APPENDIX

Appendix I—Useful Software and **R** Packages

Throughout this book we have used a suite of software and **R** packages, all of which are freely available online. To make life a little easier for you, here we provide you with a list of all software and **R** packages, download links, and some (hopefully) helpful tips regarding their installation.

20.3 WinBUGS

Although **WinBUGS** (Gilks et al., 1994) is becoming increasingly obsolete with the faster and more flexible **OpenBUGS** (Lunn et al., 2009) and **JAGS** (Plummer, 2003), there are still situations in which the program comes in handy. The .exe file can be downloaded from http://www.mrc-bsu.cam.ac.uk/bugs/winbugs/contents.shtml. On 32-bit machines you can just go ahead and double-click on the .exe file and follow the installation instructions on the screen. On 64-bit machines, according to the **BUGS** project you should download a zip file (from the same page) and unzip it into a folder of your choice. There are a couple of additional steps to make **BUGS** run. First, you need to obtain a key (which is free and valid for life) here: `http://www.mrc-bsu.cam.ac.uk/bugs/winbugs/WinBUGS14_immortality_key.txt`. The key comes with instructions on how to activate it. Second, you need to update the basic **WinBUGS** version to the most current one (which is from August 2007) following the instructions given here: `http://www.mrc-bsu.cam.ac.uk/bugs/winbugs/WinBUGS14_cumulative_patch_No3_06_08_07_RELEASE.txt`. **WinBUGS** is ready to use after quitting and reopening it. Remember that **WinBUGS** only runs on Windows machines. Also, there appears to be a problem installing the program in Vista, although we have no personal experience with this.

20.3.1 WinBUGS through R

While you can run**WinBUGS** as a standalone application, we recommend you access it from within **R** using the package `R2WinBUGS` (Sturtz et al., 2005), so you can conveniently process your output, make graphs, etc. `R2WinBUGS` also allows you to run models in **OpenBUGS** (see below). You can install the package from within **R** directly from a cran mirror. In addition to the usual package help document

Spatial Capture-Recapture. http://dx.doi.org/10.1016/B978-0-12-405939-9.00028-1

(http://cran.r-project.org/web/packages/R2WinBUGS/R2WinBUGS.pdf), you can also download a short manual with some examples (http://voteview.com/bayes_beach/R2WinBUGS.pdf).

20.4 OpenBUGS

OpenBUGS is the up-to-date version of **WinBUGS** and can be downloaded here: http://www.openbugs.info/w/Downloads (Windows, Mac, and Linux versions are available). The name "**OpenBUGS**" refers to the software being open source, so users do not need to download a license key, like they have to for **WinBUGS** (although the license key for **WinBUGS** is free and valid for life). For Windows, install by double-clicking on the .exe file and following the instructions on the installer screen. Compared to **WinBUGS**, **OpenBUGS** has more built-in functions. The method of how to determine the right updater for each model parameter has changed and the user can manually control the MCMC algorithm used to update model parameters. Several other changes have been implemented in **OpenBUGS** and a detailed list of differences between the two **BUGS** versions can be found at http://www.openbugs.info/w/OpenVsWin. We have encountered convergence problems with simple SCR models in this program. There is an extensive help archive for both **WinBUGS** and **OpenBUGS** and you can subscribe to a mailing list, where people pose and answer questions of how to use these programs at http://www.mrc-bsu.cam.ac.uk/bugs/overview/list.shtml.

20.4.1 OpenBUGS through R

Like **WinBUGS**, **OpenBUGS** can be used as a standalone application or through **R**. There are several packages that allow **R** to interface with **OpenBUGS**, all of which can be installed directly from a cran mirror:

`R2WinBUGS`: One of the arguments in the `bugs` call is `program`, which lets you specify either **WinBUGS** or **OpenBUGS**. This is a convenient option, because after having worked through some of this book you will likely be familiar with the format of `bugs` output and other functions of the `R2WinBUGS` package.

`R2OpenBUGS` (Sturtz et al., 2005) is very similar to, and actually based on, `R2WinBUGS` and it is unclear to us what can be gained by using one over the other. Arguments of the `bugs` call differ slightly between the two packages, and given that `R2WinBUGS` allows for the use of both **OpenBUGS** and **WinBUGS**, it is probably easiest to stick with it.

`BRugs` (Thomas et al., 2006) has the convenient feature that all pieces of a **BUGS** analysis can be run from within **R**, including checking the model syntax, something that requires opening the **BUGS** GUI with other packages. In addition to the help document at http://www.biostat.umn.edu/brad/software/~BRugs/BRugs_9_21_07.pdf there is a **WinBUGS** style manual you can access at http://www.rni.helsinki.fi/openbugs/OpenBUGS/Docu/BRugs%20Manual.html. ~~BRugs has the convenient feature that all pieces of a **BUGS**~~

analysis can be run from within **R**, including checking the model syntax, something that requires opening the **BUGS** GUI with other packages.

20.5 JAGS

JAGS (Just Another Gibbs Sampler) (Plummer, 2003) runs SCR models considerably faster than **WinBUGS**, does not have the convergence problem with simple SCR models we have encountered in **OpenBUGS**, but similar to the latter program, is flexible and constantly updated. Writing a **JAGS** model is virtually identical to writing a **WinBUGS** model. However, some functions may have slightly different names and you can look up available functions and their use in the **JAGS** manual (`http://iweb.dl.sourceforge.net/project/mcmc-jags/Manuals/3.x/jags_user_manual.pdf`). One potential downside is that **JAGS** can be very particular when it comes to initial values. These may have to be set as close to truth as possible for the model to start. Although **JAGS** lets you run several parallel Markov chains, this characteristic interferes with the idea of using overdispersed initial values for the different chains. Also, we have found that, when running models, sometimes **JAGS** crashes for unclear reasons, taking **R** down with it. Oftentimes, in order to make the program run again, you'll have to go through downloading and installing it again (remove the non-functioning version first).

JAGS has a variety of functions that are not available in **WinBUGS**. For example, **JAGS** allows you to supply observed data for some deterministic functions of unobserved variables. In **BUGS**, we cannot supply data to logical nodes. Another useful feature is, that the adaptive phase of the model (the burn-in) is run separately from the sampling from the stationary Markov chains. This allows you to easily add more iterations to the adaptive phase if necessary, without the need to start from 0. There are other, more subtle differences, and there is an entire manual section on differences between **JAGS** and **OpenBUGS**.

JAGS is available for download at `http://sourceforge.net/projects/mcmc-jags/files/`, together with the **R** package `rjags` (Plummer, 2011), which allows running **JAGS** through **R**, user and installation manuals and examples. Under the above address **JAGS** is available for Windows and Mac; Linux binaries are distributed separately, and you can find links to various sources here: `http://mcmc-jags.sourceforge.net/`. **JAGS** comes with a 32-bit and a 64-bit version and can be installed by double-clicking on the .exe file and following the instructions on the installer screen. For questions and problems concerning **JAGS**, there is a forum online at `http://sourceforge.net/projects/mcmc-jags/forums/forum/610037`.

20.5.1 JAGS through R

Unlike the two **BUGS** programs, **JAGS** does not have a GUI interface, but a command line interface that can be used to run the program as a standalone application. **JAGS** will solely perform the MCMC simulation; analyzing and summarizing the output has to be done outside of **JAGS**. To run **JAGS** through **R**, you have two options.

`rjags`: As mentioned above, `rjags` can be downloaded from the same site as **JAGS** and is being maintained by the creator of **JAGS**, which means it is guaranteed to stay up to date as **JAGS** changes. The package can also be installed from a cran mirror and the help document can be accessed at `http://cran.r-project.org/web/packages/rjags/rjags.pdf`.

`R2jags`: Alternatively, the package `R2jags` (Su and Yajima, 2011) provides a means of accessing **JAGS** through **R**. We prefer `rjags` for the reason named above, as well as because it stores data in a more memory-efficient way and has better `plot` and `summary` methods.

20.6 R

At the time of the preparation of this list, **R** for Windows is at version 2.15.0, which can be downloaded at http://cran.r-project.org/bin/windows/base/. This site also contains helpful tips on how to install **R** in Windows Vista, how to update **R** packages, etc. Installation of **R** in Windows is straightforward: download the .exe file, double-click on it, and follow the instructions of the Windows installer. The later versions of **R** come with versions for both 32-bit and 64-bit machines. The **R** site (`http://mirrors.softliste.de/cran/`) has an extensive FAQ section (Hornik, 2011), which includes instructions on how to install **R** on Unix and Mac computers.

20.6.1 R packages

This section provides an alphabetical list of useful **R** packages. There is a huge number of **R** packages and by no means is this list intended to be complete in terms of what is useful. Rather, we list packages that we are familiar with and that we employ at one point or the other in this book. Unless explicitly stated otherwise, all packages can be installed directly from within **R** trough a cran mirror.

`adapt` (Genz et al., 2007): A package for multi-dimensional numerical integration. The package has been removed from the CRAN repository but can be obtained from `http://cran.r-project.org/src/contrib/Archive/adapt/`.

`coda` (Plummer et al., 2006): Lets you summarize and perform diagnostics on MCMC output. For a list and description of functions, see the manual at `http://cran.r-project.org/web/packages/coda/coda.pdf`.

`gdistance` (van Etten, 2011): A package for calculating distances and routes on geographical grids that can be used to calculate least cost path surfaces. Manual at `http://cran.r-project.org/web/packages/gdistance/gdistance.pdf`.

`igraph` (Csardi and Nepusz, 2006): Provides routines for graphs and network analysis. Manual at `http://cran.r-project.org/web/packages/igraph/igraph.pdf`.

`inline` (Sklyar et al., 2010): Allows the user to define **R** functions with inlined **C**, **C++** or **Fortran** code. Manual at `http://cran.r-project.org/web/packages/inline/inline.pdf`.

`maps` (Becker et al., 2012): A package for the display of maps. Manual at `http://cran.r-project.org/web/packages/maps/index.html`.

`maptools` (Lewin-Koh et al., 2011): Provides a set of tools for reading and manipulating spatial data, especially ESRI shapefiles. Manual at `http://cran.r-project.org/web/packages/maptools/maptools.pdf`.

`mvtnorm` (Genz et al., 2012): Computes multivariate normal and *t* probabilities, quantiles, random deviates and densities. Manual at `http://cran.r-project.org/web/packages/mvtnorm/mvtnorm.pdf`.

`parallel`: Contains a suite of functions for parallel computing on multiple computer cores and comes with **R** versions 2.14.0 or higher. More information about the package can be found at `http://stat.ethz.ch/R-manual/R-devel/library/parallel/doc/parallel.pdf`.

`R2cuba` (Hahn et al., 2010): Another package for multi-dimensional integration. Manual at `http://cran.r-project.org/web/packages/R2Cuba/R2Cuba.pdf`.

`raster` (Hijmans and van Etten, 2012): Provides functions for geographic analysis and modeling with raster data. Manual at `http://cran.r-project.org/web/packages/raster/raster.pdf`.

`Rcpp` (Eddelbuettel and François, 2011): Provides **R** functions as well as a **C++** library that facilitates the integration of **R** and **C++**. Manual at `http://cran.r-project.org/web/packages/Rcpp/Rcpp.pdf`.

`RcppArmadillo` (François et al., 2011): A templated **C++** linear algebra library, integrating the `Armadillo` library and **R**. Manual at `http://cran.r-project.org/web/packages/RcppArmadillo/RcppArmadillo.pdf`.

`reshape` (Wickham and Hadley, 2007): Allows you to easily manipulate, summarize and reshape data. Manual at `http://cran.r-project.org/web/packages/reshape/reshape.pdf`.

`rgeos` (Bivand and Rundel, 2011): Provides many useful functions for spatial operations, such as intersecting or buffering spatial features. Manual at `http://cran.r-project.org/web/packages/rgeos/rgeos.pdf`.

`SCRbayes` (Russell et al., 2012): Provides a Bayesian implementation of certain kinds of SCR search-encounter models. This packages is not available on CRAN but can be downloaded at `http://www.mbr-pwrc.usgs.gov/software/SCRbayes.shtml`.

`secr` (Efford et al., 2009a): An allround package for fitting a wide array of SCR models in a frequentist framework. Manual at `http://cran.r-project.org/web/packages/secr/secr.pdf`.

`shapefiles` (Stabler, 2006): Allows you to read and write ESRI shapefiles (i.e., shapefiles you would use in **ArcGIS**). Manual at `http://cran.r-project.org/web/packages/shapefiles/shapefiles.pdf`.

`snow` (Tierney et al., 2011), `snowfall` (Knaus, 2010): Provide functionality for parallel computing. The latter is a more user-friendly wrapper around the former. Manuals at `http://cran.r-project.org/web/packages/snowfall/snowfall.pdf` and `http://cran.r-project.org/web/packages/snow/snow.pdf`.

`sp` (Pebesma and Bivand, 2011): A package for plotting, selecting, subsetting, etc. spatial data. `sp` and `spatstat` (see below) are complementary in may ways and data formats can be easily converted between the two packages. Manual at `http://cran.r-project.org/web/packages/sp/sp.pdf`.

`SPACECAP` (Gopalaswamy et al., 2012a): Provides a user friendly GUI interface to fit SCR models with a binomial observation model in a Bayesian framework. Manual at `http://www.icesi.edu.co/CRAN/web/packages/SPACECAP/SPACECAP.pdf`.

`spatstat` (Baddeley and Turner, 2005): An extensive package for analyzing spatial data. We use it, for example, to generate random points within a ~~state space~~ that cannot be described as a rectangle but consists of a (or several) arbitrary polygon (s). Manual at `http://cran.r-project.org/web/packages/spatstat/spatstat.pdf`.

`unmarked` (Fiske and Chandler, 2011): Fits hierarchical models of animal abundance and occurrence to data collected using a range of predominantly direct observation based methods. Manual at `http://cran.r-project.org/web/packages/unmarked/unmarked.pdf`.