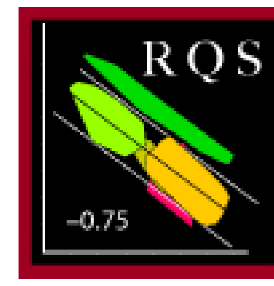
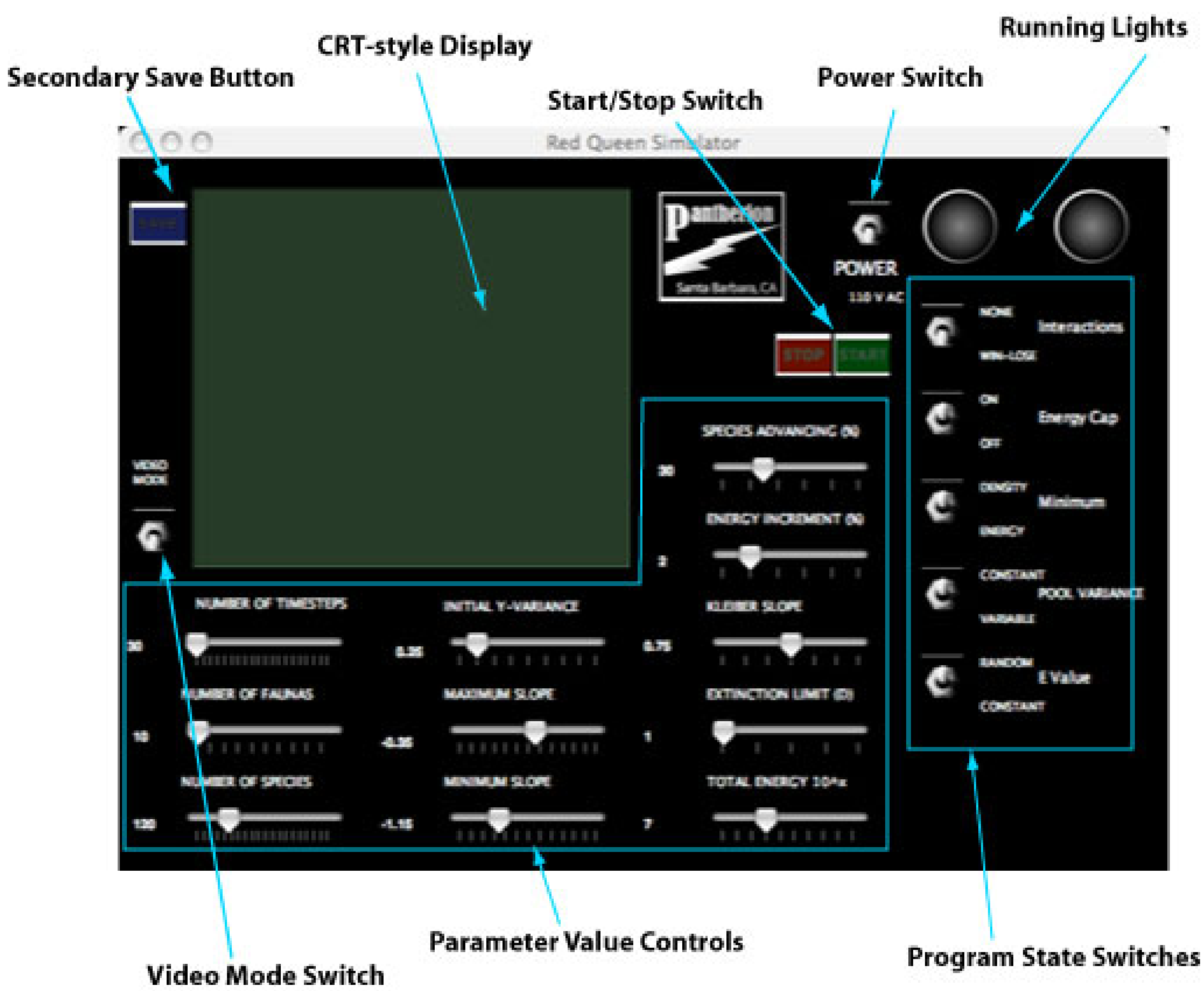
Red Queen Simulator



User's Manual

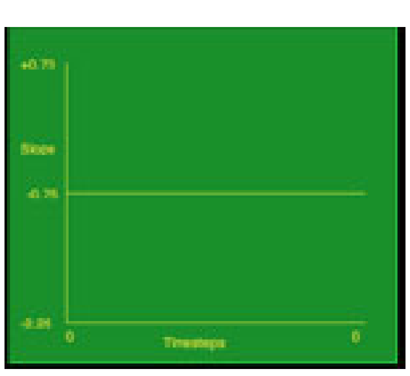
The *Red Queen Simulator* allows a user to follow the trajectories, over time, of size-abundance regressions in communities, and to observe the effects on these trajectories of evolutionary "winner-loser" interactions among the species. The simulation, its assumptions and scientific relevance are described in Damuth (2007) and in a brief set of notes for users wanting a rapid outline orientation.

1. Upon successful launch, the user is presented with this graphical display, which is reminiscent of a conventional electronic laboratory device of the last century:



Before a simulation run, users can modify many parameters and program states. *Quick Start:* The default values at startup will perform a quick simulation of 10 faunas for 30 timesteps each, with species interactions turned on. This will allow you to explore how the application works with some reasonable settings. IMPORTANT: Nothing will happen until you turn on the Power Switch!

2 To begin, turn on the Power switch by clicking on it once. You will notice the left running light will glow red, indicating power, the Start Button will be illuminated, and the CRT-Style display will begin to warm up. After a few seconds the Display will show an empty graph (below, 3). The application is now ready to run a simulation.



3 This is the "Slopes" screen, with slope values on the vertical axis and timesteps on the horizontal axis.

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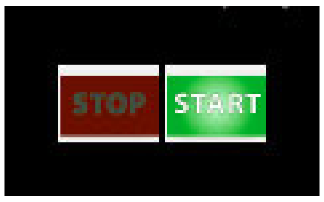
Basic Controls



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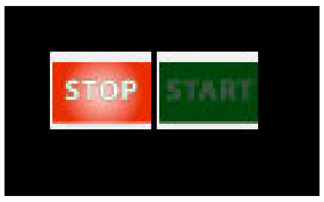
START — Begins the simulation run. The currently specified Number of Faunas are followed for the specified Number of Timesteps. The right running light glows green while the simulation is executing. At the conclusion, two files are automatically saved in the current working directory (where the application was started): `rqxxx.params.txt`, and `rqxxx.output.txt`, where "xxx" is a run identification number (starting at 001 and increasing by 1 each time a run is performed from that directory). The *params* file lists the parameter values and program states for the run, and the output file the mean value and 95% confidence interval of the faunal slopes for each timestep.

MAC OS Only: You can use the Preferences option under the application's name in the Finder's menu bar in order to choose an alternate location for the output files.



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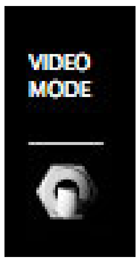
STOP — Aborts the currently running simulation. Note that after an abort, the application nevertheless writes the *params* and *output* files, but can use only the information already accumulated, so the statistics may be inaccurate.



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VIDEO MODE — This switches the display between showing the default "Slopes" graph (3) to show the regression of log population size ("density") on log body mass at each timestep. Each point is a single species. New species flash red during the first timestep that they appear. The horizontal (Body Mass) axis is fixed and values range between 0 and 6. The vertical axis (population size) is essentially arbitrary and depends on the Total Energy Available (10).

Although you can toggle between these two video modes while a run is in progress, they do not pass information to each other; the slopes display starts from a clean slate each time the mode is changed, so it would not show the complete run.

Note: The application initially attempts to scale the regression graph so that the regression appears in the center, but it is not always successful, and can't anticipate the ultimate results. Sometimes changing the Total Energy Available will help the application to choose more wisely.

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At the conclusion of each run the SECONDARY SAVE button illuminates. Its function depends upon the display's current video mode. If in the default Slopes mode, clicking the SAVE button allows one to save an image of the display in PNG format (works well ONLY in MAC OS X; if using other platforms use a screen grabber application instead!). If in Regression mode, the button allows you to save a text file with the energy-use and body-mass values of the current (final) regression, which is showing on the display. This way, one can analyze the community data ultimately produced by a run. However, you cannot sample sequential regressions throughout the course of a run using the current application.

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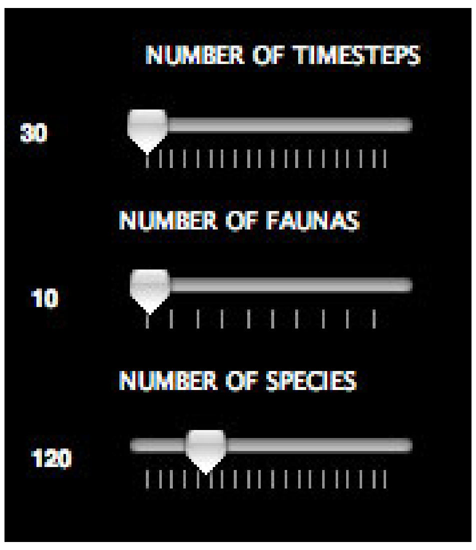
Parameter Sliders

These allow one to set the values for various parameters. The application checks them at the beginning of a run only — changing their values while a run is in progress has no effect. Change the values by clicking and dragging with the mouse. Alternatively, for finer control click the slider with the mouse to select it, and use the right and left arrow keys change the values.



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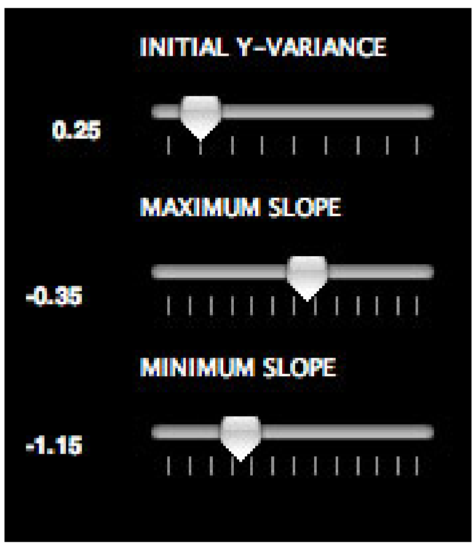
NUMBER OF TIMESTEPS and NUMBER OF FAUNAS are straightforward. These determine for how many timesteps each fauna is followed, and for how many faunas this process is repeated, the whole constituting one run.

NUMBER OF SPECIES represents the initial number of species in each fauna. Because species sometimes become extinct and are not replaced right away, this is a maximum value and the average throughout the course of the timesteps is somewhat less than this, depending on the other parameters.

The number of species has a marked effect on the speed at which the simulation runs. Also, note that the simulation tends to become **unstable** if you specify fewer than about 20 species.



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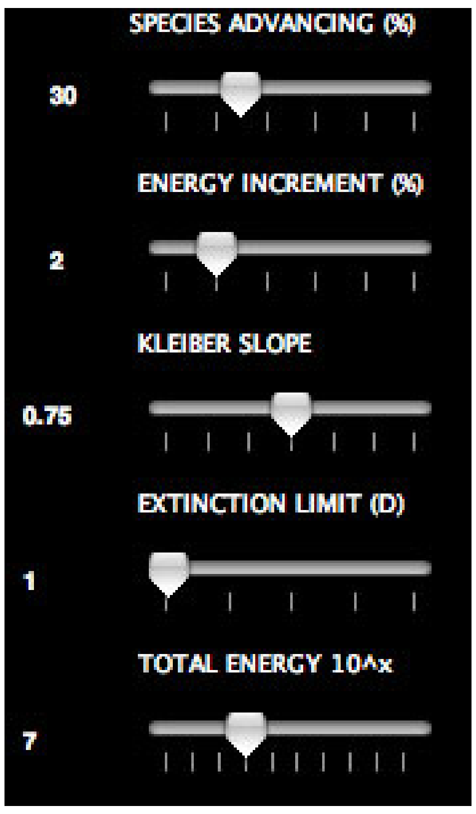
Each iteration within a run starts with a new fauna, for which a slope has been specified (or randomly generated) for the fauna's regression of population size on body mass. The species are randomly assigned body masses, then are assigned population sizes based on this slope. The population sizes are then randomly dispersed about the line of the slope, by means of a Gaussian distribution using the INITIAL Y-VARIANCE. This makes it possible to start the simulations with realistic-looking faunas rather than ones where every species lines up along the slope. (A value of about 0.25 produces faunas that look reasonably like empirical ones.) After the first timestep, the actual variation about the regression slope depends on the simulation processes and is no longer constrained by the initial y-variance. (See POOL VARIANCE, 11).

The MAXIMUM and MINIMUM SLOPE values set the range of slopes that will be used to start new faunas. Slope values will be chosen from a uniform distribution within the bounds set here. In the case where both sliders are set to the same value, all faunas in a run will start with the same slope.

NOTE: Certain assumptions of the model cause the simulation to tend to be **unstable** if the slope becomes very shallow or positive, particularly in combination with some values for TOTAL ENERGY (10). Although it is possible to set a positive slope value for the initial slope, this can increase the probability that the application will exceed some of its numerical limits. Try it anyway — it can be informative.



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SPECIES ADVANCING — The expected percentage of species that will make an evolutionary advance in a given timestep.

ENERGY INCREMENT — For a species making an evolutionary advance, the percentage by which each individual increases its energy. This can be given a small random component using the *E value* program state (11).

KLEIBER SLOPE — This allows one to explore the behavior of the simulation under alternate exponents for the scaling of individual metabolism. The most widely accepted empirical value is approximately 0.75 .

TOTAL ENERGY — The total energy available to the fauna is 5 X 10^{x}, where *x* is the value specified here. Much of the time this value is arbitrary and will have no effect on the simulation. However, it does interact with the number of species and can affect the behavior of the simulation. It is possible, for example, to have it set too low, such that within the first few timesteps most of the species go extinct, leading to unpredictable behavior. Likewise, if it is set too high and some species become energetically dominant, their energy use may exceed numerical limits and cause an error. Many times what is happening will be apparent from the visual output. If you are having trouble with **instability** even though the other parameters seem reasonable, try varying the Total Energy.

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Program States

There are 5 switches at the right that control overall states of the simulation.

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INTERACTIONS — The simulation is designed to study the effects of "winner-loser" interactions, so they are the default. However, one can also remove species interactions (leaving everything else the same) and compare the behavior of species abundances under random walks. Instead of there being winners and corresponding losers, winners simply gain or lose a small amount of energy. Extinction and replacement of species occurs as usual. There are two possible modes, depending on the ENERGY CAP setting.

ENERGY CAP — (Used ONLY if the INTERACTIONS are set to "NONE"). When "ON", the gain or loss to any focal species is immediately portioned out (as a loss or gain, respectively) to all other species equally. The total amount of energy remains fixed, and the gain or loss by the focal species does not change the population sizes of any of the other species relative to each other. When "OFF", winner species simply lose or gain energy without any regard to other species. In this case, the total amount of energy used by all species of the fauna can change, and increase without limit. Simulation behavior under both modes is very similar, and differs radically from that seen under winner-loser interactions.

MINIMUM — Simply a toggle that determines whether the criterion for species extinction is the result of low population size ("Density"; how low a population is determined by the Extinction Limit slider [10]), or the result of relatively low energy. In the latter case the species becomes extinct when it reaches one half of the lowest energy observed for any species in the initial regression.

POOL VARIANCE — Indicates the variance used to generate new species from "outside" the community. If CONSTANT, it is always the value of *Initial Y-Variance* (9). If VARIABLE, the variance about the current timestep's regression is used. Note: New species are assigned a random body mass, and the slope for making new species is always the current slope exhibited by the community.The Pool Variance is the variance about that slope. The effect of this state is negligible.

E VALUE — Determines whether the amount of energy demanded in an evolutionary advance has a small random component added. The effect of t his state is negligible.

