Program MARK – a 'gentle introduction'

Program **MARK** is the most comprehensive and widely used software application currently available for the 'analysis of data from *marked* individuals' (hence the name **MARK**). **MARK** is a very flexible and powerful program, with many options, and a lot of technical sophistication. It encompasses virtually all currently used methods for analysis of marked individuals – including many new approaches only recently described in the primary literature.

As such, **MARK** is not a program that you can learn to use without some instruction. However, the only 'bundled' documentation for **MARK** is the integrated 'help file'. This is not to slight the help file – it is extremely comprehensive, and covers many of the 'technical details'. For people with a strong background in analysis of these sorts of data, and especially experienced users of **E/M-SURGE** and **POPAN** (the other 'big' applications in common use), the help file alone may, in fact, be sufficient to get you 'up and running' with **MARK** with only a bit of work. **MARK** draws heavily on the strengths of other applications, and aspects and underlying principles are (to varying degrees) similar across many applications.

However, for the 'new user', who may have little to no background in the analysis of these sort of data, learning how to use **MARK** from the help file alone is very inefficient, and is often a frustrating exercise. This type of user needs a different type of 'documentation'. It was with this type of user in mind that we developed this book – a comprehensive example-driven 'tutorial' on the theory, mechanics and practice of using **MARK**.

Of course, **MARK** is not the only program available for analysis of encounter data from marked individuals (see http://www.phidot.org/software/ for pointers to other available software), so you may wonder "why bother with **MARK**?". The short answer is that **MARK** offers far more flexibility and power in statistical modeling and hypothesis testing than other widely available and frequently used programs. It also uses a consistent, and familiar 'Windows interface', and allows the user to work with a consistent data format throughout. If you're just starting out, and have to pick one program to become proficient with, we strongly suggest you spend your time with **MARK**. Of course, there may be reasons why you don't want to use **MARK**, but on average, it'll be well worth your while.

About this book

This book is intended to allow you to (in effect) 'teach yourself how to use **MARK**'. We have included much of the material we normally cover in the classroom or during workshops, placing as much emphasis on 'why things work the way they do' as on 'now...press this button'. Our basic view of learning to use software is that the only way to really master an application is to understand what it is doing, and then to practice the mechanics of the application (over and over again).

Having said that, it is worth letting you know right from the beginning that this is **not** a book on the

theory of analysis of data from marked individuals (in the strict sense), and should not be cited as such.[*] This guide is intended simply to be an accessible means by which you can learn *how* to use **MARK**. In the process, however, we do cover a fair bit of the 'conceptual theory'. If you're an experienced analyst of these sort of data, you'll quickly find which parts you can skip, and which you can't. Regardless, we urge you to read the current literature (see below) – it is the only way to keep up with the many recent developments in the analysis of data from marked individuals.

Structure of the book

Chapters 1 through 7 are the 'core' mechanical and conceptual 'skill-building' chapters. Chapters 8 and higher are focused on more advanced applications. For newcomers, we **strongly** suggest that you work through Chapters 1 through 7 first. And, by 'working through', we mean sitting at the computer, with this book, and working through **all** of the computer exercises.

This book is largely based on the premise that you 'learn by doing'. Chapter 1 provides a simple introduction to some of the ideas and theory. Chapter 2 covers the basics of data formatting (the obvious first step to analyzing your data). Chapters 3 to 7 provide detailed instruction on the 'basics' of using **MARK**, within the context of 'standard' open population mark-recapture analysis.

We decided to begin with basic mark-recapture for two reasons. First, it is the basis for most of the commonly used software applications currently in wide use. Since most experienced analysts will probably have some level of experience with one or more of these applications, building the core introduction around mark-recapture seems to present the minimal learning curve. Second, if you understand basic mark-recapture analysis, you can pick up the other types of analysis fairly quickly.

In these first chapters, we will take you through the process of using **MARK**, working for the most part with 'practice' data sets[†], starting with the basic rudiments, and ending with some fairly sophisticated examples. Our goal is to provide you with enough understanding of how **MARK** works so that even if we don't explicitly cover the particular problem you're working on, you should be able to figure out how to approach the problem with **MARK**, on your own. In fact, we measure the success of this book by how little you'll need to refer to it again, once you've gone through all of the core chapters. Once you have worked through Chapters 1 through 7, you should be able to jump to any of the following chapters with relative ease. All succeeding chapters are reasonably self-contained, but do presume you're familiar with basic mark-recapture theory, and (especially) how it is implemented in **MARK**.

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sidebars – extra information

Interspersed throughout most chapters will be 'sidebars' – small snippets of technical information, conceptual arm-waving, or other information which we think is potentially useful for you to read – but not so essential that they can't be skipped over to maintain your flow of the reading of the main body of the text. Whenever you come across one of these sidebar items, it might be worth at least reading the first few lines to see what it refers to.

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[*] We're occasionally asked how to properly cite this book. Easy answer – please don't. This book is not a 'technical reference', but a 'software manual'. The various 'technical' bits in the book (i.e., suggestions on how to approach some sorts of analysis, guides to interpreting results...) are drawn from our collective experience, and the primary literature, the latter of which should be cited in all cases.

[†] Most of the practice data sets are contained in the file markdata.zip, which can be downloaded from the same website you accessed to download this book. The last item of the drop-down menu where you select chapters (left-hand side of the page) is a link to the example files. If you can't find the files there, check the /mark/examples subdirectory that is created when you install **MARK**.

Getting MARK and installing it on your computer

The primary source for program **MARK** is Gary White's **MARK** web page, which is currently located at

https://sites.warnercnr.colostate.edu/gwhite/program-mark/

New versions, miscellaneous notes, and general comments concerning **MARK** are found there, as well as links to lecture notes, and other relevant information. And, if you're reading this, then you've obviously found the 'other **MARK** website', maintained by Evan Cooch.

http://www.phidot.org/software/mark/

The purpose of this 'other' website is twofold: (i) to provide access to this book, and (ii) to provide a locally mirrored copy of the **MARK** install files (either one website or the other is always likely to be 'up and running'). Updates to **MARK** are relatively frequent – and attempts are made to keep the book as current as the software. At present, the only way to check for new versions of both the software and the book is to periodically visit the **MARK** website(s), and look to see if another version has been posted. Alternatively, you can register for the online **MARK** discussion forum (see below), which will send periodic emails announcing new releases of **MARK**.

Now, about installing **MARK**. Before we go into the details – some quick comments:

- **MARK** is a native Windows program. For most users, this means a computer running Windows 10 → Windows 11 as the operating system. However, as 'virtualization' software gets better and better, it has become more tractable to run **MARK** on a non-Windows platform (e.g., using virtualization software – VMWare, or VirtualBox are popular options). Some details about running **MARK** on a non-Windows machine can be found on the **MARK** website.

- Running **MARK** also requires a 'real computer' – we recommend *minimally* a machine with a multi-core CPU clocked at ≥ 2.4 GHz (**MARK** supports and makes use of multi-core processors), with at least 8 GB of RAM (> 8 GB strongly recommended). We also suggest getting a decent sized monitor (≥ 24 inches – you'll discover why we make this recommendation the first time you pull up a 'big, ugly' design matrix).

You install **MARK** using a fairly standard setup program. Once you've downloaded the **MARK** `setup.exe` program, simply double-click it, and off you go! It is a fairly standard Windows installer, with prompts for where you want to install **MARK**, and so forth. The installation is generally uneventful. Once the install program has finished, you're done – no need to re-boot your machine. The install routine should have placed a short-cut to **MARK** for you on your desktop.

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upgrading from an earlier installation

Updates to **MARK** are fairly frequent (with the pace of change being roughly proportional to the rate at which new methods enter the literature). To upgrade an existing **MARK** installation, you should

1. **uninstall the old version**, using the standard 'uninstall software' option from the Windows control panel (ignore any error messages you might get about Windows not being able to unregister certain items – these are spurious). If you really want to be thorough, follow this by manually deleting the **MARK** subdirectory as well (although this isn't really necessary).

2. **install the new version**. For some older versions of Windows, you *may* get an error message or two concerning problems trying to register certain graphics components – ignore these.

3. **test the installation**. double-click the **MARK** icon that should have been placed on the desktop during installation, and make sure the **MARK** GUI starts up correctly. If it does, you should be fine.

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Finding help

No matter how good the documentation, there will always be things that remain unclear, or simply aren't covered in this book (although we keep trying). As such, it's nice to have some options for getting help (beyond the earlier suggestion to 'check the help file'). To serve that purpose, we have created a web-based discussion forum where you can ask questions, make suggestions for **MARK**[*], and so forth. The forum can be accessed at

<div align="center">

`http://www.phidot.org/forum`

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In addition to providing a resource for getting answers to specific technical questions, registering for the forum[†] is also a convenient way to learn about recent changes to **MARK** (and this book), and finding out about upcoming workshops and training sessions.
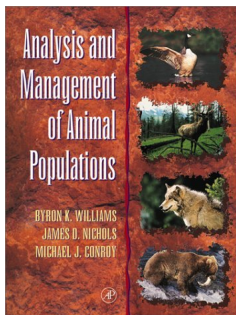
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[*] The forum also hosts similar discussions for a number of other software applications; e.g., **PRESENCE**, **M/E-SURGE**…

[†] Registration for the forum is free, and you have a fair bit of control over how much 'email traffic' it generates.
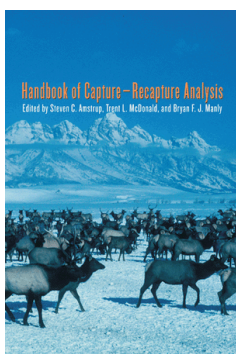
References & background reading

The literature for analysis of data from marked individuals is very large – and growing at an exponential rate (100-150 new papers per year in recent years). As such, it's easy to feel that keeping up with the literature is not even remotely tractable. Don't fret – it's unlikely anyone reads <u>all</u> the papers.[*]

Fortunately, there have been several recently published books, which do much of the collation and synthesis of this large literature for you – we **<u>strongly</u>** suggest that you get access (in some fashion) to the following 3 books:
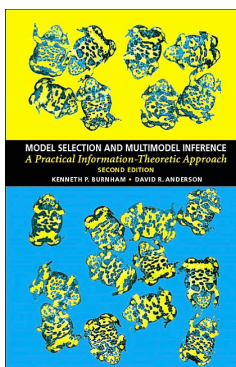
Analysis and Management of Animal Populations – Ken Williams, Jim Nichols, and Mike Conroy. (2002) Academic Press. 1,040 pages.

A comprehensive volume that is the *de facto* standard reference for the integration of modeling, estimation, and management, written by 3 of the luminaries in the field. It provides a superb synthesis of most of the vast literature on estimation from data from marked individuals, as part of a cohesive framework of construction and use of models in conservation management.

Handbook of Capture-Recapture Analysis – Steve Amstrup, Lyman MacDonald, and Bryan Manly. (2006) Princeton University Press. 296 pages.

In some ways, a precis of some of the key 'estimation' sections of the WNC book (above), in others, a more detailed 'guide' to several extensions to methods discussed in WNC. A very good, compact summary of estimation methods, with a focus on practical application.

Model Selection and Multi-Model Inference (2nd Edition) – Ken Burnham and David Anderson. (2002) Spring-Verlag. 496 pages.

So you want to fit models to data, eh? Well, fundamental to this process is the issue of selecting amongst such models. How should you do this? Burnham and Anderson cover this critical issue in great detail – and in so doing, will give you a solid basis for the mechanics, and theory, of model selection as applied to analysis of data from marked individuals.

Collectively, these books represent the *minimum* library you should have at your disposal, and are essential companions to this book.

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[*] With the likely exception of Jim Nichols, who is a 'special case' in several respects...

Acknowledgements

The first draft of this book was written over two weeks in 1998. It was approximately 150 pages in length. The current edition of the book is now >1,200 pages, and has gone through numerous revisions, based almost entirely on comments, corrections and feedback submitted by many of the several thousand people who have used the book in its various incarnations. In addition, over the past several years, several important chapters have been contributed by some of our colleagues. These contributions are so significant that we now consider ourselves as merely 'editors' of the larger effort by the community of **MARK** users to document the software. Any strengths of this book come from these collegial interactions – its failings, however, are our fault alone. We believe in earnest that the only truly 'dumb' question is one never asked. Hopefully, most of your questions concerning the use of program **MARK** are answered here.

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