Documentation for Quantitative Biological Risk Assessment Tool (QBRAT)

Version 3.2

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Introduction

Application Overview

This document describes a software application called the Quantitative Biological Risk Assessment Tool (QBRAT) developed for Fisheries and Oceans Canada to implement a Biological Risk Assessment Framework. The application is structured around that framework's decision chain which is used to model invasion by an exotic species. The chain consists of four levels, each representing a question with respect to the invasion by a species at a particular location: "Arrives?", "Survives?", "Establishes?", and "Spreads?". With each question is associated a probability of success or failure, success leading to the next level in the chain. With each failure is associated a numeric estimate of impact, and a risk is calculated as the product of that impact and all of the probabilities leading to that point in the chain. A fifth impact and risk is associated with success at the final level in the chain. A Total Biological Risk (R_B) is calculated simply as the sum of the five risks.

With version 2 and higher, the risk chain has been modified to associate a fixed cost with each chain level, in addition to the probabilities and impacts described above. When a fixed cost is multiplied by the product of probabilities leading to each point in the chain, the result is termed here as a management cost, and the sum of the four such products is the total management cost (C_T) anticipated as the consequence of a species invasion.

Version 3 introduces support for categorical impacts and/or costs.

The purpose of the software described here is to:

1. collect the probabilities, impact estimates, and fixed cost estimates provided by the user,
2. collect estimates of uncertainty with respect to those values, and
3. run a Monte Carlo simulation to illustrate the likely distribution of total biological risks and management costs given those estimates and to gauge the sensitivity of those results to uncertainty surrounding the probability, impact, and fixed cost estimates.

Requirements

The software was written in Microsoft Visual Basic 6 (VB6) and has no special requirements other than a Win32 operating system and a reasonably fast machine. A Pentium 2-400 or faster with at least 256 MB of memory is recommended. Best results will be obtained with an 800 x 600 or better display using 16-bit colours or higher.

The only external requirement is the presence on the system of a licensed copy of Entisoft Tools (v2.1 Standard), which is normally ensured by installing the software using the install set provided by JEMSys.

Using the QBRAT software

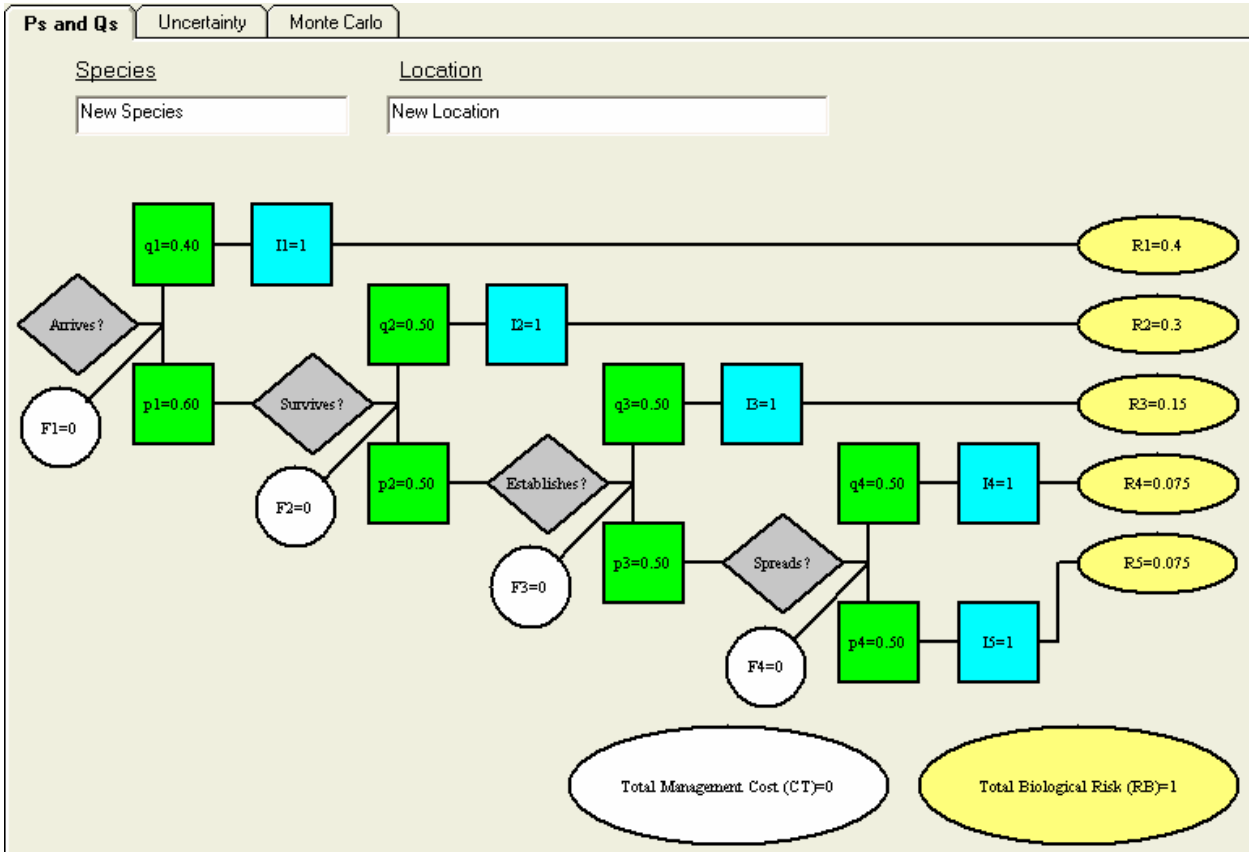
Overview

The software consists of a single window with all of that window's elements organised using a tab structure with three tabs:

1. **Ps and Qs,** where the primary data (estimated mean probabilities, impacts, and fixed costs) are collected,
2. **Uncertainty**, where uncertainties are assigned to those data, and
3. **Monte Carlo**, where the Monte Carlo simulation is done.

These are described separately below. Usually the work of an analysis would proceed in tab order as though you were working with a wizard. However, you are not constrained to doing so. Going back and forth at any time and in any order is allowed.

Ps and Qs Tab

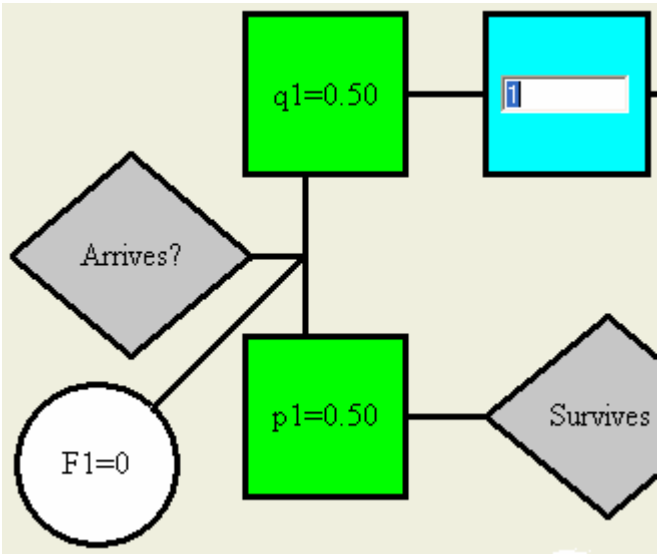


The **Ps and Qs** tab contains two text boxes for specifying the species and location to which an analysis applies, and it contains a graphical representation of the decision chain. The latter consists of four types of elements: a) decision diamonds which (for the purposes of the software) identify the level in the decision chain, b) square boxes which associate particular probabilities and impacts with the chain level, c) circles which associate a fixed cost with each chain level, and d) risk ovals which just display the risks calculated for each chain level. A large oval in the lower-right corner shows the R_B value computed given the probabilities and impacts currently displayed on the chain, and a second large oval to its left displays the corresponding C_T value.

To begin an analysis, just enter text (any text, any length) in the species and location boxes and then enter estimates of probabilities, impacts, and fixed costs as described next.

Entering the primary data (means)

Other than the two text boxes, the only parts of the **Ps and Qs** tab which are interactive are the square probability and impact boxes, and the circular fixed cost elements.. The probability boxes are labelled “pn” and “qn” where n is the level in the decision chain, p is the probability of success at that level, and q its complement (the probability of failure). Impact boxes are usually coloured differently and are labelled “In”. The fixed cost circles are labelled "Fn". To enter a value in any of these elements, just click somewhere inside of the box or circle, and a floating text box will appear and have the focus, e.g.:



For probabilities, just enter a number in the text box between zero and one inclusive. For estimates of impacts or fixed costs enter any numeric value. To hide the floating text box and display the value you just entered in the chain box, do one of three things:

1. Hit the Enter key
2. Click somewhere else in the application, including another square box
3. Hit the Tab key to move to the next box, or Shift-Tab to the previous.

Entries outside the range of allowable values as well as non-numeric values will simply be ignored. Also, since p and q are complementary, a value entered for one will automatically be reflected in the other so that at each chain level, the two always sum to one. The q probabilities are not actually retained and dealt with as such anywhere else in the application. Being able to enter them here is simply a alternative way of enter p values.

Calculation of risks and management costs

At any level in the chain, a risk is associated with the q probability box and is calculated as the product of the associated impact with the q probability (1-p) and all of the p values for prior elements in the chain. Thus:

$R1 = I1 * (1-p1)$

$R2 = I2 * p1 * (1-p2)$

$R3 = I3 * p1 * p2 * (1-p3)$

$R4 = I4* p1 * p2 * p3 * (1-p4)$

an additional impact and risk is associated with the p probability box at the last level in the chain:

$R5 = I5* p1 * p2 * p3 * p4$

The Total Biological Risk is given by:

$R_B= R1 + R2 + R3 + R4 + R5$

Management costs are calculated in an analogous manner:

$C1 = F1$

$C2 = F2 * p1$

$C3 = F3 * p1 * p2$

$C4 = F4 * p1 * p2 * p3$

The Total Management Cost is given by:

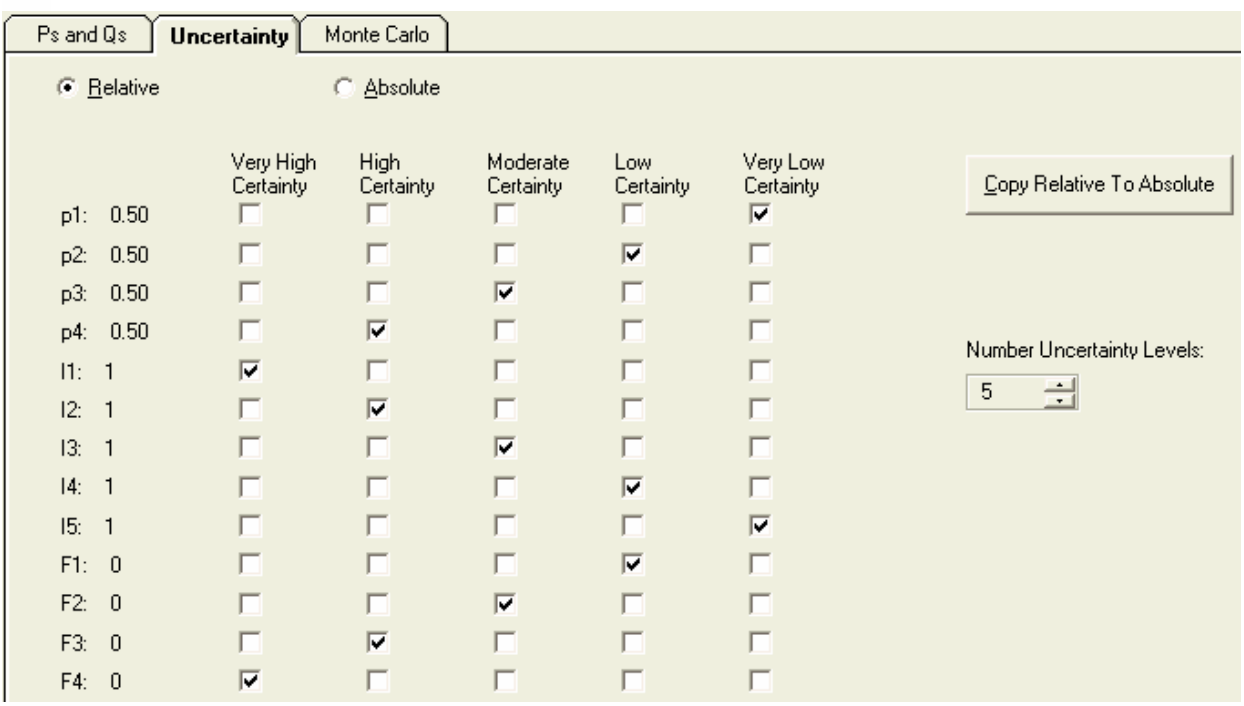
$C_T = C1 + C2 + C3 + C4$

Uncertainty Tab

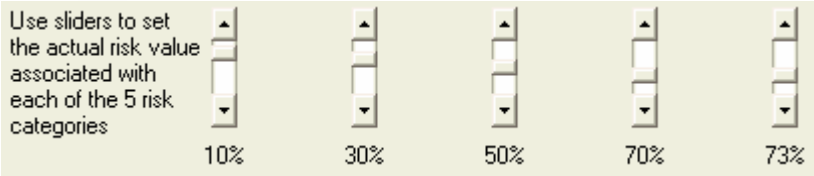
Before a Monte Carlo simulation can be done using the primary data (means) entered on the **Ps and Qs** tab, estimates of uncertainty around those values must be obtained. There are two aspects of each uncertainty, an assumed measure of variability and the assumed form of the underlying probability distribution. In this application, variability is ultimately always expressed as a standard deviation (SD) which may be expressed absolutely as such, or it may be expressed relatively as a percent relative to its associated mean value. The supported distribution types are limited to uniform, normal, and log-normal. For the four probabilities, the beta distribution is also supported.

The **Uncertainty** tab has two radio button options: **Relative** and **Absolute**, described separately below. Their function is to collect uncertainty estimates in either of the two ways just mentioned. They function independently and can always be used that way, but in practice the distinction between the two may become blurred as you may wish to combine their functions.

Relative uncertainty



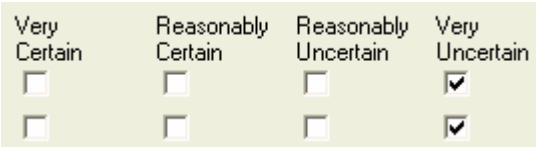
The **Relative Uncertainty** tab provides access to a simple and straightforward way of expressing uncertainty. The four p probabilities, five impacts, and four fixed costs collected on the **Ps and Qs** tab are arranged down the left side. For each, one can place a check mark in one column corresponding to one of five generic levels of uncertainty: “Very High Certainty”, “High Certainty”, “Moderate Certainty”, “Low Certainty”, and “Very Low Certainty”. Beneath each column is a slider that associates with that column a numeric value between 0 and 100%, which ultimately is translated to an SD expressed as a percent relative to the mean.:



These can be changed at any time and will be retained from time to time. As you move the sliders up and down, the software acts to ensure that the ordering of the five values remains consistent with the intent of the columns.

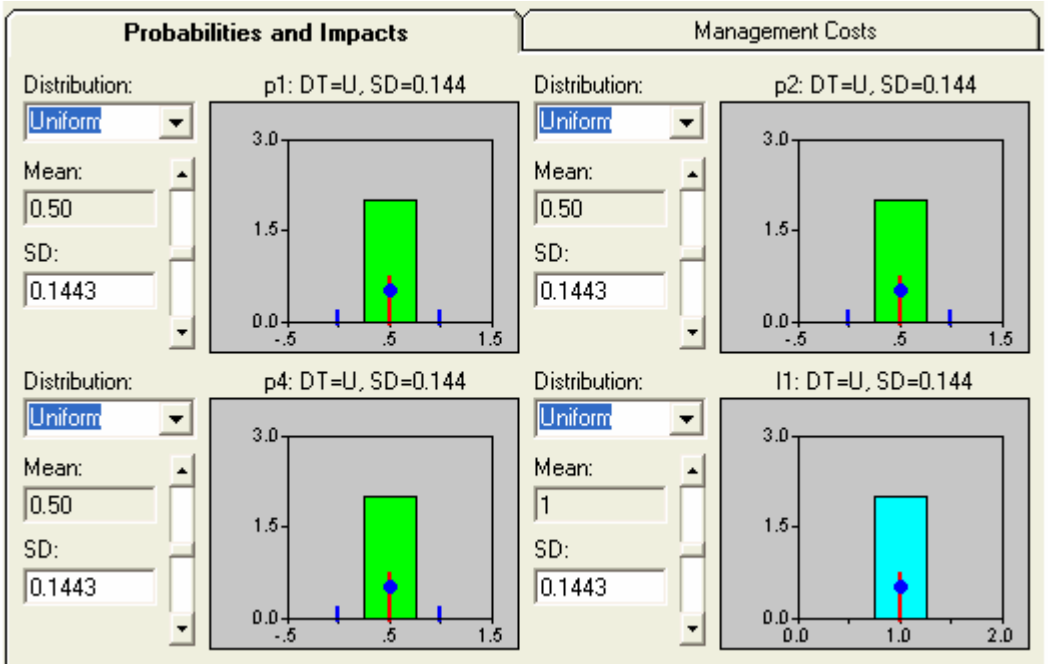
A weakness of this scheme is that it produces SD values of zero when the mean is zero, it being possible to enter such mean values on the **Ps and Qs** tab. To deal with this situation and with the fact that the assumed distribution when working on the **Relative Uncertainty** tab is always the uniform distribution, the **Copy Relative to Absolute** button is provided. Click on this to set up the **Absolute Uncertainty** tab with the equivalent of the settings currently on the **Relative Uncertainty** tab.

Beneath the **Copy Relative to Absolute** button is an up-down spinner labelled **Number Uncertain Levels** which allows you to change the number of uncertainty levels from five to four and vice versa. When the number of levels is four, the software behaves as it did for earlier versions. There are four sliders and that many columns in the checkbox array, labelled as:



Absolute uncertainty

The **Absolute Uncertainty** tab is shown in part here:

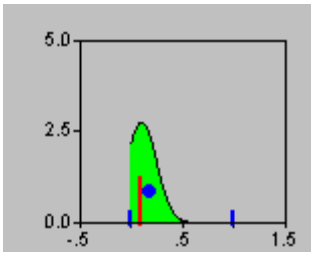


What's shown here are four of a three-by-three array of absolute uncertainty elements on the **Probabilities and Impacts** sub-tab, one for each of the nine means (four p values and five I values). Clicking on the **Management Costs** sub-tab would reveal a similar array of four uncertainty elements corresponding to the four fixed costs. Each features a plot of the calculated probability distribution given its mean and the current value of SD. Above the plot, a label identifies which of the means is involved, as well as showing the distribution type ("DT") and the SD value. To the left of the plot there is a drop-down box allowing you to switch between distributions, a text box showing the value of the mean (which cannot be changed here), and a text box where an SD value may be entered.

The latter text box and the slider to the right of it are where the work on this tab takes place. Entering a value in the text box changes the "base" value of the SD associated with the mean above it. Doing so resets the slider to its midpoint. Moving the slider over its range then changes the SD value between 2/3 and 1.5 times its base value. As that motion occurs, the SD value shown in the text box and in the plot label also changes. The changing SD value is immediately reflected in an updated plot of the distribution.

An alternative to entering the SD value as an absolute value is to enter it as a coefficient of variation (CV) which is done by appending "%" to the number entered. When this is done, a base value of the SD is computed using the percent relative to the mean. As the slider is moved, the text box shows a changing percent (labelled now as "Plus/Minus" for uniform distributions and "CV" for the others), but the plot label continues to show the implied SD, which is the value that will actually be used in the Monte Carlo simulations.

Some details regarding the plots are illustrated here:



The small blue bars at zero and one on the x-axis are intended to show that the probability distribution has been constrained to that range (truncated). This will be true of all of the p distribution plots. The red bar shows the mean (expected value) as entered on the **Ps and Qs** tab, while the small blue circle shows an estimate of the expected value implied by the truncated distribution. That is, it illustrates the bias introduced by truncating the distribution. It's shown on all 13 plots because its location and that of the mean will not be the same for log-normally distributed values.

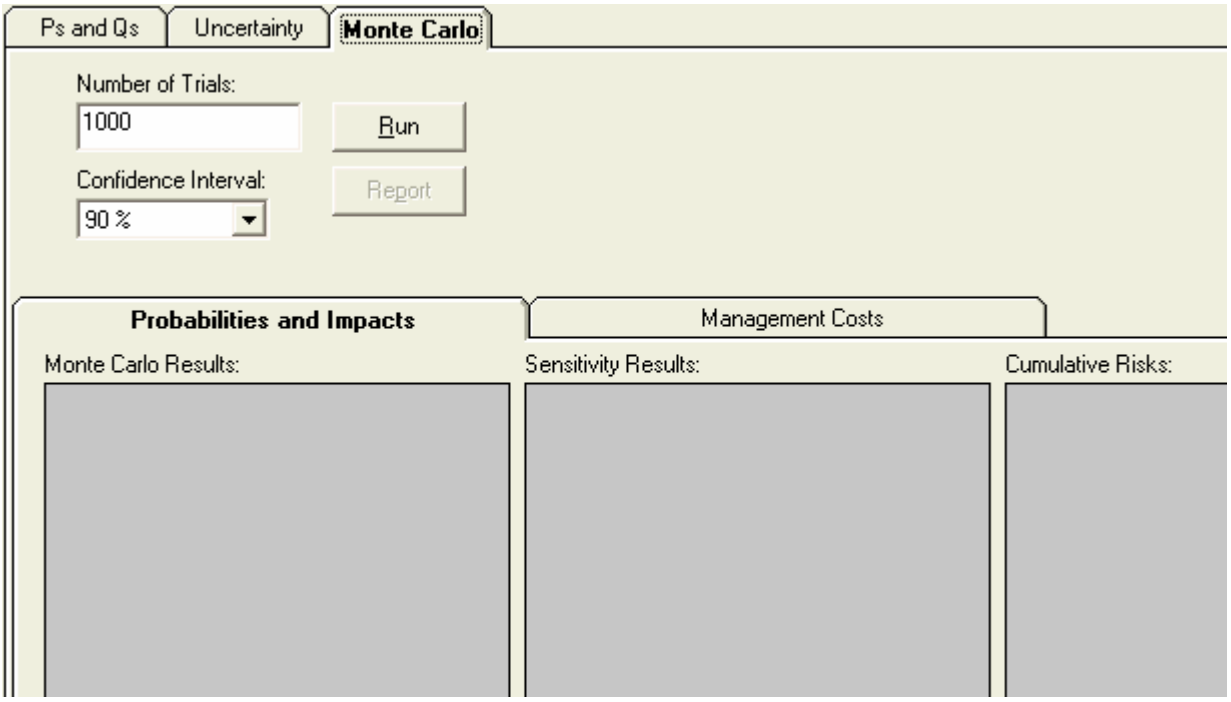
If categorical data are involved for impacts or costs, a plot will not be generated. In it's place a small non-interactive table is presented, showing the category values and their associated probabilities:

Impact	P (0-1)
-200	0.45
-100	0.05
0	0
100	0.35
200	0.15

See "Using Categorical Impacts and Costs" below for details.

Monte Carlo Tab

When a complete set of means has been entered as the primary data on the **Ps and Qs** tab and corresponding SD values estimated on the **Uncertainty** tab, a Monte Carlo simulation is possible. Prior to running one, the **Monte Carlo** tab looks (in part) like this:

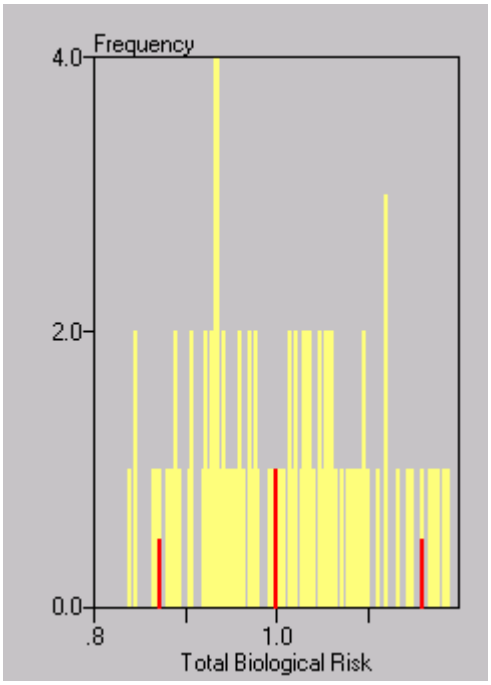


Provided here are a text box to enter the number of simulation trials to run, a drop-down list of three possible confidence intervals (90, 95, and 99 %) to generate, and buttons to run the simulation and to generate a report. Note that there are again two sub-tabs, **Probabilities and Impacts** and **Management Costs**, showing results for risks and costs respectively. Space is provided on each sub-tab for three plots of results, all of which are initially blank. The **Report** button is initially disabled because there are no results on which to report.

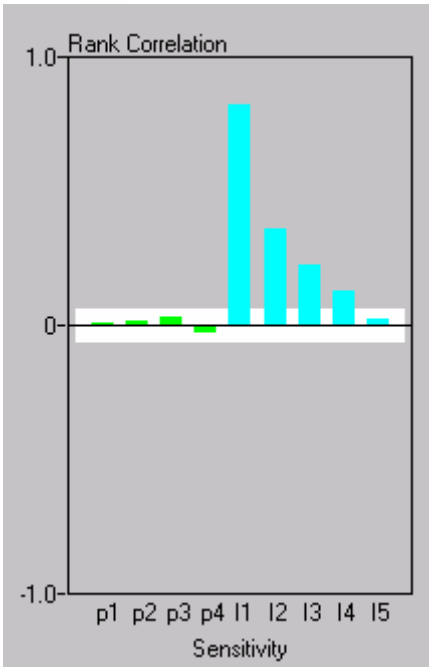
Note that the description of the results below is specifically for those that appear on the **Probabilities and Impacts** sub-tab. Everything described also applies to the **Management Costs** sub-tab.

Running a simulation

To run a simulation, choose a number of trials between 1000 and 100000, the desired confidence interval, and click on the **Run** button. When the simulation has completed (which may take a few seconds to a few minutes), a frequency plot of the results is shown in the left-hand plot:



This shows the simulation R_B values as a frequency distribution where the heights of the bars add up to the number of trials chosen. The red bar in the middle of the plot is the mean value of R_B as shown in the large oval on the **Ps and Qs** tab. The smaller red bars on either side of the mean represent the limits of the chosen confidence interval. A second plot shows the results of a sensitivity analysis:

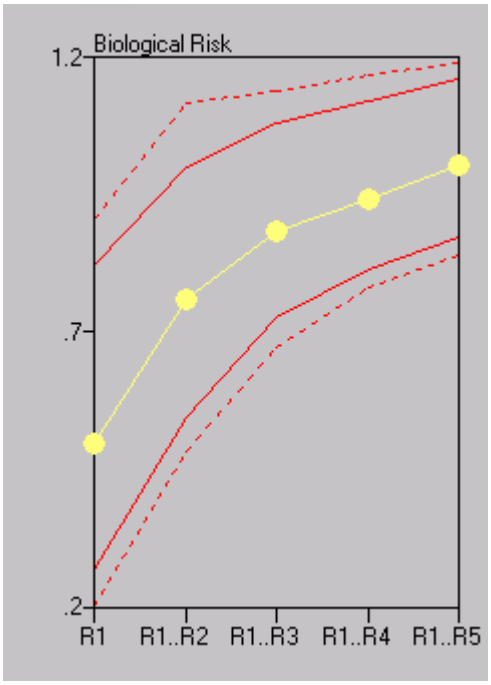


What this is intended to show is how variation in each of nine values (four p values and five impact values) is correlated with variation in R_B. There is a bar plotted along the x-axis for each of the nine values and on the y-axis are rank correlation coefficients from -1 to +1. Centred about the zero

correlation line is a shaded area which represents the region inside of which the correlation coefficients are not significantly different from zero. Details of this analysis and the simulation process in general are provided below under Monte Carlo Simulation Algorithms.

Additional information concerning sensitivity is available via a pop-up menu over the sensitivity plot and is discussed below under Sensitivity Details.

The third and final plot looks something like this:



The central line here is a plot of simulation means for cumulative biological risks, where R1 is the simulation mean of R1 (c.f. "Calculation of risks and management costs" above), R1..R2 is the same for the sum of R1 and R2, etc..

With any of these plots, some customisation can be achieved by double-clicking on the plot itself, popping-up the plot options module, described below as part of the **Options** module.

Also appearing on the Monte Carlo tab after a simulation run is the following:

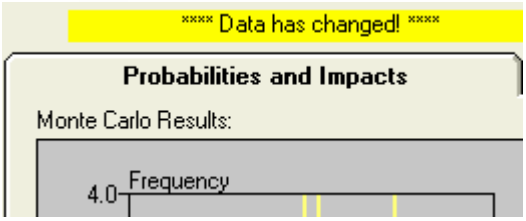
TBR, Sim Mean, Sim SD, Lower Limit, Upper Limit:

1	1.013	10.18	0.8412	1.175
1	1.002	10.06	0.8729	1.159

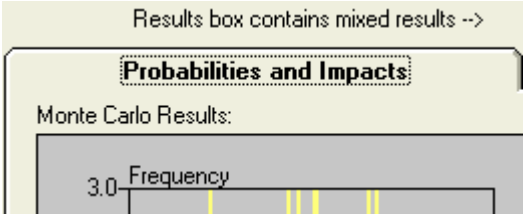
It shows the R_B value (the same value appearing as the red bar on the frequency plot) and the sample mean and standard deviation for the simulation results. Also shown are the simulation confidence limits, corresponding to the smaller red bars on the frequency plot. It accumulates these results over

successive simulation runs until the **Clear** button is clicked. A similar but separate results box accumulates total management cost results and is the box visible when the **Management Costs** sub-tab is clicked. In either case, the last line in the results box always corresponds to the most recent simulation run and the currently displayed graphs.

There is one final consideration about this application view. Since you are not constrained to using the application as a wizard, it's possible to switch away from the **Monte Carlo** tab and change something that would effectively invalidate the results currently showing on the simulation tab. The software detects this and warns you instead of simply discarding the current set of results:

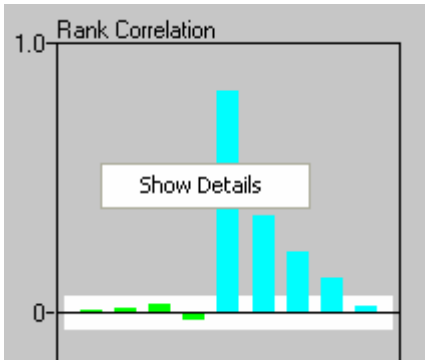


Things otherwise remain the same, and it's possible to switch back and undo the change made with the effect of restoring things to the state they were in before the change. However, as long as the results box contains results obtained with differing input data or specifications, some sort of warning will remain visible. If a simulation is run with the warning appearing as it does above, the warning will change to the following and remain that way until the **Clear** button is clicked:



Sensitivity details

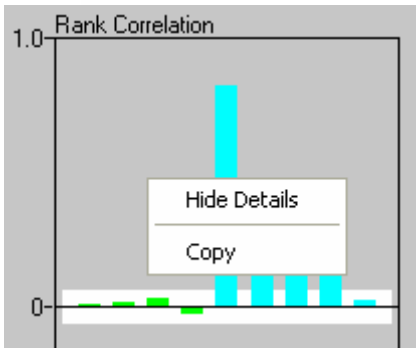
As discussed above, if a Monte Carlo simulation is successful, a sensitivity plot will appear on each **Monte Carlo** sub-tab, showing rank correlation coefficients relating variation in the simulation value with variation in each of the input values represented by the vertical bars. If you right click anywhere on the plot a pop-up menu will appear, looking something like the following;



Clicking on the **Show Details** menu item causes a table like the following to be displayed immediately above the plot:

Raw R2=	0.997			Const=N
Ranks R2=	0.961			Tails=2
	SPEA	PEAR	SRC	SRRC
p1	.007	.001	-.003	-.067
p2	.017	.017	-.004	-.073
p3	.031	.035	.016	-.030
p4	-.024	-.019	-.001	-.076
I1	.823*	.822	.524	.766
I2	.359*	.372	.250	.320
I3	.226*	.228	.119	.124
I4	.125*	.126	.069	.050
I5	.020	.025	.055	.007

Right-clicking on the plot while such a details table is showing brings up a different pop-up menu:



Clicking on the **Hide Details** item hides the table. Clicking on the **Copy** item causes the table to be copied to the clipboard from which it may be pasted directly into applications such as Excel.

While the details table is showing, the plot is interactive in that as the mouse cursor is moved over the bars, the corresponding row in the details table is highlighted, making it easy to relate the plot to its associated details.

The details contained in the table are as follows:

1. Raw R2 - the squared multiple r obtained by doing a linear regression of the simulation result on the input factors before rank-transformation of the simulation trial data
2. Ranks R2 - the same quantity computed after rank-transformation of the simulation trial data
3. Const - "Y" or "N", denoting whether or not a constant was included in the multiple regression
4. Tails - 1 or 2, denoting whether or not the t-test of the rank correlation coefficients is one- or two-tailed, relating to the shaded area on the plot as discussed below

Each input factor is identified at the beginning of rows five and higher, and for each of them there is a value for each of four sensitivity metrics, where each metric relates variation in the simulation value (total risk or total cost) to variation in the input factor. The metrics are identified as they are in SimLab (c.f. SIMLAB, 2004 and Saltelli et al., 2004):

5. SPEA - Spearman's rank correlation coefficients (the values also appearing in the plot), calculated as Pearson's correlation coefficients using rank-transformed data
6. PEAR - Pearson's correlation coefficients computed before rank-transformation
7. SRC - standardised regression coefficients before rank-transformation
8. SRRC - standardised regression coefficients After rank-transformation

Rank transformation is discussed below under Sensitivity Analysis and properly accounts for ties, which can occur, especially when the simulation results consist entirely of zeroes.

Hypothesis testing of the SPEA values is done using a t-test as explained below. Since the null hypothesis is rejected when a rank correlation is not equal to zero, the test should be two-tailed, but the software does support a one-tailed test, hence the need to report in the details table which sort of test was done. In that table, values of SPEA significantly different from zero are marked with an appended asterisk. These are values that fall outside of the shaded zone on the sensitivity plots. The width of that zone is a function of the simulation number of trials and of the significance level which is the same as the level chosen for the confidence interval, i.e., 90, 95, or 90 percent.

Creating a report

Clicking on the **Report** button causes the software to prompt for a destination RTF file. When one has been chosen, the software reads a file called “ReportTemplate.rtf” and makes substitutions in its contents with:

1. the current primary data
2. the implied biological risks, management costs and their respective totals
3. simulation statistics (N, mean, SD, and confidence limits)
4. sensitivity results (as rank correlation coefficients, their significance, and associated R^2 values)
5. cumulative risk or cost results (each as simulation mean, min, max, and confidence limits)
6. and monochrome versions of the same plots as appear on the **Monte Carlo** tab.

The report generated always reflects the results obtained with the most recent simulation run. It has two pages, the first for biological risks, the second for management costs.

The resulting report appears in the destination RTF file and can be opening directly by Microsoft Word. A copy is also left on the clipboard and can be pasted from there into Word. Word 97 or later is

required to read the RTF files. If Word is present on the user's machine and is the application associated with the RTF file extension, it will optionally open the RTF file automatically.

The black and white plots that are part of the report are the same as those that appear on-screen except that the R_B ,C_T, and limits bars appear as a somewhat wider cross-hatched versions on the frequency plot. The shaded area that appears in sensitivity plots appears in the equivalent plot report as a box with a dashed outline.

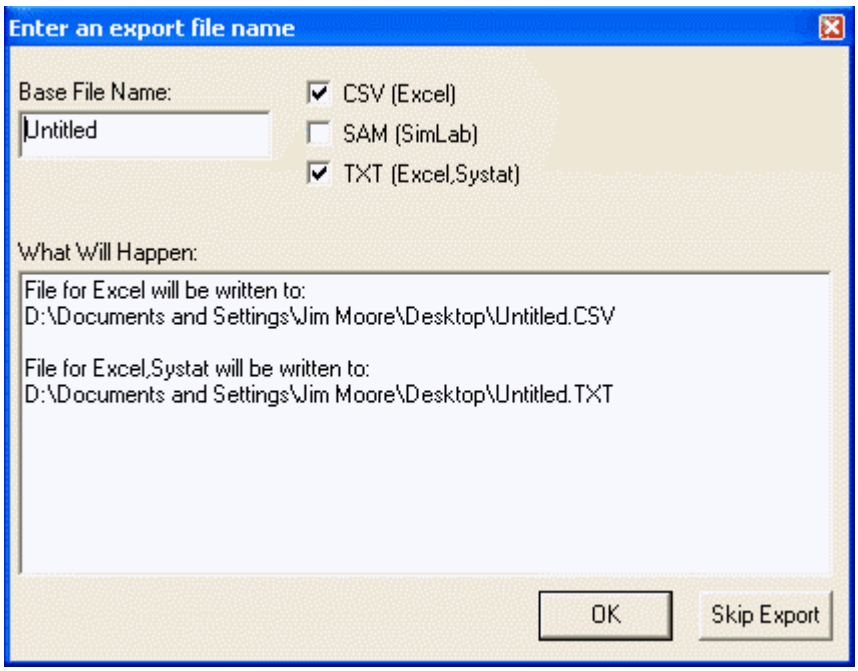
When the report is for a simulation involving categorical data, an extra page is appended which shows the categorical data. For each impact or cost for which there is categorical data, a little table appears, looking very much like the tables used to edit and display that data by the QBRAT software, each table consisting of a column of category values and a column of category probabilities. If the RTF reader (such as Microsoft Word) is compatible with RTF v1.6 or later, there will be an array of up to five impacts tables in a single row (if impacts are categorical), and a similar row of costs tables. For less capable RTF readers, the tables appear in a single column along the left side of the page.

Note that if there is reason to believe that the "ReportTemplate.rtf" file (located in the application folder) is corrupted or not up to date, it can be deleted, and the software will recreate it the next time a report is requested.

Exporting simulation results

To enable an analysis of simulation trial data that goes beyond the features provided by QBRAT, the software provides a means for exporting that simulation data in one of several formats. Support for this feature appears in two places in the application.

First, the **Options** module described below has an **Exports** tab on which you select a folder into which the exported data will be written and on which you select one or more formats to be used when writing the data. Initiating an export of simulation trial data requires that one or more file formats be selected on this tab. When this is so, a dialog like the following will open at the start of any simulation run:



In the text box labelled **Base File Name** enter a file name without an extension. This defaults to "Untitled" but can be anything you wish, so long as it's a valid file name. An extension will be added to this name which is appropriate for each selected file format. You may also use this opportunity to change the latter. In the large text box at the bottom of the dialog a description is provided of the actions that will occur as a result of your choices in this dialog. Clicking on the **OK** button causes the Monte Carlo simulation to run, during which the desired exports occurs. The **Skip Export** button cancels the file export, but the simulation run still occurs. Note that a warning is provided concerning the overwriting of existing files, but this is the only such warning. Finally, if the file format choices are all unchecked, no export will occur and this dialog will not appear again until a format is selected again in the **Options** module.

The currently supported export file formats are as follows:

1. CSV - comma-delimited text suitable for import into Excel and other applications; all simulation trial data is included
2. TXT - tab-delimited text suitable for import into Excel, Systat and other applications; again, all simulation trial data is included
3. SAM - proprietary import format for use by SimLab; only risks data is included in the file having the chosen name; costs data is written to a second file named by appending "_Costs" to that name. To facilitate use of SAM files within SimLab, two model files (QBRAT.imd and Costs.imd) are distributed with QBRAT and can be found in a folder called "Simlab" beneath the application folder.

Application Menus

File

The file menu includes these features:

1. New
2. Open
3. Save
4. Save As
5. Save Plot Options
6. Batch Mode
7. Exit

The last causes, as usual, the application to end and unload itself. The first four all relate to the state of application's internal data. The latter constitutes everything about the application that can vary from moment to moment, including the primary data and uncertainty specifications. It represents the application's state. With that in mind, the first four menu items perform these functions:

1. **New** - restores the application state to what is was at start-up except that all primary data and uncertainty specifications are given a set of internally defined default values
2. **Open** - restores the application state to that saved as a file with either **Save** or **Save As**
3. **Save** - writes the application state to a disk file using a format identical to the application initialisation file; the file name used is same as the one from the most recent **Open**
4. **Save As** - does the same thing, but with an opportunity to select a file name as the destination

   Version 2.5 adds these file menu items:

5. **Save Plot Options** - saves changes made to simulation plots (such as axis limits and tick intervals) to the applications options file, making them the default the next time the application is run
6. **Batch Mode** - opens the application's batch control module for creating, saving, and running risk assessment scenarios in batches

Edit

The edit menu includes these features:

1. **Copy** - copies the contents of the currently active control (a text box or picture box) to the clipboard
2. **Cut -** does the same, except for text boxes only and removes the selected text
3. **Paste** - pastes text from the clipboard into the currently active control

The first two of these are enabled only when the active control is a text box or picture, and even then only when it makes sense to do so. For example, for a copy there must either be selected text or their must be a qualifying picture. The latter consist of the chain image on the **Ps and Qs** tab, all of the little plots on the **Absolute Uncertainty** tab, and the plots on the **Monte Carlo** tab.

The **Paste** feature is only enabled when there is text to be pasted and the active control is a text box.

Options

There are five items on this menu:

1. **Custom Random Number Generator -** a checked menu item which toggles when clicked. When checked, the Monte Carlo simulations use a custom pseudorandom number generator called "ran1", coded from Sprott (1991). When not checked, VB6's internal Rnd() function is employed.
2. **Hide Management Costs** - another checked menu item. When checked, everything related to fixed management costs is removed from the user interface and reports, appearing not to be part of the application

   Version 3 adds two more checked menu items turning categorical impacts or costs on and off (where n is the current number of categories):

3. **Categorical Impacts (n)**
4. **Categorical Costs (n)**

   Version 2.5 added:

5. **Manage –** opens the **Options** module wherein the contents of the application's options file can be managed, allowing control of some aspects of the application's operation and appearance.

Help

There are two items on this menu:

1. **Risk Assessment Help -** shows this help file
2. **About -** shows the usual application About dialog

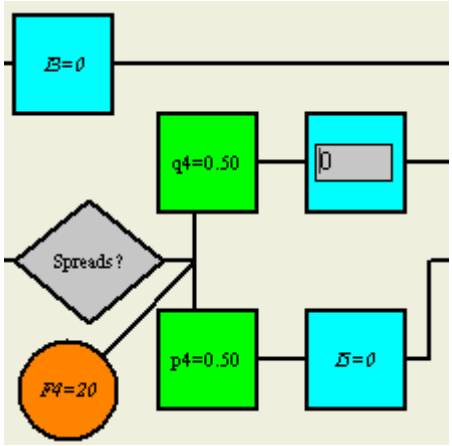
Using Categorical Impacts and Costs

The bulk of the description of QBRAT above has dealt with impacts and costs as each being a single value representing the mean of a continuous probability density having a form defined by the user in terms of distribution type and variance. It is also possible to represent impacts and costs as having a discrete distribution with each having a small finite number of possible values, each value having user-defined probability of occurrence. When so represented, impacts and/or costs are referred to as "categorical".

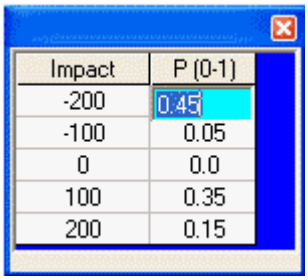
When impacts or costs are categorical in QBRAT, you define a set of one to five category values and you define corresponding probabilities for each. The values chosen may be anything in the domain of real numbers and are the same throughout the decision chain, i.e., when impacts are categorical the same set of impact category values is used for all five impacts in the decision chain and when costs are categorical the same set of cost category values is used through the chain. At each level in the chain. the associated probabilities are free to very between zero and one, with the constraint that the sum of those probabilities must be one. The mean value associated with each categorical impact or cost is the probability-weighted mean of the category values. The uncertainty attached to each mean is inferred from the set of category values and probabilities as a discrete probability density, analogous, for example, to the set of values and probabilities associated with each face of a die.

Impacts or costs may be categorical or both may be categorical. Whether or not they are is determined by the checked state of the corresponding checkbox on the **Calculation** tab of the **Options** module or of the corresponding menu item on the **Options** menu. The number of categories for either impacts or costs may be independently varied using the corresponding up-down spinner of the **Calculation** tab, and as noted above, can be from one to five.

When categories are in effect, the affected elements of the decision chain as displayed on the **Ps and Qs** tab are changed in appearance, their text being italicised and the floating text box appearing with a grey background, its text being the current probability-weighted mean of the category values, e.g.:



In this context, the floating text box will not directly allow editing, it's purpose being to serve as a stepping stone to a special table editor which permits the entry of category probabilities. To open the table editor, either double-click on the greyed-out floating text box or press the space bar while the textbox has the focus. Doing so brings up a simple two-column table with category values in the left column and currently associated probabilities in the right column:



Impact	P (0-1)
-200	0.45
-100	0.05
0	0.0
100	0.35
200	0.15

The category values may not be changed here, but instead must be entered through the **Calculation** tab of the **Options** module as described below. However, clicking anywhere in the probability column (or using the usual cursor movement keys) will allow the probabilities to be edited. Pressing escape will close the table editor with no changes, while closing the editor using the control box at the upper right will cause the data to be updated with your changes and a new mean value computed. Zeroes may be entered in the probability column and will be retained as such, unless all rows are zero, in which case all probabilities will be set to one divided by the number of categories. Negative values are treated as zeroes and values greater than one are treated as one. Whenever there is at least one positive non-zero value, the probabilities are always automatically adjusted such that they sum to one.

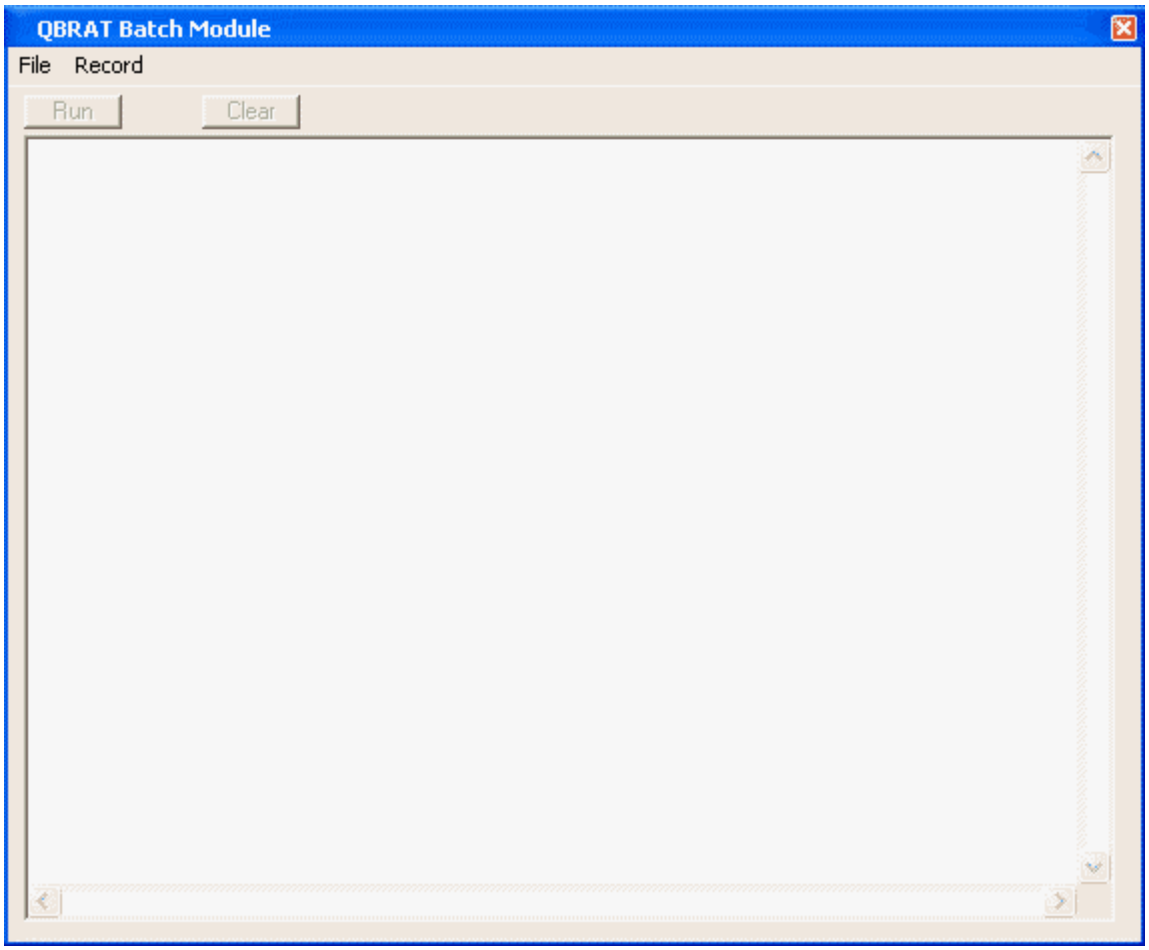
Apart from clicking directly in a cell to be edited, focus may be shifted from cell to cell within the table editor using Enter, Shift-Enter, the Up and Down arrow keys, and the Page Up and Page Down keys. In addition, the value in the cell above may be copied to the cell being edited by pressing Control-Quote.

When impacts or costs are categorical, their rows will not be visible on the **Relative Uncertainty** tab. On the **Absolute Uncertainty** tab they will be represented simply by an instance of their data in table editor format, but the data may not be edited there.

Because for categorical data there can be much more data than can be accommodated by the usual format of simulation reports, those reports will include the mean for impacts and costs as usual, but where the distribution type and standard deviation normally appear, an asterisk appears instead. A special third page is added to the report for the purposes of documenting categorical input data. On that page tabular representations of all categorical impact and/or cost data are presented.

Running Scenarios in Batch Mode

The batch control module is opened from the **File** menu by clicking on **Batch Mode**. Initially it will look like this:

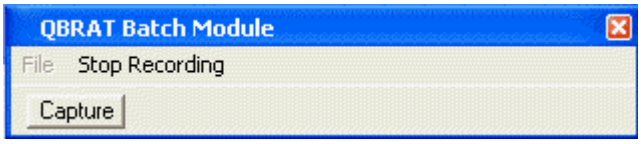


The objective when using the batch control module is to populate the large central text box with batch scenario specifications, one line per scenario. This may be in either of two ways:

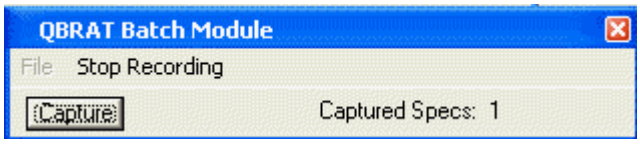
1. From this batch module's **File** menu, use **Open** to locate and load the contents of an existing batch file (*.RAB) saved earlier.

2. Use the batch module's recording mode to create and capture batch scenarios specified by making the desired changes in the main QBRAT application.

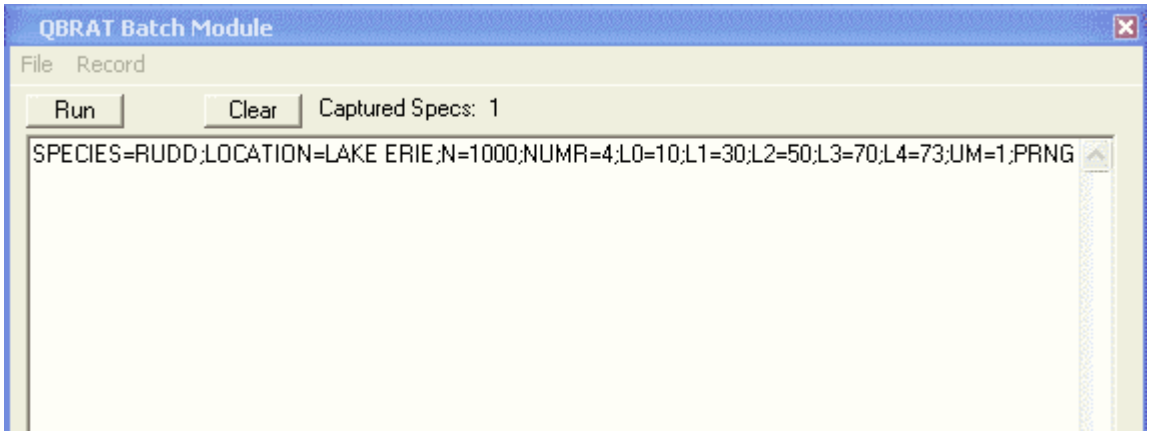
To do the latter, click on the batch module's **Record** menu item. This will cause the window to collapse and become docked to QBRAT's title bar, looking like this:



Create the application state representing one batch specification by switching back to the main application and making the desired changes to species name, location, probabilities, impacts, costs, and uncertainties, etc.. Capture that state by clicking on the batch module's **Capture** button. A counter will appear, providing evidence of capture and showing you how many scenario specifications have been captured:



Continue doing this until you've captured all of the specifications constituting one batch, then click on the **Stop Recording** menu item. The window will be restored to its full size, centred over the main application, and now showing the captured specifications in its main textbox. In this case there is only one, but a number between 150 and 200 can be captured:



With one or more scenario specifications available, the batch in the textbox can be:

1. Discarded by clicking on the **Clear** button or
2. Saved to a RAB file using the **Save** item of the **File** menu and/or
3. Run by clicking on the **Run** button.

If the batch is run, you will be prompted to provide the name of a file to which the results will be written, after which the batch will be run, the results appearing in the designated file. The latter is always a comma-delimited text file (*.CSV), and can be opened directly into applications such as Microsoft Excel. The first line in the CSV file has column headers which identify the data items in the remainder of the file. First the input data:

SPECIES	Scenario species
LOCATION	Scenario location
N	Number of simulation trials
NUMR	Number of relative uncertainty levels
L0	Percent uncertainty associated with the first relative level
L1	Percent uncertainty associated with the second relative level
L2	Percent uncertainty associated with the third relative level
L3	Percent uncertainty associated with the fourth relative level
L4	Percent uncertainty associated with the fifth relative level
UM	Uncertainty model: 0=Relative, 1=Absolute
PRNG	Pseudo-random number generator: 0=VB6, 1=Custom
CI	Confidence interval: 0=90, 1=95, 2=99
CATI	Whether or not impacts are categorical (True or False)
CATC	Whether or not costs are categorical (True or False)
NUMI	Number of impact categories
NUMC	Number of cost categories
VN	Software version
P1	p1 probability
P1D	Distribution associated with that value
P1V	Uncertainty measure for that value
….	
I1	I1 impact
I1D	Distribution associated with that value
I1V	Uncertainty measure for that value
….	
F1	F1 cost
F1D	Distribution associated with that value
F1V	Uncertainty measure for that value
….	

If categorical data are involved, there will be series of columns containing that input data, each pipe-delimited list representing category values, followed by probabilities:

ICAT1	-200|-100|0|100|200|0.45|0.05|0|0.35|0.15
ICAT2	-200|-100|0|100|200|0.2|0.2|0.2|0.2|0.2
ICAT3	-200|-100|0|100|200|0.2|0.2|0.2|0.2|0.2
ICAT4	-200|-100|0|100|200|0.2|0.2|0.2|0.2|0.2

ICAT5	-200|-100|0|100|200|0.2|0.2|0.2|0.2|0.2
FCAT1	10|20|30|0.333333|0.333333|0.333333
FCAT2	10|20|30|0.333333|0.333333|0.333333
FCAT3	10|20|30|0.333333|0.333333|0.333333
FCAT4	10|20|30|0.333333|0.333333|0.333333

The input data is then followed by fields containing the simulation results:

n	Number of trials again
TBR	Total biological risk estimate
TBRMean	Simulation mean of the same
TBRSD	Simulation standard deviation of the same
TBRMin	Simulation minimum value
TBRMax	Simulation maximum value
TBRLCL	Simulation lower confidence limit
TBRUCL	Simulation upper confidence limit
Cost	Management cost estimate
CostMean	Simulation mean of the same
CostSD	Simulation standard deviation of the same
CostMin	Simulation minimum value
CostMax	Simulation maximum value
CostLCL	Simulation lower confidence limit
CostUCL	Simulation upper confidence limit

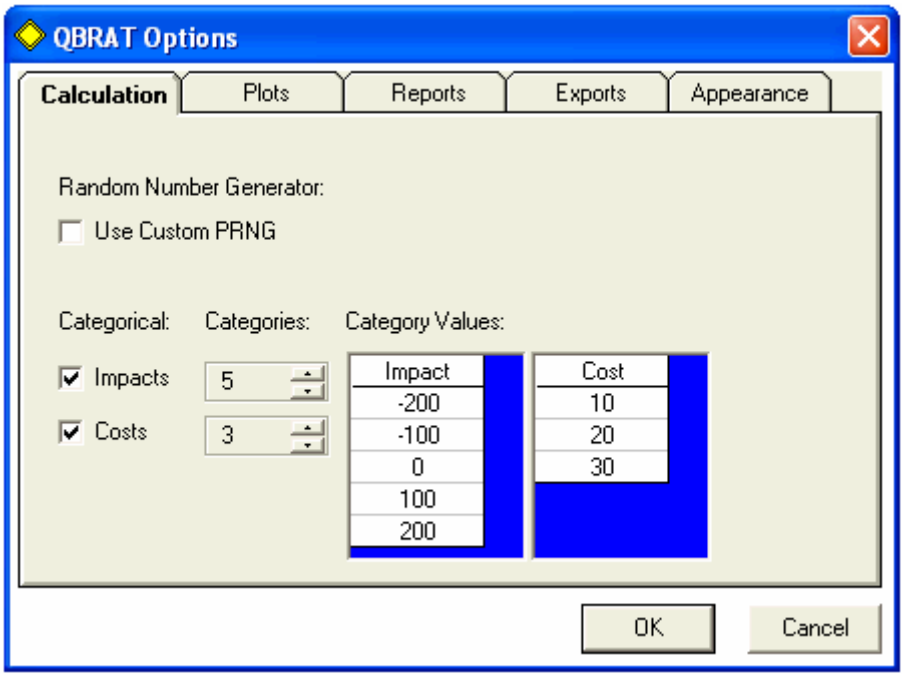
The remainder of the file has one line per batch scenario specification, each line beginning with the specification itself and ending with simulation results.

When the capture mode is used to create scenario specifications, there will be a term in the specification for every item in the application's state data. Normally this will be the only way that scenario specifications are created, since it's the most convenient and most accurate. It is possible, however, to create batch files externally using a text editor. If this is done, several things should be kept in mind:

1. The batch file must be named with an RAB extension.
2. Each line in the file must have terms delimited with ";".
3. Each term is a combination of an identifier, "=", and an associated value.
4. For primary data (probabilities, impacts, and costs), the associated value is a comma-delimited list of mean, distribution type identifier ("U","N", "LN", or "B"), and uncertainty measure. For relative uncertainty, the latter is also represented by identifiers ("L0", "L1", "L2", "L3","L4"), otherwise by the standard deviation.
5. It not necessary to specify all possible terms. When the batch is run, application state values normally associated with missing terms will simply keep the value already in existence.

QBRAT Options Module

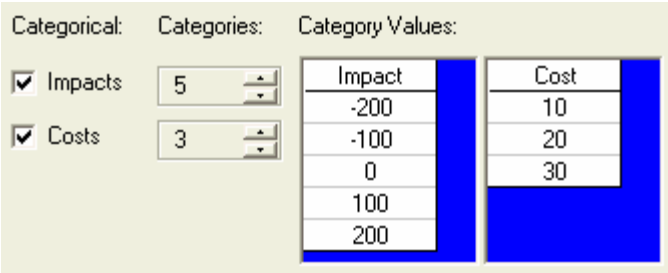
The main application has a number of options which control its appearance and operation. The data for these are stored in the application options file (PRiskAssess3Options.ini) and can be managed by editing that file. A better way to do it, however, is to bring up the options module by clicking on the **Manage** item of the **Options** main menu item:



There are five tabs:

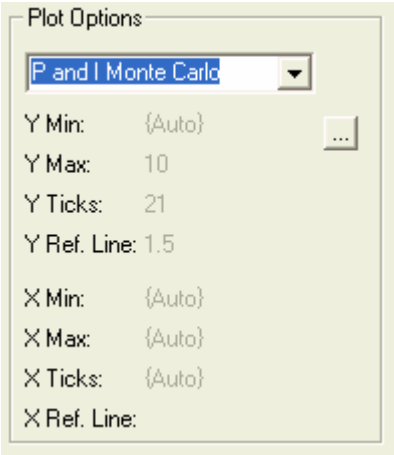
1. **Calculation** - currently duplicates the pseudorandom number generator choice found on the **Options** main menu item and provides the means for controlling categorical data (see below)
2. **Plots** - provides an alternate way of setting plot axis specifications (more below)
3. **Reports** - currently just one checkbox labelled **Open Report After Generation.** This turns on and off the feature whereby simulation reports are automatically opened.
4. **Exports** - provides a means for specifying the folder to receive exported simulation trial data and for specifying the export format(s) to be used
5. **Appearance** - this currently has three features: setting application colours, a duplication of the **Hide Management Costs** item of the **Options** main menu item, and setting the number of decimal places used to display probabilities. This tab is described more fully below.

The lower part of the **Calculation** tab looks like this:

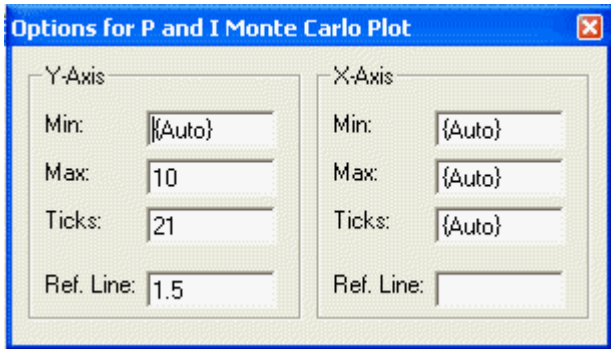


One the left are check boxes for determining whether or not categorical impacts and/or costs are involved. To their right are up-down spinner for selecting numbers of categories between one and five. Finally to their right are two edit tables for entering the category values to be used throughout the risk chain, the number of rows corresponding to the number of categories. As described elsewhere for edit tables, clicking on a row highlights the table cell and enables changing its value. Category values may theoretically be any numeric in the domain of real numbers, which in practice is >= -1.79E+308 and <=1.79E+308. If either impacts or costs are not categorical, the corresponding edit table will be greyed-out and not editable.

The **Plots** tab looks like this:

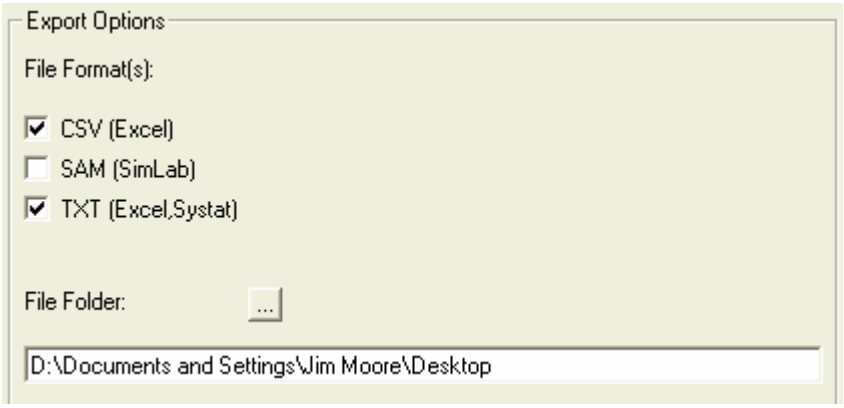


The drop-down list at the top allows a choice of one of six types of plots. The remainder of the tab shows what the current plot axis settings are for that type of plot. Clicking on the little button brings up the plot axis options dialog, shown here in its default state:



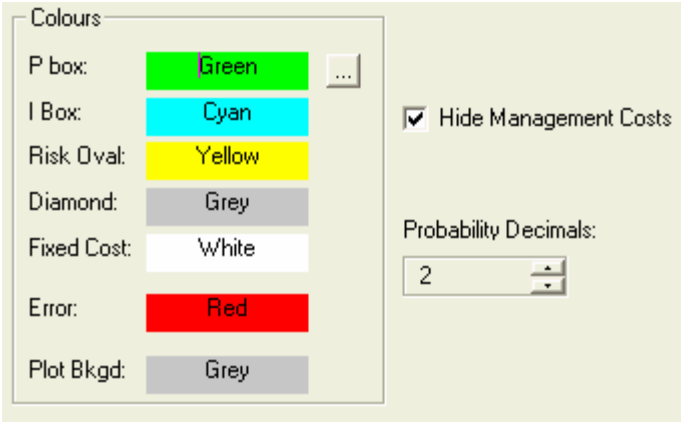
With this dialog box you can change for each axis the plot axis minimum and maximum, the number of axis tick marks, and you can specify the value at which a reference line is to be drawn perpendicular to the axis. The changes are plot-specific, as indicated by the dialog caption. These changes will remain in effect until the application is closed, affecting plots of that type both on screen and in simulation reports. Using the **Save Plot Options** item on the **File** menu allows retention of settings between sessions. To restore an item to "{Auto}", just clear its textbox.

The **Exports** tab looks like the following:



Use the button and text box at the bottom of this tab to navigate to the folder to which you would like simulation export files to be written. This folder path will be retained from session to session until it's changed again in this module. For an export to occur, one or more of three file formats must be selected by checking the corresponding checkbox. If so, an opportunity to specify a file name for exports is presented at simulation run time.

The **Appearance** tab of the options module looks like this:



The area on the left of this tab allows you to change the colours associated with various features of the application: the colours associated with the elements of the decision chain, the plot background colour, and the colour used to highlight errors. To change a colour, click on the associated coloured box, causing the little button to move to the right of that box. Then click the little button, bringing up a standard colour choice dialog. Make the choice and close the colour dialog. The updated colour will appear to the left of the button. The complete set of updated colours will be employed immediately upon closing of the options module and returning to the main application.

The **Hide Management Costs** item duplicates the same item appearing on the **Options** main menu. The **Probability Decimals** item allows you to change the way probabilities are displayed throughout the application and in simulation reports. Clicking on the little arrows allows the default value of 2 decimal places to be changed to something between 1 and 4.

Monte Carlo Simulation Algorithms

Pseudorandom Number Generators

The Monte Carlo simulation requires a good source of pseudorandom numbers generated on the 0 - 1 interval with a uniform distribution. By default, the application uses VB6's internal Rnd() function, which on another occasion has been found to meet some of the less complex criteria for testing pseudorandom number generators (PRNGs), such as:

1. serial plots of r_i against r_{i+1}
2. "buckets" tests
3. one-sample Kolmogorov-Smirnov (KS) tests
4. and correlations between bins.

This function inherently generates real numbers with single (4-byte) precision. For the purposes of this application, double (8-byte) precision numbers are generated by summing two consecutive values generated by Rnd() plus a small double value (.0000001), the same technique used by Entisoft in their Entisoft Tools library. Values greater than one resulting from this operation are set to the value minus one.

For those not convinced, it's possible to add another PRNG and use it instead. At the moment the ran1 generator coded from Sprott (1991) is the only such generator included. It's the PRNG called when you select "Custom Random Number Generator" on the **Options** menu. It generates double-precision numbers natively. Nothing is known as of this writing about the properties of the number stream produced by this generator.

Monte Carlo Simulation

The basic algorithm for performing the Monte Carlo simulation is as follows:

1. Define the simulation properties:
    a) Number of trials (N) as specified by the user on the Monte Carlo tab
    b) Define a probability density for each of the 13 primary data items (four probabilities, five impacts, and four fixed costs):
        i. Distribution type (uniform, normal, log-normal, or beta): user specified on the Uncertainty tab
        ii. Mean: the 13 primary data items from the Ps and Qs tab
        iii. SD: again, user-specified on the Uncertainty tab separately for each of the 13 values
2. Initialise the pseudorandom number generator (PRNG):
    a) Define and save a seed using the time (seconds from midnight)
        i. VB6: -1 * time
        ii. ran1: -100 * time
    b) Use the defined seed to reseed the chosen PRNG
    c) [Note: the saved seed could be used to provide reproducibility of results, but currently this is NOT done.]
3. For each of N trials:
    a) Draw 13 pairs of pseudo-random numbers (PRN) from the PRNG and
        i. Arrange the 13 pairs as a 2 by 13 table
        ii. Shuffle by sorting on one row of that table
        iii. Assign the shuffled values from the other row to the primary data items
    b) Transform each PRN to the desired value:
        i. Uniform: just scale the PRN, assuming that SD^2 is 12 times the range, which in turn maps to the zero to one PRN interval; the mean is presumed to be at the midpoint of the range
        ii. Normal: call Entisoft's NormalInverse function, passing the PRN, mean, and SD
        iii. Lognormal: call Entisoft's LogNormalInverse function, passing the PRN, transformed mean, and transformed SD (more about this transformation below)
        iv. Beta: call Entisoft's BetaInverse function, passing the PRN, and two parameters (Alpha and Beta) as inferred from the mean and SD (also more about this below)
        v. Categorical: call a custom routine which returns a category value obtained by entering a look-up table inferred from the categorical data (see below at the end of this topic for details)
    c) For probabilities, truncate the transformed PRN at the zero and one bounds.

d) Compute five cumulative risk (sum of R_1 to R_j, j=1, 2, 3, 4, or 5) values from the transformed p- and impact values. Compute four cumulative management cost (sum of C_1 to C_j, j=1, 2, 3, or 4) values from the transformed p- and fixed cost values. Note that the last of the five risk values is the same as the Total Biological Risk (R_B), and the last of the four management costs values is the same as the Total Management Cost (C_T).

The result of this operation is a large table with N rows and 22 columns, one for each of the 13 parameters, five for the cumulative risk values, and four for the cumulative cost values.

Analysis of the results in this table proceeds in four steps:

1. Do simple statistics (sample mean and SD) on the N simulated R_B values. Report these in the multi-line text box on the **Monte Carlo** tab and as "Simulation Statistics" in the report. Do the same for the C_T management cost values.
2. Develop confidence limits for each of the five cumulative risk results, obtaining these as percentiles of each result's distribution. The percentiles obtained are (1 - x/100)/2 for the lower limit and (1 + x/100)/2, where x is the chosen confidence interval (90, 95, or 99%). Report these along with minima, maxima, and simulation mean for each of the 5 results in the "Cumulative Risk" section of the report. Show a plot of the results on the **Monte Carlo** tab and in the report. Do the analogous thing for the four cumulative cost results.
3. Develop a frequency distribution of the N R_B results, dividing their range into 200 equal intervals. Show a plot of the results on the **Monte Carlo** tab and in the report. Again, do the same for the cost results.
4. Do a sensitivity analysis using the values in the N by 22 table, as described below. Show plots of the results on the **Monte Carlo** tab and in the report.

Note that all of this is straightforward for simulations involving the uniform and normal distributions. For the log-normal, however, the mean and SD do not correspond directly to the parameters μ and σ of that distribution. Instead, what we're calling the mean and SD here are treated as the expected value and square root of the variance of a log-normal distribution which are related to the distribution parameters as:

$$\text{Mean} = \exp(\mu + \sigma^2/2)$$

$$\text{Variance (i.e. } SD^2) = \exp(2*\mu + \sigma^2)*(\exp(\sigma^2)-1)$$

These relationships were used throughout the application wherever is was necessary to pass parameters to one of Entisoft's log-normal functions. Inferring the parameters of the beta distribution was done as follows:

1. first the ratio of Beta to Alpha can be inferred from the mean:

   r = (1/Mean) - 1

2. then Beta can be inferred from that and the SD:

   Beta = (r / (1 + r)) * ((r / ((SD ^ 2) * ((1 + r) ^ 2))) - 1)

3. and finally:

Alpha = Beta/r

For categorical impacts/costs, look-up tables are developed for each impact or cost by sorting on category value in ascending order, then doing a cumulative sum of probabilities, so that, for example:

Impact	P (0-1)

-200	0.45
-100	0.05
0	0
100	0.35
200	0.15

becomes:

Impact	P (0-1)
-200	0.45
-100	0.5
0	0.5
100	0.85
200	1

At look-up time a pseudorandom value between 0 and 1 is generated and then compared with the values in the cumulative-p column of the look-up table. The result of the look-up is the category value associated with the first cumulative-p value >= the pseudorandom value.

Sensitivity Analysis

As described above, the initial result of a Monte Carlo simulation is a table of simulated parameters and R_B results with N (the number of trials) rows and 22 columns, one for each parameter, five for the cumulative risk results, and four for the cumulative cost values. Sensitivity parameters are developed from this follows:

1. All values are replaced by their ranks within their respective columns. Tied values are replaced by the average of their ranks.
2. Pearson's correlation coefficients are then computed between each of the nine probability and impact columns and the column with the R_B (i.e., sum of R1 to R5) results. The same was then done for each of the eight probability and fixed cost columns and C_T (i.e., sum of C1 to C4) results.

From this process, nine rank correlation coefficients result for the risk results, providing a measure of the extent to which variation in the R_B results is related to variation in each of the nine constituent parameters. Similarly, eight rank correlation coefficients result for the management cost results. These two sets of rank correlation coefficients appear as bar charts on their respective **Monte Carlo** sub-tabs and in their respective pages in the report. The report also provides the actual coefficients.

Before this rank transformation is done, a check on the linearity of the trial simulation results is done by performing a multiple linear regression of R_B on each of its nine input factors and of C_T on each of its eight. By default a constant is not included in these regressions, though it's possible to change that (c.f. the description of RiskAssess3.ini below). The retained products of this analysis are the squared multiple correlation coefficient (R^2) and standardised regression coefficients (SRCs) which appear on the **Sensitivity Details** dialog. Pearson's correlation coefficients are also computed on this untransformed data for comparison with the rank-transformed values.

After rank transformation, the regression is done again, yielding a rank-transformed R^2, transformed standardised regression coefficients (SRRCs), and the sensitivity coefficients described above. The latter are really instances of Spearman's rho (ρ) and may be tested for being significantly different from 0, using a t-test based on the following expressions:

$$t = \frac{\rho}{\sqrt{\left(1-\rho^2\right) \big/ \left(N-2\right)}}$$

which may be rearranged as follows:

$$\rho = \frac{t}{\sqrt{N-2+t^2}}$$

Thus a value of t is chosen for a given level of significance, depending on N and the probability of a Type I error, which for QBRAT may be 0.10, 0.05, or 0.01. From that value, the second expression may be used to estimate the smallest absolute value of the rank correlation coefficient which is considered to be significantly different from zero. Since the null hypothesis rejected when the rank correlation coefficient is not equal to zero, the value of t should be chosen in accordance with a two-tailed test. However, an entry in RiskAssess3.ini does allow a one-tailed test if desired.

References

Saltelli, A., S. Tarantola, F. Campolongo, and M. Ratto. 2004. Sensitivity Analysis in Practice, A Guide to Assessing Scientific Models. John Wiley and Sons Ltd., England.

SIMLAB. 2004. Version 2.2 Simulation Environment for Uncertainty and Sensitivity Analysis, developed by the Joint Research Centre of the European Commission. [http://simlab.jrc.cec.eu.int/]

Sprott, J.C. 1991. Numerical recipes, routines and examples in BASIC. Cambridge: Cambridge University Press.

External File Structures

RiskAssess3.ini

The application state referred to above under the discussion of **File** operations is maintained in a simple array. That array is populated at application start-up by reading from an application initialisation file called “RiskAssess3.ini”. The contents of the file will generally represent the application state at the last time the application was shut down. It looks like the following, where comments have been added here for explanatory purposes (following “;”):

```
[App Defaults]
Species=New Species             ; the contents of the “Species” text box
Location=New Location; the contents of the “Location” text box
N Trials=1000                   ; the contents of the “Number of  Trials” text box
Level 0=10                      ; the position of the first relative uncertainty slider
Level 1=30                      ; the position of the second relative uncertainty slider
Level 2=50                      ; the position of the third relative uncertainty slider
Level 3=70                      ; the position of the fourth relative uncertainty slider
Level 4=73                      ; the position of the fifth relative uncertainty slider
Uncertainty Module=1            ; the uncertainty module last in use (0=relative, 1=absolute)
PRNG=0                          ; the PRNG last in use (0=VB, 1=custom)
PRNG Seed=59032.52              ; the PRNG seed last used
Confidence Choice=1             ; the simulation confidence limits (0=90%,1=95%, 2=99%)
Categorical Impacts=True        ; whether or not impacts are categorical
Categorical Costs=True          ; whether or not costs are categorical
Num Impact Categories=5         ; the number of categories for categorical impacts (1 to 5)
Num Cost Categories=3           ; the number of categories for categorical costs (1 to 5)
Num Rel Unc Categories=5        ; the number of relative uncertainty levels (4 or 5)
Software Version=3              ; the current software version
Reg Use Constant=False          ; whether to include a constant in the sensitivity regression analysis
Rho Two Tails=True              ; whether to test sensitivities with a two- or one-tailed t-test

[Relative Uncertainty]          ; these are the relative uncertainty settings for the 13 parameters
                                ; arranged as “mean, distribution, checkbox column (0 to 4 or 0 to 3)”
p1=0.5,0,2
p2=0.5,0,2
p3=0.5,0,2
p4=0.5,0,2
I1=1,0,2
I2=1,0,2
I3=1,0,2
I4=1,0,2
I5=1,0,2
FC1=0,0,2
FC2=0,0,1
FC3=0,0,1
FC4=0,0,0

[Absolute Uncertainty]          ; these are the absolute uncertainty settings for the 13 parameters
                                ; arranged as “mean, distribution, SD”
p1=0.5,0,0.144337567297406
p2=0.5,0,0.144337567297406
p3=0.5,0,0.144337567297406
p4=0.5,0,0.144337567297406
I1=1,0,0.144337567297406
I2=1,0,0.144337567297406
I3=1,0,0.144337567297406
I4=1,0,0.144337567297406
```

```
I5=1,0,0.144337567297406
FC1=0,0,0.144337567297406
FC2=0,0,0.144337567297406
FC3=0,0,0.144337567297406
FC4=0,0,0.144337567297406

[Primary Data]                  ; redundant save of the data on the Ps and Qs tab
p1=0.5
p2=0.5
p3=0.5
p4=0.5
I1=1
I2=1
I3=1
I4=1
I5=1
FC1=0
FC2=0
FC3=0
FC4=0

[Primary Cat Data]              ; last state of the application category data
I1=-200,-100,0,100,200,0.45,0.05,0,0.35,0.15    ; for impact 1, the category values, then p-values
I2=-200,-100,0,100,200,0.2,0.2,0.2,0.2,0.2      ; etc.
I3=-200,-100,0,100,200,0.2,0.2,0.2,0.2,0.2
I4=-200,-100,0,100,200,0.2,0.2,0.2,0.2,0.2
I5=-200,-100,0,100,200,0.2,0.2,0.2,0.2,0.2
Ix=-200,-100,0,100,200                          ; impact category values entered in the Options module
FC1=10,20,30,0.333333,0.333333,0.333333         ; for cost 1, the category values, then p-values
FC2=10,20,30,0.333333,0.333333,0.333333         ; etc.
FC3=10,20,30,0.333333,0.333333,0.333333
FC4=10,20,30,0.333333,0.333333,0.333333
FCx=10,20,30                                    ; cost category values entered in the Options module
```

All of these values constitute the application's state, and all are effected by start-up and shut-down. They can be manipulated externally using a text editor, but there is little point in doing so, except possibly for changing the number of trials to some value not allowed by the software.

RiskAssess3Options.ini

Version 2.5 of the software introduces this second INI file containing all of those items formerly in the application INI which related to application appearance and several others. In general, these are the items managed by the options module.

```
[App Colours]
pBox=&H00FF00           ; background colour to associate with probabilities
IBox=&HFFFF00           ; background colour to associate with impacts
Oval=&H7FFFFF           ; background colour to associate with risks
```

```
Diamond=&HC0C0C0            ; background colour to associate with decision diamonds
FixedCost=&HFFFFFF          ; background colour to associate with costs
Error=&H0000FF              ; background colour to associate with error states
Plot Background=&HC0C0C0    ; background colour to use for plots

[Appearance]
Hide Management Options=True
Probability Decimal Places=2

[Reports]
Open After Generation=False

[App Defaults]
Report Path=D:\Documents and Settings\User\Desktop   ; last folder to which reports were written
Save Path=D:\Program Files\RiskAss3\Main App\Saves ; last folder to which application data was saved
Batch Path=D:\Program Files\RiskAss3\Main App\Batches; last folder to which batch files were saved
Export Path=D:\Program Files\RiskAss3\Main App       ; last folder to which trial data were exported

[Plot Options]
; plot specs: Xmin, Xmax,Xticks,XreferenceLine,Ymin, Ymax,Yticks,YreferenceLine

PandI Monte Carlo=Auto,Auto,Auto,,Auto,Auto,Auto,
PandI Sensitivity=Auto,Auto,Auto,,Auto,Auto,Auto,
PandI Cumulative=Auto,Auto,Auto,,Auto,Auto,Auto,
Costs Monte Carlo=Auto,Auto,Auto,,Auto,Auto,Auto,
Costs Sensitivity=Auto,Auto,Auto,,Auto,Auto,Auto,

Costs Cumulative=Auto,Auto,Auto,,Auto,Auto,Auto,
```

All values can be manipulated externally with a text editor, but the only values that should be are the colour settings and the report and file save paths. Normally there is little point in doing that sort of manipulation, since the software in the options module will do it for you.

The colour settings are either named colours or hexadecimal integers where the latter must (!) include the leading “&H” and otherwise represent RGB colour specifications. In such cases, the first two characters to the right of “&H” represent the amount of blue (00 to FF), the next two the amount of green, and the last two the amount of red. Black is given by “&H000000” while at the other extreme white is given by “&HFFFFFF”. Supported named colours are: Grey (or Gray), Black, White, Green, Red, Yellow, Blue, Cyan, and Magenta.

Saved files

To keep things simple, the data saved and read through **File** menu operations use exactly the same format (and same code) as that used for the application initialisation file. The file extension is changed to “RAF” to distinguish to two uses of this data format.