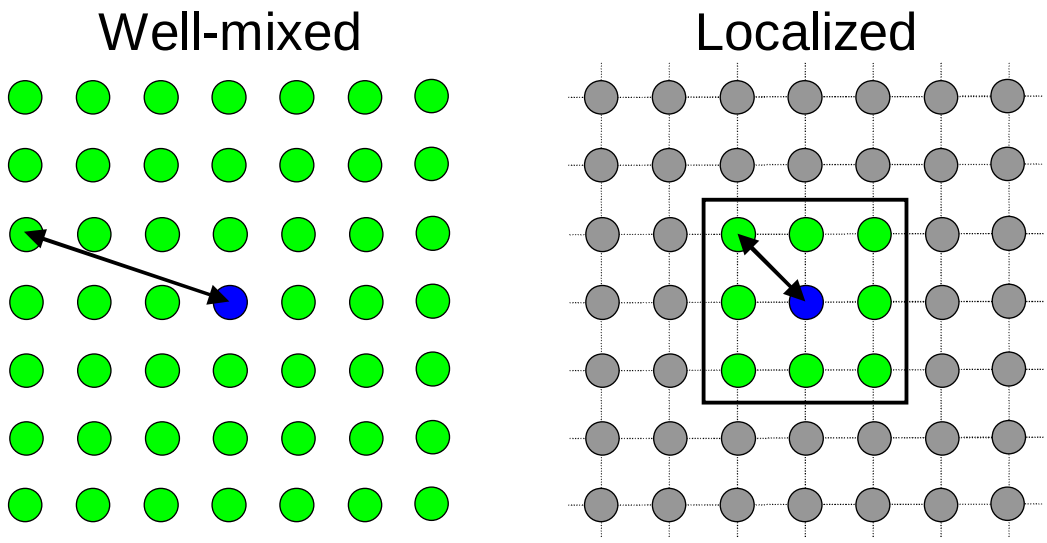
Evolutionary model. Population of 3 strains: R(ock), P(aper), and S(cissors).

Process:

- pick random pair of players
- pair plays Rock-Paper-Scissors and winner replaces loser
  - R + P → 2 P
  - P + S → 2 S
  - S + R → 2 R
- repeat

Testing Spatial Effects

- Well-mixed: any 2 players can be paired
- Localized: a player can only be paired with another in its neighbourhood



Can smoothly make transition from localized to well-mixed by expanding local neighbourhood.

Steps to Solving with R2DToo

1) Build simulation
2) Run
3) Collect data
4) Data analysis

Step 1: Build Simulation

Can use any compiler (Basic, Pascal, C++, etc.) which can create dynamic link libraries to write simulation.

(C++) Pseudocode:

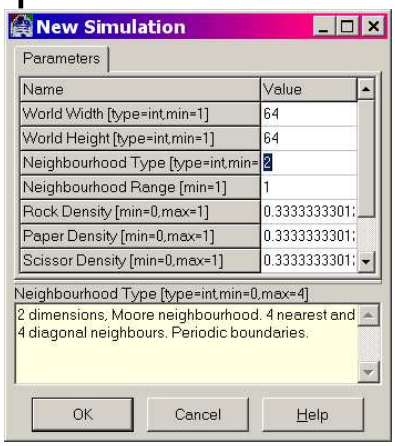
```
//-------------------------------------------------------------
onTick() {    // onTick is required by R2DToo
   // R2DToo provides shuffleAgents and forEachAgent
   shuffleAgents();
   forEachAgent(updateAgent);
}
//-------------------------------------------------------------
updateAgent(a, nbr, nbrCount) {
   b = getPartner(a,nbr,nbrCount);
   if (b)   play(a, b);
}
//-------------------------------------------------------------
play(a, b) {
   R=0; P=1; S=2;//   R, P, S
   update[3][3] = {   {R, P, R},    // R
                      {P, P, S},    // P
                      {R, S, S}};   // S
a[0] = b[0] = update[ a[0] ][ b[0] ];
}
//-------------------------------------------------------------
```

Now we compile our code to create model.dll.
Then we run R2DToo and load model.dll into it.

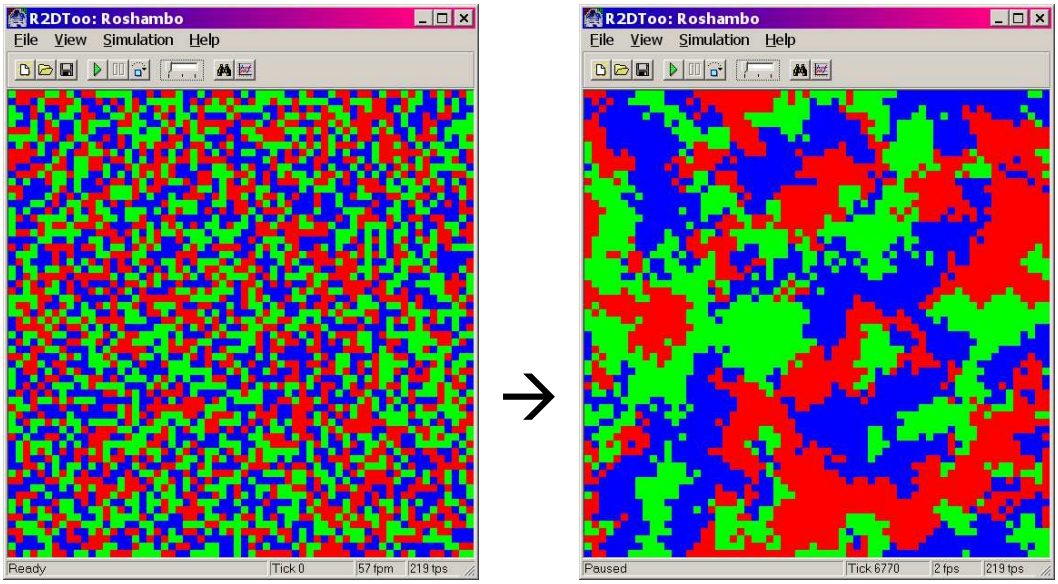
Step 2: Run

R2DToo interface:

Set-up a new simulation…



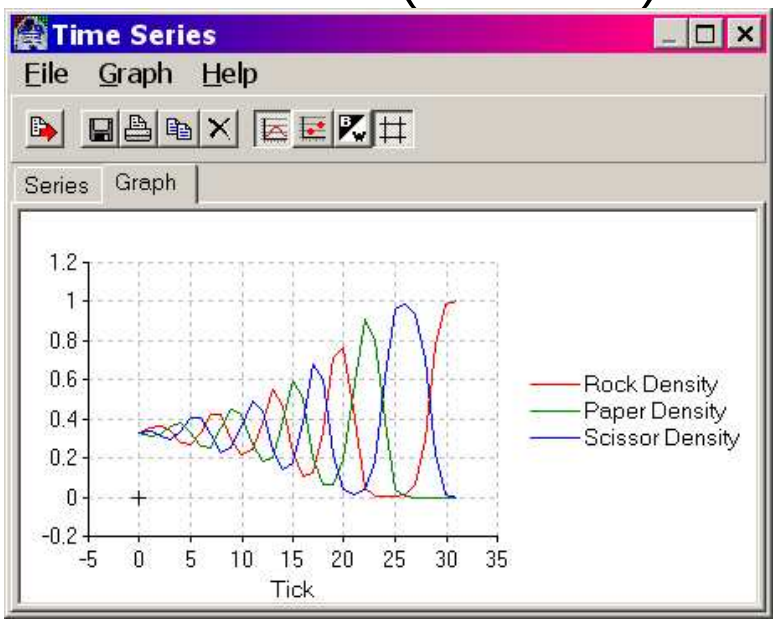
and run it…



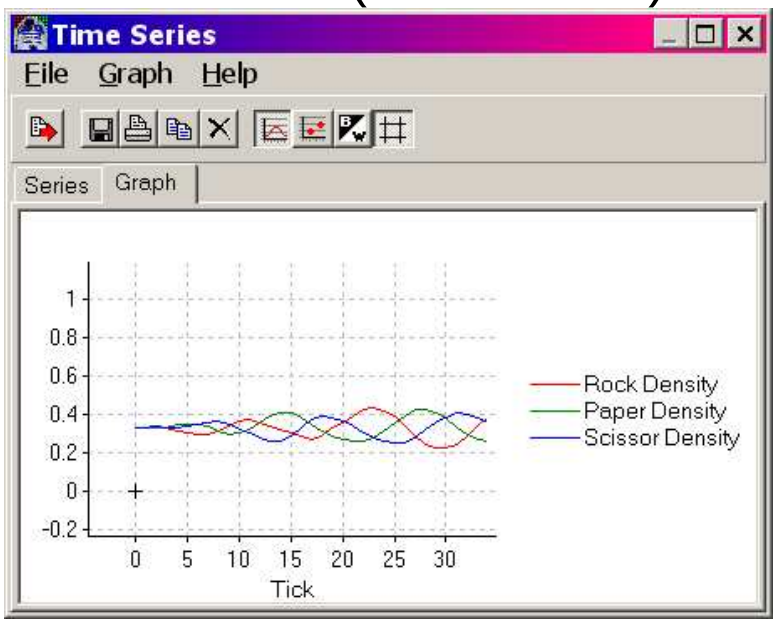
(Legend: Rock, Paper, Scissors)

R2DToo captures and displays statistics.

Well-mixed (extinction)



Localized (coexistence)



(1 Tick=1 Generation)

So there is something special about space.

Step 3: Collect Data

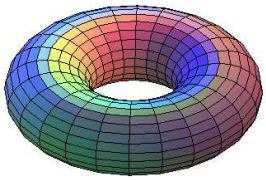
R2DToo can be automated via scripting.

Wrote JavaScript to:

- set system size and dispersal range
- set conditional stop if any species goes extinct or time limit exceeded
- run simulation and wait for it to stop
- record time to .csv file
- repeat

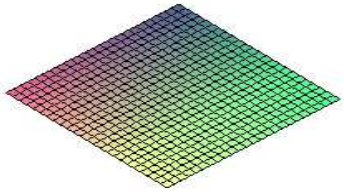
Experiment 1: Donut World

To avoid edge effects simulations commonly use wrap-around boundaries so space is on surface of donut.



Experiment 2: Square World

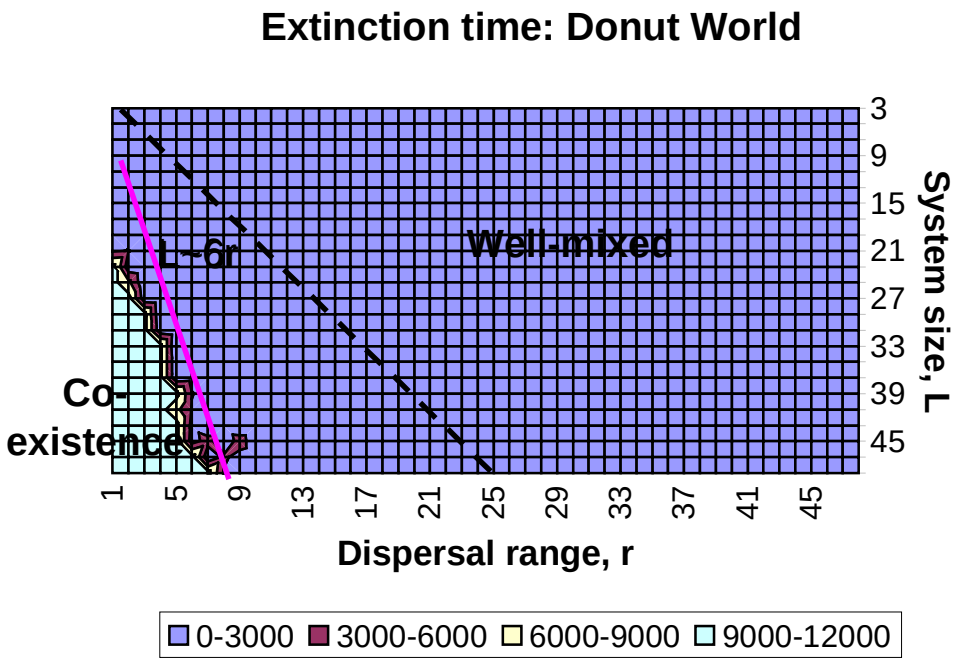
We will also explicitly include edges so world is a square. More realistic, like a square petri dish.



Step 4: Data Analysis

Generate extinction time contour plots.

Experiment 1: Donut World

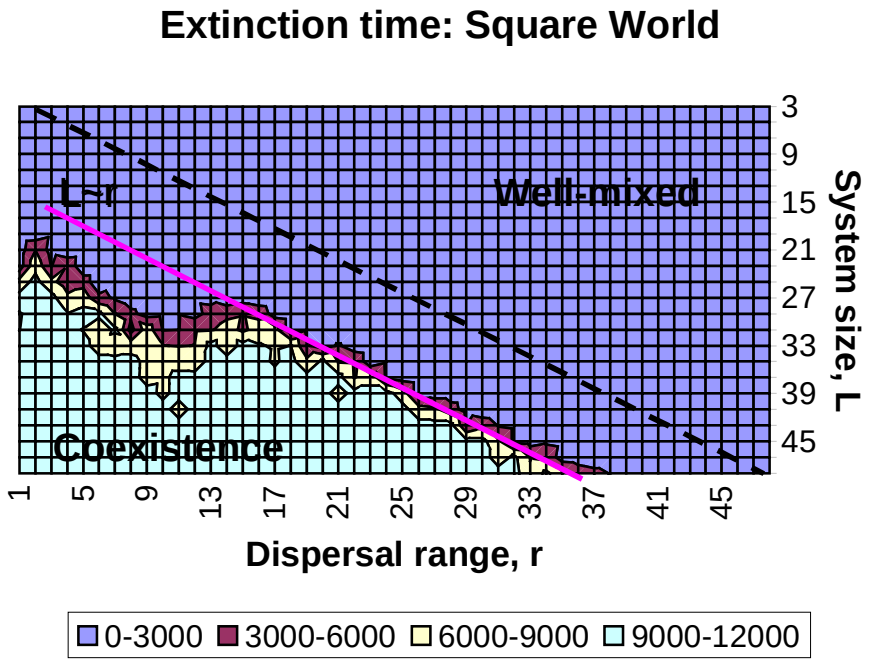


Diversity if space greater than **six** dispersal ranges.

Would expect this if we assume noise-driven extinctions. (This was my claim at EDG.)

Experiment 2: Square World

My prediction: I expected edges to disrupt space so would need larger space to see coexistence.



Diversity if space greater than **one** dispersal range.

Space matters *more* for square world.

Maybe edges provide refuge to maintain diversity? Or waves of dominance crash against edge?

Summary

Demonstrated R2DToo. Case study = spatial effects in non-transitive system.

Found space plays important role in maintaining diversity. Edges enhance effect.

Predicted how “big” space has to be to have effect.

Simulation makes it easy to test other networks. Eg. long-range links (random networks) same as well-mixed.

Q: How could R2DToo be improved for you?

You can find R2DToo at
http://rikblok.cjb.net/software/r2dtoo

References

Kerr, B., Riley, M.A., Feldman, M.W. & Bohannan, B.J. (2002) *Nature*, **418**, 171—174.