ZSL CAMERA TRAP ANALYSIS PACKAGE

DATA ANALYSIS USER GUIDE

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1. Introduction

Over the last 20 years, camera traps—remote, automatic cameras—have revolutionized wildlife ecology and conservation. Although advances in digital technology have increased capacity while lowering prices, the increasing number of camera-trap surveys is resulting in overwhelming amounts of data. Data processing is often slow, with multiple, laborious data manipulations resulting in incomplete analysis and delayed reporting. The lack of centralized data storage systems and efficient image processing and data analysis tools is hampering monitoring efforts and conservation outcomes. Hence, the challenge has moved from data acquisition to data management, analysis and interpretation.

ZSL has developed a proprietary state of the art camera-trap software package for managing and processing large volumes of image data efficiently and reliably, translating this information into standardised outputs for monitoring the status of wildlife species and communities and the threats impacting them.

The current version (version 1) of the software package has the following key features.

- Configurable data model including country level species templates.
- Image viewing, filtering (by species, camera stations etc.) and editing.
- Formatting and exporting tables, charts and maps in Excel, Word, csv and xml formats.
- Survey effort outputs / reports.
- Species level outputs / reports
    - Species list (taxonomically ordered with information on habitat, habit, tropic level, adult body weight, average home range or territory size, IUCN Red List threat status) with number of images, number of events and number of camera stations detected.
    - Raw and rarefaction accumulation curves, and species richness estimates.
    - Spatial-temporal plots.
    - Trapping rates with standard errors (overall and daily / seasonal).
    - Occupancy and detection probability estimates with option to model with up-to five site covariates.
    - Activity plots (radial and bar plots).
    - Distribution maps on camera-trap grids in Google Earth, QGIS and ArcGIS (via ArcReader).

The following features will be available in version 2 of the software package.

- Image metadata processing tool.
- Population density estimates for marked animals (spatially explicit capture-recapture modelling).
- Movement pattern analysis and home range estimation for marked animals.
- Population density estimates for unmarked animals.
- Activity level modelling.

- Diversity measures.
- Species community structure analyses.
- Statistical tests (chi-square, circular statistics etc.).
- Cross survey analyses.
- Standardised reports generation in Word and RTF.

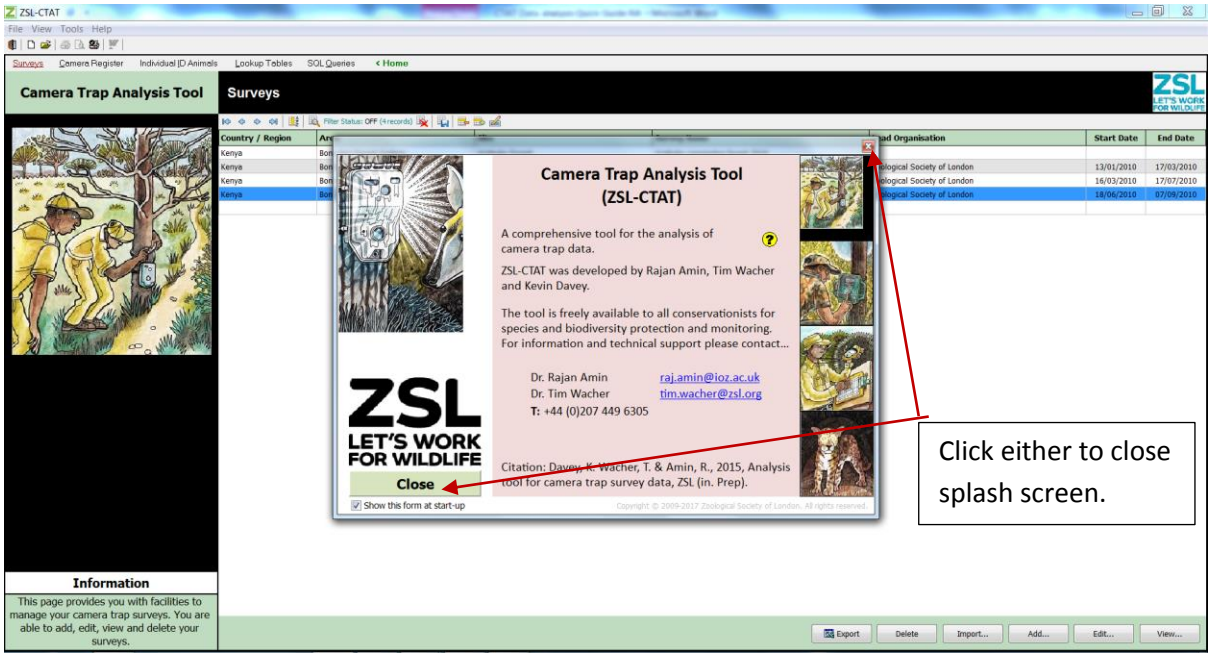
This user guide explains how to analyse imported data from a camera trap grid or 'survey' in the ZSL Camera Data Analysis Package (CTAP).

2. Creating a database

2.1 Starting the application

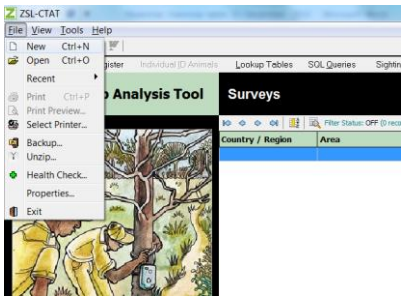
Please refer to the software installation guide to install the software on your computer.

Click on the CTAP icon to start the program. The program will display a splash screen which can be closed by clicking on the top right corner of the splash screen or clicking the 'Close' button.



2.2 Creating a camera-trap database for an area

A new camera-trap database can be created from the *File* menu using the *New* option as shown below



The software will lead you through five steps in the Creating New Database wizard

Step 1. Wizard help information page.

Step 2. Specifying database name and location.

Step 3. Specifying GPS coordinate system for the location of survey cameras. Optionally you can specify limits to the data to prevent incorrect data being entered.

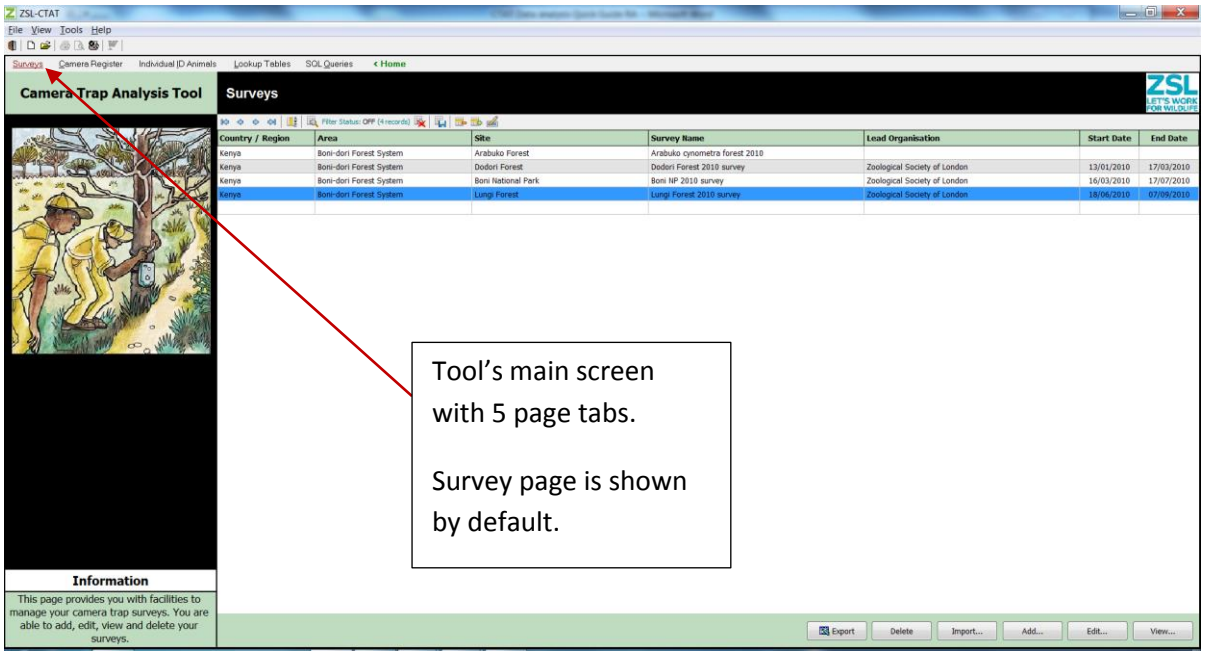
Step 4. Specifying additional information on geographical location ‘Country’ and selecting Country Species List available in the software. If your country species list is not available then you will have to enter/import this information after creating the database. Select ‘Record Sightings of Individual ID Animals’ option if you are planning to enter and analyse data on individually identified animals for species such as tiger.

Step 5. Finishing the creation of the database by confirming the data entered.

3. Managing surveys

The main screen has five page tabs

1. Surveys page – where you import, view and analyse your survey data.
2. Camera Register page – which lists all the cameras in your surveys.
3. Individual ID Animals page – lists all the individually identified animals that you have entered and imported across all surveys e.g. list of tigers detected.
4. Lookup Tables page – in this page you can view and edit information in the lookup tables.
5. SQL Queries page – here you can setup queries for extracting various combinations of your survey data for further analysis and reporting.



3.1 Surveys page

The surveys page lists all the surveys imported into the database. You can open a survey, and view, update and analyse its data. You can also import and export data of a selected survey.

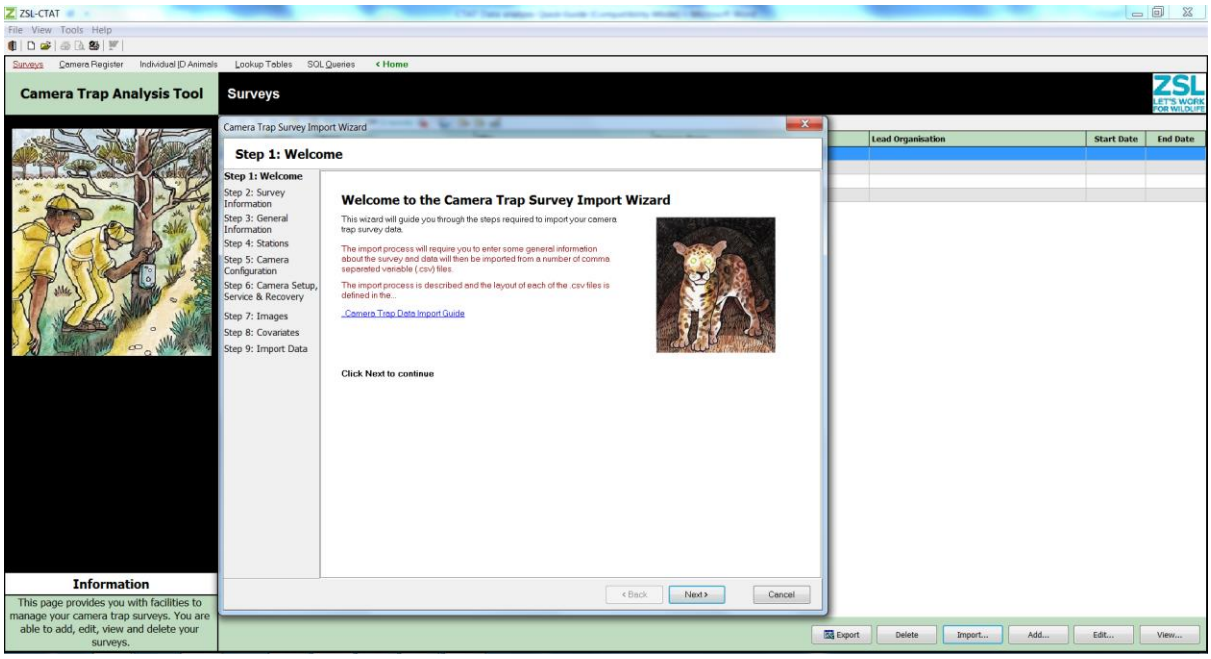
3.2 Importing surveys

Survey data is imported through a wizard in nine steps. Refer to the data preparation and import guide. Steps are summarised below.

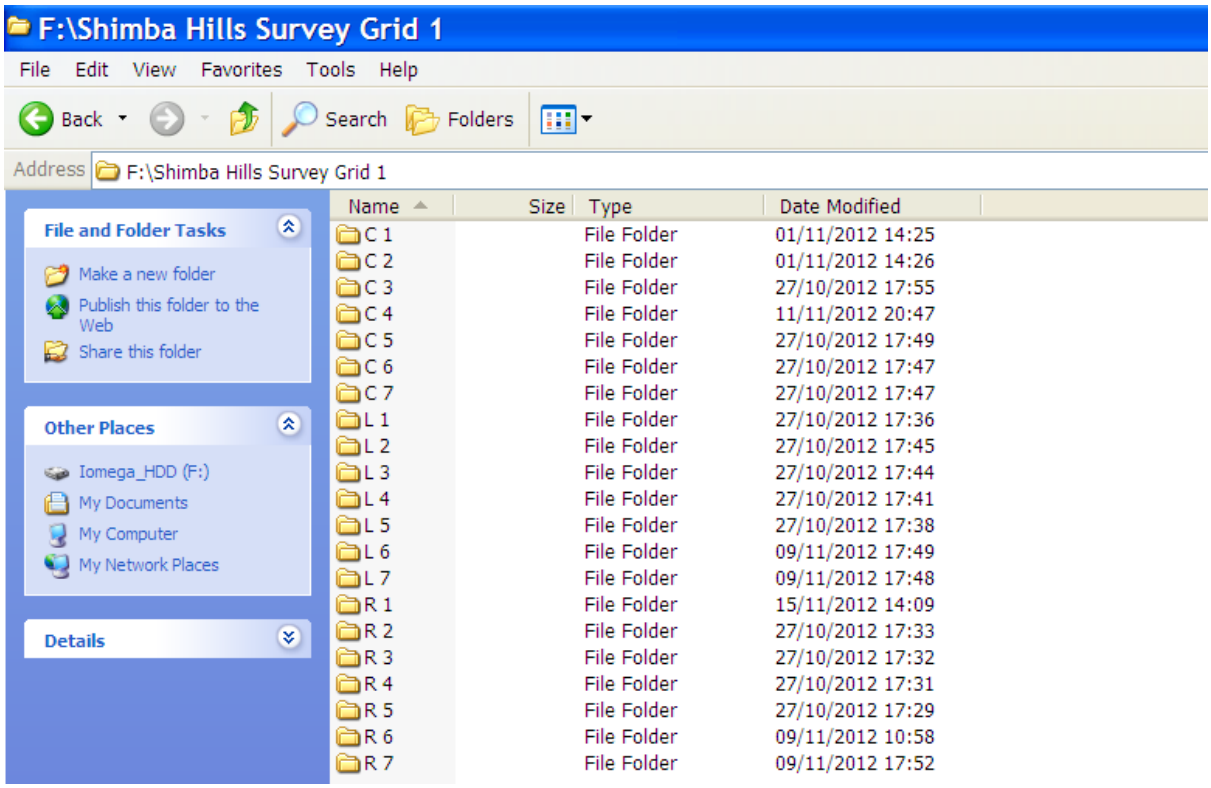
For optimum use, it is advised that you keep the number of surveys in the database to maximum 5-10.

Step1. On clicking on the import button, the Wizard Welcome page is displayed.

Note that if the species have not been defined in the lookup table *tblAnimal* then the following message is displayed "Please first import or enter species records in the tblAnimal table found in the "Lookup Tables" menu on the top of the tool page".

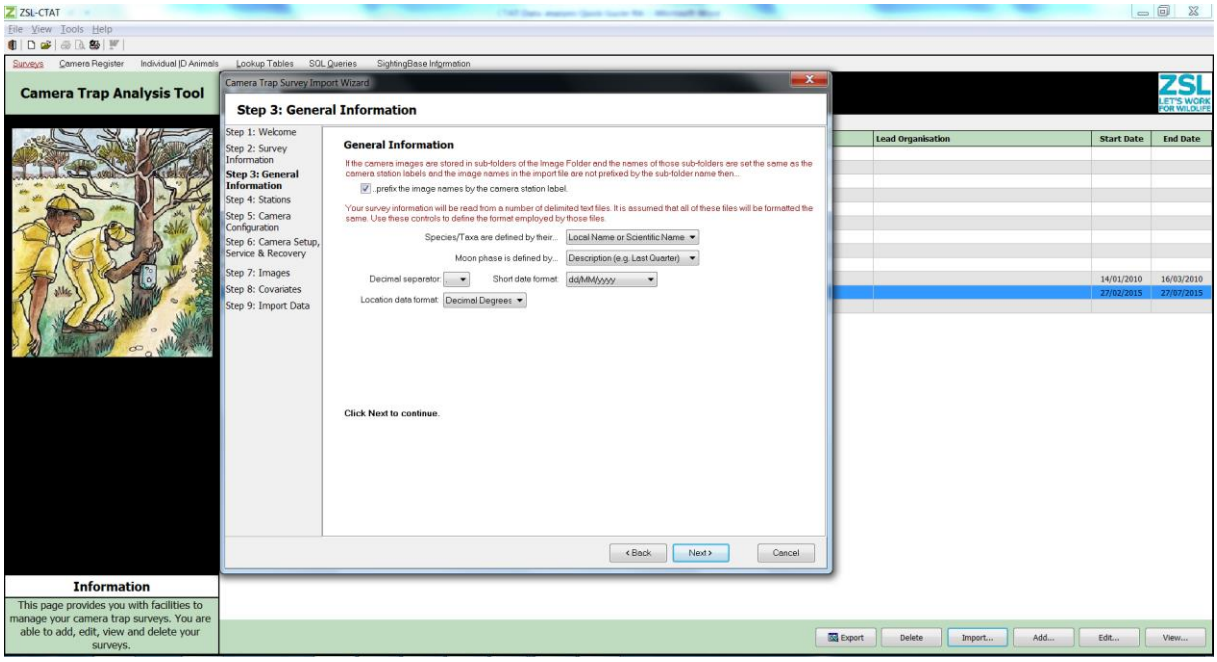


Step 2. Entering survey information. Some of the fields are optional and you will be prompted (on clicking the 'Next' button) if you haven't completed all the compulsory fields. You also need to specify the path to the image folder if you would like to view the images. An invalid path will be highlighted in Red. We recommend you save your images in subfolders (under the survey folder) with subfolder names same as the camera station labels/names defined in the survey data. The path to the survey folder then needs to be set and the software will automatically augment the camera station names to the image names (see Step 3 below) to display the images. For the example below the path would be set to F:\Shimba Hills Survey Grid 1 and the camera station folder names (e.g. C 1) are the same as the Camera Station names in the data.

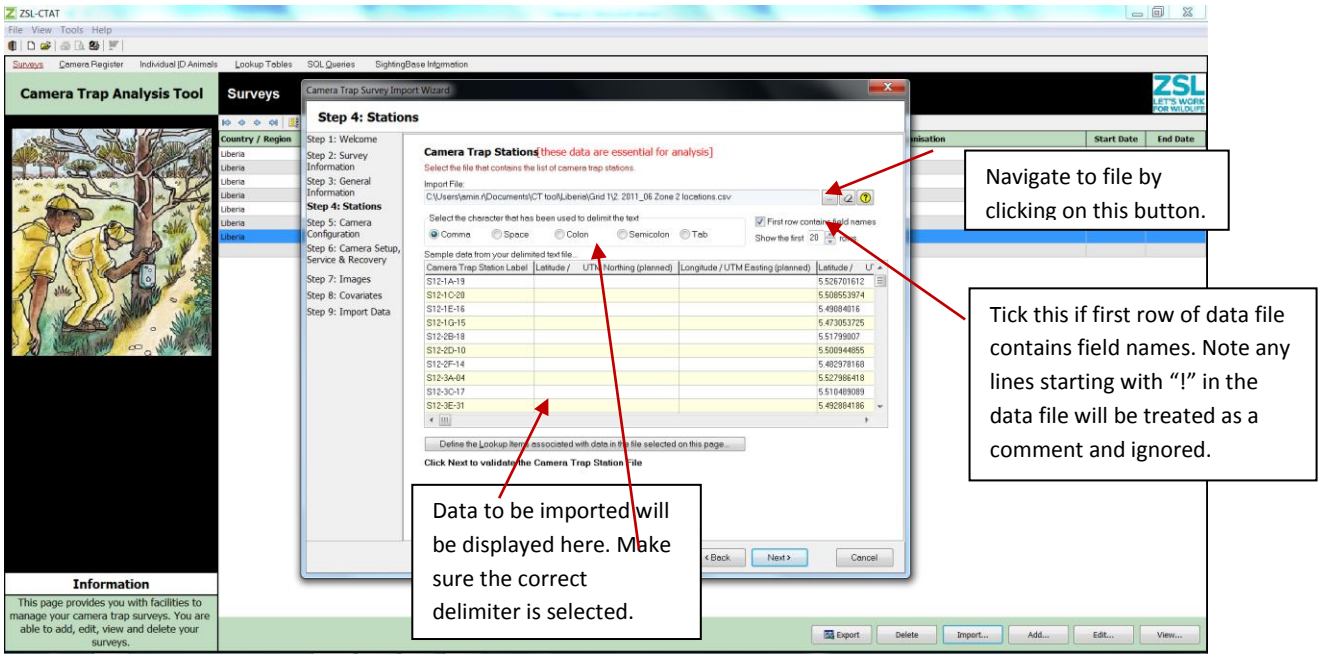


Step 3. Entering general information on the data. Here you can specify

i) Prefixing the images by the camera station label (see above).
ii) Description or code used to define moon phase if applicable.
iii) Decimal separator and date format (depending on your computer settings).
iv) Location data format.

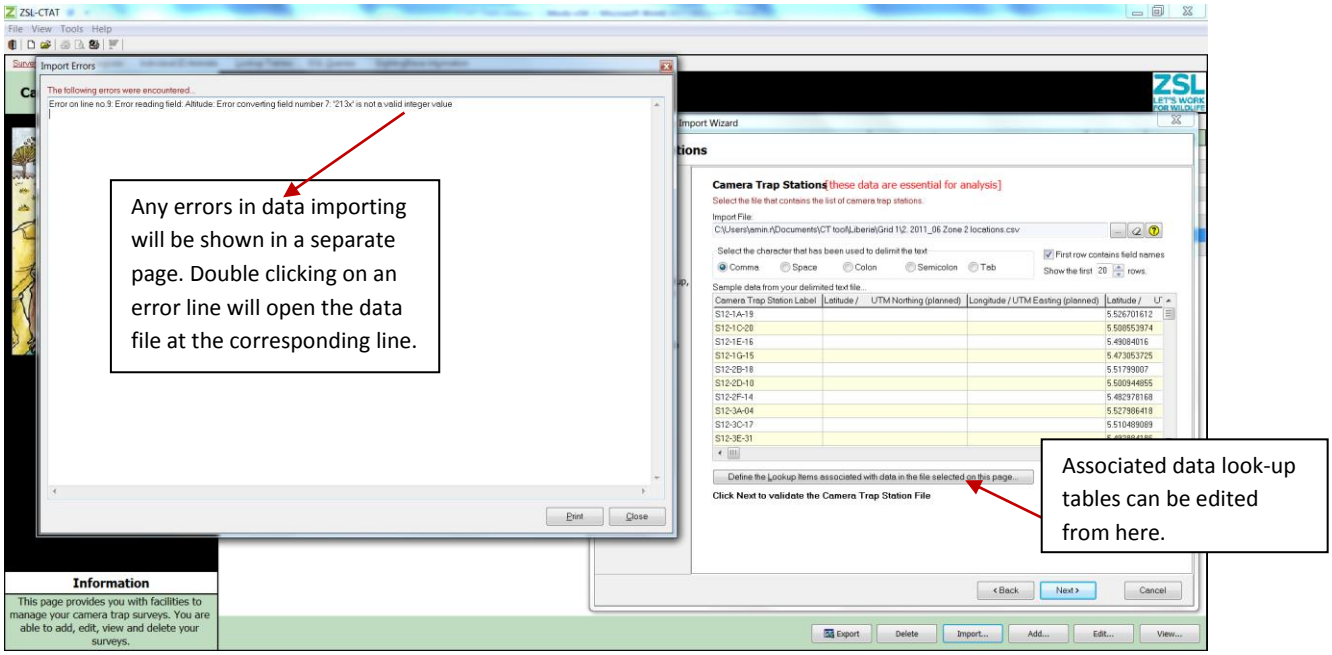


Step 4. Importing camera station data from the csv file. Make sure to click first row contains field names if these are defined in the data file so that these are ignored during data importing.



Any errors in the data or incompatibility with lookup table items will be shown in a separate window. Double clicking on one of the error lines will open the data file at the corresponding line.

The associated data lookup tables can also be opened from the data page and updated to fix the problem.



The process is the same as above for Steps 5-8. Note some of the fields are optional.

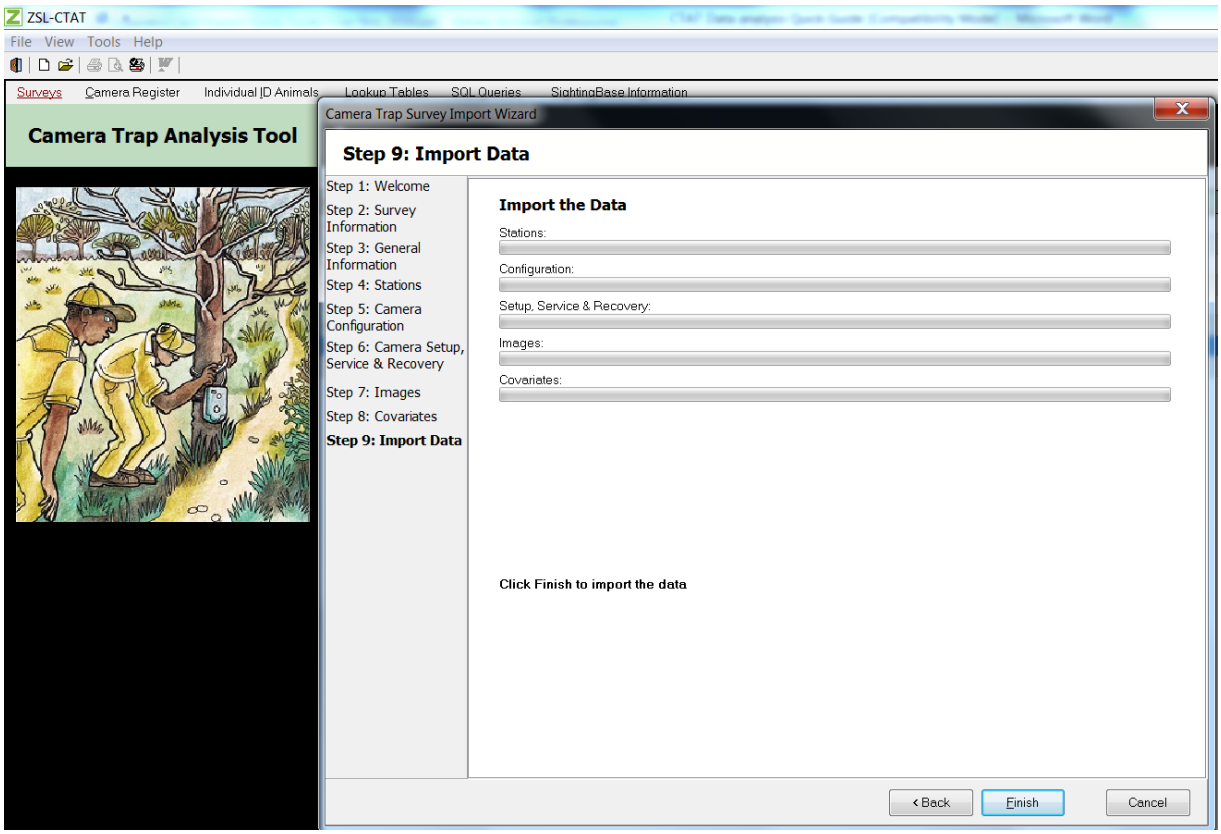
Step 5. Importing data on camera settings used during the survey.

Step 6. Importing camera setup, service and recovery history data.

Step 7. Importing image content data.

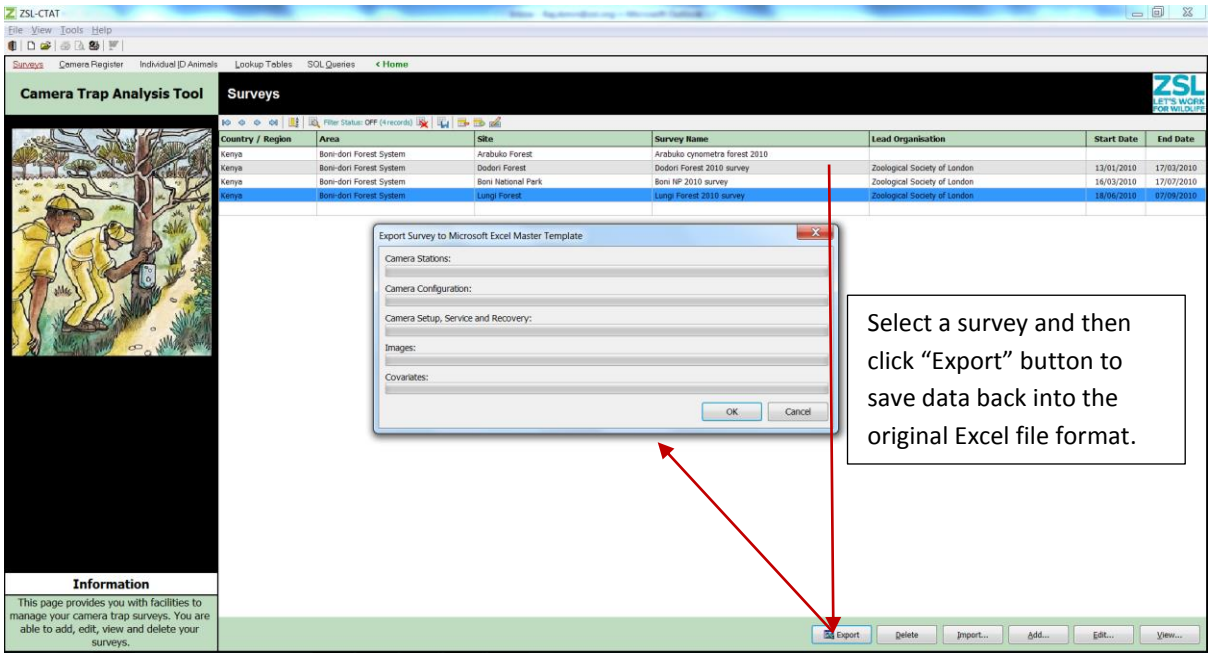
Step 8. Importing camera site covariates (optional). You can click next if you don't have any camera site covariates to import and analyse. Note any camera station environment parameters defined in camera station data (step 4 above) will also be available for occupancy covariate modelling.

Step 9. Importing all the data. This may take a while depending on the amount of data.



3.3 Exporting surveys

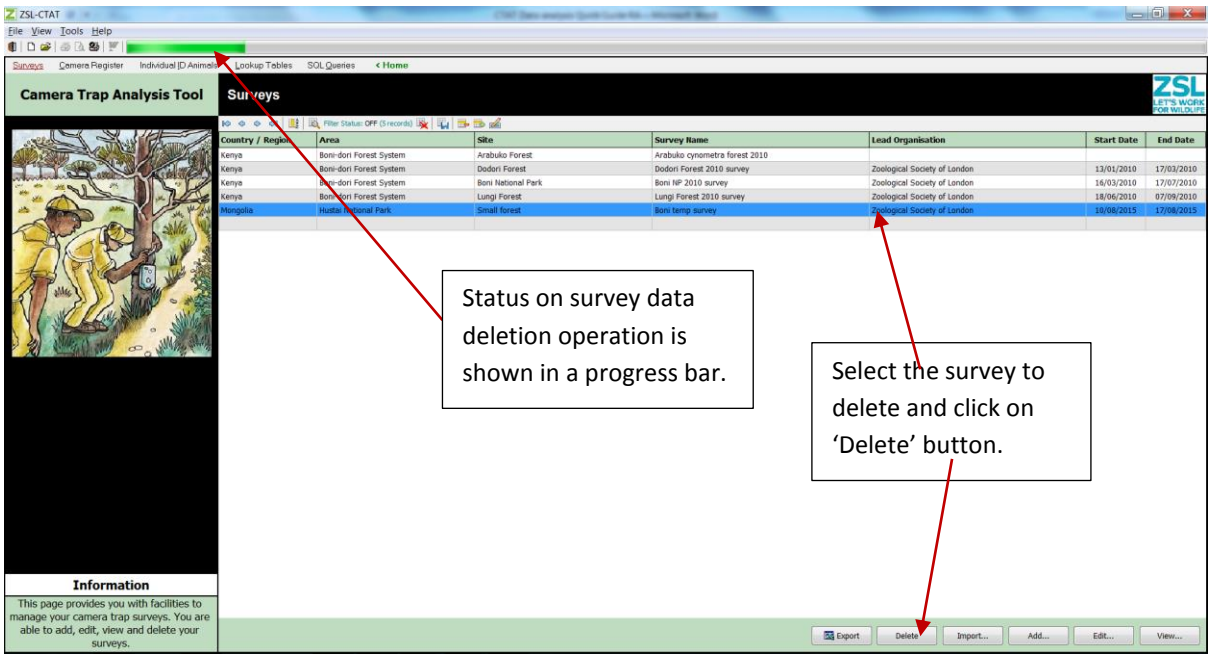
All the survey data can be exported back into the Excel data template by selecting a survey and clicking the 'Export' button in the Survey's page. Note: this can take a while.



Note that the data label rows in the Excel data template sheets are set to remain visible while you scroll through the data rows so if the data is not visible than you may need to change the display resolution or unfreeze the data label rows.

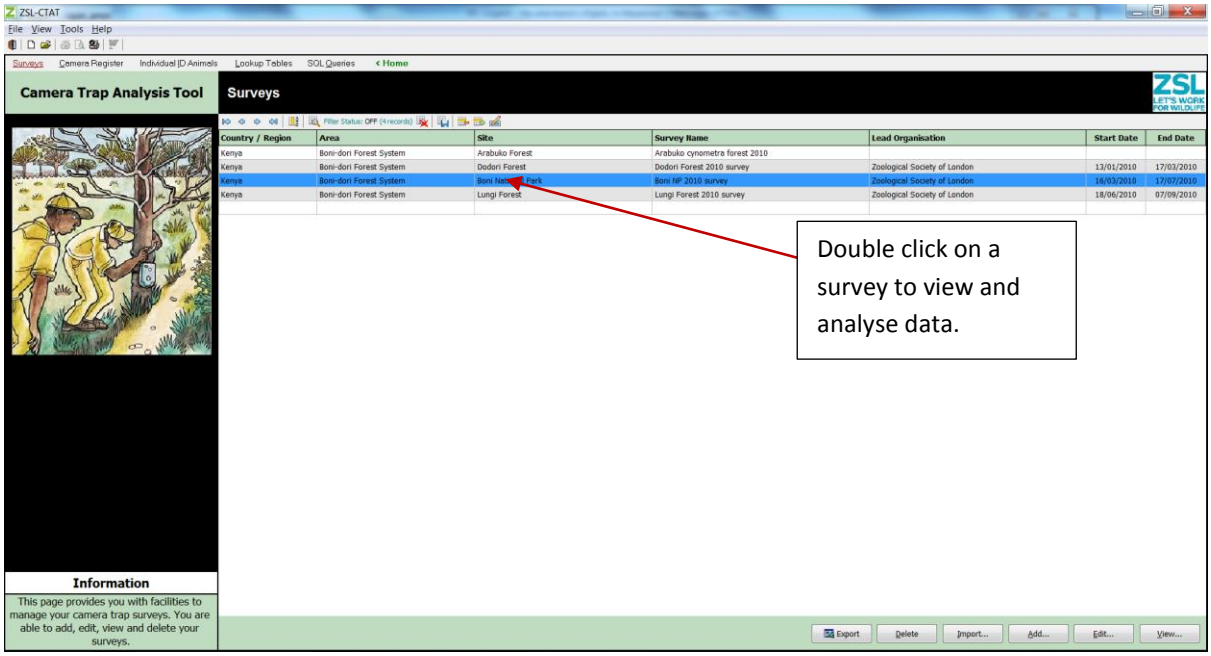
3.4 Deleting surveys

A survey can be deleted from the database by selecting it and then clicking the 'Delete' button. This operation can take some time depending on the amount of data. Its progress is shown in a scroll bar at the top of the page.



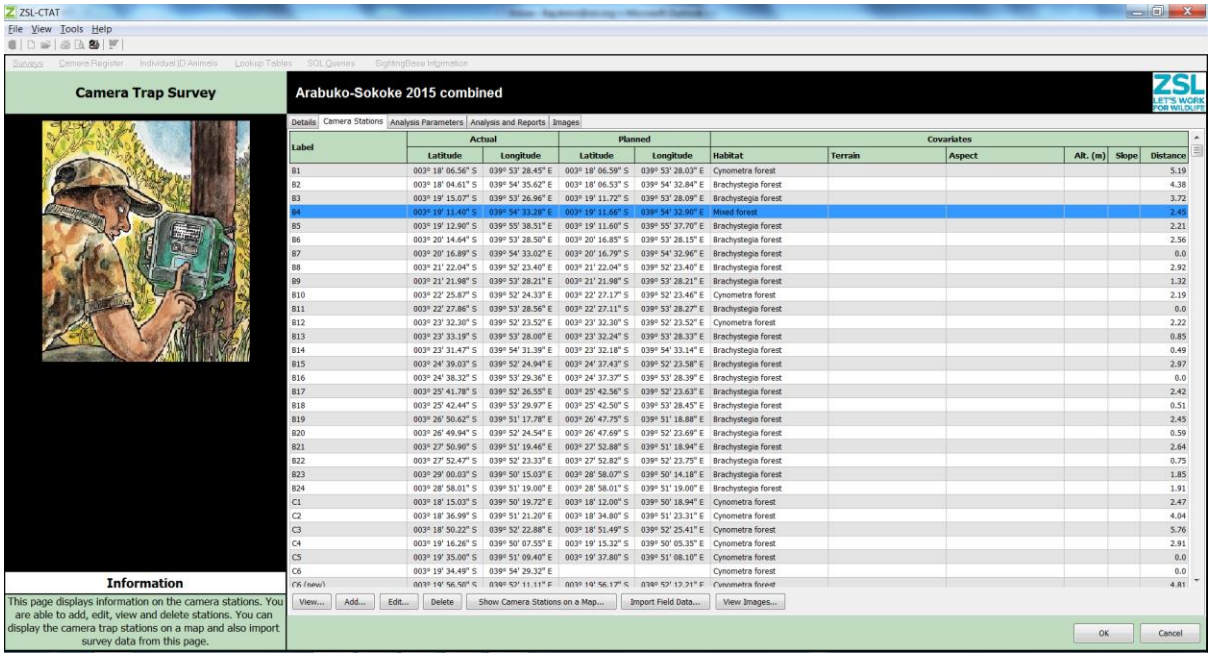
3.5 Viewing and editing survey data

Double click on a survey listed in the Survey's page to view, edit and analyse its data.

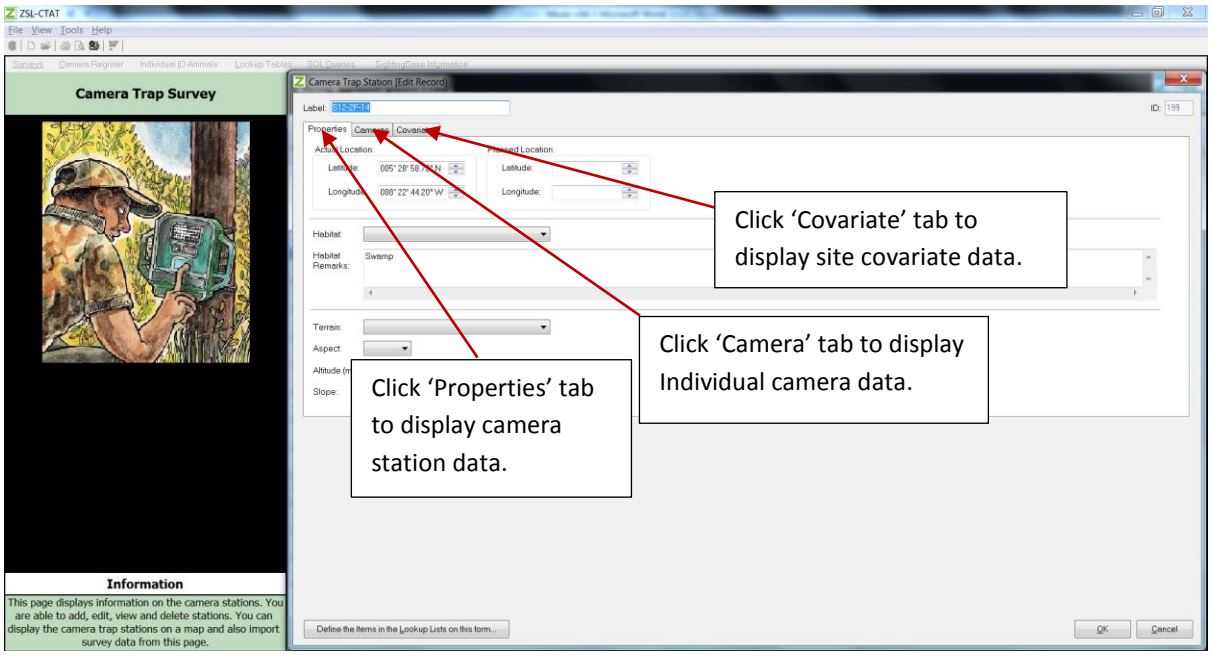


3.5.1 Viewing and editing camera station data

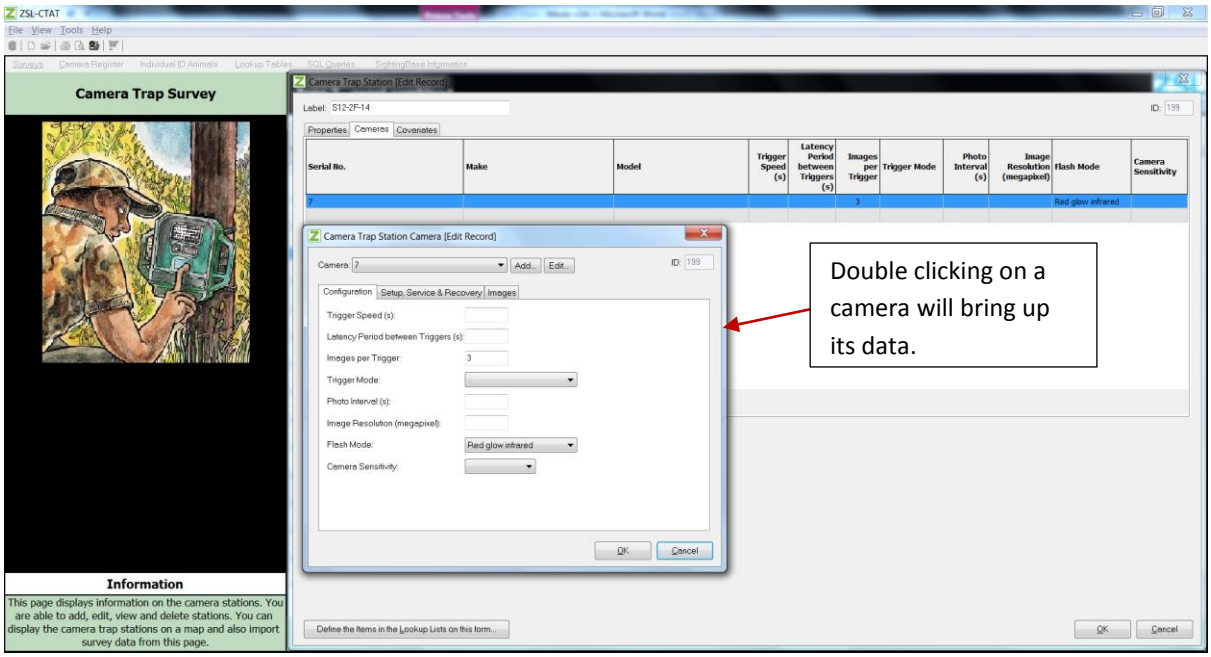
Selecting the 'Camera Stations' tab in the Survey Details page will list the survey camera stations with their location and environment parameters.



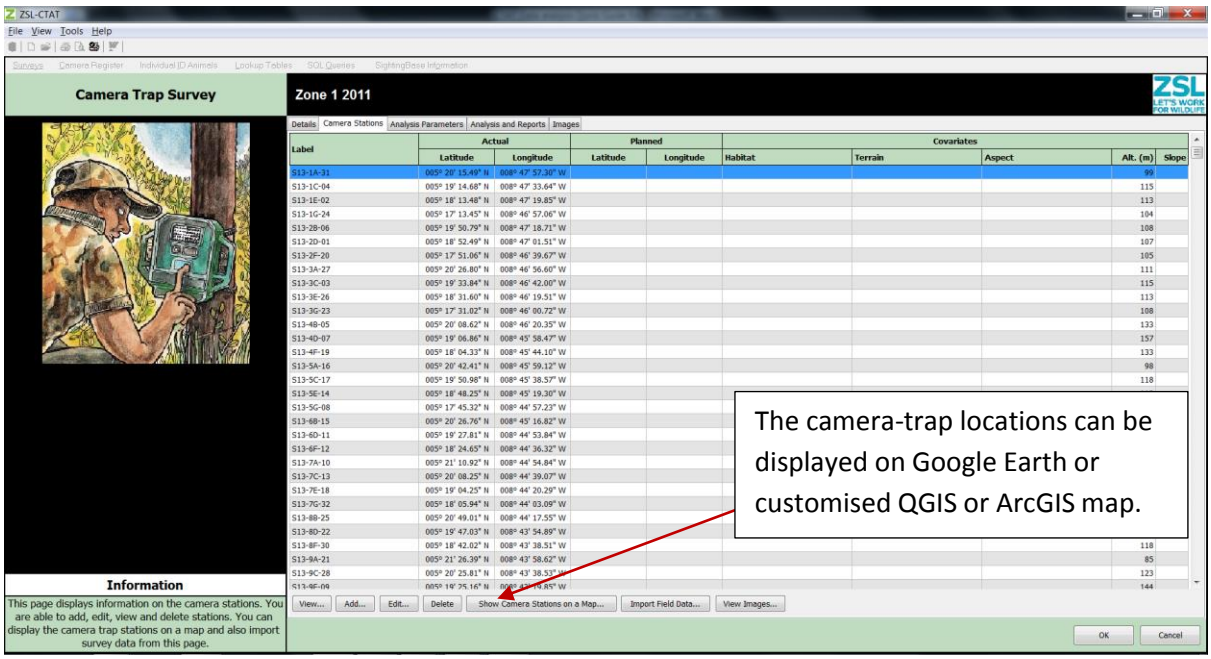
Clicking on a camera station will display its camera data. All the cameras deployed at a station (including replacements, paired) will be displayed.

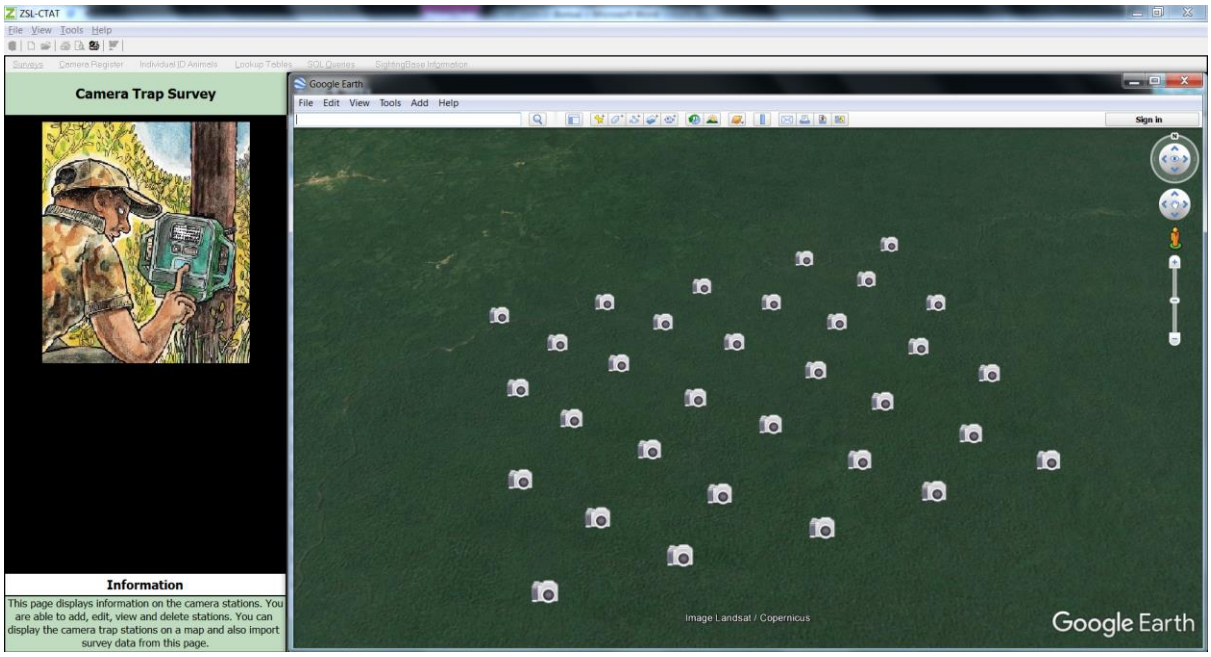


Data on individual cameras can be viewed by clicking the 'Cameras' tab and then double clicking on the individual camera.



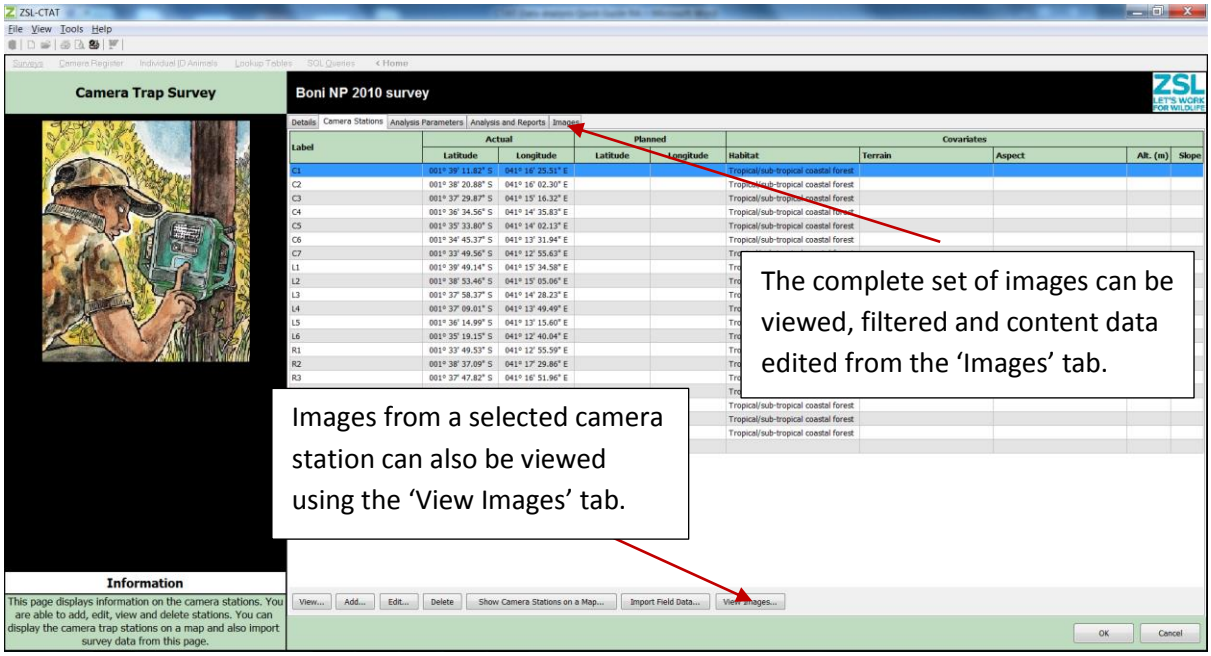
Survey camera locations can also be displayed in Google Earth or customised QGIS or ArcReader map. You will need to have Google Earth / QGIS / ArcReader installed and the project files for QGIS / ArcReader (see QGIS / ArcReader user notes).

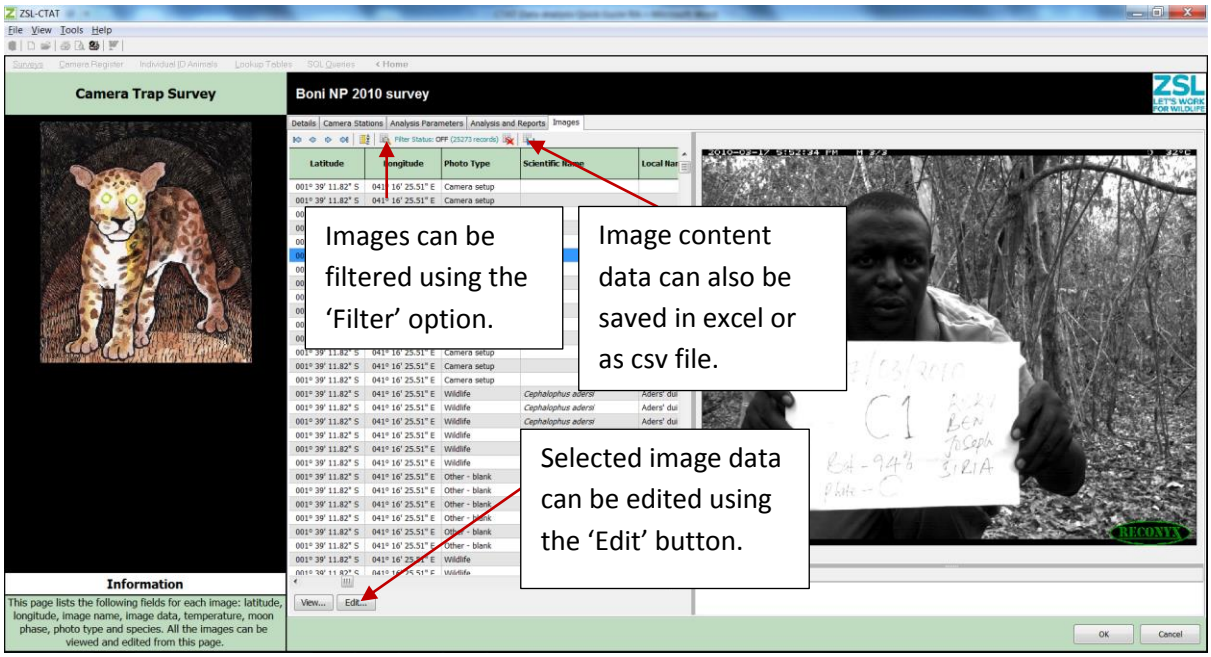




3.5.2 Viewing, filtering and editing camera images

Survey images can be viewed, filtered and content data edited using the 'Images' tab in the survey details page. Images from each camera station can also be viewed from the 'Camera Stations' page.





Filtering images

Images can be filtered using the 'Filter' option in the Images page (see above). A number of filter parameters are available.

Date interval

Time interval

Photo type (multi-select)

Moon phase (multi-select)

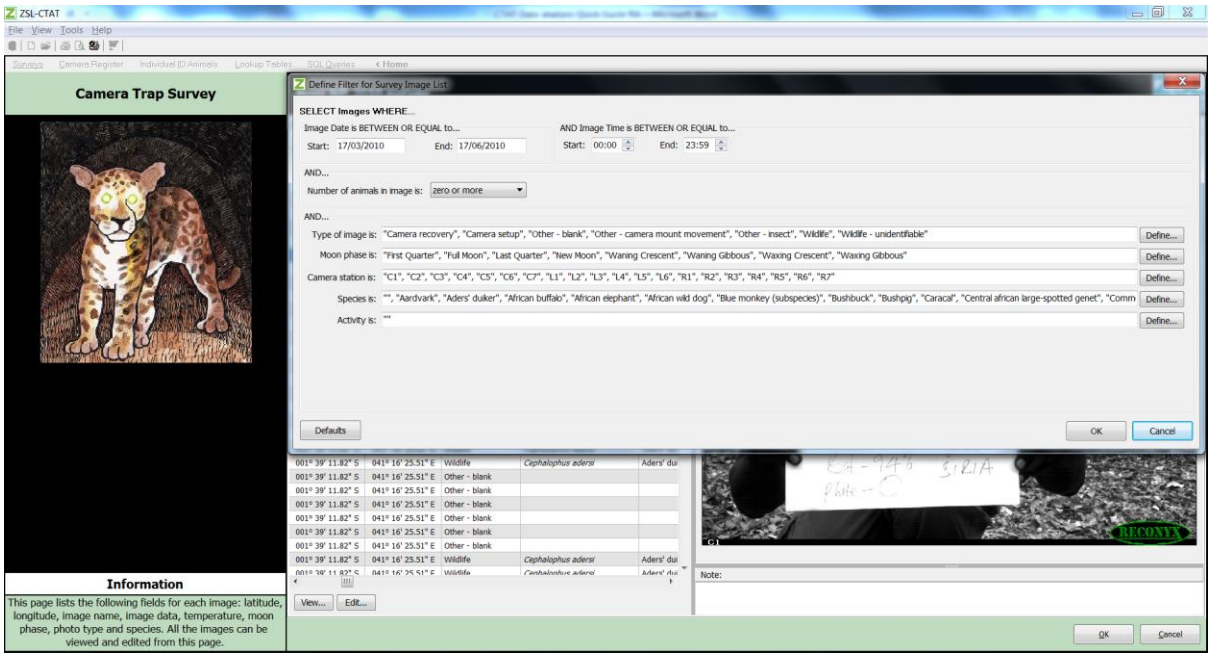
Camera stations (multi-select)

Species (multi-select)

Activity type (multi-select)

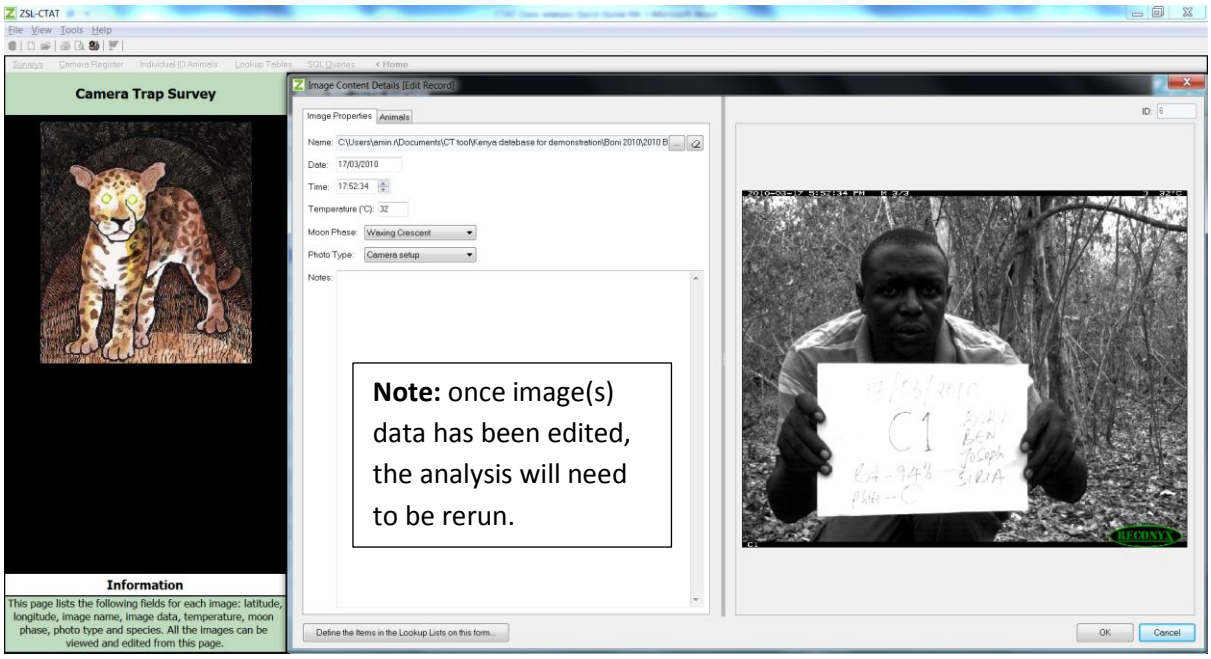
Number of animals seen

Animal ID / Animal name (this field will only be available when the 'Record Individual ID Animals' parameter is set – refer to the administration and configuration section).

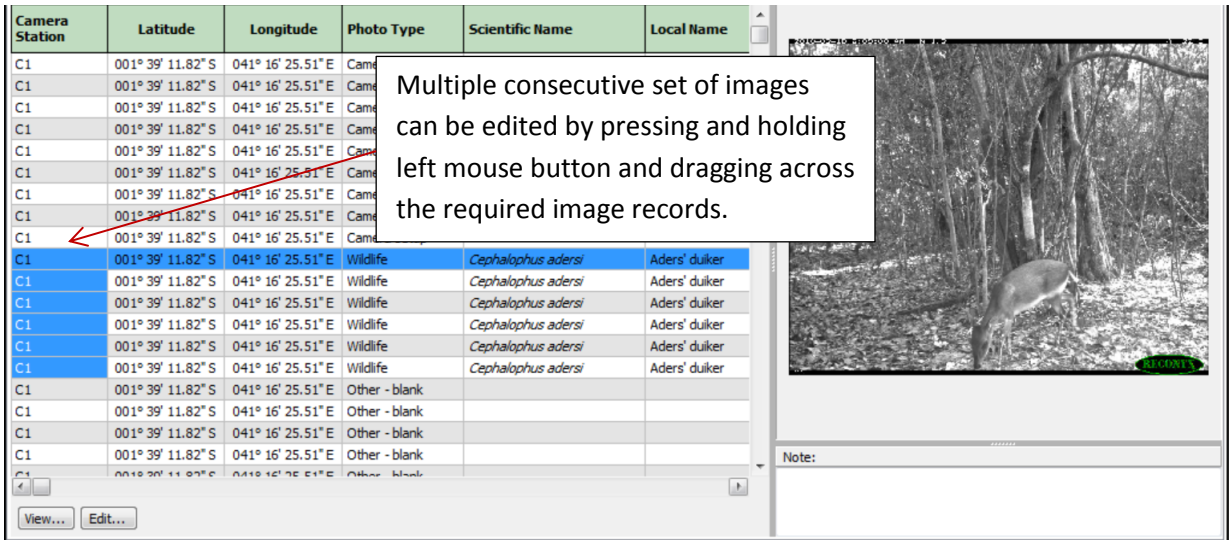


Editing Images

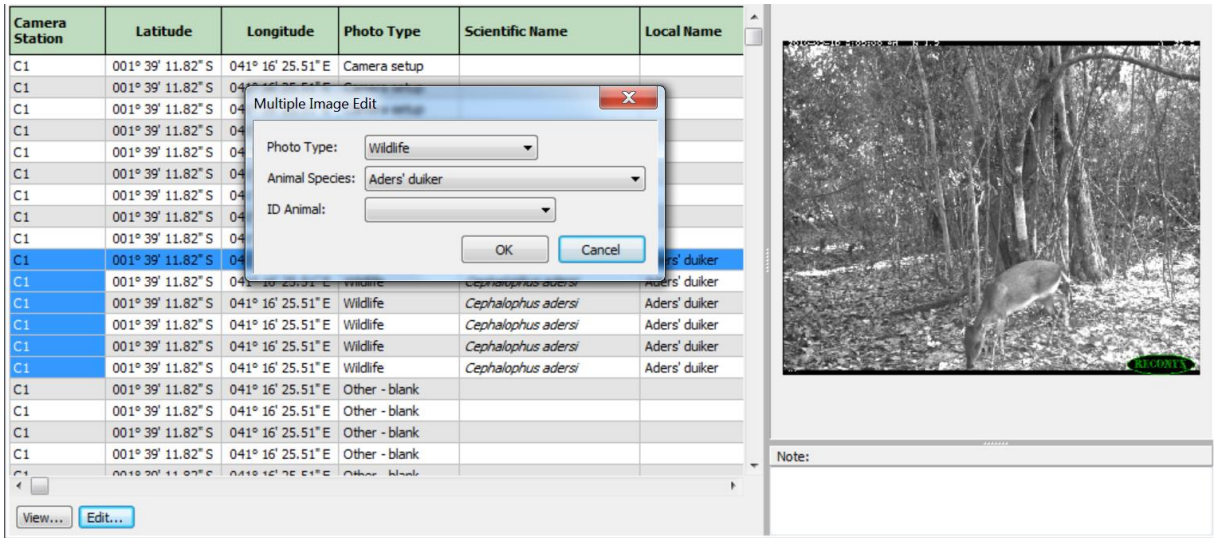
Selected image(s) data can be edited using the 'Edit' button on the 'Images' page. For a single image record this will bring up the following image content details which can be edited.



Multiple consecutive set of images can also be edited by pressing and holding left mouse button and dragging across the required image records to select them.



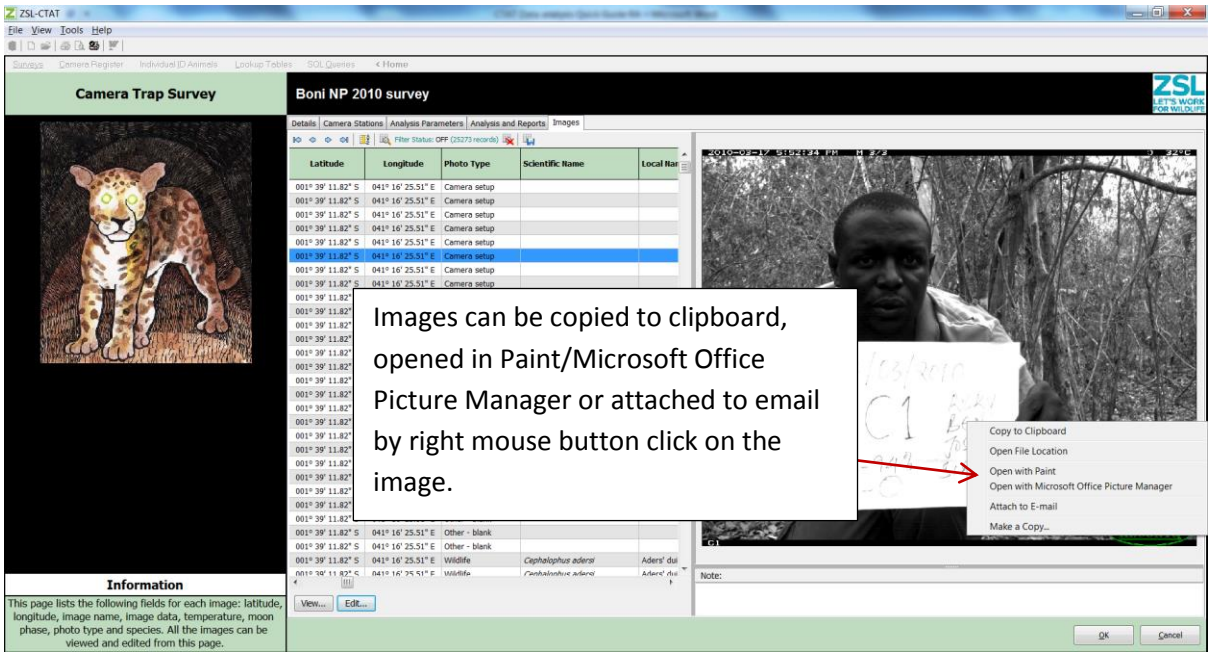
Clicking the edit button on the bottom of the page will bring up the 'Multiple Image Edit' page.



<u>Note: once image data has been edited, the analysis will need to be rerun (see section 4).</u>

<u>Exporting images</u>

Images can be copied to clipboard, opened in Paint/Microsoft Office Picture Manager or attached to email by right mouse button click on the image.

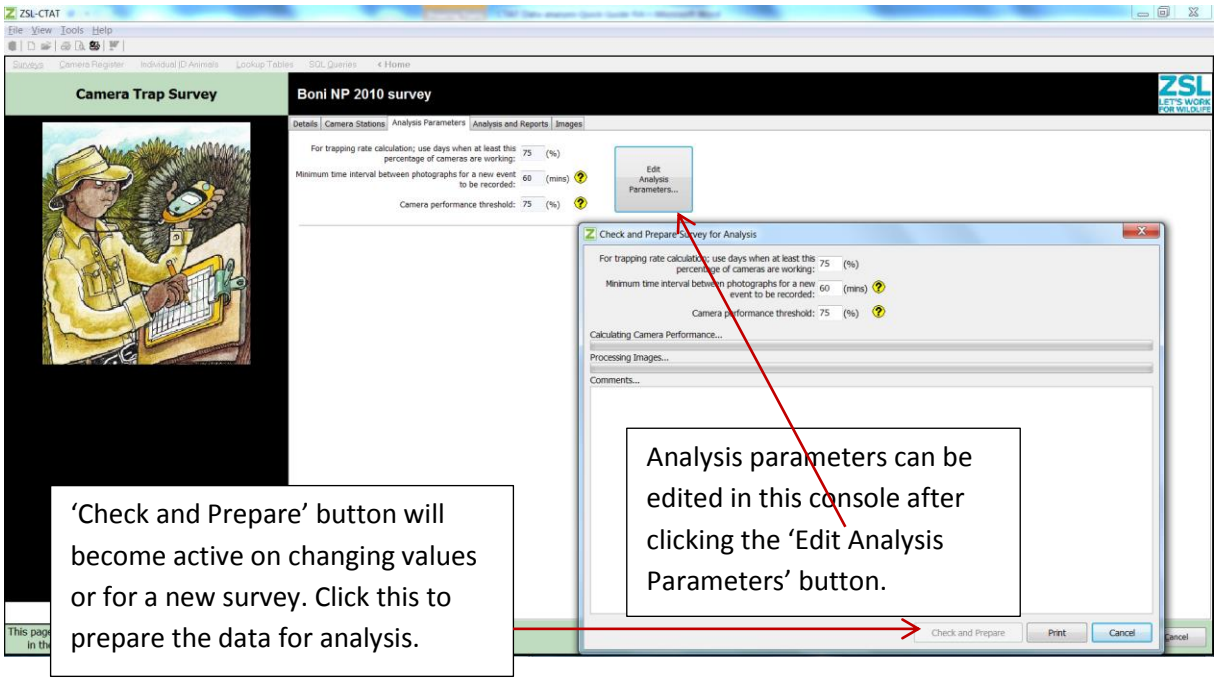


Images can be copied to clipboard, opened in Paint/Microsoft Office Picture Manager or attached to email by right mouse button click on the image.

4. Analysing camera-trap survey data

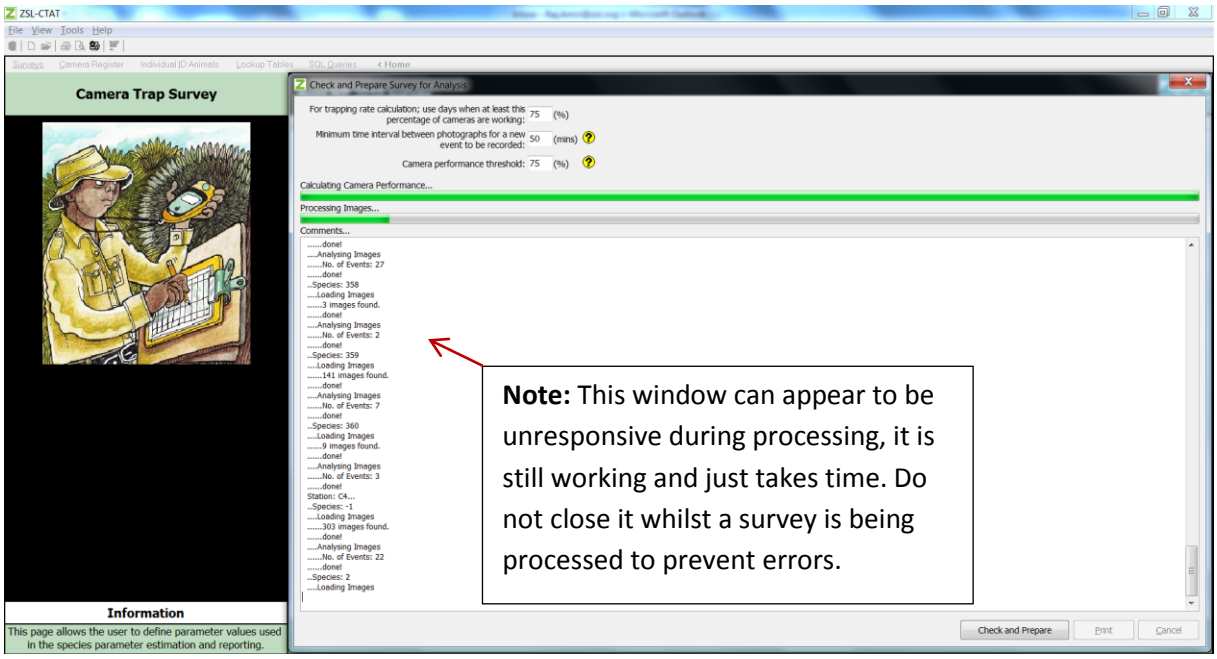
4.1 Preparing data for analysis

There are a few parameters that need to be set for analysis. These can be accessed from the 'Analysis Parameters' tab. The parameters can be edited as required using the 'Edit Analysis Parameters' button, which will open the editing page. The yellow question marks provide notes on the respective parameters.



- Parameter 1: For species trapping rate calculation: trapping rates for each survey day are calculated first and then the mean and standard error are calculated from the daily trapping rates. Only survey days when at least the defined percentage of cameras are operational are used in the calculation to ensure survey effort was consistent across days.
- Parameters 2: Minimum time interval between photographs for a new "independent" event to be recorded for a species. The default value is 60 minutes. Many of analyses in the tool are based on events so it is important to adjust the value as per your analysis.
- Parameter 3: This threshold value "x" is used to display camera performance on google map, QGIS or ArcReader based on levels: a) complete failure (0 days of camera functioning); b) low performance (operational for ">0 and < x%" of the survey duration); c) high performance (operational for >= x% of survey duration).

Once the parameters for the analysis have been confirmed / updated, clicking the 'Check and Prepare' button will process the data for analysis.

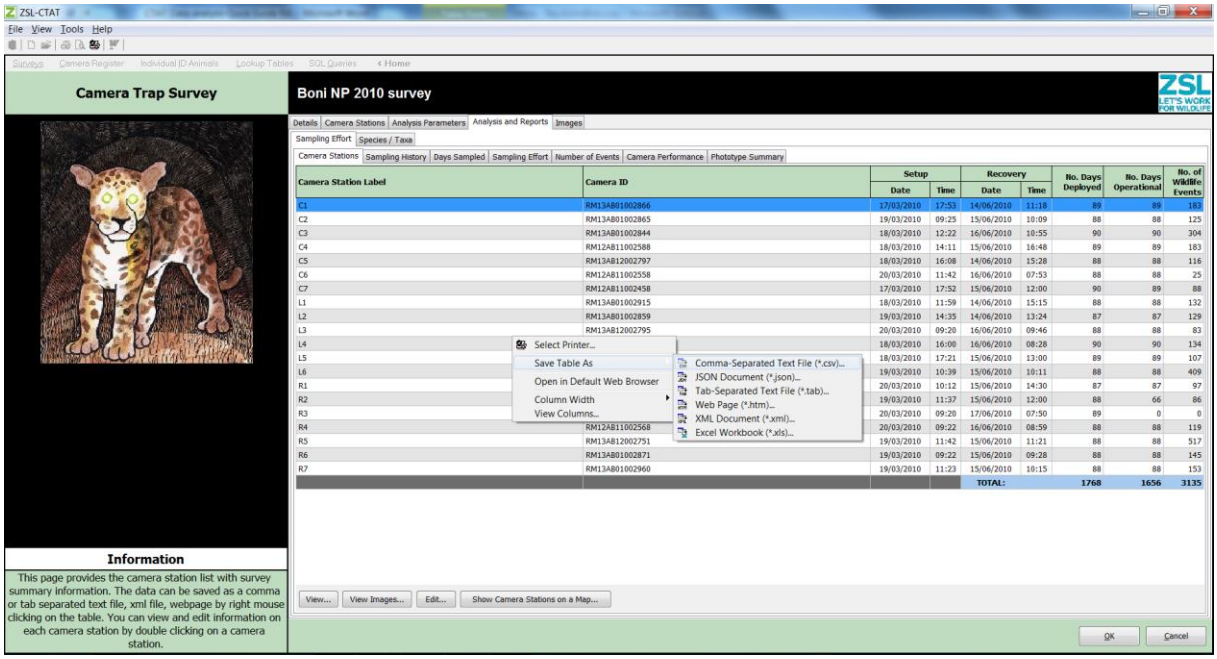


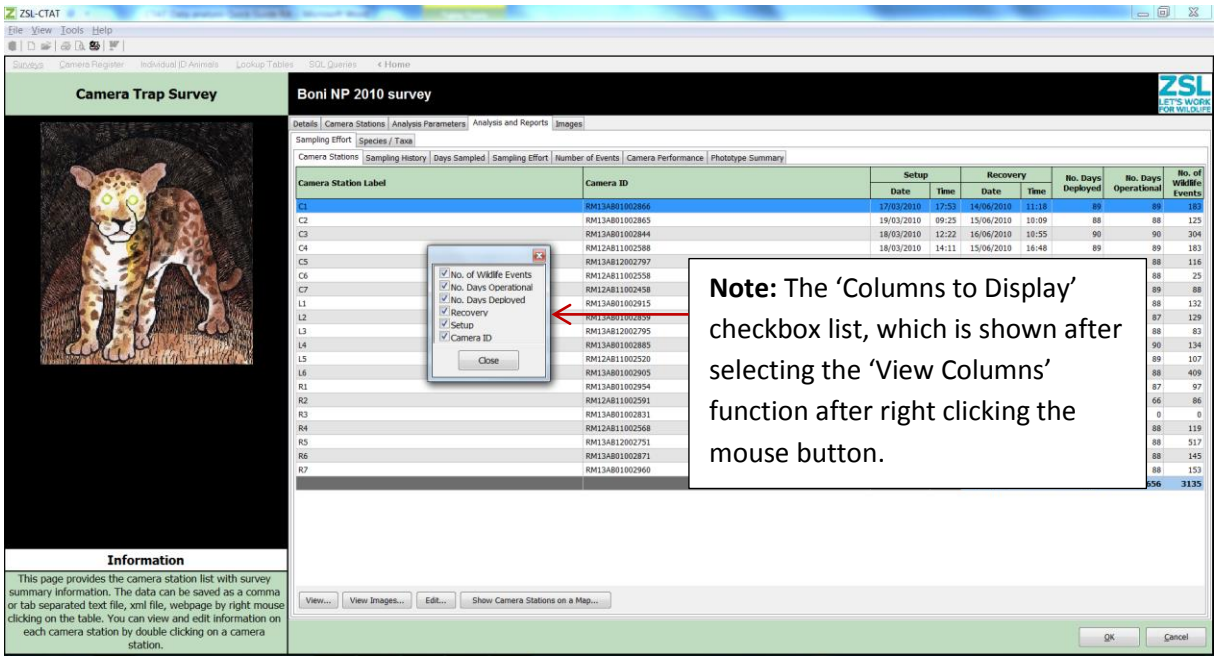
Note that analysis based on events (species richness, occupancy) will be cleared on reanalysing the events or for a new survey.

<u>Customising and exporting tables and graphs within the tool</u>

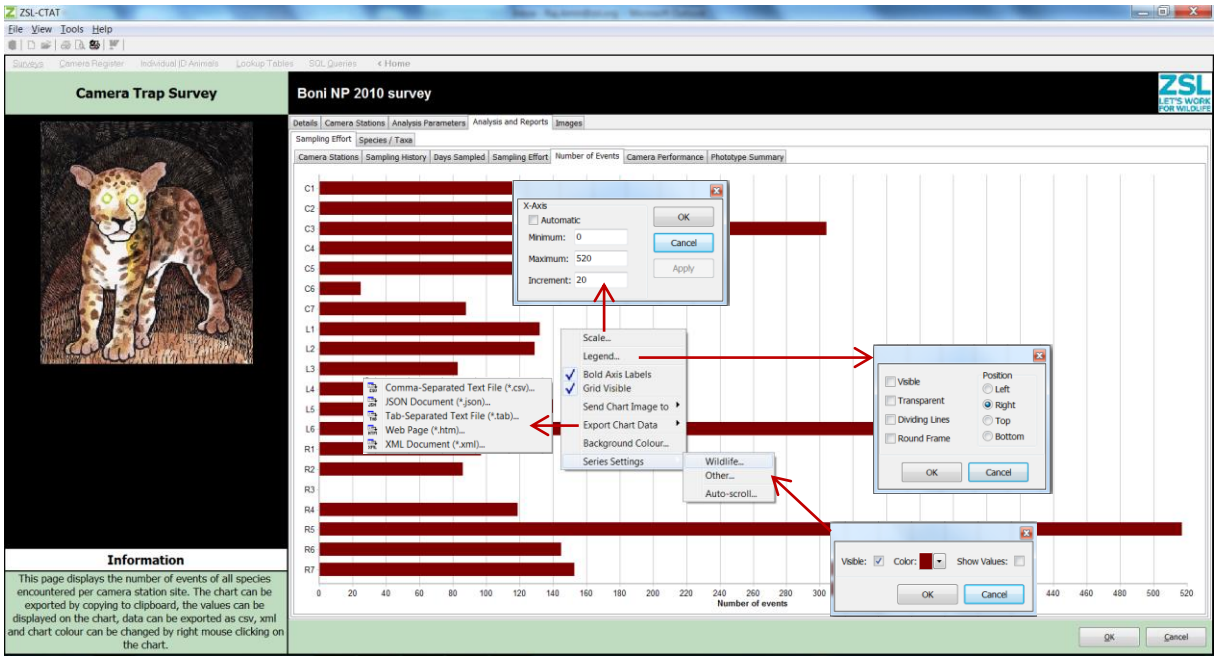
All tables and graphs produced by the tool can be customised and exported in different formats.

Tables can be saved in a range of formats (Comma separated text file ".csv", JSON document ".json", Tab separated text file ".tab", Web page ".htm", XML document ".xml" and Excel workbook ".xls") by right mouse clicking on a table. Selecting 'View Columns' will bring up a tick menu to select which fields / columns are displayed and exported.





For graphs, the scale, colour scheme and legend can be altered. Graphs can be exported as an image file to clipboard, Excel or Word. The data for the graphs can also be exported by selecting the export chart data option.



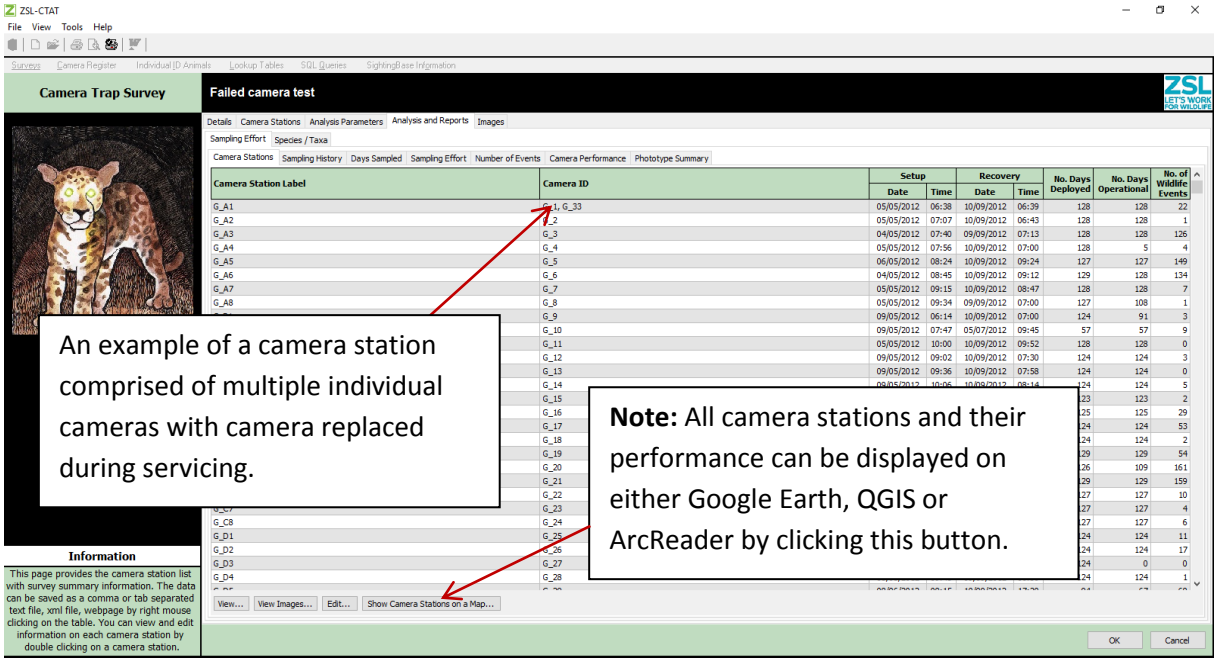
Pages can be resized and moved as needed using the mouse to fit neatly within the program given the different computer screen resolutions.

4.2 Sampling effort

The pages under the sampling effort tab provide outputs on survey effort. There are seven page reports on: Camera Stations, Sampling History, Days Sampled, Sampling Effort, Number of Events, Camera Performance and Phototype Summary.

4.2.1 Camera stations

The 'Camera Stations' page summarises the setup, service and recovery history of each camera station which can include multiple individual cameras at a station (either paired or cameras replaced during service). The number of days the cameras were deployed and operational at each station are calculated and displayed. The number of wildlife events recorded at each station is also displayed. The total survey days deployed and days operational are provided in the bottom row.



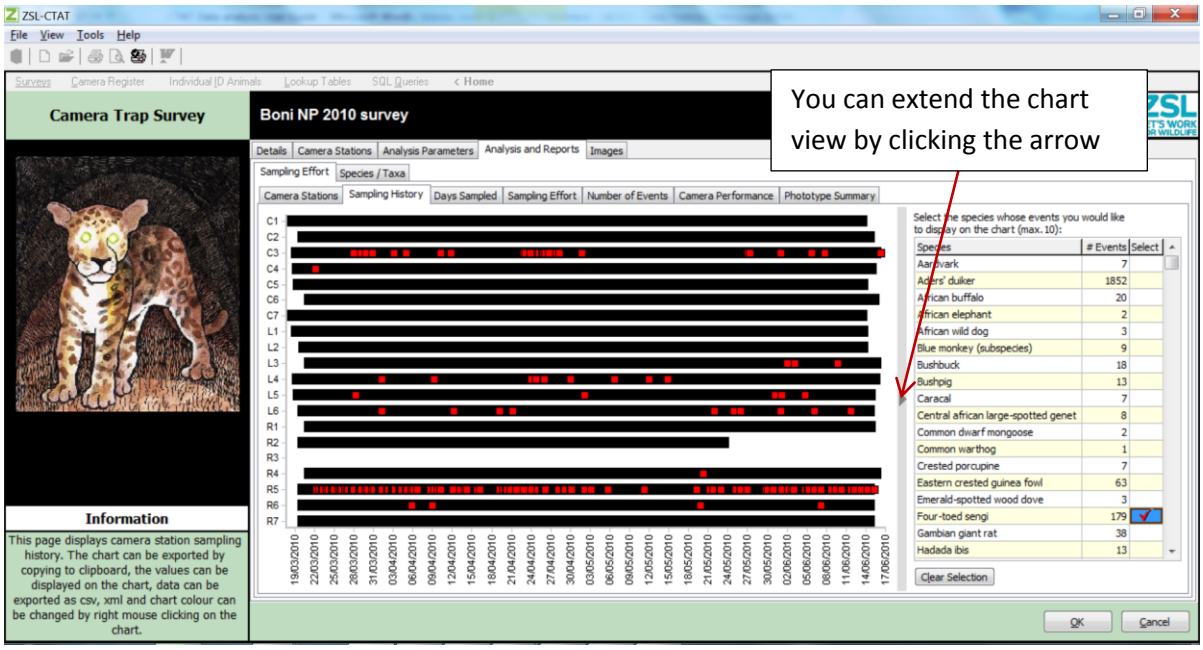
Double clicking the camera station or using the 'View' button will bring up all the data for that camera station.

4.2.2 Sampling history

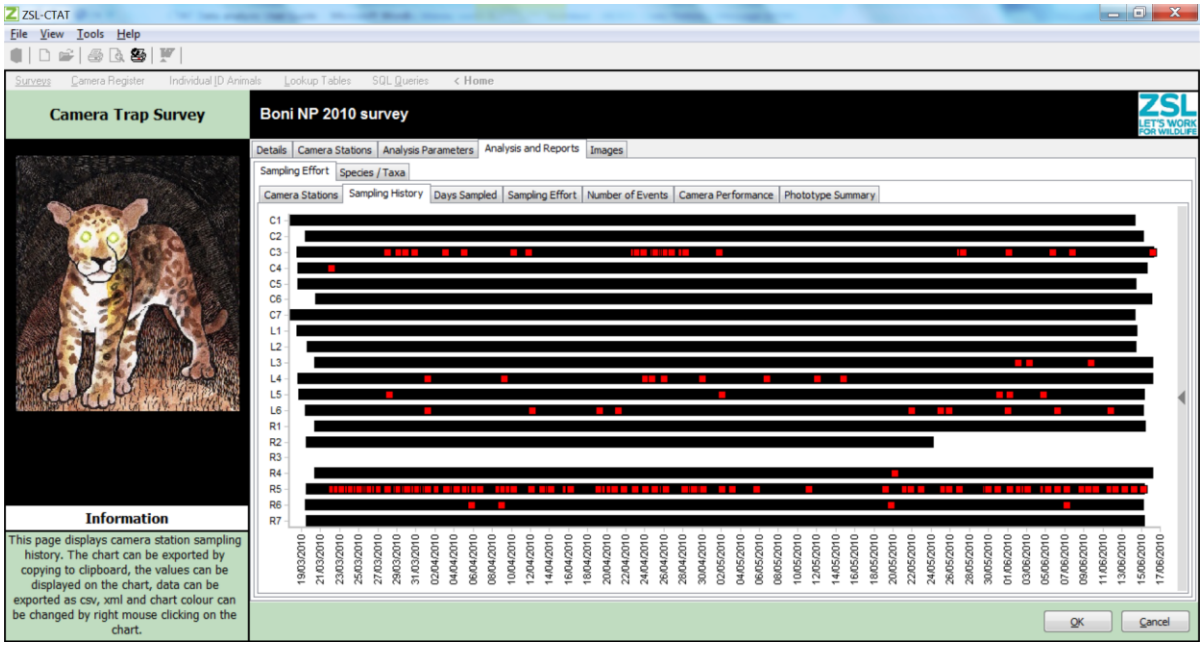
The 'Sampling History' page displays a bar chart of time periods over which each camera was active. A camera station with multiple cameras deployed (for example because of camera failures) will have a single row that comprises multiple disjointed bars, where each bar represents a camera's active sampling period.

The first date will be the date the first camera was setup and the last date will be the date the last camera was recovered or stopped working. Gaps in the bar plots represent cameras not functioning; service events will also displayed often as very small gaps.

Independent photographic events for up to 10 species can also be displayed on the chart by selecting the species from the right hand panel.

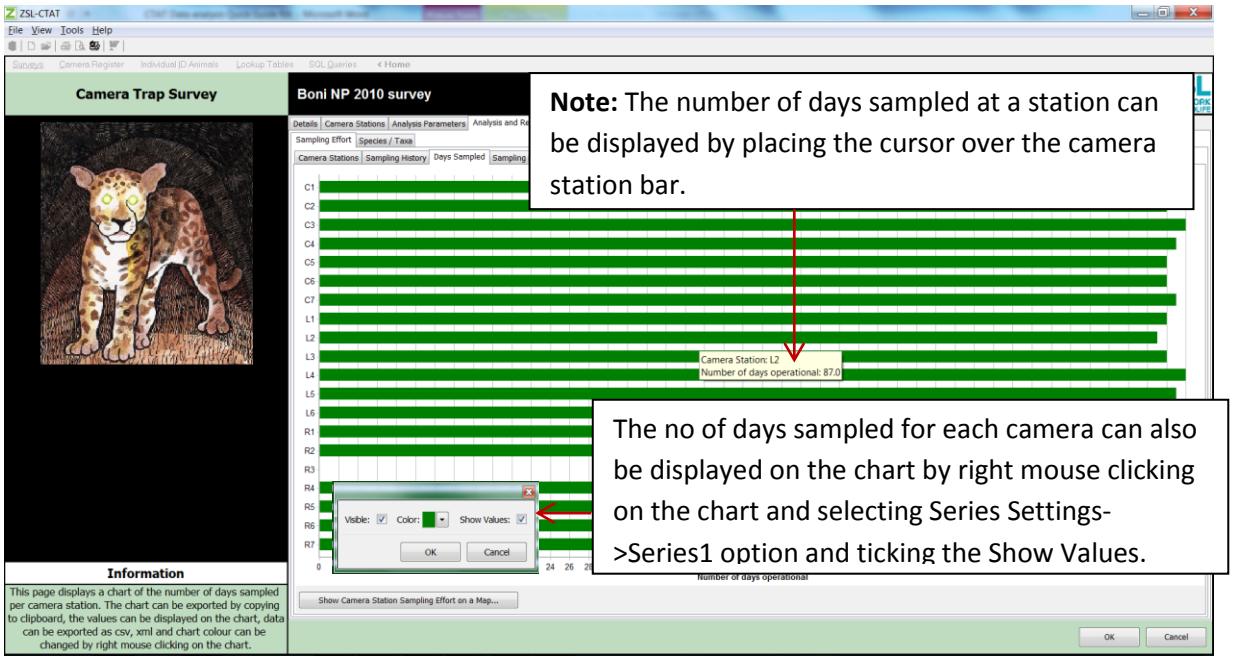


The chart view can also be extended by clicking on the side arrow as shown in the figure above.

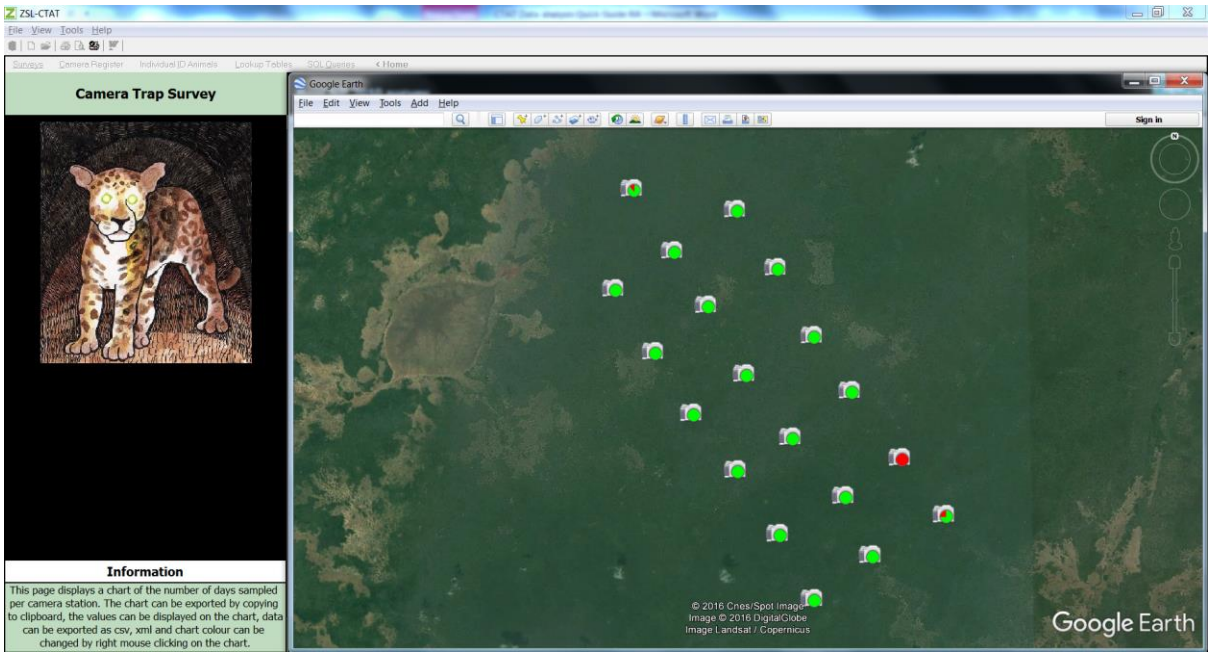


4.2.3 Days sampled

This page displays the number of days each camera station was operational during the survey.

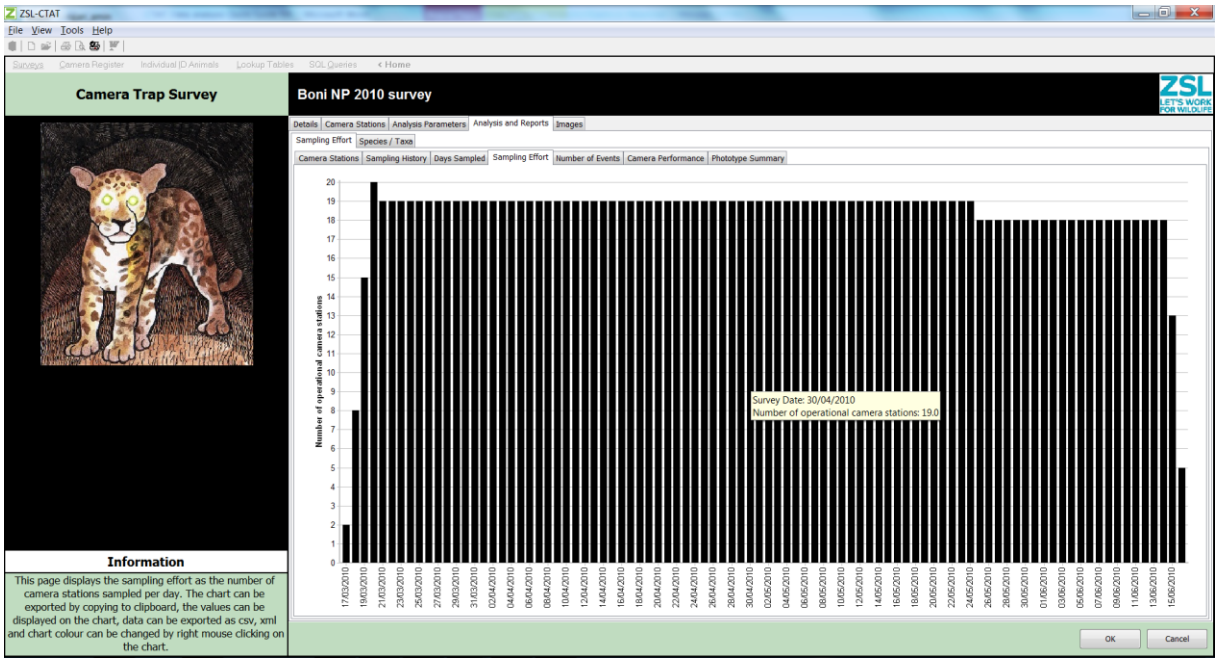


The days sampled can be displayed on a map by clicking the 'Show Camera Station Sampling Effort on a Map' button at the bottom of the page. Each camera station is displayed in Google Earth or QGIS/ArcReader at the location defined by the GPS co-ordinates with a pie chart showing the proportion of days operational (compared to the number of days the camera(s) was deployed).



4.2.4 Sampling effort

Sampling effort is displayed as the number of cameras (camera stations) which are operational per day. This provides an intuitive visual reference to establish how many cameras were operating at a given date, and is a good way of checking that survey effort has been consistent over the survey duration.

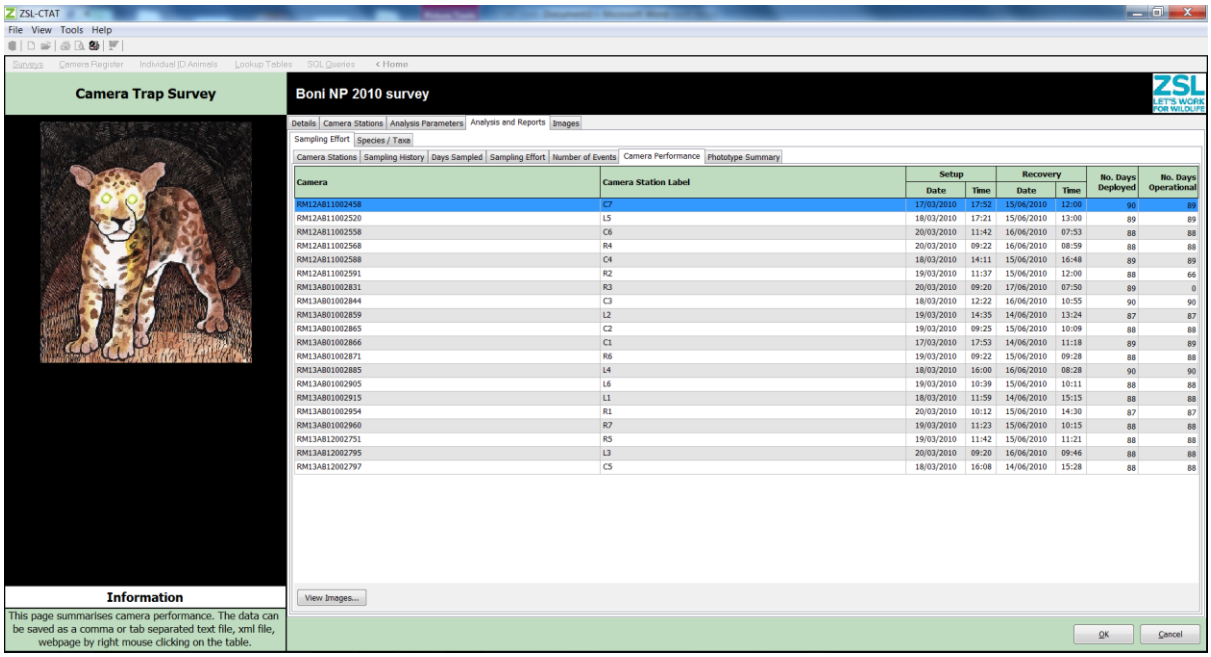


4.2.5 Number of events

This page displays the number of events for all wildlife encountered at each camera station.

4.2.6 Camera performance

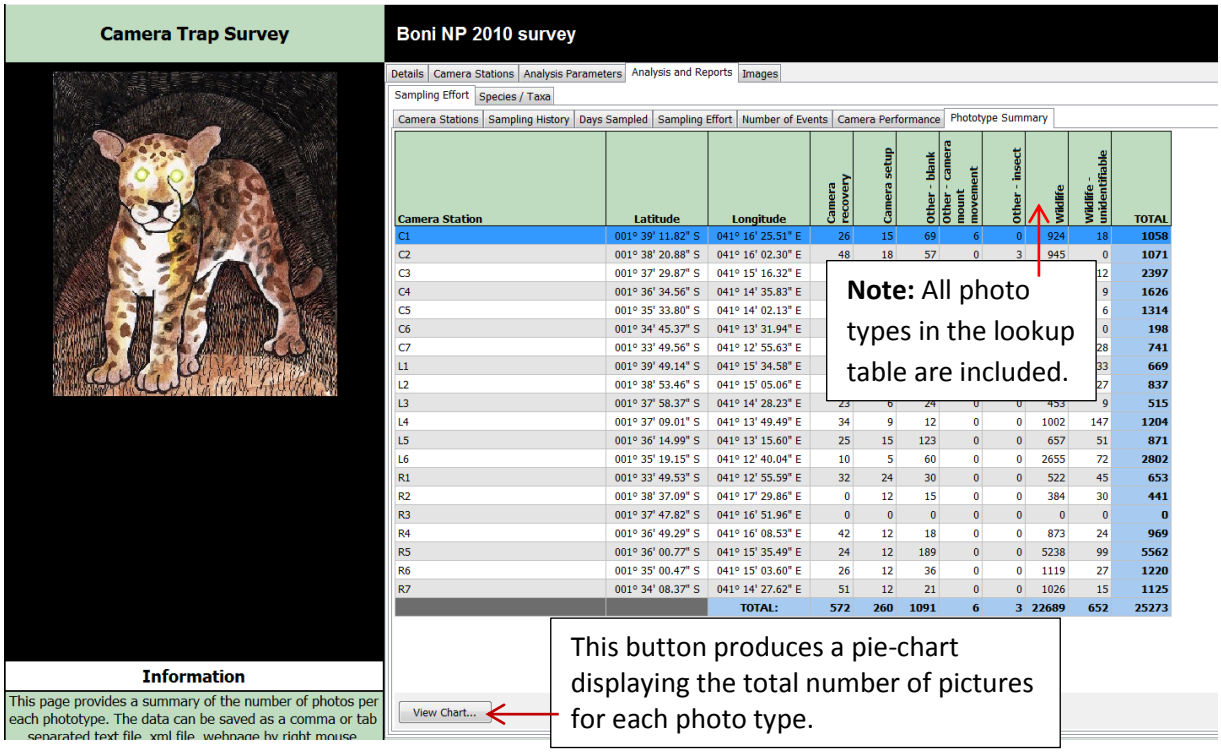
The ‘Camera Performance’ page displays the setup, service and recovery dates and times for each individual camera. The number of days the camera was deployed and was operational is also calculated and displayed.

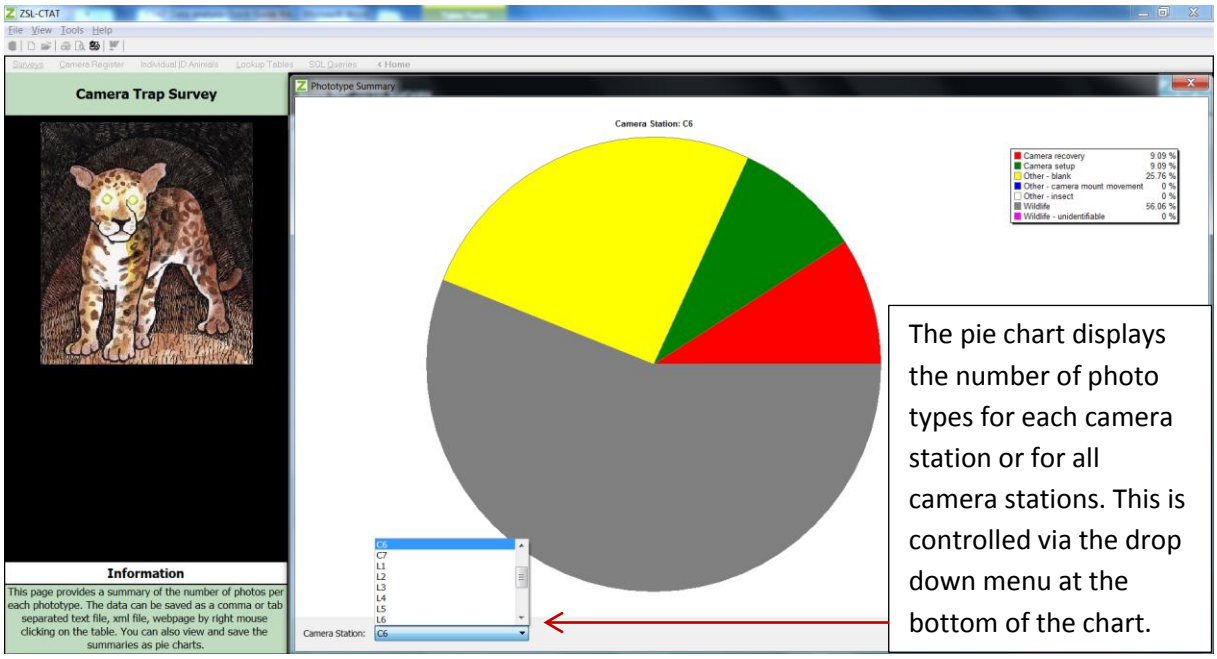


4.2.7 Photo type summary

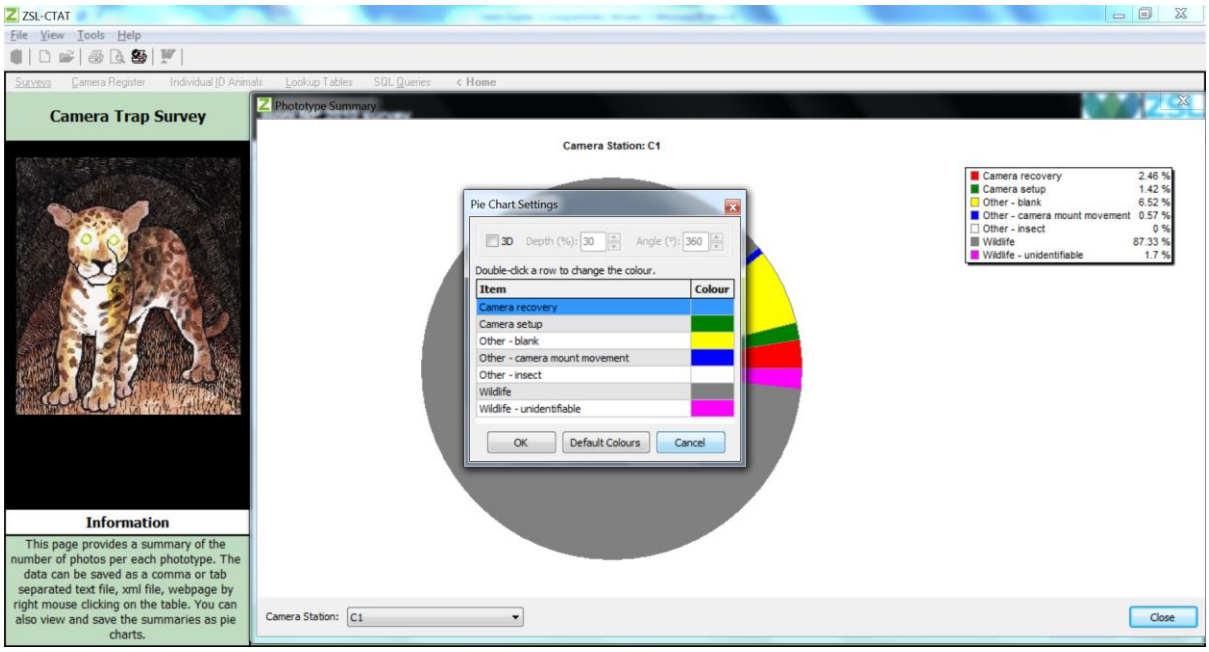
The 'Phototype Summary' page displays the total number of photos for each photo type (such as wildlife, livestock, other-shadow) at each camera station. The total number of photos is displayed for each station in the last column and for each photo type in the bottom row.

The data can also be presented as a pie chart using the 'View Chart' button at the bottom of the page. Pie charts can be viewed and exported to Excel etc. This allows quick assessment of potential issues with false triggers associated with camera positioning, vegetation etc.





Colours for the pie chart can be changed by clicking the right mouse button and selecting settings option.



4.3 Species

The pages within the Species tab provide a range of species level analyses and outputs. There are currently seven pages

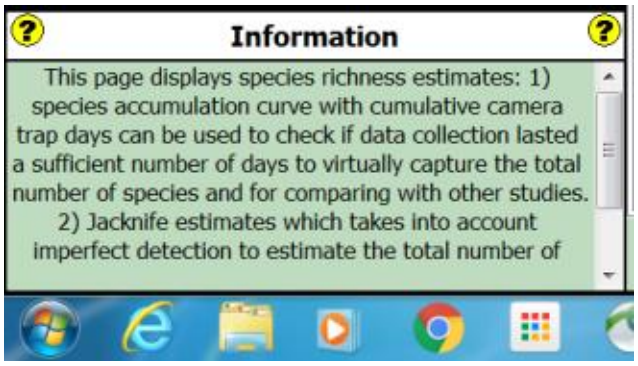
1. Species List
2. Species Richness
3. Species Events per Day
4. Species Trapping Rate

5. Species Occupancy
6. Species Distribution
7. Species Activity Pattern.

Additional analysis will be added in Phase 2 including

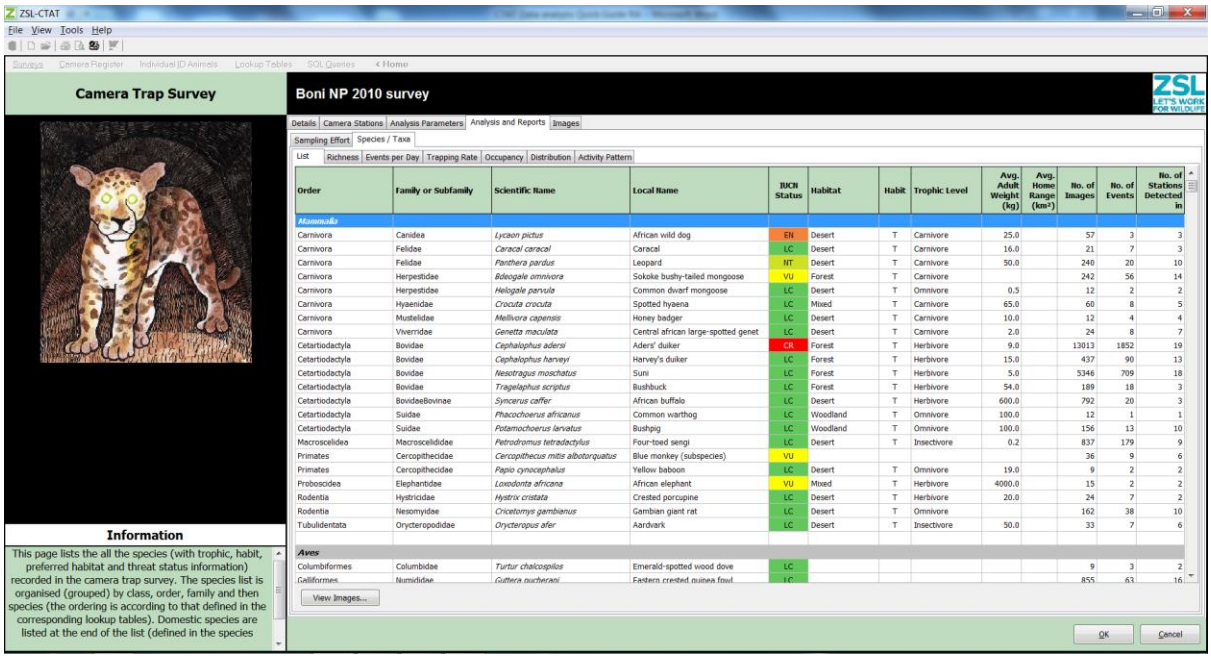
- Community structure analysis
- Additional statistical tests (χ^2, circular stats. etc.)
- Spatially explicit capture-recapture modelling for population density estimates for marked animals such as tiger
- Movement pattern analysis and home range estimation for marked animals
- Population density estimates for unmarked animals
- Activity modelling
- Cross survey analyses.

Summary help information is also provided in the bottom left panel of each page. More information is available on clicking the help "question mark".

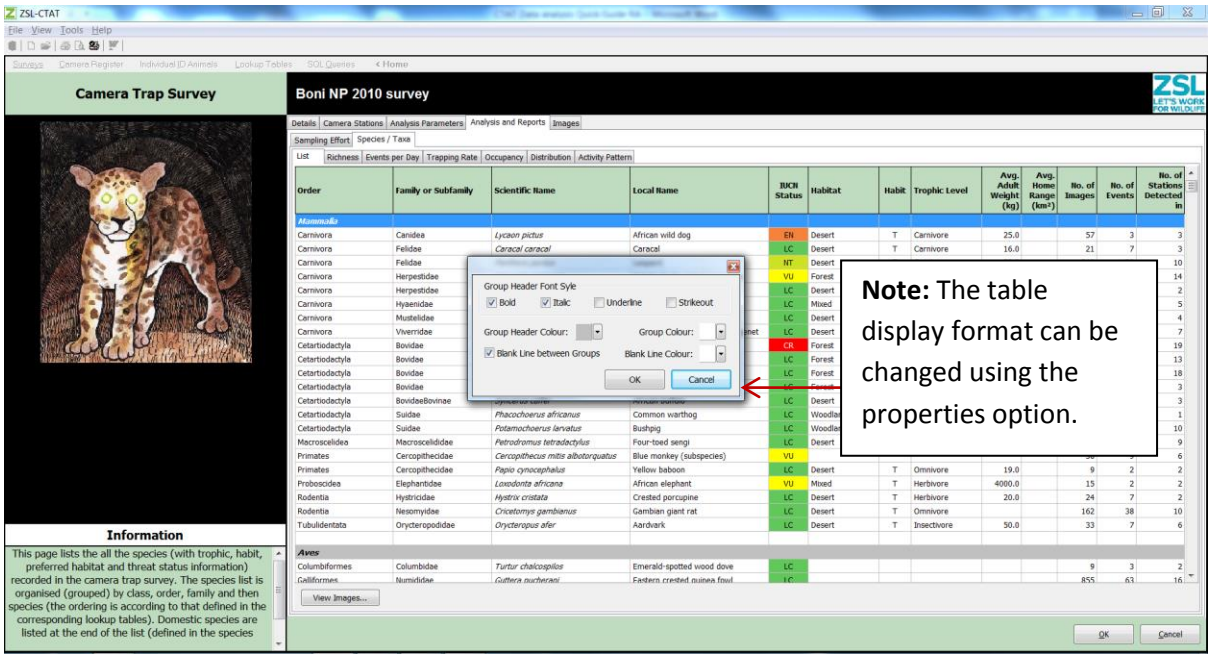


4.3.1 Species list

This page provides a species list arranged by class (starting with mammals and birds) and then order, family and species (scientific name) in alphabetical order. Species level information on IUCN status, habitat preference, habit (arboreal, terrestrial etc.), tropic level (carnivore, omnivore etc.), average adult body weight and average home range is also provided. It is important to fill in the species lookup table so that this information is presented accurately and fully. Any domestic species (also defined in the lookup table) detected are listed at the end of the list. The number of images, number of events and number of camera stations in which the species was detected are also presented.



The table display format can be changed by clicking right mouse button and selecting properties option.



As with all tables, the information can be exported to Word, Excel etc.

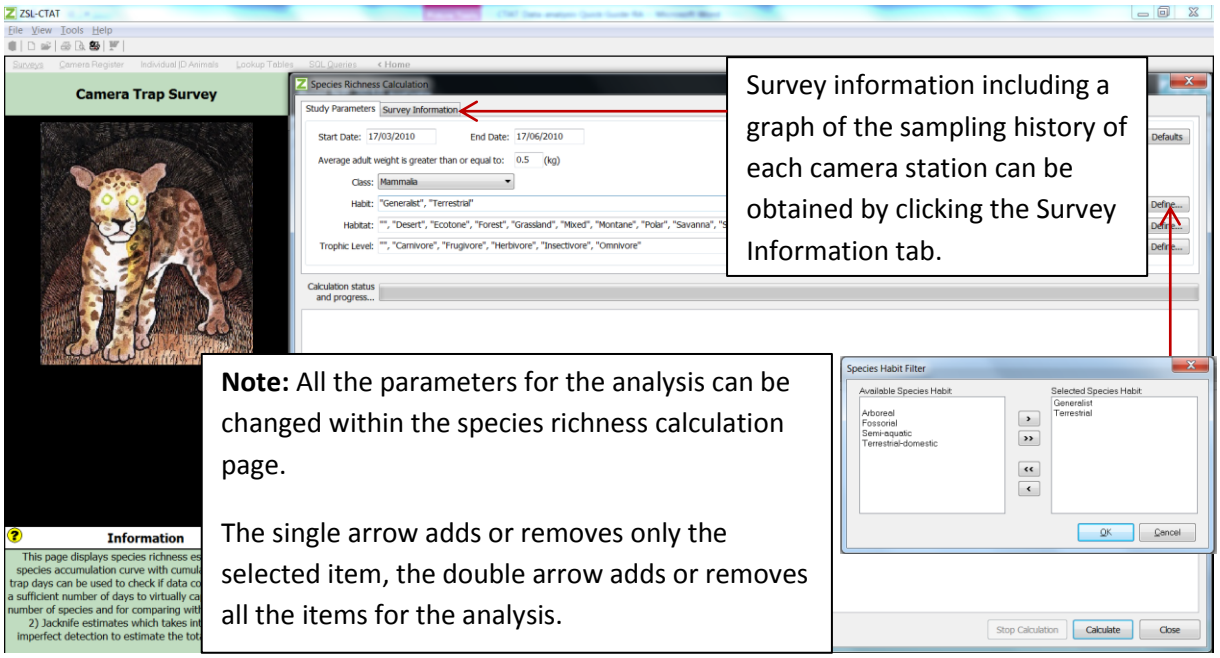
4.3.2 Species richness

This page provides the species accumulation curves, and species richness estimate. These are calculated within the R statistical package by clicking on the 'Calculate Richness' button. This will bring up the Species Richness Calculation page where the following parameters can be set for the calculation.

- Time period over which to derive the estimates.
- Groups/classes of species to include in the analysis.
- Species of specific habits, habitats and trophic levels to be included in the analysis.
- Species of specified range of body weights to be included in the analysis.

The parameters can be reset to their default values by clicking the 'Defaults' button.

Survey information including a graph of the sampling history of each camera station can be obtained by clicking the Survey Information tab. This can assist with deciding whether the analysis time period needs to be changed to ensure equal survey effort.



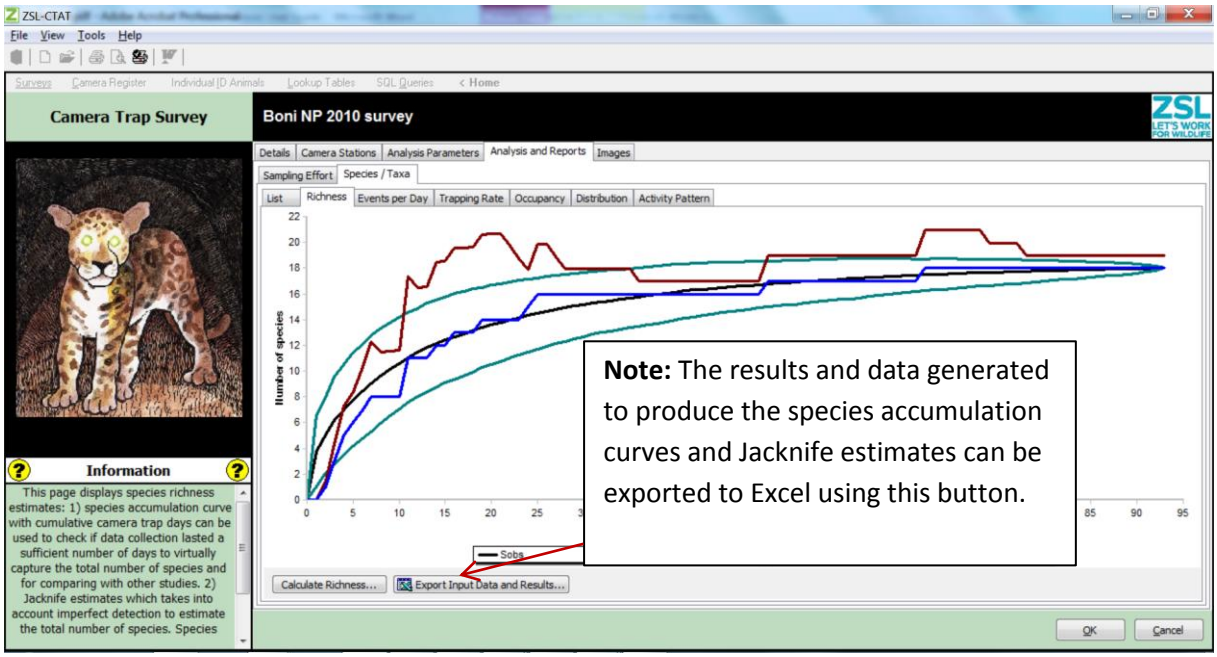
Three outputs are provided.

1) Observed species accumulation curve with the cumulative species detected over time (camera days).

2) Species sample-based rarefaction curve (smooth line) is the expected number of species (and its confidence interval calculated from its *unconditional* standard deviation) based on a number of possible combinations of samples from the survey data. This can be used to check if survey duration was sufficient to capture all or majority of the species. In the calculation of the species rarefaction curve, the order in which the samples are included is randomised 1000 times and the results used to derive 95% confidence intervals around the mean. Even though this approach ignores imperfect detection of individual species, it is useful for comparison with other studies.

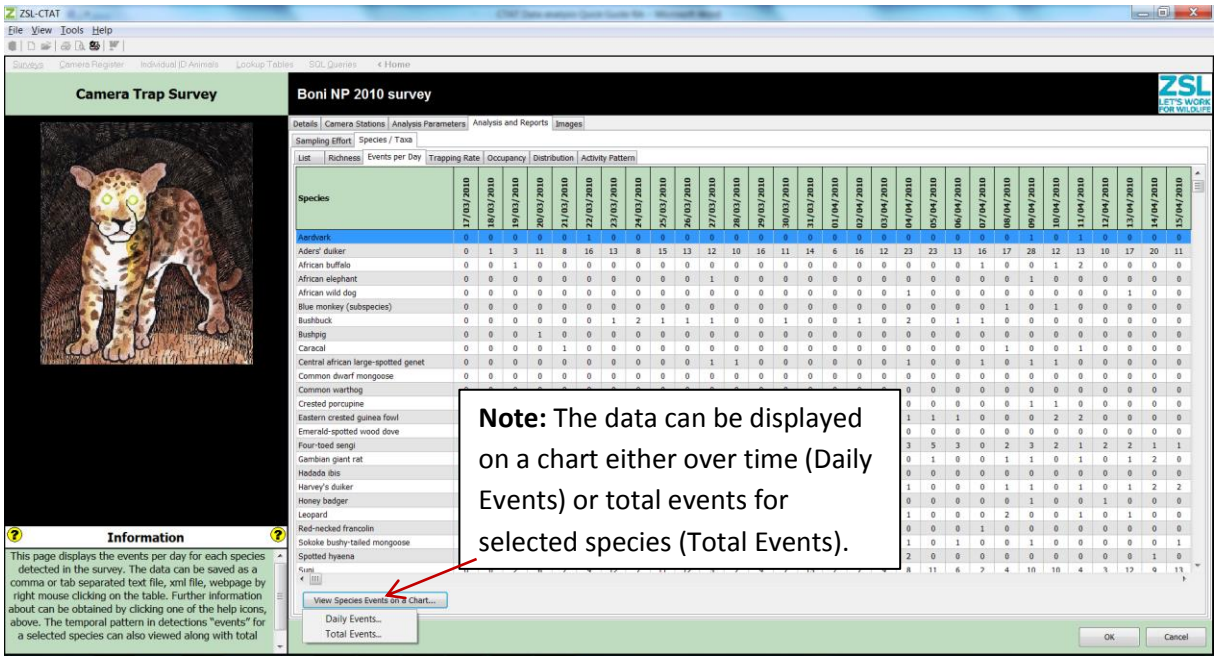
3) Jackknife (order 1) estimate curve which takes into account imperfect detection to estimate the total number of species. The non-parametric incidence-based estimator Jackknife with order one gives the most reliable estimate for large numbers of camera days. Jackknife estimators also assume that the community composition does not change over the time of the study (closure), and that there is no temporal variation in capture probability for all species.

The habit of a species can affect detectability, for example arboreal species are less likely to be detected in cameras set at ground level and targeted for terrestrial species. Similarly very small species are less likely to trigger cameras. Therefore, it is necessary to establish a defined subset of species of approximately similar detectability in order to develop a comparable index of mammalian species diversity from camera trapping data. For ground based surveys, this is typically set for terrestrial species greater than 0.5 or 1 kg in average adult body weight.



4.3.3 Species events

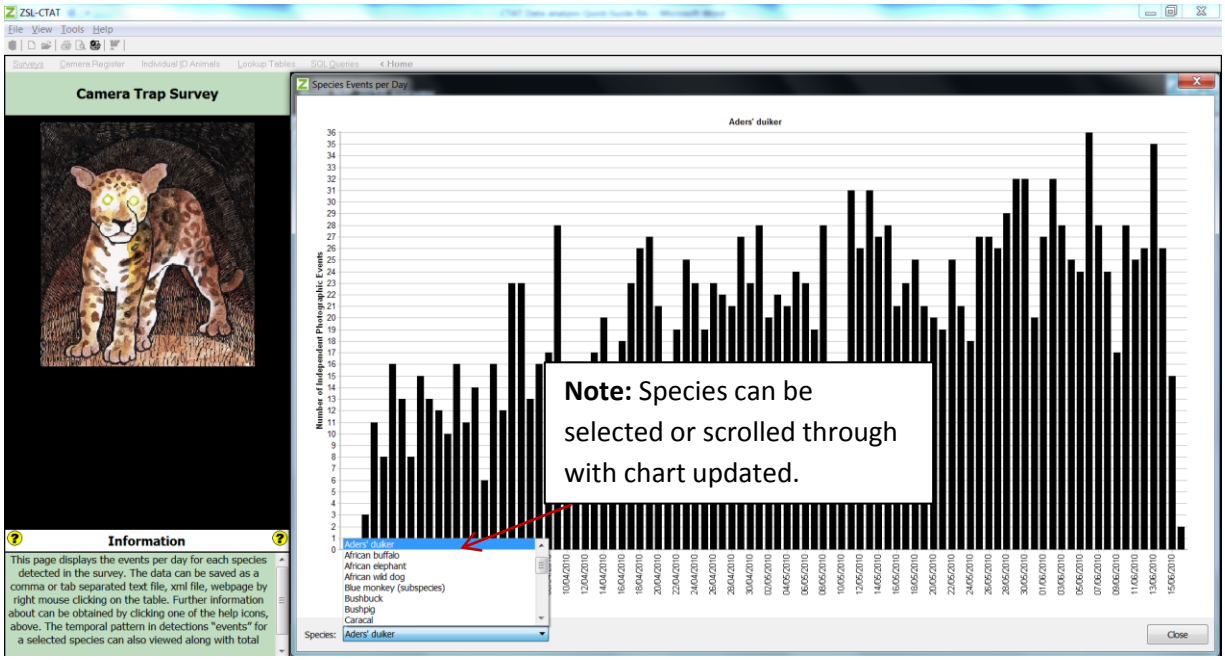
The 'Events' page displays the number of independent photographic events per day for each species detected in the survey. An independent photographic event is defined as any sequence of images for a given species occurring after an interval of equal to or greater than the interval defined in 'analysis parameters' from the previous image sequence of that species. The default setting for this event interval is 60 minutes.



Two options are available to display data on a chart by clicking on the 'View Species Events on a Chart' button.

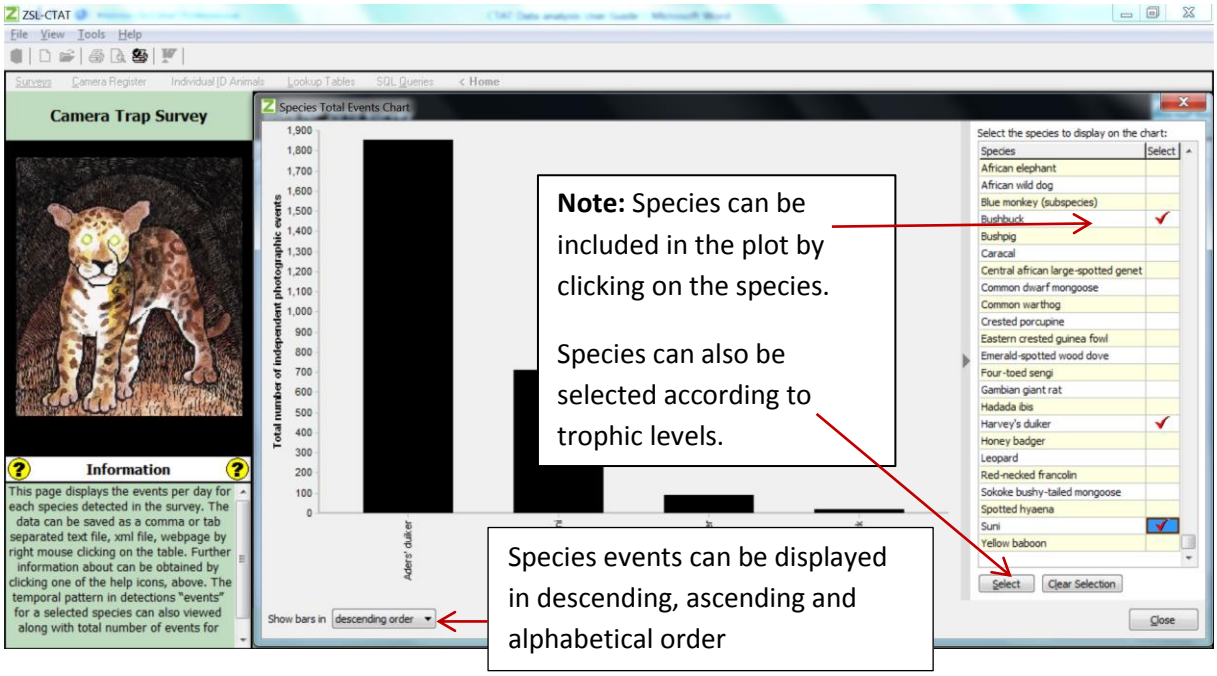
Daily Events: The number of events per day over time for each species can be displayed as a bar plot to assess changes over time.

Note: the daily plot does not take into account variation in the number of cameras operational per day (see section 4.3.4 for trapping rates).



Total Events: The total number of events for selected species over the entire duration of the survey can also be displayed as a bar chart. Multiple species can be selected by clicking the species in the

species list. Species can also be selected according to trophic level (carnivore, herbivore etc.). The species events can be displayed in descending, ascending and alphabetical order.



4.3.4 Species trapping rate

Species trapping rate is calculated as the mean number of independent photographic events per trap day x 100.

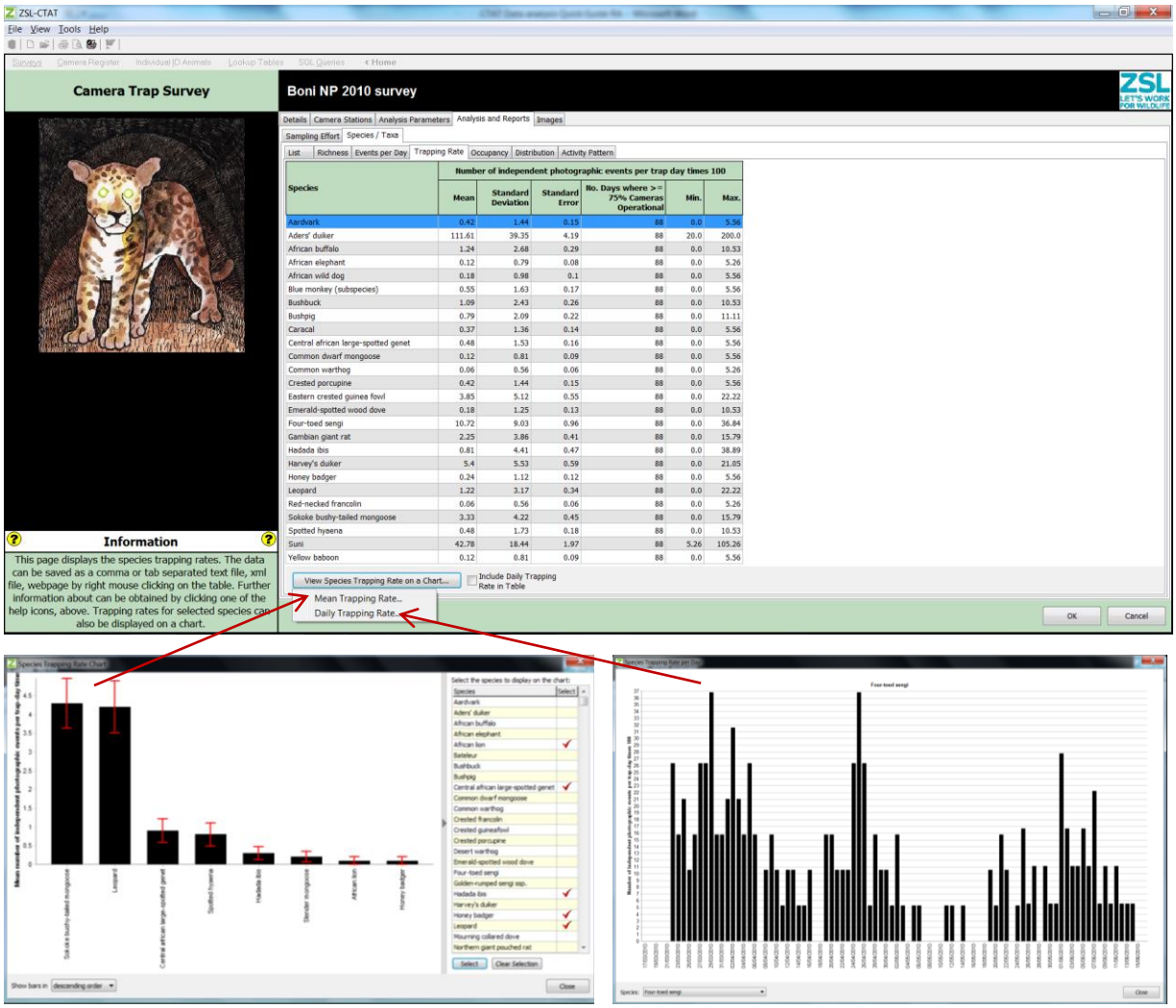
Trapping rate provides a simple index of relative abundance with the assumption that a target species will trigger cameras in relation to their density, all other factors being equal. Trapping rates provide a comparative index within species, if a standardized protocol is used for the surveys (including consistent positioning and management of cameras to ensure detection probabilities are similar).

The mean trapping rate with standard deviation, standard error and the minimum and maximum daily trapping rates are provided for each species. These parameters are calculated from the daily trapping rate using trap days with survey effort greater than or equal to the defined value (i.e. the percentage of cameras operational).

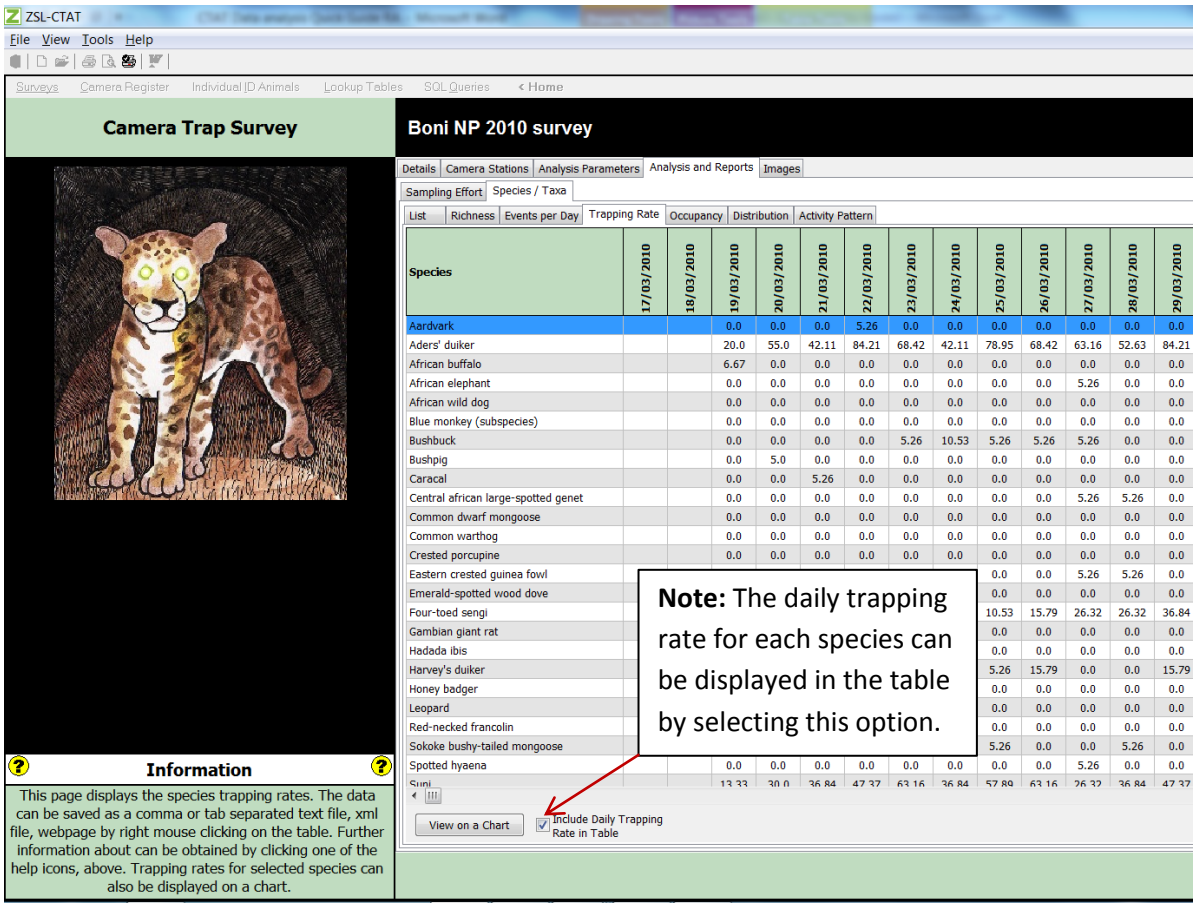
Two options are available to display data on a chart by clicking on the 'View Species Trapping Rate on a Chart' button.

Daily Trapping Rate: Daily trapping rate over time for each species can be displayed as a bar plot to assess changes over time. Note: this plot takes into account variation in the number of cameras operational per day.

Mean Trapping Rate: The mean trapping rate for selected species over the entire duration of the survey can also be displayed as a bar chart along with the standard error. Multiple species can be selected by clicking the species in the species list. Species can also be selected according to trophic level (carnivore, herbivore etc.). The species trapping rates can be displayed in descending, ascending and alphabetical order.



The daily trapping rate for each species can be displayed in the table (and then exported as needed) by ticking the 'Include Daily Trapping Rate in Table' box which is next to the 'View Species Trapping Rate on a Chart' button.



Species	17/03/2010	18/03/2010	19/03/2010	20/03/2010	21/03/2010	22/03/2010	23/03/2010	24/03/2010	25/03/2010	26/03/2010	27/03/2010	28/03/2010	29/03/2010
Aardvark			0.0	0.0	0.0	5.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aders' duiker			20.0	55.0	42.11	84.21	68.42	42.11	78.95	68.42	63.16	52.63	84.21
African buffalo			6.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
African elephant			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.26	0.0	0.0
African wild dog			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Blue monkey (subspecies)			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bushbuck			0.0	0.0	0.0	0.0	5.26	10.53	5.26	5.26	5.26	0.0	0.0
Bushpig			0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Caracal			0.0	0.0	5.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Central african large-spotted genet			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.26	5.26	0.0
Common dwarf mongoose			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Common warthog			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crested porcupine			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eastern crested guinea fowl									0.0	0.0	5.26	5.26	0.0
Emerald-spotted wood dove									0.0	0.0	0.0	0.0	0.0
Four-toed sengi									10.53	15.79	26.32	26.32	36.84
Gambian giant rat									0.0	0.0	0.0	0.0	0.0
Hadada ibis									0.0	0.0	0.0	0.0	0.0
Harvey's duiker									5.26	15.79	0.0	0.0	15.79
Honey badger									0.0	0.0	0.0	0.0	0.0
Leopard									0.0	0.0	0.0	0.0	0.0
Red-necked francolin									0.0	0.0	0.0	0.0	0.0
Sokoke bushy-tailed mongoose									5.26	0.0	0.0	5.26	0.0
Spotted hyaena			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.26	0.0	0.0
Suni			13.33	30.0	36.84	47.37	63.16	36.84	57.89	63.16	26.32	36.84	47.37

4.3.5 Species occupancy

Species occupancy is defined as the proportion of area occupied (or used - where camera spacing is less than the species home range) by a species. Naïve occupancy is defined as the number of cameras at which a species was detected divided by the total number of operational cameras. Species detection probability is defined as the likelihood that a species is detected by a camera when present.

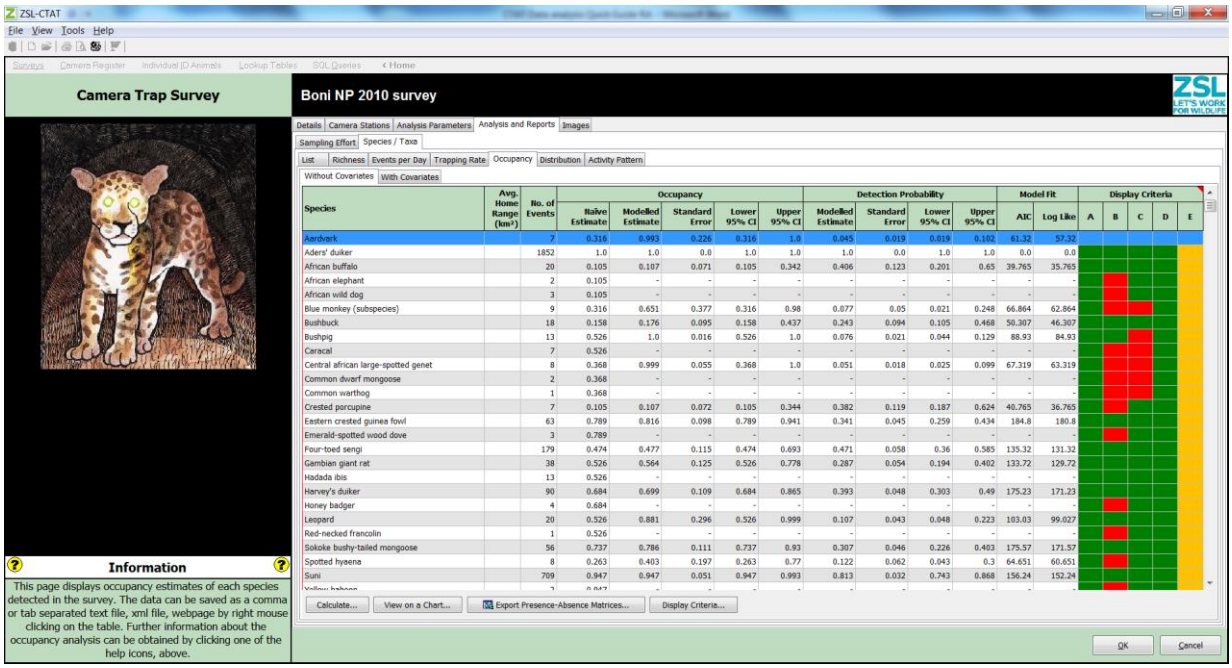
Modelled occupancy estimates are corrected by detection probability and are therefore a more rigorous index of abundance for both within and between species comparisons. This, however, is limited to surveys generating adequate data sets and where camera spacing is greater than the species home range (so that an individual is likely to be detected in only one camera), and occupancy is not confounded by changes in the home range.

Factors influencing occupancy and detection probability can also be incorporated into occupancy modelling.

The tool allows occupancy (and detection probability) to be modelled with or without site covariates.

<u>Modelling occupancy without covariates</u>

To model occupancy without covariates, 'Without Covariates' tab is selected to bring up the 'Occupancy without Covariates' page.



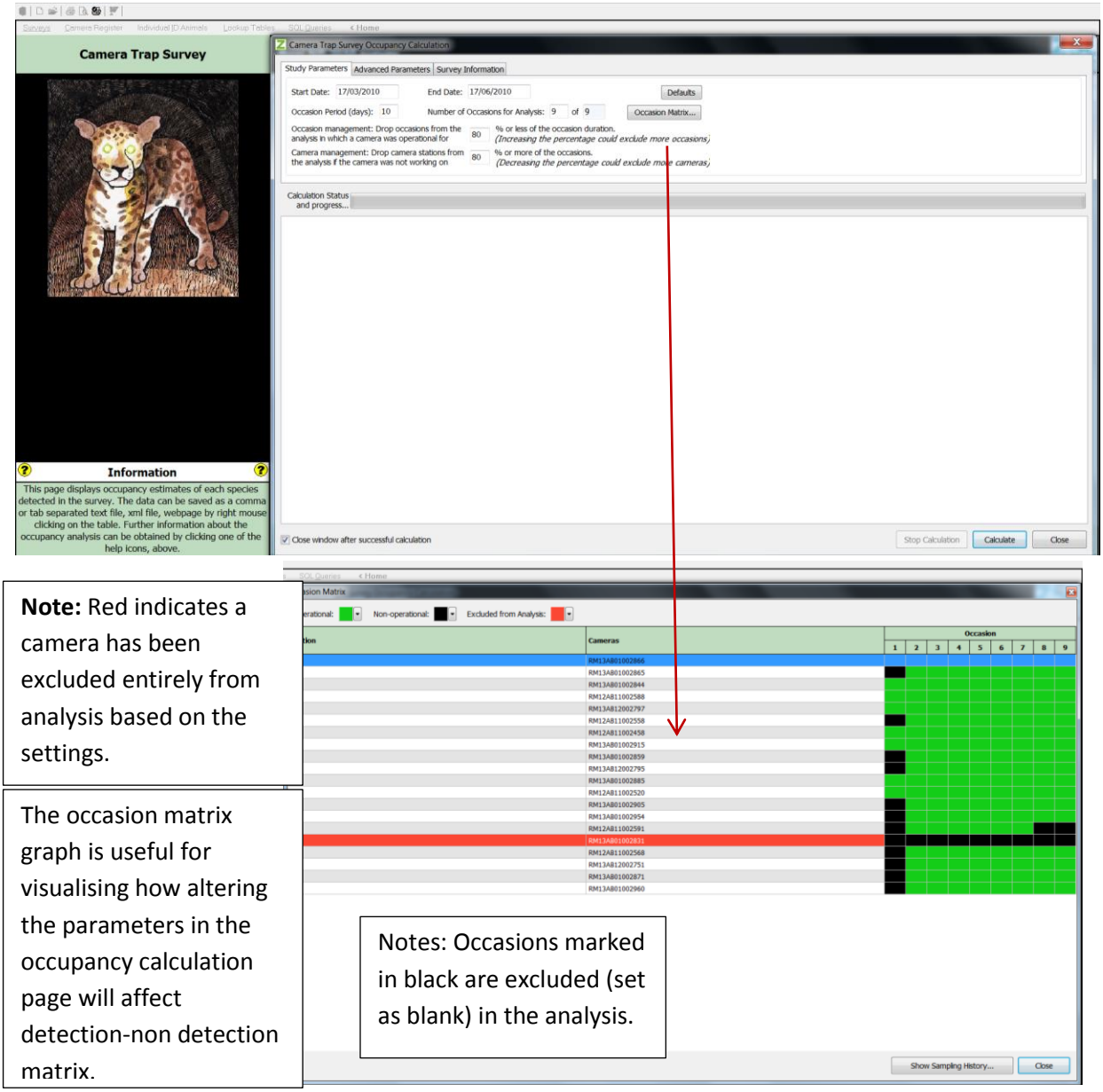
On clicking the 'Calculate' button will bring up the 'Occupancy Calculation' page, where the following parameters can be defined:

1) The start and end dates for the occupancy analysis (default settings: Start Date = the date first camera was setup; End Date = date the last camera was recovered).

2) The length of the occasion period (default: 5 days) and the number of occasions out of the total available number to be analysed. Note that grouping days into sampling occasions may improve detection probability of rarer species.

3) Occasion management defines when an occasion for a camera station is removed from the analysis based on whether the camera station was operational for *xx*% or less of each occasion duration (default: 80%). Increasing the percentage value will exclude (set as blank) more occasions from analysis. *Example:* with 80% setting and each occasion period lasting five days, camera stations operational for three out of the five days would have that occasion set as blank in the analysis.

4) Camera management defines when a camera station is removed from the occupancy analysis, based on the camera station not operational on *xx*% or more of the occasions (default: 80%). Decreasing this percentage will exclude more camera stations from analysis. *Example:* with 80% setting, in a 10 occasion analysis camera stations functioning for 2 occasions or more would be included in the analysis.



Note: Red indicates a camera has been excluded entirely from analysis based on the settings.

The occasion matrix graph is useful for visualising how altering the parameters in the occupancy calculation page will affect detection-non detection matrix.

Notes: Occasions marked in black are excluded (set as blank) in the analysis.

The 'Advanced Parameters' tab also provides an option to set two data parameters as occupancy modelling can fail (causing an error in R) when the detection data/counts are very few. The algorithm implemented in the tool will not perform the modelling for the following two data thresholds (i.e. if either of the two criteria below is not met then occupancy modelling is not carried out).

Naïve occupancy threshold: occupancy modelling will only be performed for naïve occupancy (i.e. proportion of camera stations where the species is detected) greater than value 'X' (default 0.1).

Number of detections threshold: occupancy modelling will only be performed when the number of detections (i.e. number of "1"s in the detection-non detection matrix) is greater than value "X" (default 5).

Clicking the 'Calculate' button on this page will start the single season occupancy modelling for each species via the R statistical software interface. The detection-non detection matrix for each species

can be exported using the 'Export Detection-Non Detection Matrices' button at the bottom of the page. This will export all of the species detection-non detection matrices into Excel with each species data in a separate page in the Excel workbook.

On completion of the analysis, the tool will populate the results table with the occupancy and detection probability estimates (with standard error and 95% confidence intervals) and also naïve occupancy. Modelled species occupancy estimates can be unreliable if there are not enough data and this is highlighted through four related criteria set by the user by clicking the 'Occupancy Display Criteria' button on the occupancy results page.

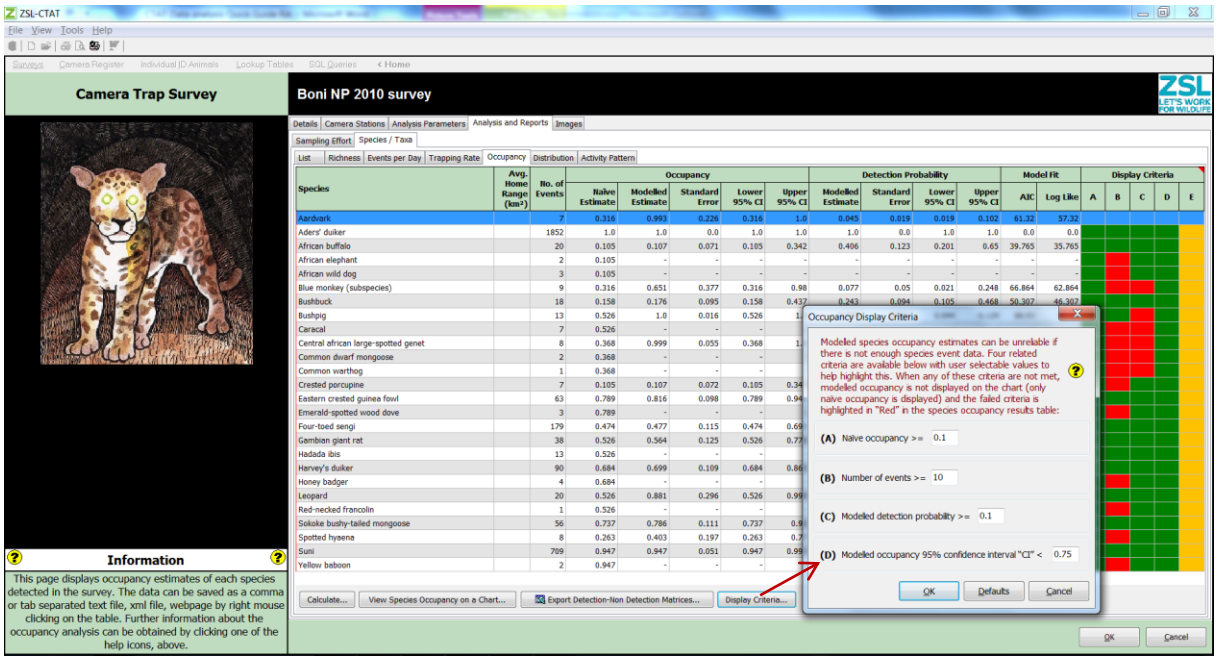
The four criteria and their default values are:

A) Naïve occupancy >=0.1: studies have shown that occupancy estimates are often not sufficiently accurate for species recorded at <10% of camera stations.
B) Number of events >=10: as sufficient species detection is required for reliable estimates.
C) Modelled detection probability >=0.1: as species need to be sampled with sufficient detection probability to allow occupancy models to be accurate (and models to converge).
D) Modelled occupancy 95% confidence interval <0.75: this relates to the level of uncertainty in the estimate.

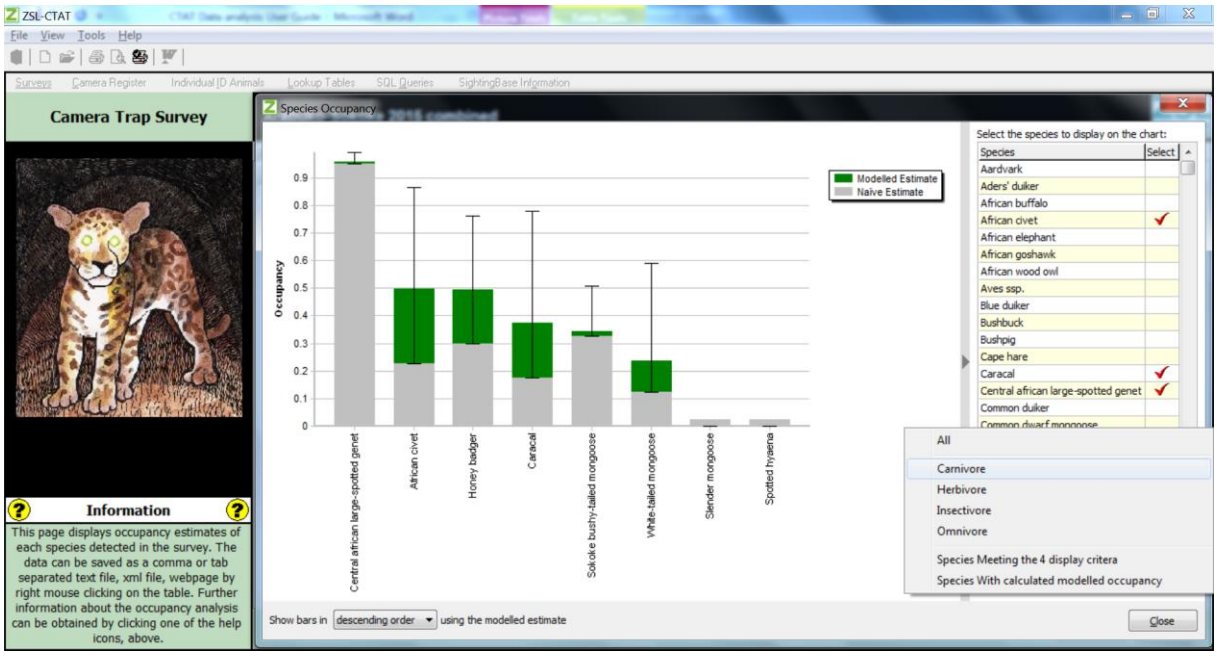
The tool also displays a fifth display indicating suitability of the estimates as a measure of proportion of area occupied by the species:

- Suitable (Green) where the species range, calculated from the home range in km^2 using area formula Πr^2 where species range = 2r, is less than or equal to camera spacing;
- Not Suitable (Red) where the species range is greater than camera spacing – in this case occupancy can be considered as proportion of area used;
- Not Defined (Amber) where the species home range and/or camera spacing are not defined.

Occupancy estimates can be used as an index of abundance (corrected by detection probability) where camera spacing is greater than the species home range (so that an individual is likely to be detected in only one camera), and occupancy is not confounded by changes in the home range.



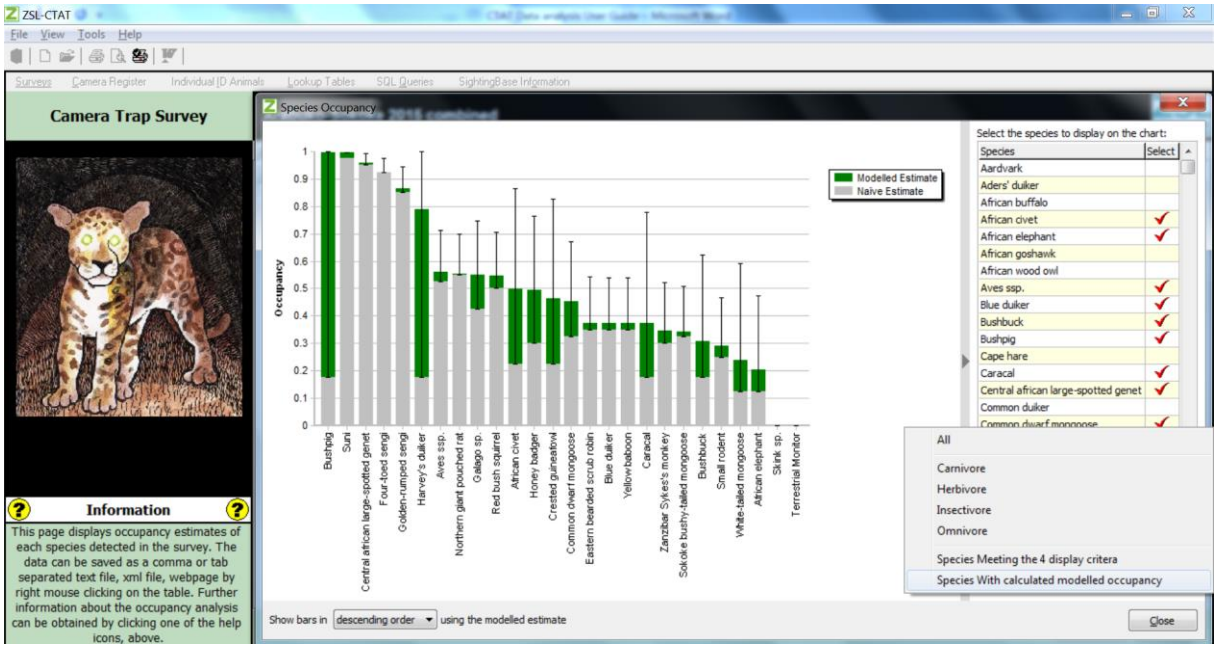
The results can also be presented on a chart by clicking 'View Species Occupancy on a Chart' button on the results page.



In the illustrated occupancy plot above, naïve occupancy is represented in grey, additional modelled occupancy in green with 95% confidence intervals as line-bars (colours can be changed by right clicking the mouse on the plot). The lower confidence interval is limited to the naïve occupancy as species occupancy cannot be lower than this observed value.

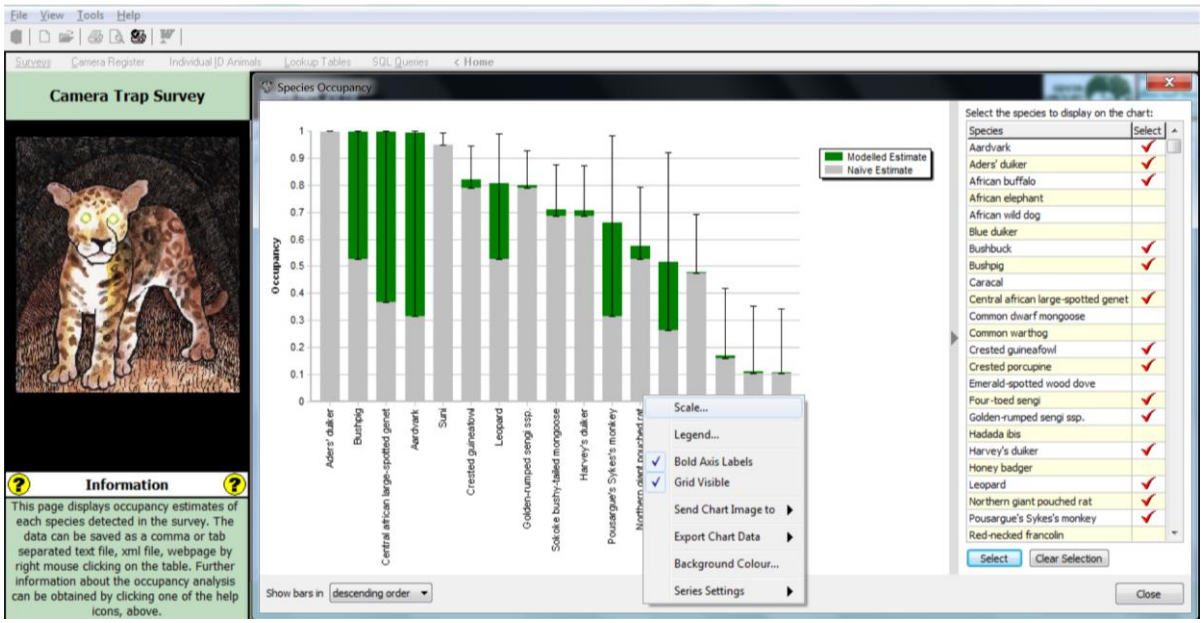
Multiple species can be selected by clicking the species in the species list. Species can also be selected according to trophic level (carnivore, herbivore etc.). Occupancy can also be displayed for

those species where all four display criteria have been met or all species with calculated modelled occupancy.



The occupancy bar plot (naïve and modelled occupancy) can also be displayed in descending or ascending values, or species alphabetical order.

The scale of the y-axis of the occupancy plot is set to 0 – 1 (the occupancy range) as a default. However this can be changed by clicking the right mouse button and selecting the "Scale" option as shown below.

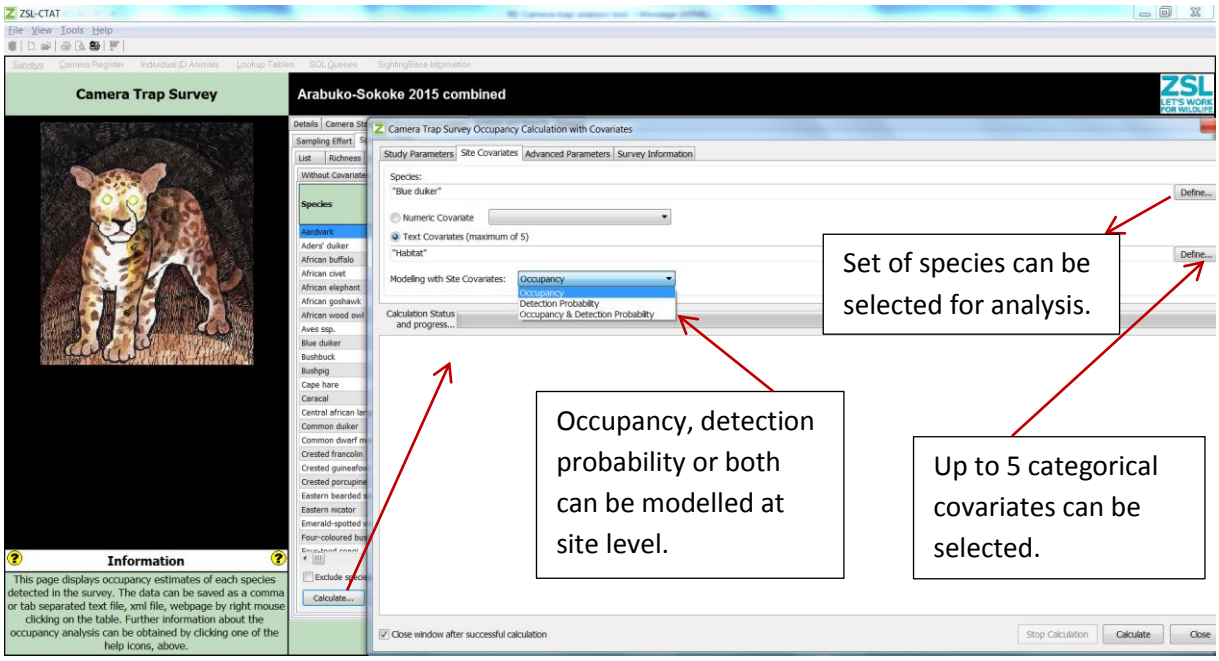


<u>Modelling occupancy and detection probability with covariates</u>

To model occupancy and/or detection probability with covariates, select the 'With Covariates' tab to bring up the 'Occupancy with Covariates' page.

Note: that this tab will only appear if site covariates have been defined. Also covariates with the same value for all sites will not be available in the analysis.

Click on the 'Calculate' button on the bottom left corner of the page to bring up the configuration page.



Four tabs are available to configure the parameters for site covariate occupancy and detection probability modelling.

Study Parameters tab: This page contains the same parameters as in the standard occupancy modelling.

- Start and end dates for the occupancy analysis.
- Length of the occasion period and the number of occasions out of the total available number to be analysed.
- Occasion management: defining when an occasion for a camera station is set to blank (removed) from the analysis based on whether the camera station was operational for *xx*% or less of the occasion duration.
- Camera management: defining when a camera station is removed from the occupancy analysis, based on the camera station not operational on *xx*% or more of the occasions.

Site Covariates tab: Here the species for occupancy modelling can be defined along with the site covariate(s) that have been entered / imported. Either numeric (one) or categorical (up-to five) can be selected.

It is often advisable to standardize numeric "continuous" covariates particularly those whose values tend to be a long way from zero. One way is to normalise to zero mean and unit standard deviation (subtracting each value from the mean and dividing by the standard deviation).

Site level modelling for occupancy, detection probability or both can be undertaken.

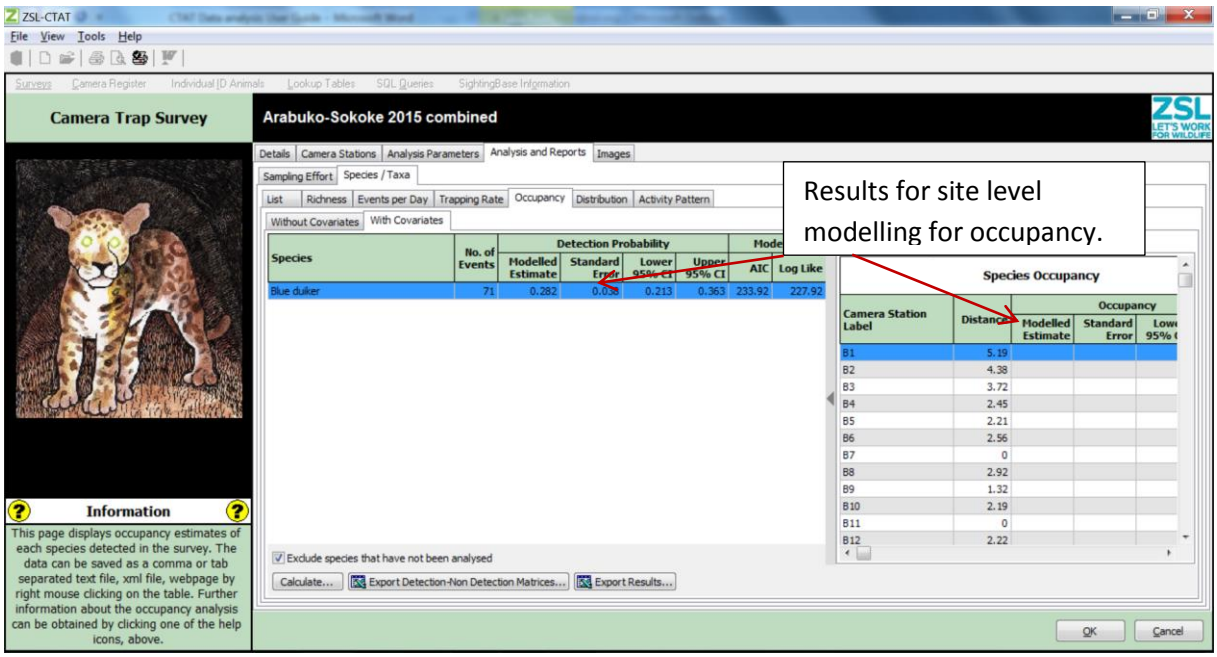
Advanced Parameters tab: As occupancy modelling can fail when detection data are very few, the tool will not perform the analysis for species with naïve occupancy and/or number of detections in the detection – non-detection matrix less than the user defined thresholds.

Survey Information tab: this page presents the survey duration and camera station sampling history information.

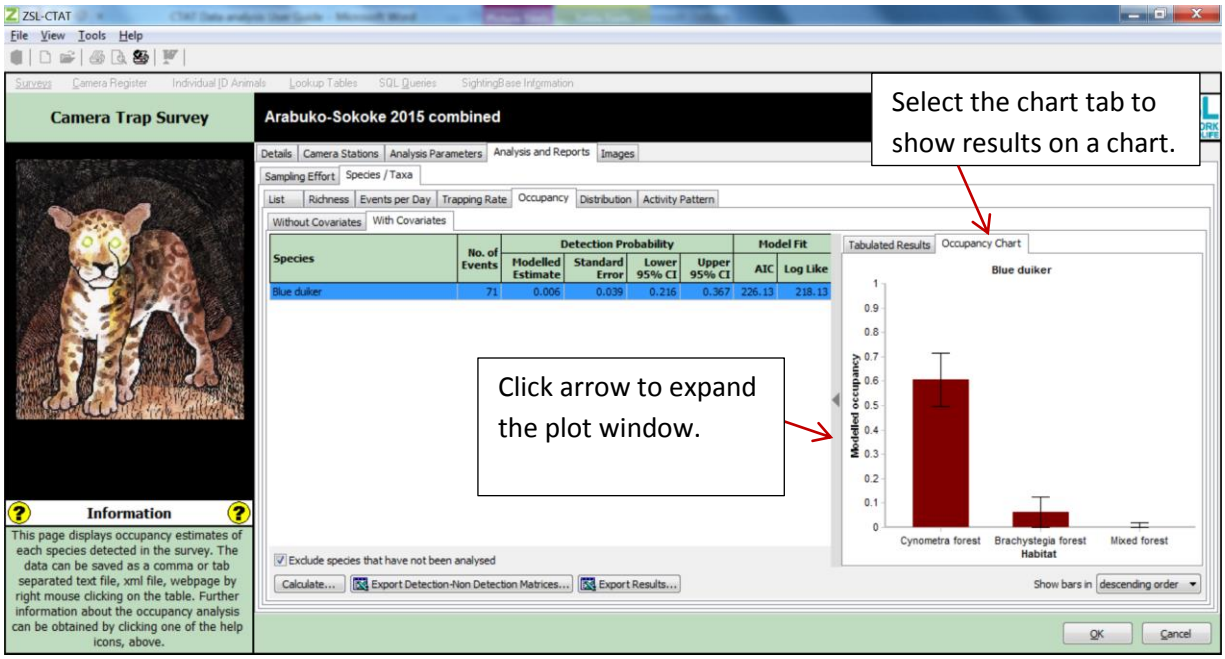
Clicking the 'Calculate' button will start the occupancy analysis in R and on completion the results for the selected species will be presented in the table and on a chart.

Results will be presented as follows.

1. For site level modelling of occupancy:
    a. overall detection probability estimate with standard error and 95% confidence interval.
    b. site 'camera station' occupancy estimates with standard error and 95% confidence interval.
2. For site level modelling of detection probability:
    a. overall occupancy estimate with standard error and 95% confidence interval.
    b. site 'camera station' detection probability estimates with standard error and 95% confidence interval.
3. For site level modelling of occupancy and detection probability:
    a. site 'camera station' occupancy and detection probability estimates with standard error and 95% confidence interval.



The occupancy / detection probability 'Chart' tab will display the results in a chart: bar plot for categorical covariates and line plot for continuous covariates. The 95% confidence intervals are also shown. The species needs to be selected first for the 'Chart' tab to appear.



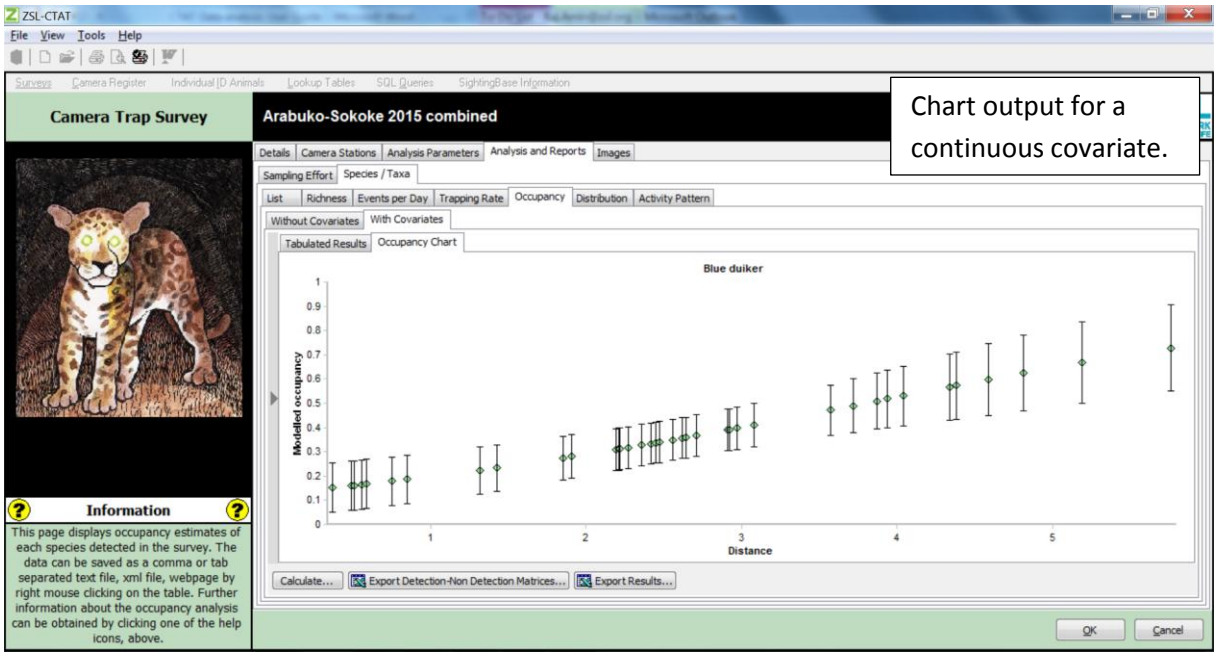
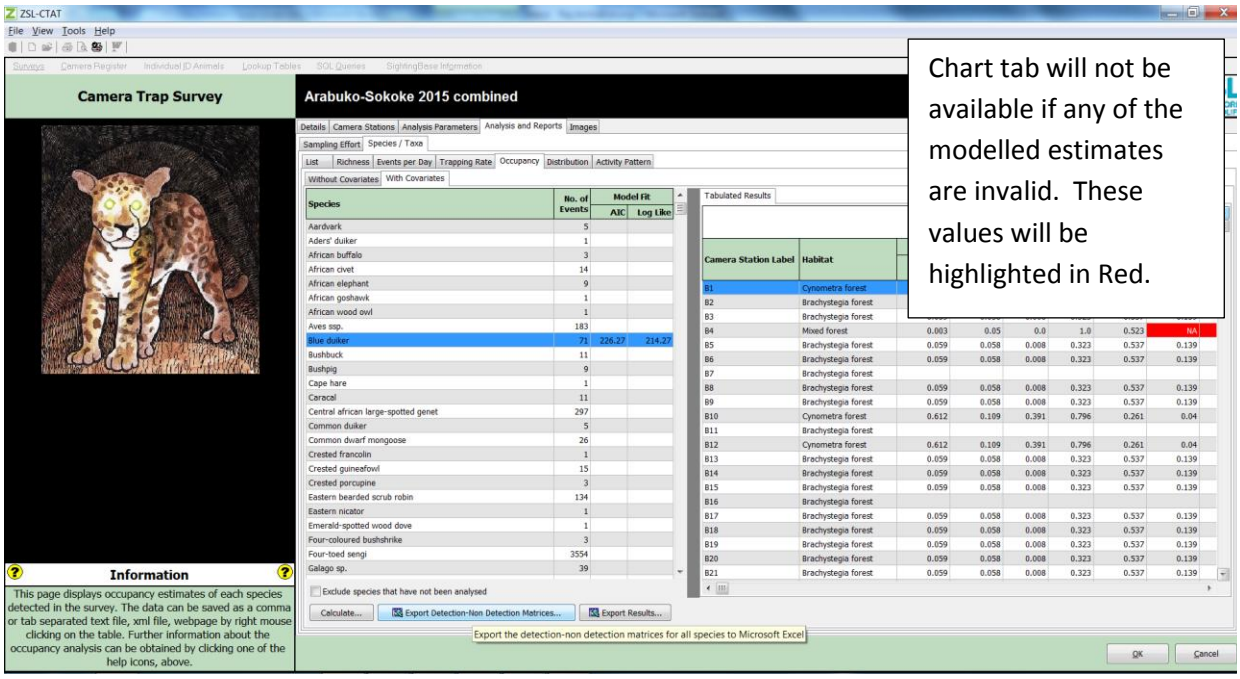
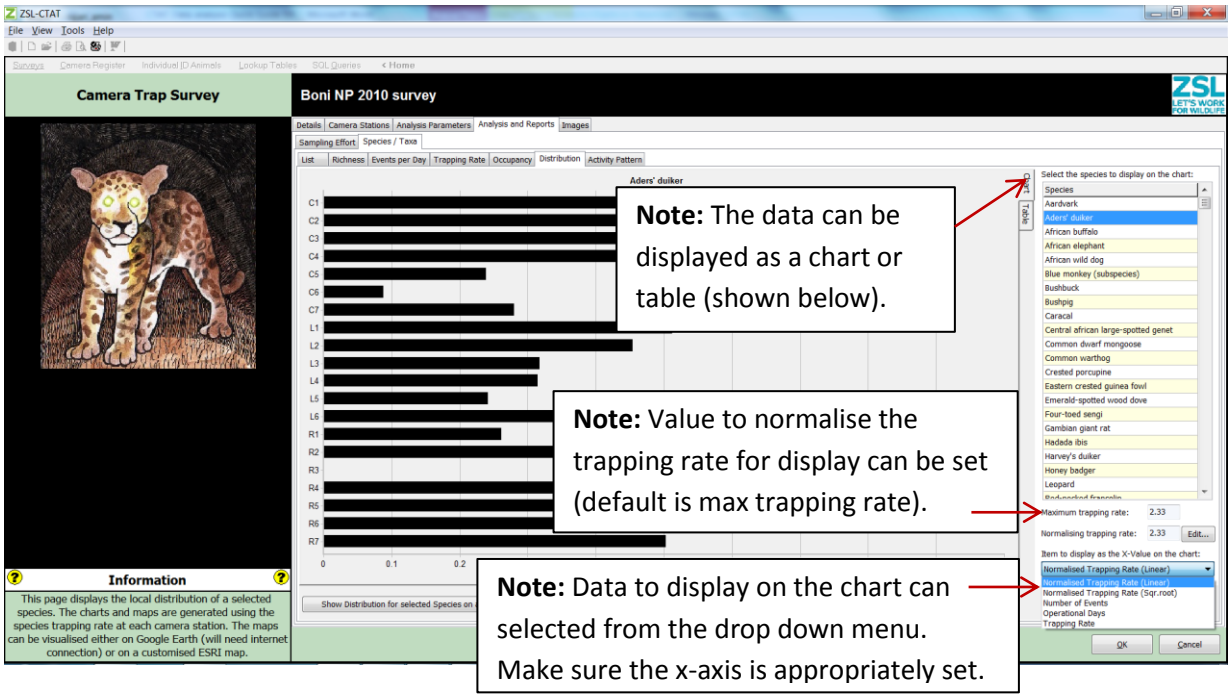


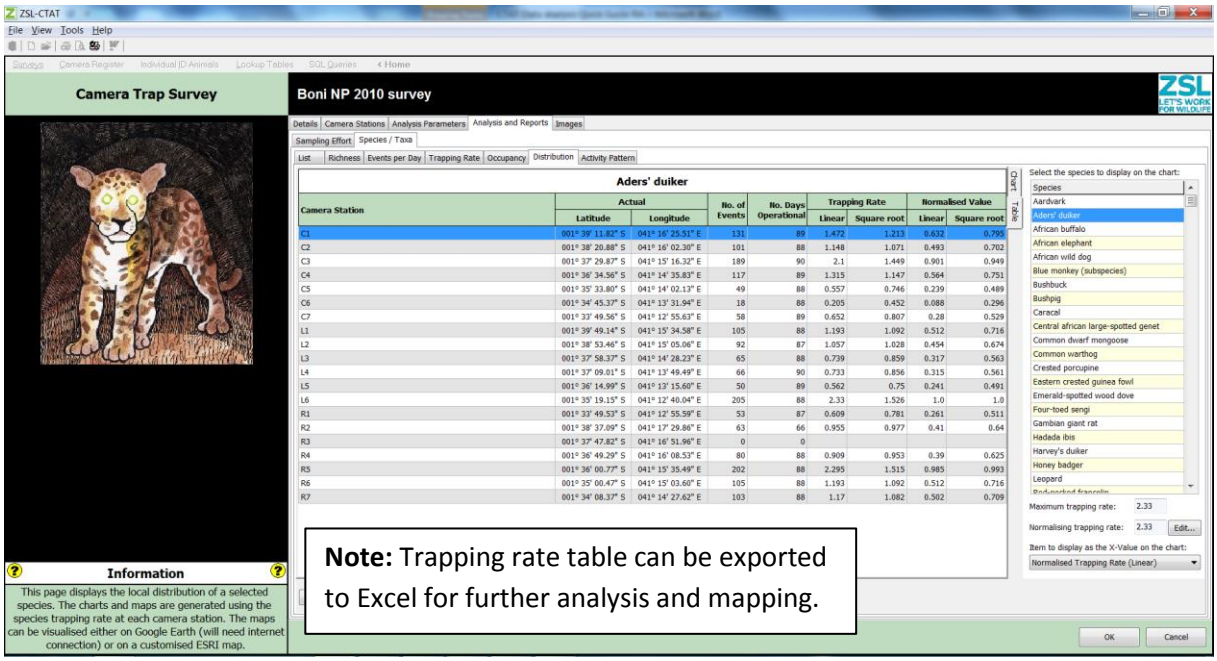
Chart tab will not be available if any of the modelled estimates are invalid. The invalid values will be highlighted in Red in the table.



4.3.6 Species distribution

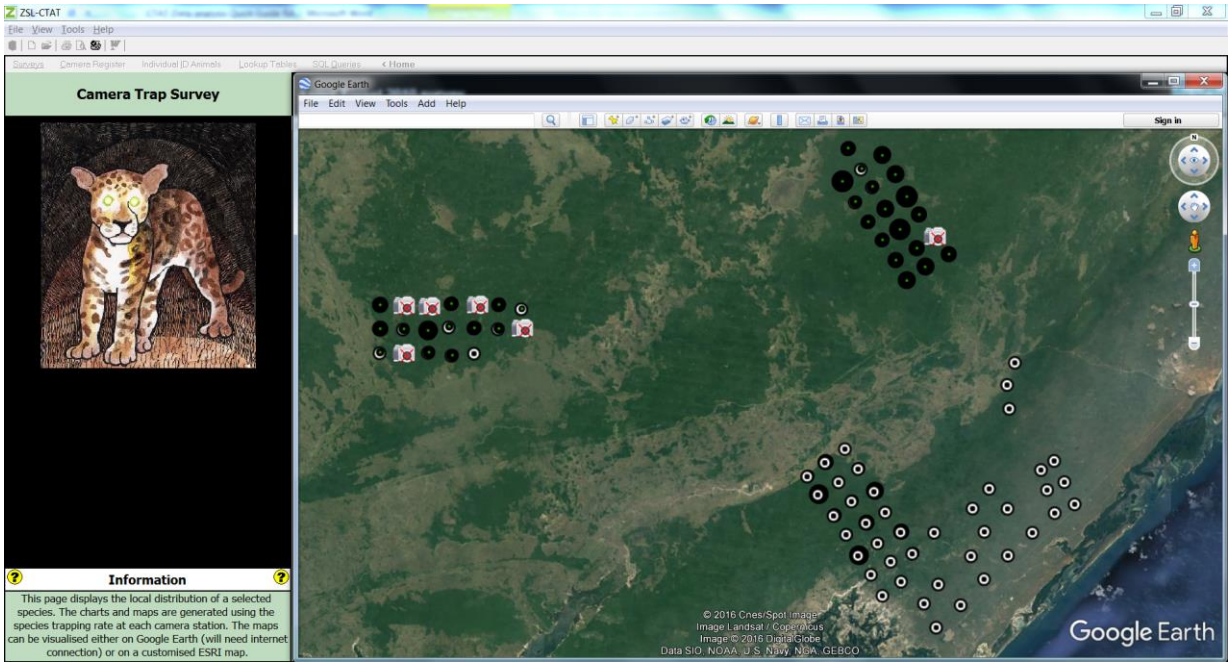
Species trapping rates (the number of independent photographic events per trap day x 100) are calculated at each camera station. These are displayed on the 'Distribution' page as a chart and table. Species is selected from the list on the right of the page. Chart outputs can be produced for trapping rates, normalised trapping rates (linear and square root transformed), number of events and number of operational days.



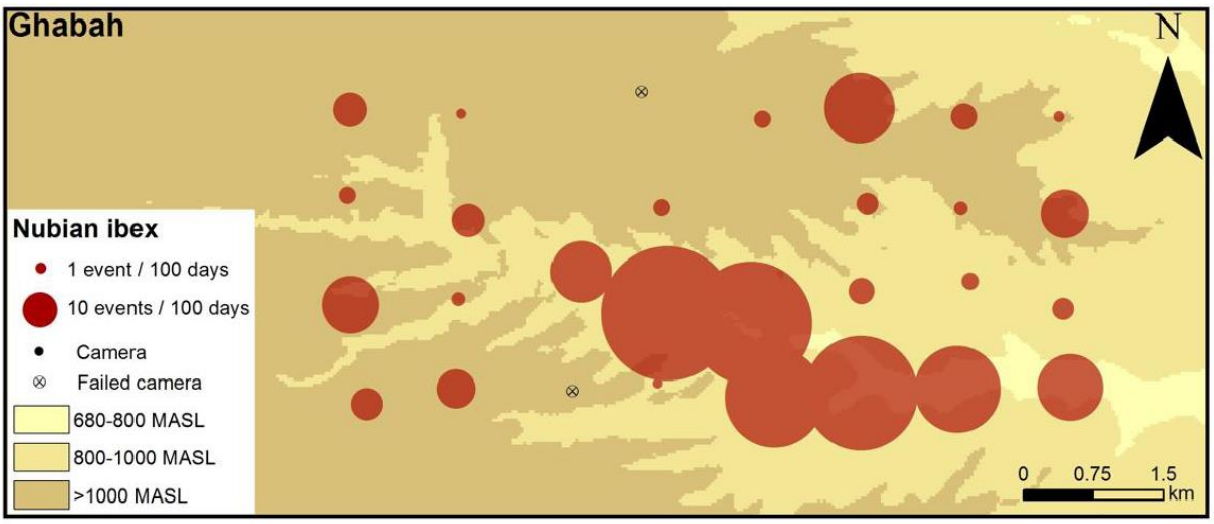


Note: Trapping rate table can be exported to Excel for further analysis and mapping.

Camera station species trapping rates (normalised linear or square root) can be displayed on Google Earth (needs internet connection) to explore spatial patterns. The value for normalising the trapping rate is set to the maximum trapping rate value as a default and can be changed in the right bottom page panel. Normalised values greater than 1 will be truncated to 1 for display on Google Earth. On the map, the trapping rates are depicted as scaled circular symbols at each camera site.



Trapping rates can be exported to Excel or csv file to generate maps in QGIS or ArcGIS for reports (see example below). QGIS and ArcGIS (via ArcReader) configured maps can also be displayed within the tool. The maps will have to be setup beforehand but once done they can be used repeatedly for various outputs.

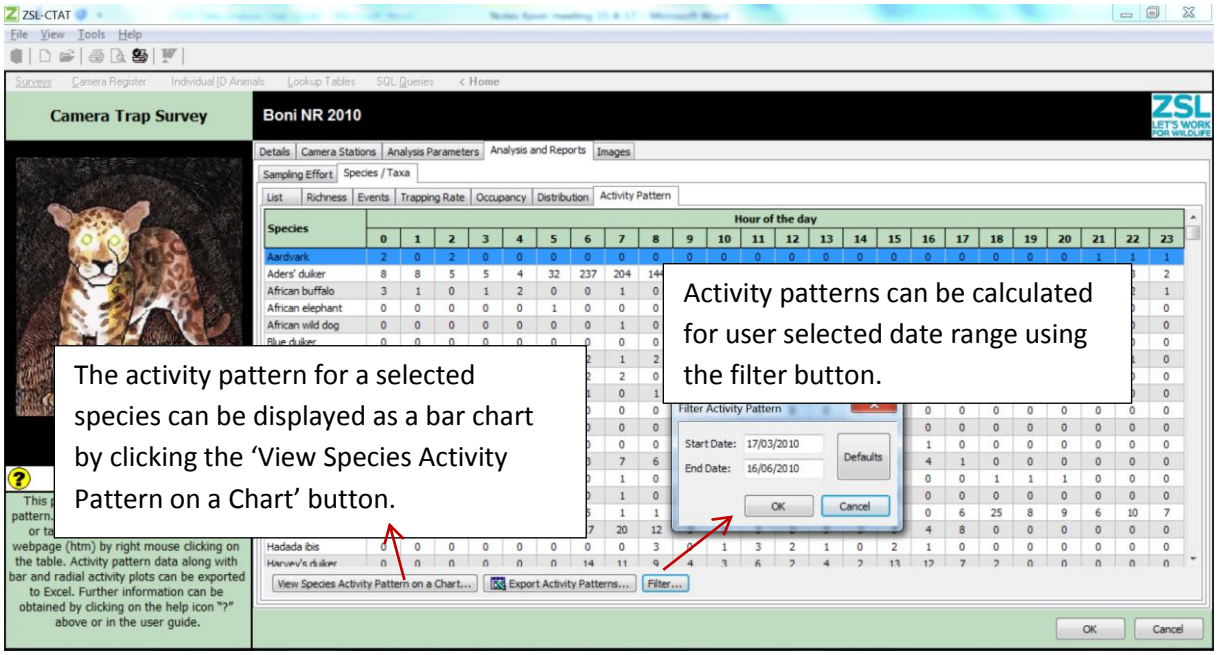


4.3.7 Species activity pattern

Circadian (24 hour) species activity patterns are derived from camera time of detection data. They are compiled from the number of independent photographic events per hour.

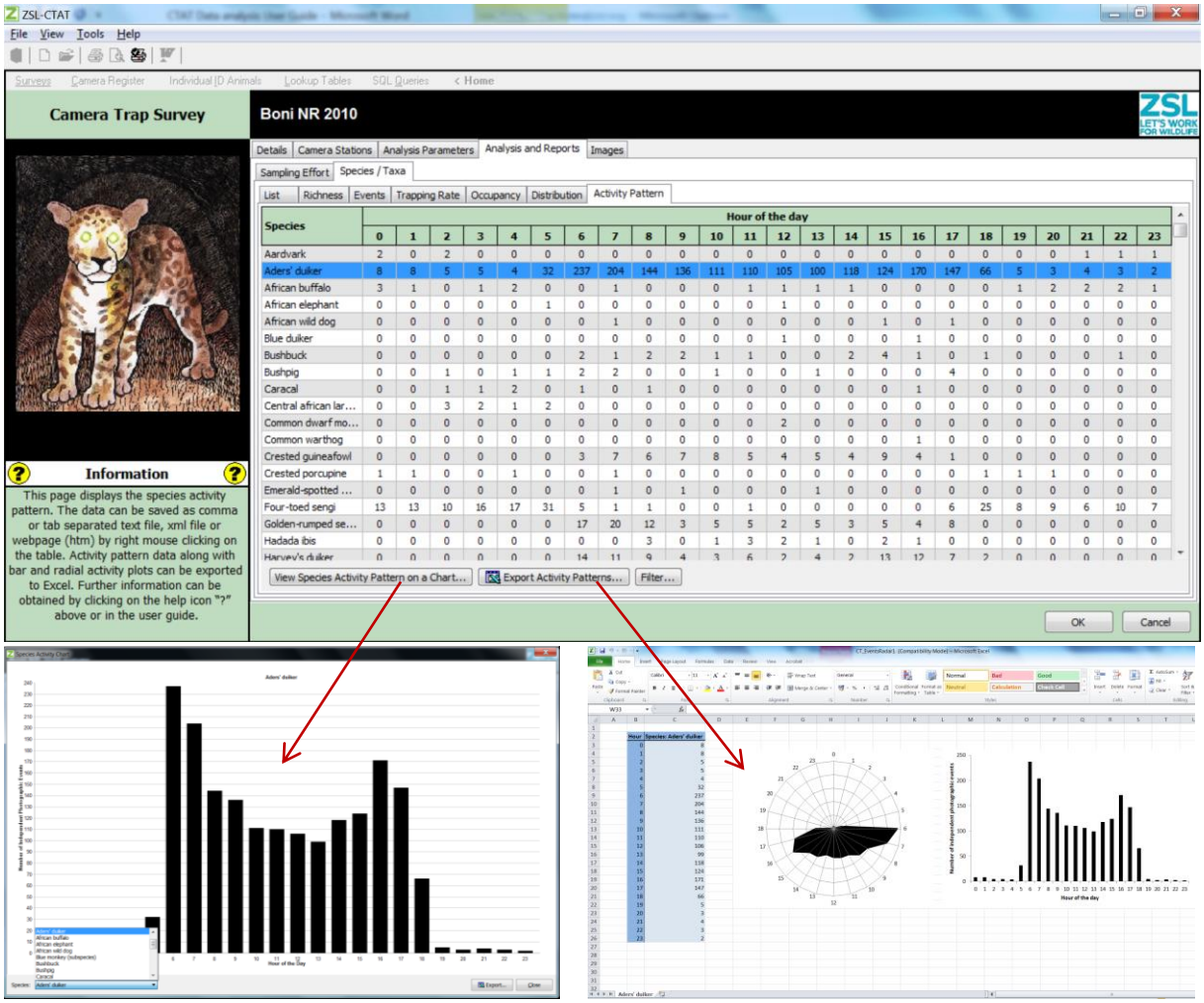
<u>Note: for species activity patterns, it may be more appropriate to set the event interval to the camera trigger interval in the 'Analysis Parameters' page.</u>

Species activity table provides the number of events "detections" for each hour for each species. Activity patterns can be calculated for user selected date range using the filter button.



The activity pattern for a selected species can be displayed as a bar chart by clicking the 'View Species Activity Pattern on a Chart' button at the bottom of the page. The species can also be selected from the drop down menu below the bar chart.

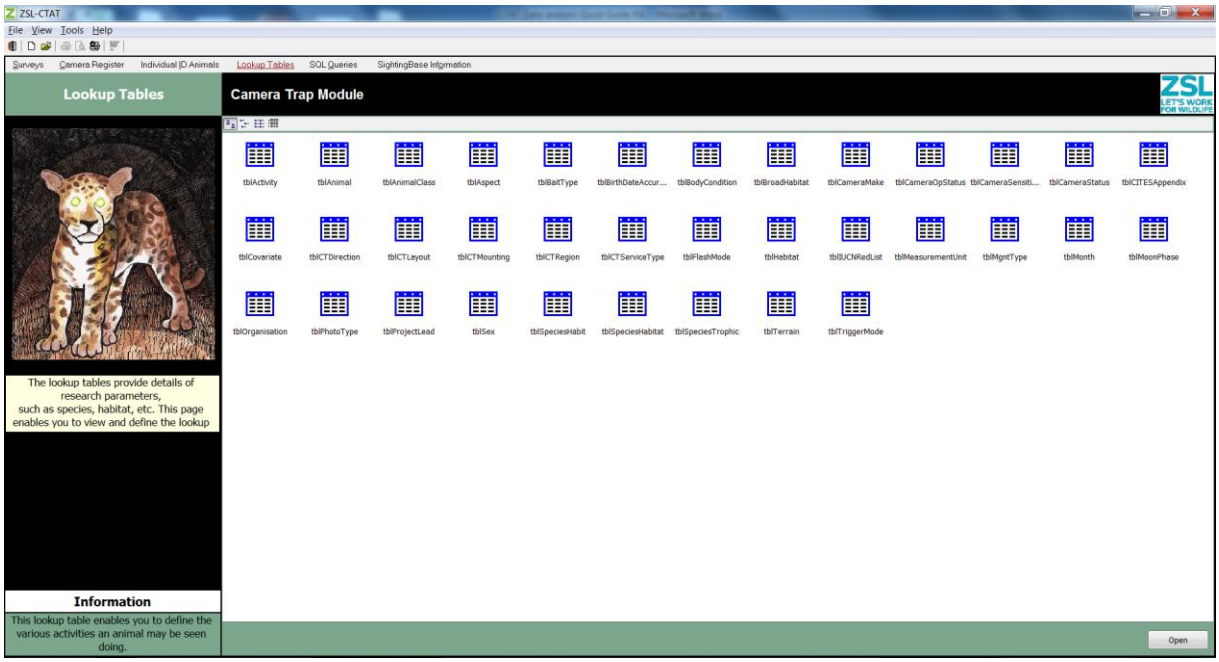
All species activity patterns can be exported into Excel by clicking the ‘Export Activity Patterns’ button at the bottom of the page. Each species has its own tab within the Excel workbook with a table containing the data and its radial and bar plots within the spreadsheet. Data and plots can also be exported for a selected species from the chart page using the “Export” button.



5. Software administration functions

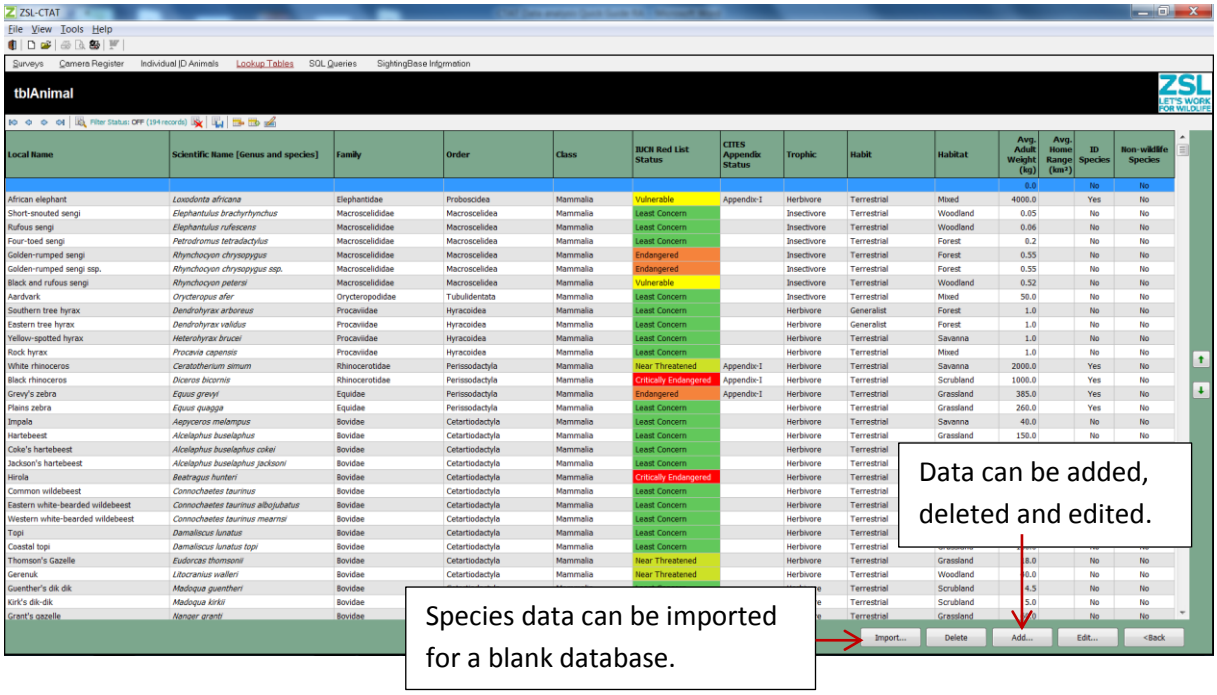
5.1 Lookup tables

The lookup tables can be viewed and edited from the Main Page->Lookup Tables.



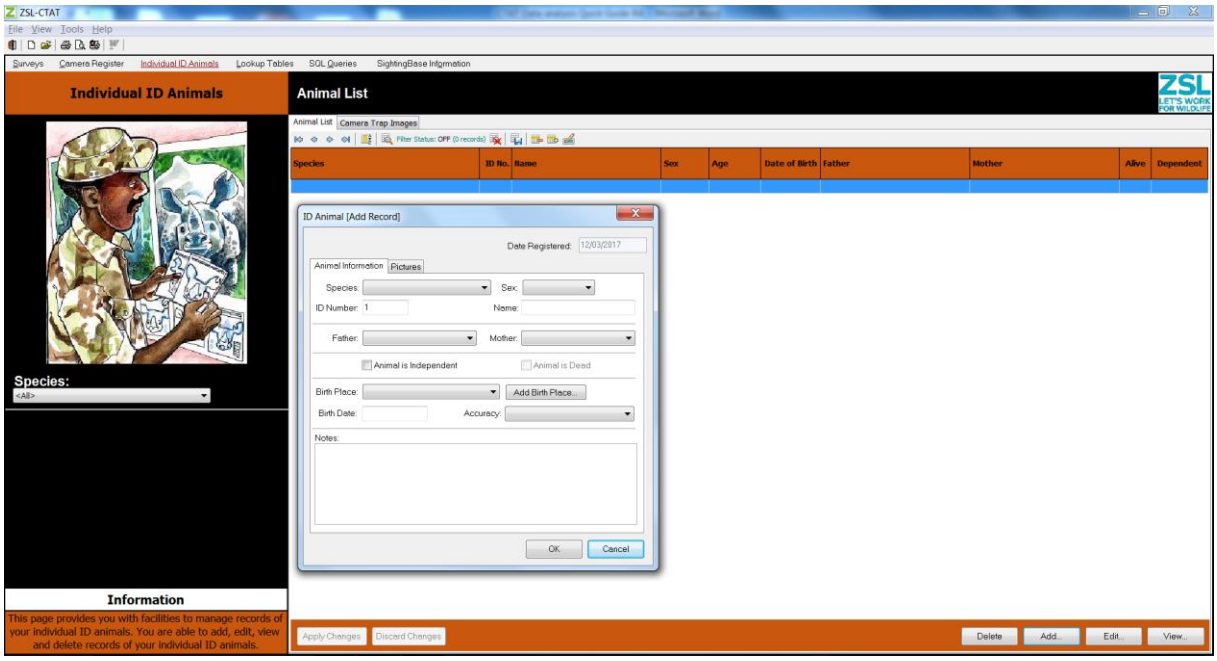
<u>tblAnimal</u>

tblAnimal contains the species information. Species data can be imported through a wizard for a blank database (without any survey data).

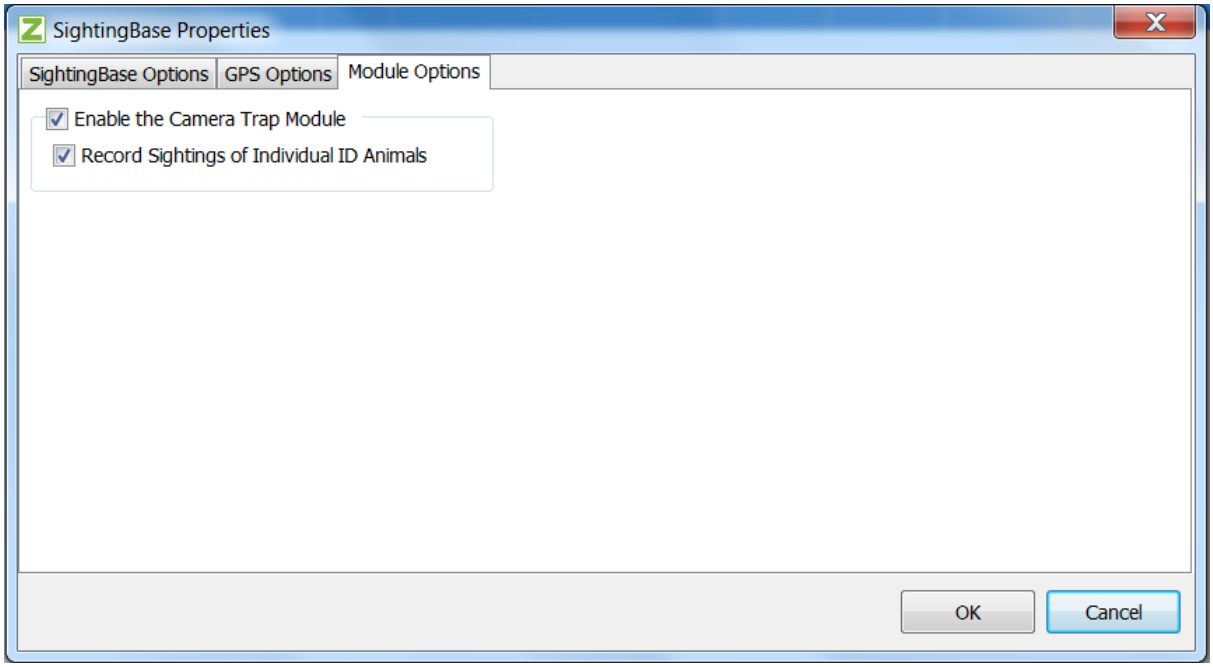


5.2 Individual ID animals table

Individual ID animals must first be registered in the 'Individual ID Animals' table before importing data containing individual animals.

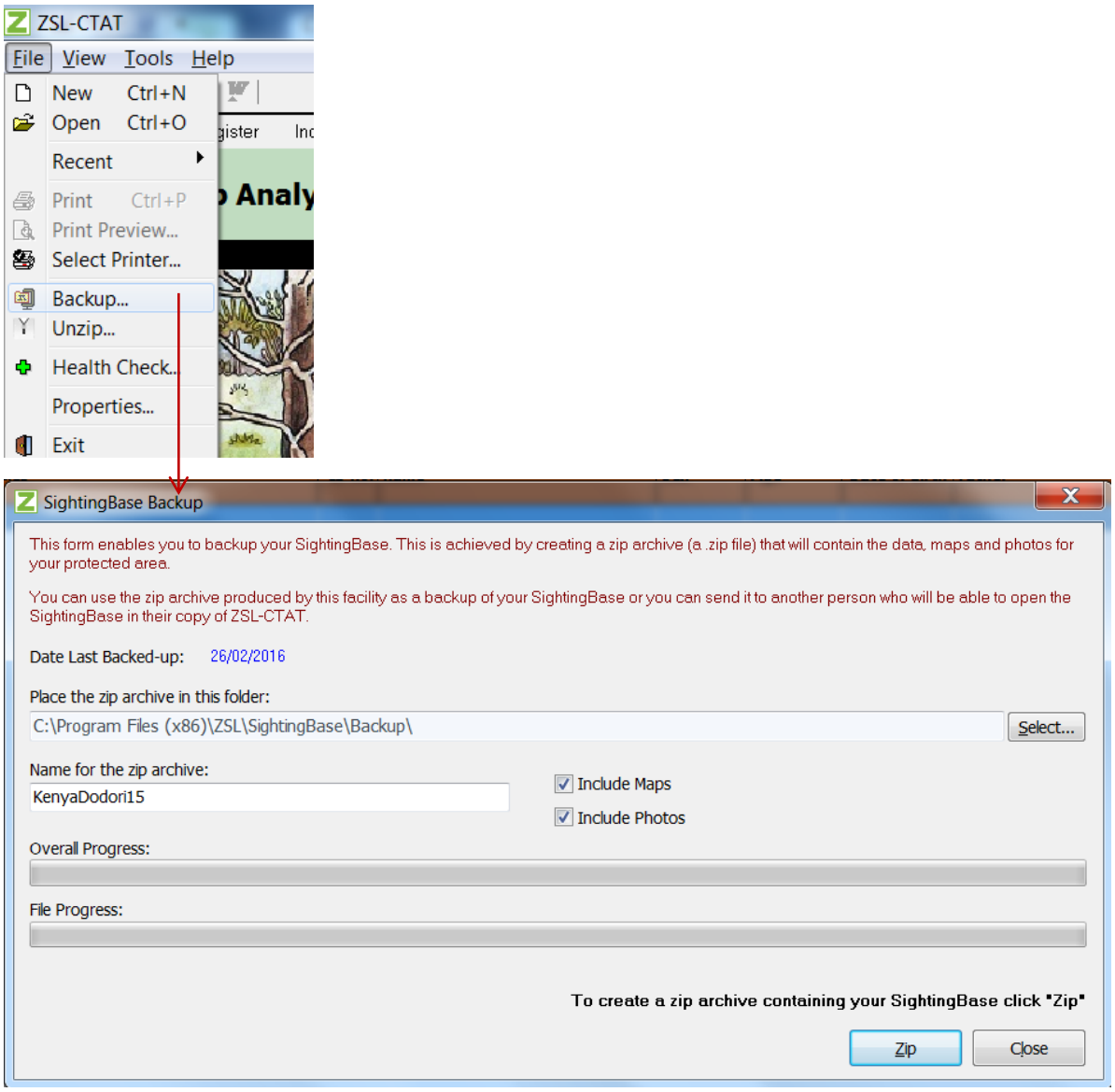


If the 'Recording sightings of Individual Animals' has not been selected during the database creation then it can done from File->Properties->Module Options and selecting the Record Sightings of Individual ID Animals.



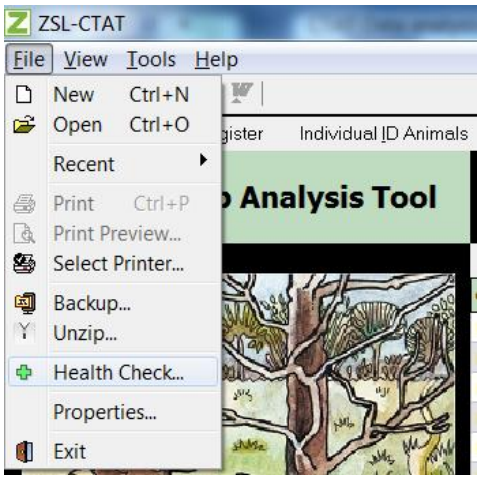
5.3 Backing-up database

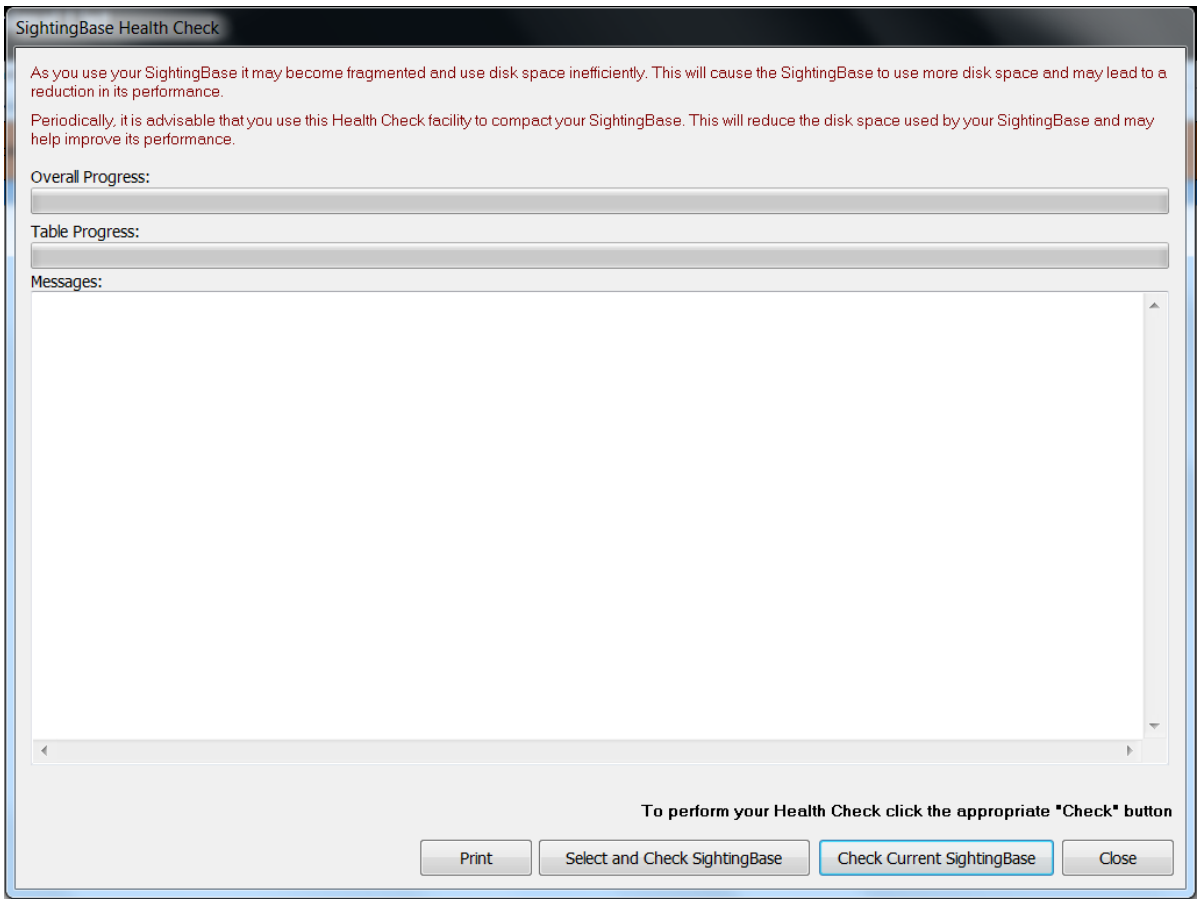
The database can be backed up from File->Backup menu. It will create a zip archive of all your data in the folder and name provided in the page.



5.4 Database health check

Over time, your database may become fragmented and use disk space inefficiently as surveys are added. It is therefore important to perform a health check of your database on a periodic basis from File->Health Check.

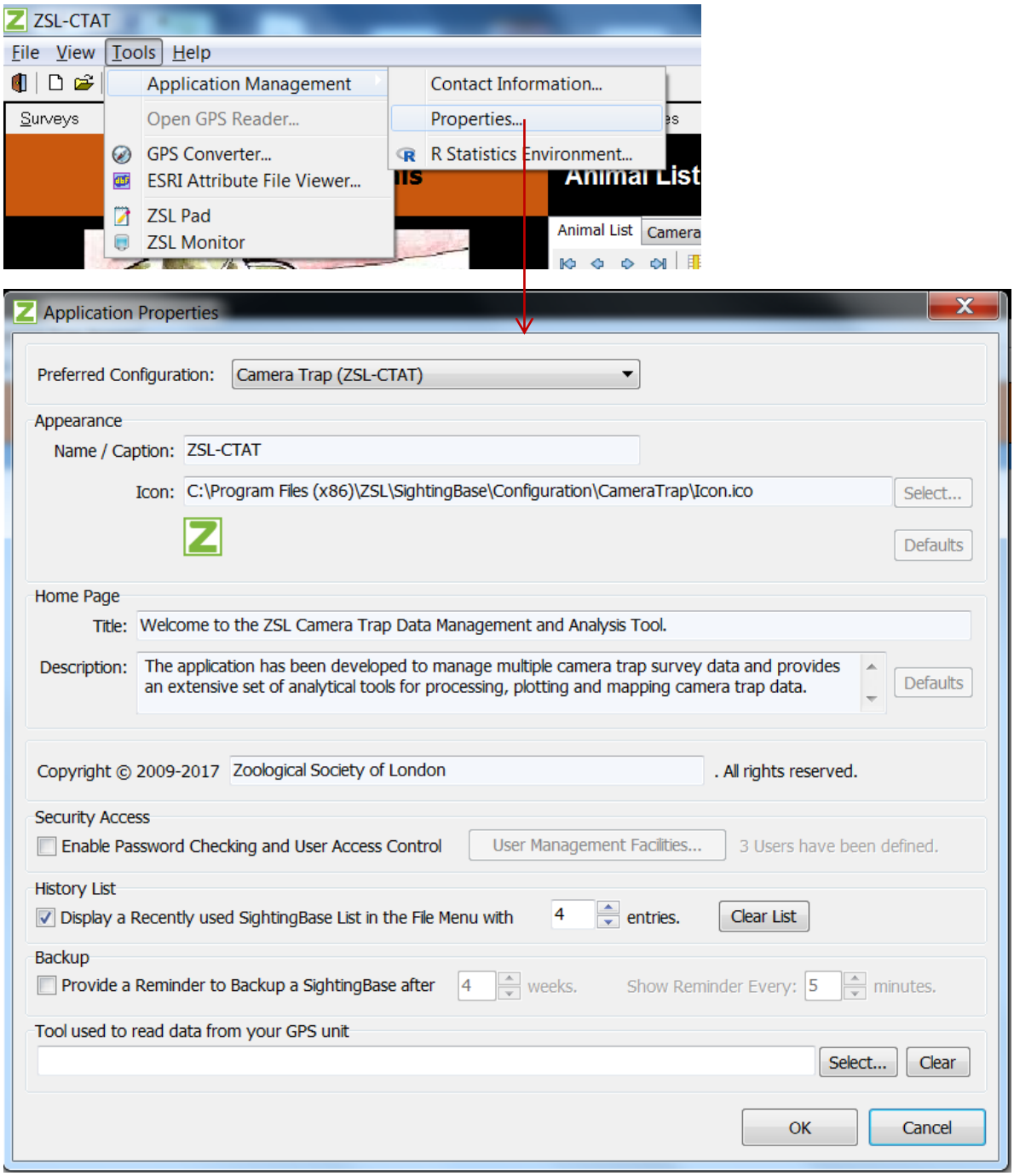




5.5 Database access

You can limit access to the database to selected users by enable security access from

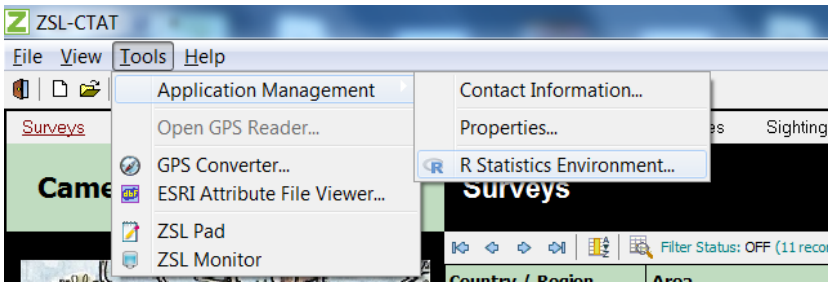
Tool->Application Management->Properties

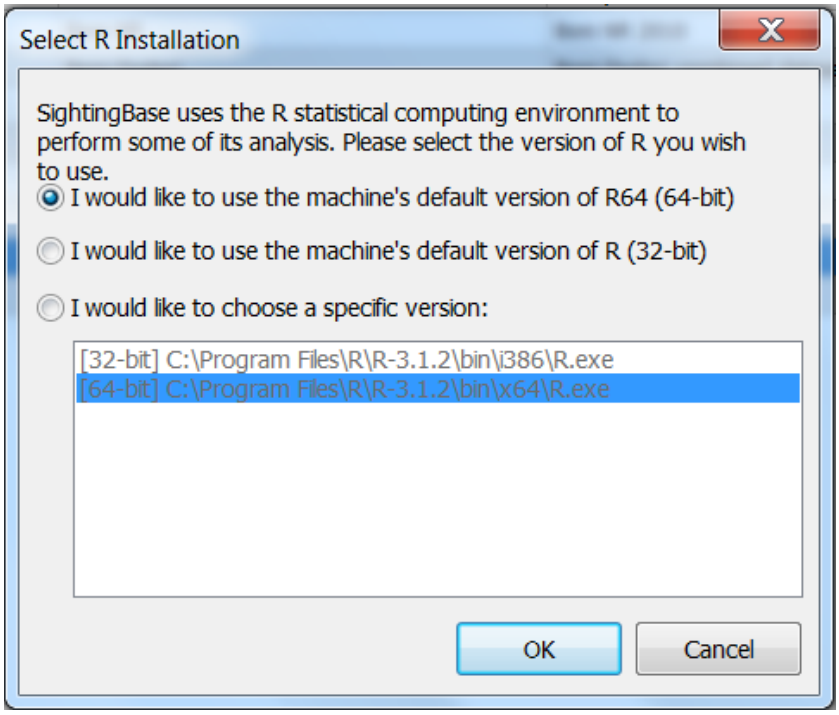


5.6 R-Statistics environment

The camera trap analysis tool uses the R statistics environment to perform some of the analysis. If you have multiple R versions installed then you can select the one you wish to use from

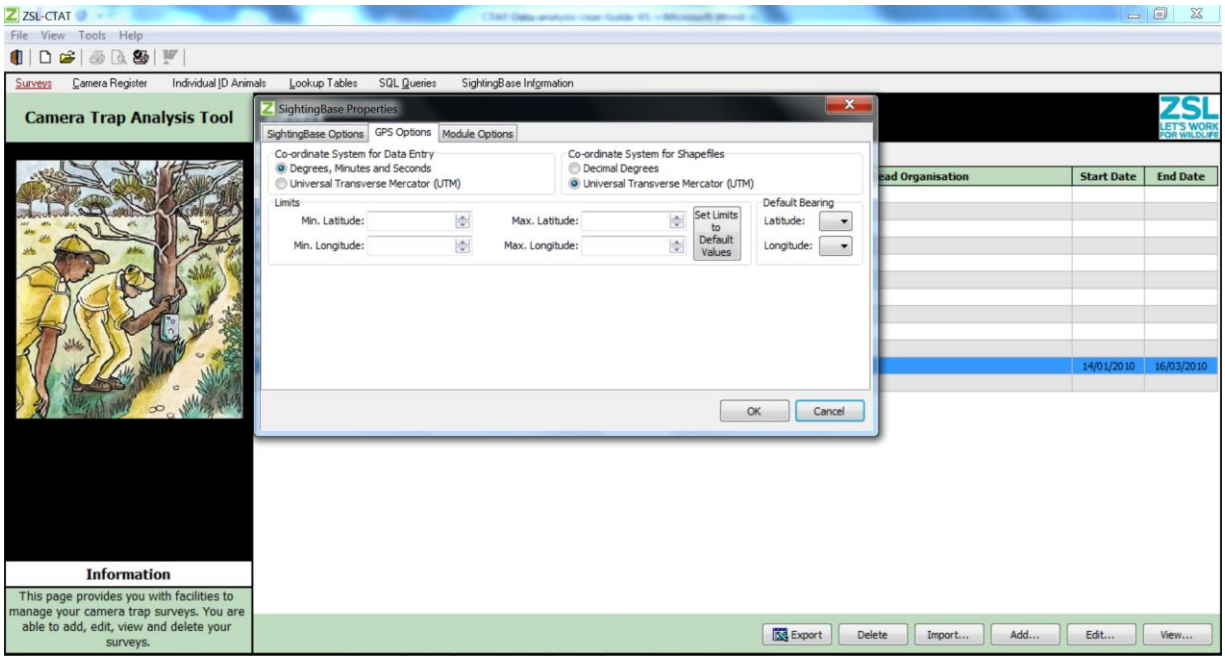
Tool->Application Management->R Statistics Environment





5.7 Coordinate systems

Coordinate system (UTM or lat/long) for data entry and exporting shapefiles for QGIS mapping can be selected from File->Properties->GPS options.


ZSL-CTAT
File View Tools Help
Surveys
Camera Register
Individual ID Animals
Lookup Tables
SQL Queries
SightingBase Information
Camera Trap Analysis Tool
SightingBase Properties
SightingBase Options
GPS Options
Module Options
Co-ordinate System for Data Entry
Degrees, Minutes and Seconds
Universal Transverse Mercator (UTM)
Co-ordinate System for Shapefiles
Decimal Degrees
Universal Transverse Mercator (UTM)
Limits
Min. Latitude:
Max. Latitude:
Min. Longitude:
Max. Longitude:
Set Limits to Default Values
Default Bearing
Latitude:
Longitude:
OK
Cancel
Start Date
End Date
14/01/2010
16/03/2010
Information
This page provides you with facilities to manage your camera trap surveys. You are able to add, edit, view and delete your surveys.
Export
Delete
Import...
Add...
Edit...
View...