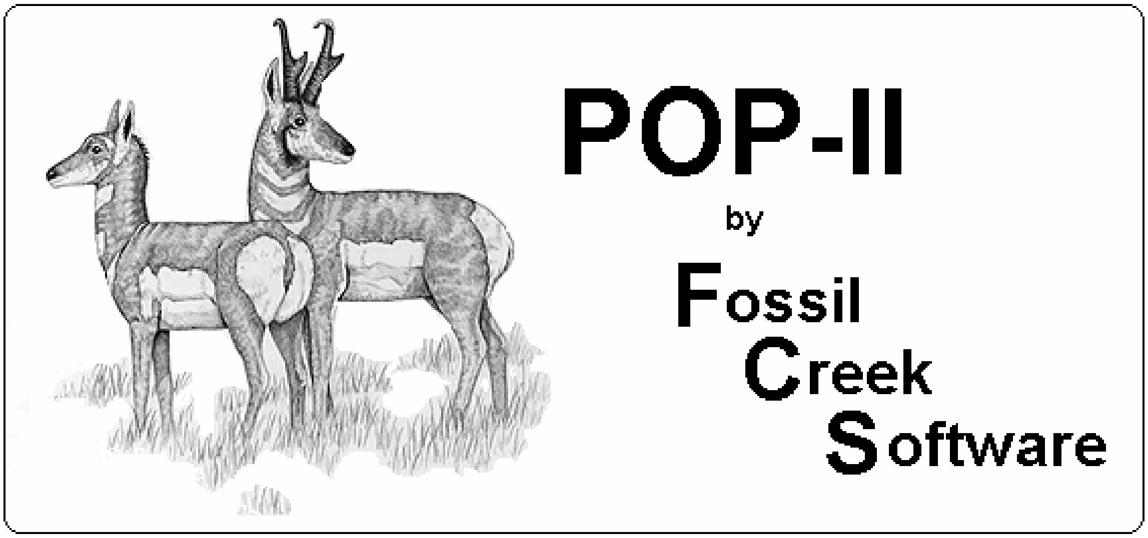

POP-II

SYSTEM DOCUMENTATION

By
John Bartholow

Windows^{TM} Version 1
Slightly Revised January, 2009

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1.0 INTRODUCTION TO POP-II

1.1 Overview

POP-II is a computer program designed to simulate the dynamics of wildlife populations. POP-II is designed especially to help wildlife resource analysts make management decisions. Additional use is being made of the program in both research and college-level teaching.

POP-II is the offspring of the highly successful program ONEPOP developed by Jack Gross and his staff at Colorado State University in the early 1970's. POP-II however, has been developed for a desktop computer, rather than a large, central computer, as was ONEPOP. Unencumbered by the seldom-used features of ONEPOP, POP-II now includes many new and improved capabilities. This version of POP-II is designed for computers running Microsoft Windows™ 95 (or later).

POP-II grew out of a perceived need for a more appropriate solution to wildlife population modeling. Managers were becoming increasingly sophisticated at statistical analysis of their data, able to explore hypotheses ever more accurately and precisely. But surprisingly, they were not able to construct a holistic picture of where a population had been and where it was going. POP-II provides the missing piece.

POP-II is being used to model many, many species of animals. No one knows exactly how many species have been modeled, but a fairly complete list would include two species of deer, elk, moose, caribou, three species of bear, pronghorn, bison, musk ox, big horn sheep, Dall sheep, mountain goats, wolf, fox, fisher, eagles, swans, pheasants, cormorants, mountain lions, bobcat, sea lions, various seals, walrus, badger, coyotes, whales, and peccary.

1.2 Advantages of POP-II

Population modeling with POP-II offers several substantive benefits over traditional approaches to population modeling. Among the benefits are:

★ **TOP LEVEL PERSUASIVENESS**

POP-II helps to test and lay out defendable management options to administrators and the public.

"The way we are set up with our management programs now in Wyoming, we would be hard pressed to do our job without POP-II." -- Wyoming Game and Fish Department manager.

★ **MORE ACCURATE PREDICTIONS**

POP-II enables establishment of sound harvest season quotas and provides input to federal planning and impact assessment. Modeling augments biological intuition with the rigor of quantitative analysis.

★ **CRITICAL ASSESSMENT OF EXISTING DATA**

POP-II is designed to allow the best use of available data while helping to pinpoint the weakest data. It also helps determine proper herd unit delineation.

★ **GUIDANCE FOR THE COLLECTION OF NEW DATA**

POP-II can calculate the contribution that every population parameter makes to the dynamics of the population and will help to better define Research's mission.

★ **DATA CONSOLIDATION**

POP-II facilitates keeping all your management data updated and archived in a central location. You and all your co-workers can stay on top of status and trends using a "common language."

★ **GREATER UNDERSTANDING OF POPULATION DYNAMICS**

POP-II allows you to integrate the understanding of population dynamics with applied population management. Sound population management cannot be conducted without a good understanding of population dynamics. POP-II also opens the "black box" of computer modeling by explaining all of its calculations.

★ **EASE OF USE**

POP-II is relatively easy to understand, extremely simple to use even after not touching it for a year, well documented, and provides easily reproducible results. If you know Windows, you already know how to operate POP-II: selective printing; on-line, context sensitive help; toolbar buttons for frequently used commands; spreadsheet-style editing; and fast, 32-bit computing power.

★ **Y2K COMPATABILITY**

And has been since 1984!

In short, POP-II offers a powerful way to increase the efficiency and effectiveness of management planning.

And What About the New Windows Version?

Beginning July, 1999:

- **Windows Compatibility -- Of Course**
  - If you know Windows, you already know how to operate POP-II
  - Select just the portions of the output you want to print
  - Print graphs with ease

- **On-line Documentation and Help**
  - Windows features: contents, index, find
  - Context sensitive help with data entry

- **Fewer Keystrokes to Get the Results You Want**
  - Toolbar buttons
  - Look at all the tables and graphs you are interested in at once

- **Spreadsheet-like Editing**
  - Scale data values up or down with ease
  - Fill values down to complete entry

- **Fast and More Accurate Computations**
  - Really flies on today's personal computers
  - Greater accuracy and precision of 32-bit computing power

- **Compatible with all your old POP-II data sets** (well mostly anyway)

1.4 About This Documentation

You should familiarize yourself with the basic content of this documentation and then focus on those sections relevant to your objectives. Feel free to skip sections of little interest.

The first section of this documentation provides general information concerning the program. Section 2 talks about how the program works and then ventures into the details you need to get the results you want. If you really want to dive in, you should start here. Section 3 discusses how to install (and uninstall) POP-II from various formats of distribution media. Section 4 discusses other technical details about the program and provides a philosophy for modeling wildlife populations with inexact data. Section 4 also provides a complete set of input and output for a test data set included with the distribution. Finally, in Section 5, references are given for further learning.

In the more technical areas, there is a method to the madness. Text in **bold** refers to software commands like menu items or buttons to push. Text in *italics* refers to specific data entry items.

2.0 HOW POP-II WORKS

POP-II simulates a closed population of animals in which births and deaths are the only factors that influence population size. It is assumed that the population has no appreciable net migration into or out of that population. As such, POP-II is a representation of reality that is a compromise between many explicit events that may affect a population in any given year and a set of events that has generally proven sufficient in a modeling context. It is also a compromise between data availability and our understanding of population dynamics. The structure of the program can be interpreted many ways. By the use of some creative adaptation, the innovative user will find ways to circumvent limitations that may arise in special circumstances.

Most species of management interest respond to the seasonality of their environment in a regular, periodic fashion. POP-II captures seven discrete steps that occur during the *Biological Year* that runs from birth pulse to birth pulse. They are illustrated in the following schematic (Figure 1):

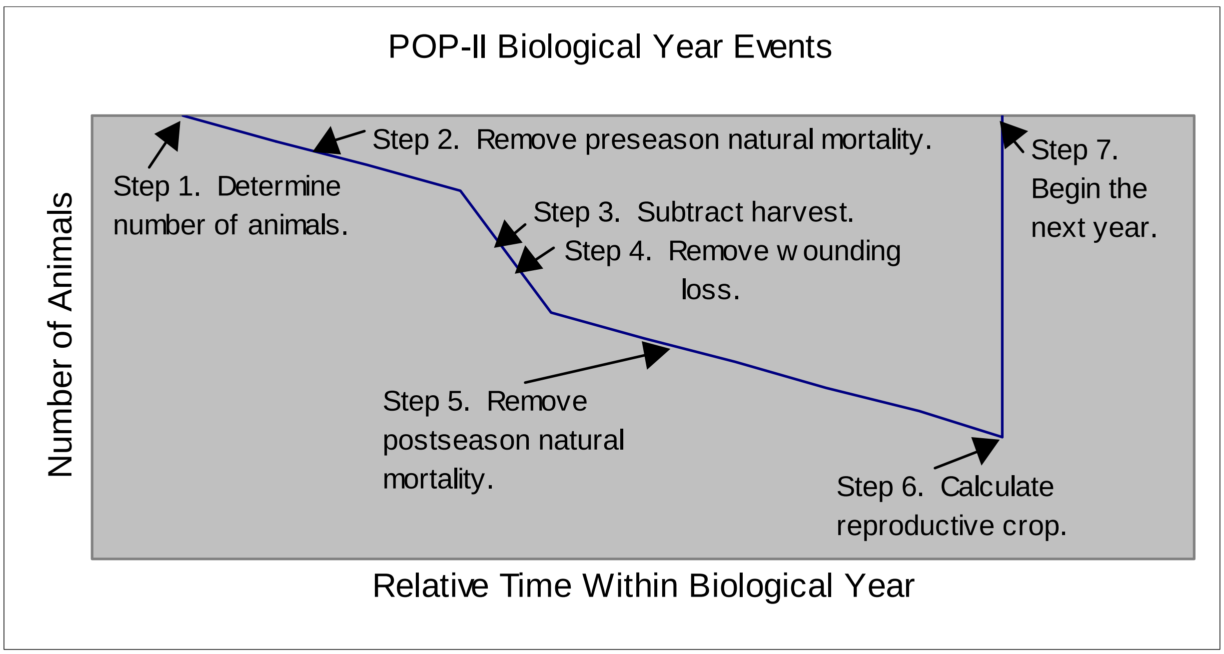


Figure 1. Schematic sequence of events in a POP-II biological year.

POP-II tracks these seven steps in a simple bookkeeping fashion for each of several age classes of both males and females: animals are subtracted for each form of mortality and added for natality. The seven steps are discussed in the following sections. Specific data requirements supporting these steps are discussed in detail in Section 2.4.

2.1 Simulation Logic

Step 1. The first thing that needs to be done is to calculate the *Initial Population Size*. This is the number of animals in each age and sex class at the beginning of the first biological year. The simulation starts just after the young are born. For example, suppose we wish to model a North American deer population. If the simulation starts in 1990, the program calculates the animals present in June of that biological year.

Step 2. The next step is to calculate and remove the animals lost to any *Preseason Natural Mortality* that occurs from the beginning of the biological year to the beginning of the harvest season. For example, if the biological year starts in June and the harvest season begins in October, we need to know which animals will die before the harvest. Natural mortality is entered as an annual percentage for each sex and age class and includes all forms of mortality during this period such as accidents, predation, disease, rutting, poaching, and so on.

Mortality rates may be adjusted annually by an age class-specific *Mortality Severity Index*. The severity index in POP-II may be used not only for weather-related mortality, but also to account for predator abundance or habitat quality.

Step 3. Next, the *Harvest* is subtracted. In most cases, you will enter a specific yearly harvest figure (number of animals, not a percentage) for three segments of the population: subadults, adult males, and adult females. The number of animals you enter will be subtracted from each population segment. The specific number of animals subtracted from each age class of the three segments is accomplished by a set of relative *Effort Values*. These effort values provide control of the relative harvest rates applied to each age class. The program first calculates the total harvest rate for each segment of the population. For example, if there are 100 adult males in the population pre-harvest and you specified that 20 are to be harvested, the harvest rate would be calculated to be 20%. In the absence of effort values, 20% of each age class of the adult male segment would be removed to accomplish the harvest.

Suppose, however, that your data supported the fact that yearlings are harvested at a rate higher than their relative number in the population. You may adjust the effort value for yearling males to be greater than the effort value(s) for the rest of the adult males to proportionately raise the harvest rate on yearlings. In total, there would still be 20 animals harvested. The same approach may be used for older trophy animals by increasing their effort values with respect to those for younger ages.

There is also an entirely different way to handle the harvest – you may let POP-II calculate it for you. If you enter a biological year for the *Desired Population Size* option, animals will be harvested by the program to achieve the desired size you choose for each of the three population segments (subadults, adult males, and adult females). You may use this feature to determine the harvest necessary to achieve a specific population quantity (for carrying capacity or standing crop) or quality (trophy or disease threshold) target. POP-II calculates the number of animals necessary to harvest, taking into account both a wounding loss rate (see Step 4) and relative effort values. That calculated number is removed and simulation continues.

Note: What POP-II calls "harvest" need not really be harvest at all. Any removal of animals from the population, such as trapping, may be considered harvest. Similarly, the harvest period may be used for special treatment of otherwise natural mortality if you know the approximate number of animals instead of the rate.

Step 4. This step is really a continuation of Step 3's, adding *wounding loss* to the annual harvest. The wounding loss rates may be used to account for poaching or other harvest related mortality, such as gear mortality. You enter wounding loss as a percentage of the known harvest for each population segment (with an extra value reserved for yearling males). For example, if there were 100 adult females harvested and you entered a wounding loss of 15 percent for that segment, an additional 15 females would be removed from the population. The wounding loss is removed from each age class in proportion to the harvest rate on that age class, i.e., in proportion to the age-specific effort values. If there is no harvest, there will be no wounding loss.

Step 5. After the harvest season, the *Postseason Natural Mortality* is calculated and subtracted from the population. As with preseason natural mortality, the postseason natural mortality uses its own *mortality severity index*.

Step 6. The next-to-last step in the biological year is to advance all the animals by one age class. Note that this is equivalent to 100% mortality for the oldest age class of animals. For this reason, it is important that you allow for the oldest animal that you might reasonably expect to find in the field.

Step 7. The final step in the simulation is to calculate the *Reproductive Crop* and insert that young crop into the (now vacant) first age classes. There are up to three categories of reproductive females in POP-II. A typical deer simulation would involve supplying an annual reproductive rate for all three categories: fawns, yearlings and all other adult females. The total number of females is summed for each category. The sum of these potentially pregnant females is multiplied by the reproductive rate for that category and split into males and females using a relative male:female *sex ratio*, which you supply.

Finally, the program proceeds to the next year of simulation, if one exists and no severe error has been detected, and the cycle repeats until completed.

What-If Simulations

POP-II may be used to simulate only the period for which field observations are available, or it may be used to simulate what may happen in the future if certain events occur, or both. Used solely to simulate the *past*, POP-II is quite useful as a "lie detector." For example, *natural mortality couldn't have been as high as we think and still have had enough males to support the harvest we know occurred.* Used as a *what-if?* tool, POP-II may be used to answer questions such as *what if we changed from an either-sex harvest season to a trophy harvest strategy?*, or *what if we could reduce over-summer predator-driven natural mortality?* Used to its full advantage, POP-II is employed to do both – simulate the past to increase confidence in the difficult to measure population parameters and simulate the future to see what may happen.

2.2 Navigating the Menus and Other Handy Tools

The Menu Bar

Near the top of POP-II's main screen you will find the menu bar. Complete operation of POP-II is possible from this menu by clicking on the appropriate items or by pressing Alt followed by the underlined letter of that item. For example, Alt-F will access the **File** menu. Menu items are "grayed out" if they are unavailable at some point during operation. The full set of commands available (and their shortcuts if available) is:

File|New – Create a new data set (Ctrl-N)
File|Open – Open an existing data set from disk (Ctrl-O)
File|Close – Close working data set
File|Save – Save data set to disk with its given name (Ctrl-S)
File|Save As – Save data set to disk with a new name
File|Print Setup – Set printer configuration, i.e., landscape/portrait
File|*n* – Open file number *n* from recent file list
File|Exit – Exit POP-II (Ctrl-X)

Edit|Control Data – Edit "control" data (Ctrl-F1)
Edit|Age-Specific Data – Edit data that applies to age classes; also get help with age distribution (Ctrl-F2)
Edit|Yearly Data – Edit annually varying data on harvest and mortality (Ctrl-F3)
Edit|Reproductive Data – Edit annually varying data on recruitment (Ctrl-F4)
Edit|Observed Data - Edit field observations (Ctrl-F5)

Run|Simulation – Run the model (Ctrl-R)
Run|...With Details – Check option if you want to see detailed "Narrative Report"

View|Data Set – Look at data set in its entirety
View|Simulation Details – Look at "Narrative Report" (Ctrl-D)
View|Tables – Select and look at tables (Ctrl-T)
View|Graphs – Select and look at graphs (Ctrl-G)
View|Age Pyramid – Look at sex and age pyramid (Ctrl-A)

Options|Large or **Small Icons –** Change toolbar icon size (Ctrl-I)

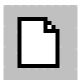
Tools|Target Practice Improve model alignment with observed data (Ctrl-P)

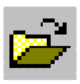
Help|Navigating POP-II – This help
Help|Contents – Main level help
Help|Search For Help On – Keyword search
Help|About POP-II – Contact information

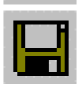
Help|About POP-III – Promotion of POP-III

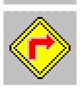
<u>The Toolbar Buttons</u>

Below the menu bar is a row of toolbar buttons that are shortcuts to frequently used menu items. Like menu items, if they are "grayed out" they are unavailable at that time. There are two differences in how the toolbar buttons work from the corresponding menu items: the buttons for **View Selected Tables** and **View Selected Graphs** go directly to the tables and graphs previously chosen via the menu bar. This helps reduce key strokes or mouse activity.

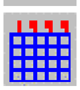
 **Create New Data Set**

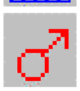
 **Open Existing Data Set**

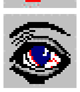
 **Save Data Set** to disk

 **Edit** data set's **Control Values** (control traffic – get it?)

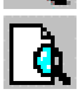
 **Edit** data set's **Age Class Data** (birthday cake – get it?)

 **Edit** data set's **Yearly Data** (calendar – get it?)

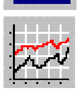
 **Edit** data set's **Reproductive Values** (ok?)

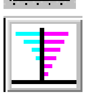
 **Edit** data set's **Observed Values**

 **Run Simulation** (with Details if checked)

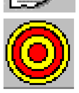
 **View Simulation Details** (like old Narrative Report; magnifying glass – get it?)

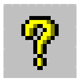
 **View Selected Tables** (selected from **View|Tables** menu)

 **View Selected Graphs** (selected from **View|Graphs** menu)

 **View Sex and Age Pyramid**

View Data Set in its entirety

 **Target Practice Tool** to improve model alignment with observed data

 **Help**

<u>Keyboard Shortcuts</u>

Alt-↓ (down arrow) – When entering values into one of the data-editing matrices, pressing Alt-Down Arrow will fill *all* cells *below* the one you are currently pointing to with the value in that highlighted cell. This only works if a single cell is highlighted. See also **Shift-Arrow**. **Note:** use care when using this option as there is no **Undo** command.

Alt-character – Selects items from menus or tabs that are the "hot key" and usually designated by an underline. For example, the **File** menu may be activated with the **Alt-F** key combination.

Alt-F-1 -- Opens the most recently used file. See File Menu.

Alt-Print Screen – Copies the active window to the Windows clipboard to paste into word processor or other application. This may give better results than the "print form" command on the right-click menu. Be sure to move form on the screen, if necessary, to not overlap the Windows Taskbar lest it be copied too.

Alt-Tab – Moves from one tab to the next on screens that have multiple tabs, such as the **Edit Observed** screen. Note that you must use arrow keys to move between rows of tabs.

Control-Arrow – Used to move to each of the four the edges of the data-editing matrices.

Control-Home and **Control-End –** Used to move to the very first (upper left) and last (lower right) cells in the data editing matrices.

Control Key Combinations

Ctrl-A = View|Age Pyramid
Ctrl-D = View|Simulation Details
Ctrl-F1 = **Edit|Control Data**
Ctrl-F2 = **Edit|Age-Specific Data**
Ctrl-F3 = **Edit|Yearly Data**
Ctrl-F4 = **Edit|Reproductive Data**
Ctrl-F5 = **Edit|Observed Data**
Ctrl-G = View|Graphs
Ctrl-I = Options|Large or **Small Icons**
Ctrl-N = **File|New**
Ctrl-O = **File|Open**
Ctrl-R = Run|Simulation
Ctrl-S = **File|Save**
Ctrl-T = View|Tables
Ctrl-X = **File|Exit**

Delete - Removes items from selected cells in an editing matrix.

Esc - Generally the same as pressing a Close or Cancel button.

F1 – Get context-sensitive help on each screen window.

Home and **End –** Moves to the leftmost and rightmost cells in the data-editing matrices.

Page Up and **Page Down –** Moves up or down as expected to the data-editing matrices.

Right Clicking – Right clicking on selected output allows access to other printing and data manipulation features, such as printing selected text or the form that appears on your screen. **Delete** may be used to remove selected values from an editing matrix. **Multiplication by a scalar** may help when editing single selected values, or groups of selected values, in one of the spreadsheets. ***Note***: to **Paste** multiple cells into an editing grid requires that the proper number of cells be selected beforehand. Occasionally, you may need to right-click in a blank area of an on-screen form to get the menu to appear. See **Shift-F10** for an alternative to using the mouse for right-clicking.

Shift-Arrow – Used to select text or groups of cells as in many Windows applications, like selecting cells by holding down the left mouse button. However, one handy feature in the data-editing matrices of POP-II is that you may select a group of cells and then type in one number which will then replace all values in the selected cells. This is similar to the **Alt-Down Arrow** command, but more versatile and specific. **Note:** use care when using this option as there is no **Undo** command.

Shift-F10 – Used in place of right clicking the mouse in circumstances when a popup menu is possible. See **Right Clicking** above for more information. Note that *Shift-F10* may not always provide access to the full pop-up menu.

Tab – The workhorse movement key, used to move from one entry box to the next entry box or command button. **Note:** use the arrow keys in the data-editing matrices to move from cell to cell.

Windows Clipboard – Under certain circumstances, you may find it possible and to your advantage to move data back and forth from POP-II to other Windows programs. POP-II will support some typical **Cut, Paste,** and **Copy** operations. **Note** that POP-II uses a Courier New Bold font in the text windows used for **Tables** and simulation **Details**. This is a proportional font and must be proportional lest columns lose their correct formatting.

Printing Graphs

I'm not sure why Windows continues to make it difficult to deal with or print graphics. One could say that it is easier than DOS, but what I think is that there are simply more options, not all of which may work for you and your printer. There are three options listed here in order of complexity and flexibility.

Option one - Use **Print Form**. This option will print a copy of the form (without the buttons) on your printer. The resolution can be rather crude, but this is the fastest way to make copies to check the progress of your simulation. If your printer has only a limited amount of memory, you may get only a partial image along with one or more errors. In such cases, I recommend using the **File|Print Setup** command to change your printer's graphic properties. You may find that a lower resolution, such as 150 dots per inch (dpi), will work for you. Experimentation with dithering options (don't ask me to explain these as I can't) may also improve the usability of the image.

Option two - Use **Alt-Print Screen** to place a bitmap copy of the active window on the Windows clipboard to paste into a word processor or other application that may deal with graphics more flexibly than can POP-II. Remember that you can push the **Trim** button to remove the buttons from the image you capture. **Alt-Print Screen** will have the POP-II Version label at the top of the image, which may or may not be advantageous. Be sure to move form on the screen, if necessary, to not overlap the Windows Taskbar.

Option three - Use the Right Click's **Copy** command to put the graph on the clipboard, then paste the results into your other application, such as a word processor or spreadsheet. This option should provide results comparable to **Alt-Print Screen**.

2.3 Typical Program Flow

A typical program command sequence might be to:

Use **File|Open** to load a data set from disk, or **File|New** to create a new data set
(**TIP:** Use **Alt-F-1** to open the most recently used file.)

Use **View|Data** to list the current values of all parameters

Use **Edit** as appropriate to update values or correct errors

Use **File|Save** to safely store the data set to your disk

Use **Run|Simulation** to make the calculations
(**Tip:** You can actually skip this step if you wish as POP-II is smart enough to know if it needs to Run the simulation after you have edited the input data.)

Use **View|Graphs** to examine the results, maybe print some out

Use **Edit** to make one or more changes

Run the model again

Use **View|Tables** to list a table or two, maybe print some out

Use **File|Save** once again to save the data set on disk for later use

If your model is generally satisfactory, use **Tools|Target Practice** to improve its fit.

Use **File|Exit** to quit the POP-II program and return to Windows

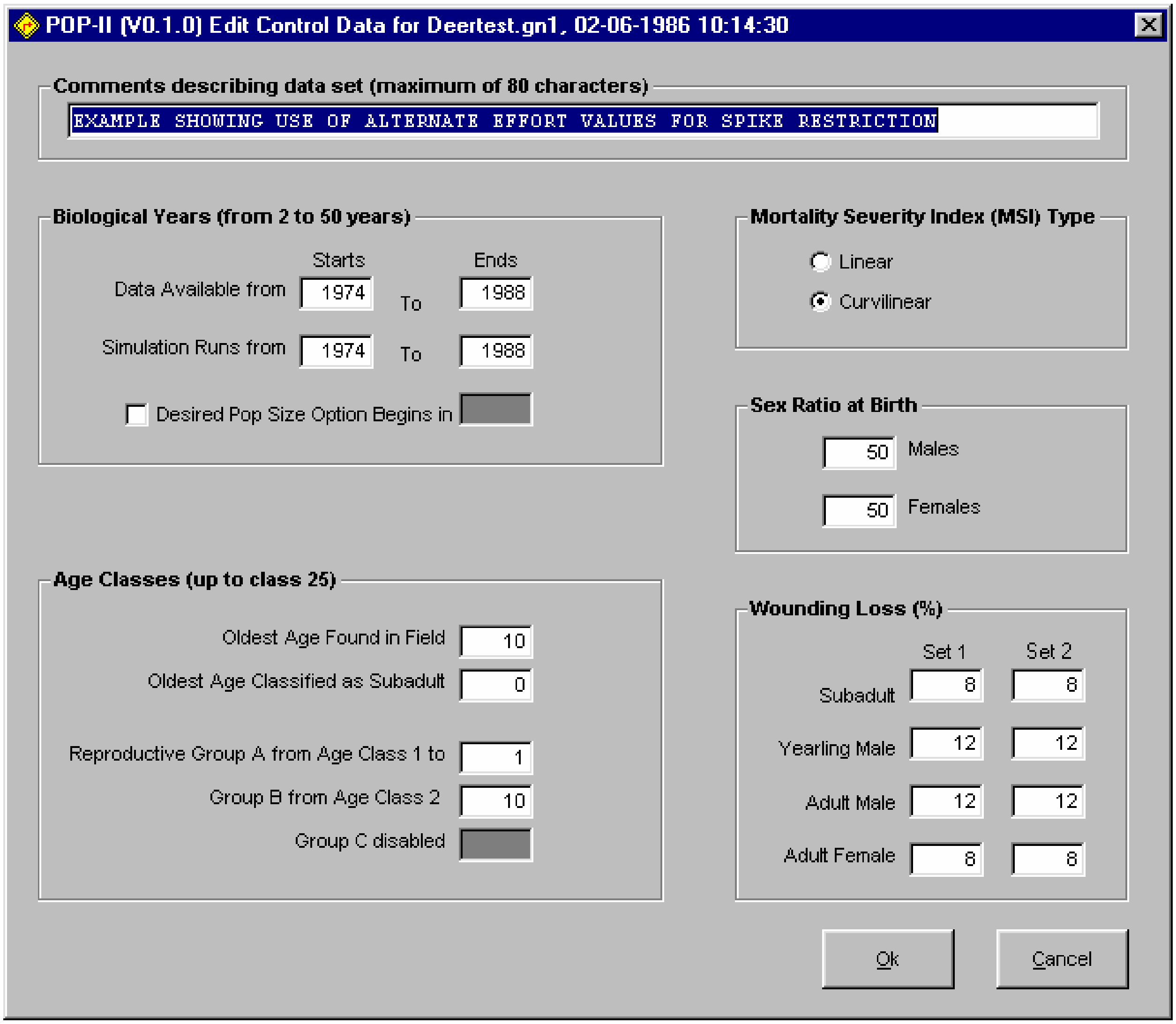
2.4 Specific Data Entry Items

One of the first things you will want to do is to enter of your own data describing a population. Choosing **File|New** will allow you to go to the data entry section of the program. When you do, you will be asked to enter the following information, contained on five separate, but related, input "forms". The forms are (1) Control Data, (2) Age Class Data, (3) Yearly Data, (4) Reproductive Data, and optionally, (5) Observed Data. There is no way to understand the ramifications of any single entry item until you understand the whole set, so experimentation and learning are in order.

Note: When choosing **File|New**, the data entry screens will display a set of "default" values as placeholders for the data you will enter. Simply enter your data in their place and press the OK button to move from screen to screen. You will have the opportunity to come back and edit all the values later.

2.4.1 Control Data

The following data entry values are included on the **Control Data** entry screen that appears as the screen image below. Pressing **OK** will update your data set with any changes you have made and continue the data entry process; pressing **Cancel** will not change the values that were on the screen when it first appeared.



Comments describing data set

You should enter a *Comment* for each data set. The *Comment* line (up to 80 characters) may be used to describe the data set or what you are testing. Put any notes about assumptions or expectations here to serve as a mind-prompter for next year when you come back to update the model. It is advisable to update your comments before you save a new version of a data set.

Biological Years

POP-II is based on a biological year, with the year "named" for the calendar year in which that biological year begins. For example, suppose the young are born primarily in June. If so, biological year 1998 extends from June 1998 through May 1999. Please keep this in mind when entering data and looking at the simulation results. Examining the Simulation Details after running your model may help you understand this.

You need to tell POP-II about the years that your data span. The *Data Available from* years are the years for which you actually supply data values. For example, suppose you want to simulate from 1986 to 1998. Enter 1986 in the *Starts* box and 1998 in the *Ends* box. For starters, enter the same values in the *Simulation Runs from* boxes. *Data Available from* years mean that POP-II may expect to find values entered for those years to enable the simulation to run. This does not mean that all values are measured field observations. Some may be estimates of past events, and some may be hypothetical in the sense of *what if we set harvest to XX to see what happens?*

TIP: Why are there two sets of years? When developing a new model, it is best to stop the simulation in the last year of "real" data until the model is satisfactorily "aligned" or calibrated. (For a description of model alignment, please see Section 4.4.) After alignment, **EDIT** the *Years of Simulation* to extend the run another few years. This keeps the "future" behavior of the model from influencing your opinion about the quality of the "historical" simulation.

TIP: One rule of thumb is to model the history of the population for at least as many years as you have age classes in the population. This allows an entire generation to be cycled through the model and reduces the effect of bias inherent in the initial conditions.

Note: There are logical limitations on the values you enter: (1) The first year of simulation must be greater than or equal to the first year of data; (2) the last year of simulation must be less than or equal to the last year of data; and (3) you must run the simulation for at least two full years. One year's worth just is not enough to do anybody any good! POP-II can handle no more than 50 years of data and 50 years of simulation. By this, I mean that you may enter 50 years of data and the simulation may start and end anywhere within those bounds. **Remember:** when I say *data*, I mean values entered to tell the simulation what to do. Not all *data* values must be measured field data.

TIP: The *Data Available from-to* values also control your ability to enter observed data values (see Section 5.4). Changing these years, especially the starting value may require double checking everything.

POP-II provides a *Desired Pop Size Option* to calculate the harvest required to reach a target postseason population size. If you want to use this option, check the box and enter the appropriate biological year in the box provided. This will determine when this option comes into play and changes the meaning of values entered in the harvest columns on the **Edit Yearly Data** entry screen. A common mistake is to enter the first year of data or beginning year of the simulation. This usually results in a catastrophic harvest of the population.

Please note that the year for the *Desired Pop Size Option* reflects the biological year. For example, suppose you wanted to achieve a population size goal after the harvest in 1984, and the harvest season closes at the end of December. In that case, the population will reach its goal in calendar year 1985. But this is still biological year 1984.

Age Classes

You should enter the *Oldest Age Found in Field*. The rule of thumb is to provide for the oldest animal one would typically find in a healthy population. If the population has been severely harvested, you may wish to allow for even older animals. In this way, the model will be able to handle older age classes if the population begins to mature under a different management alternative. There may be no more than 25 age classes and no less than two.

POP-II's first age class is labeled zero (0). POP-II's age class 0 is what many people call age ½. Class 1 is a 1½-year-old, or yearling, and so on. The oldest age class will automatically suffer 100% postseason natural mortality when the ages are advanced. You should check the Sex and Age Pyramid display after you believe you have a satisfactory alignment to make sure animals are not unrealistically "stacking up" in the older age classes. Having a large percentage of the population in these older age classes would likely indicate mortality rates that are too low.

The *Oldest Age Classified as Subadult* allows for grouping of the simulation results in categories meaningful to the population under study. For example, for deer, subadults would be only age class zero (fawns). In modeling bear however, subadults (cubs) typically would be the age classes zero to three. You will be asked later for the harvest data for subadults as a single category.

In addition, you will be entering reproductive rates for a maximum of *three reproductive groups* for each biological year. In preparation for that, you must set the upper age limit of those groups. Remember that the age classes are advanced before reproduction. So, for example, if Group A is to include only fawns from the previous biological year (that give birth on their first birthday), enter a "1" for the upper limit of that category. If you do, Category Two will automatically have a lower limit of age class 2. This process is repeated for the other two categories.

If you desire only one category, you may “consume” all the age classes in Group A. If you do, the remaining entry boxes will be disabled. Perhaps more typical would be to exclude young of the (previous) year from breeding. In this case, set Group A's upper limit to 1 but set the reproductive rates for that Group to zero later in the data entry process.

Note that at times it may be desirable to include a rate for one or more age classes that had not actually bred the year before to better match field data that cannot visually distinguish among age groups.

As you enter or edit the Group age limits, the software will try to eliminate illogical entries. It may automatically change limits in response to your editing and may beep at you if it complains. When all is said and done, just make sure that you get what you want. If in doubt, examine the Simulation **Details**, which should tell you exactly what the model is doing age class by age class to calculate the reproductive crop.

Note: POP-II may complain somewhat about the reproductive age categories if you load data sets created with some previous versions of the program, including some of the test data sets packaged with the Windows version (since they too are old). The program may beep as you tab the cursor over the age values and change them, or it may beep when you first press the **Ok** button on the editing screen. In such cases, please double check that you are getting the behavior you want by examining the **Details** carefully before proceeding. It is my expectation that all will be well, but sometimes I'm wrong.

Mortality Severity Index Type

There are two ways to annually adjust the natural mortality rates entered on the **Edit Age Class Data** entry screen. One uses a multiplier on a curvilinear scale such that subadults are more strongly influenced by severe weather or other stressful events than are adults. The second is a linear multiplier that simply scales the natural mortality rates by a multiplicative value. The "default" method used by POP-II is curvilinear, as it has proven robust in many circumstances. However, the linear method may work as well or better for some populations. See the more detailed explanation of the *MSI values* later in this document for more information.

Sex Ratio at Birth

Your entry for *Sex Ratio* is straightforward. 50:50, 1:1, or 100:100 are all legitimate ways of entering these values and are equivalent. Though simple to enter, this is a highly sensitive parameter over a multi-year period and should be given careful attention.

Wounding Loss

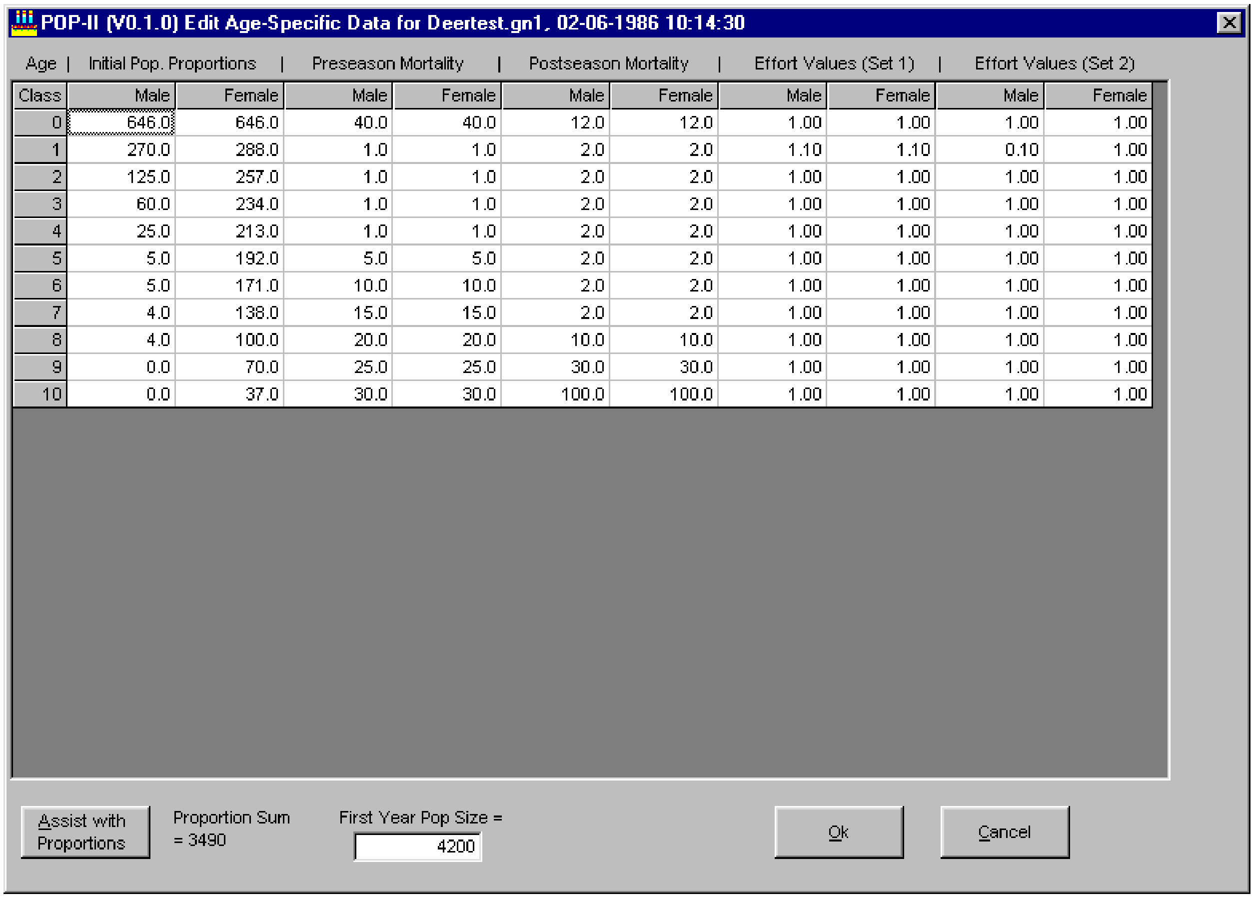
The legitimate harvest (values entered later) is subject to additional, unrecorded mortality termed *wounding loss*. For every animal legally taken, it is assumed that some percentage is either illegally taken, or wounded and dies. In situations where there is no harvest for a particular population segment, such as adult females for example, any accidental loss must be handled as a natural mortality factor. You should enter a Wounding Loss figure for each of four population segments: *subadults*, *yearling males*, *adult males*, and *adult females*. Wounding loss is entered as a percentage of the legal harvest.

There are two sets of wounding loss values. *Set 1* is used when the *Effort Set* (entered later) equals zero or one; the alternate set is used when the *Effort Set* equals two.

Note: If you are using a yearling male wounding loss that is significantly different than the wounding loss for the rest of the males, the desired population size option will not provide the exact results you requested, but they will be close. This is because it is difficult to compute an analytic solution with more than one wounding loss within a population segment. Check the Simulation **Details** for "exact" values. **Note** that some values may be rounded or truncated in the **Details** listing, so *exact* must be taken with a grain of salt.

2.4.2 Age-Specific Data

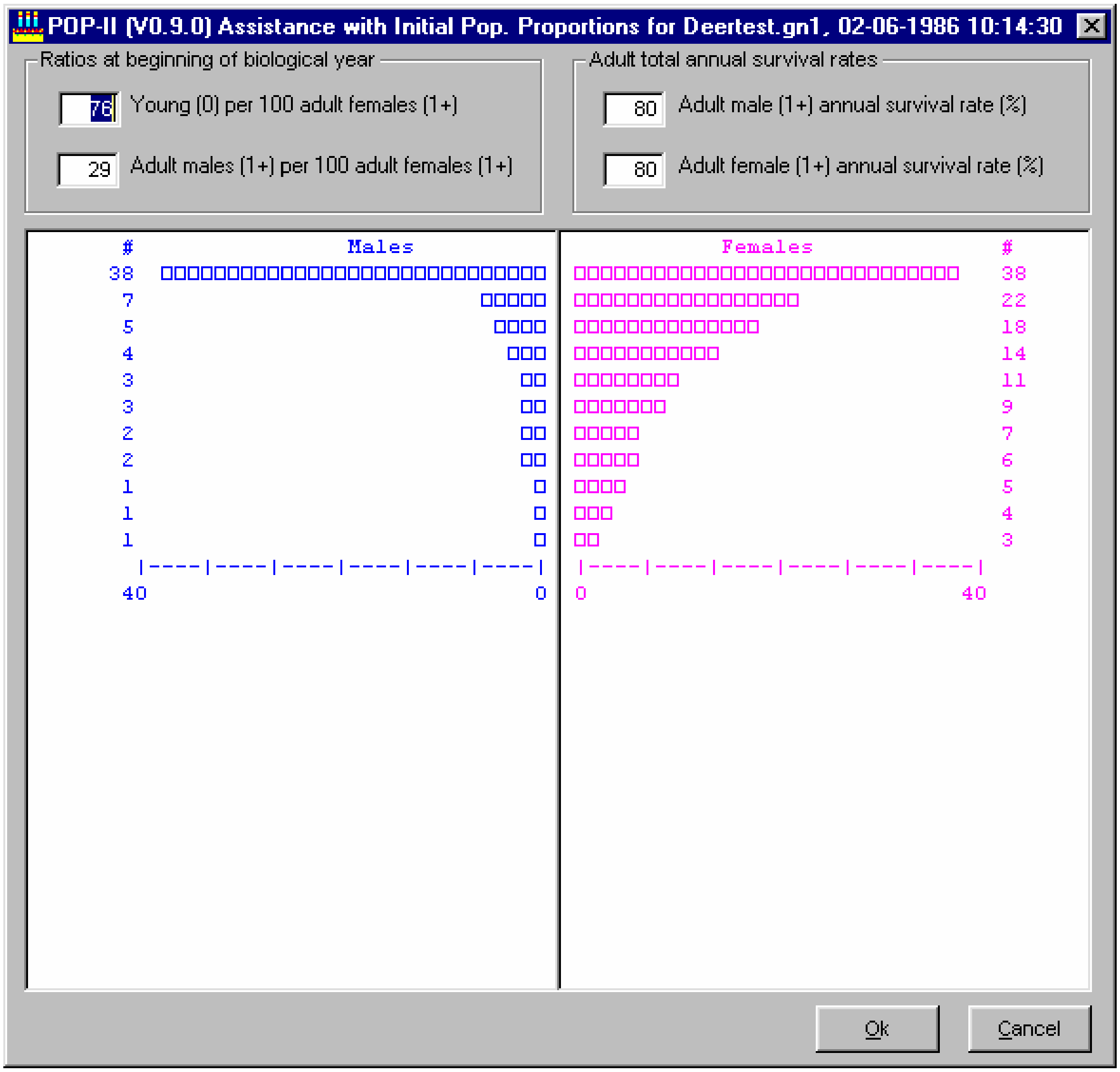
Age specific data include the *initial population proportions*, *pre- and postseason mortality*, and *harvest effort* values for each sex and age class. It's data entry screen appears below.



Initial Population Proportions

POP-II needs to know the number of animals in each sex and age class just after the young are born in the first biological year of the simulation – the *initial population proportions*. These are termed *proportions* because the values entered are really used in the model to proportion the *first year population size*. Therefore, you may enter numbers of animals, percent of population, or any other relative age and sex proportioning factors in the matrix on your entry screen. Values for young of the year are placed in age class 0, yearlings in class 1, etc. If considered as percents, the sum of the percentages for all age classes and both sexes together should add to approximately 100%; it is not the case that the male age classes add to 100% and the female classes to 100%.

There are two ways to enter the *initial population proportions*. You may either type them in yourself, one number for each sex and age class, or you may let the computer assist you. If you choose **Assist with Proportions**, you will enter the number of *Young (0) per 100 adult females (1+)*, *Adult males (1+) per 100 adult females (1+)* for the initial values, and estimated *total annual mortality rates* for both adult males and adult females on a form as shown below. Total mortality includes all natural and harvest-related mortality. The program will then calculate the relative proportions for each sex and age class and provide a colorful schematic showing the age class decline curve for each sex. Pressing **Ok** returns you to the previous screen and fills in the new initial values.



Since we are dealing with proportions, you must also enter a *First Year Pop Size* to start the ball rolling. With this value, POP-II calculates the scaling factor necessary to adjust the *proportions* to the beginning-of-year total. The initial proportions are used for relative age/sex structure in the first year only. The starting population sizes for each age class for each biological year are given in the **Simulation Details** if you need to know them.

Note: It is often true that you have no, or poor, estimates of preseason natural mortality, or simply want to ignore that mortality because your estimate of reproductive rates really comes from your fall ratios and you feel that over-summer mortality is light. If you do not want to include the preseason natural mortality, you may set the preseason mortality to zero and proportion the initial population values to represent the population immediately preharvest.

Natural Mortality Rates

Natural Mortality Rates represent all non-harvest mortality factors and are entered as percentages for each sex and age class. The percentages entered will decrease the population during the preseason and postseason periods. You will enter a *preseason mortality rate* for each sex and age class. If, for example, you enter a mortality rate of 20 percent for yearling males, 20 out of every 100 yearling males will be removed before the start of the harvest. There is no natural mortality during the harvest period in POP-II. The oldest age of each sex will be forced to suffer 100% mortality in the postseason period. Mortality rates entered are not additive between the pre- and post-season periods; that is, the preseason mortality rate is independent of the postseason rate.

TIP: Natural mortality rates work in conjunction with the annual *mortality severity indexes* (entered on the **Yearly Data** screen). If these severity indexes are used, the natural mortality rates you enter here will typically represent minimum values which are adjusted upwards with the severity indexes.

Effort Values

Effort values are used to adjust the relative harvest rate among the age classes for each sex. Age-specific differences in harvest rates may be explained by either hunter selectivity (such as selecting trophies or avoiding young of the year) or animal vulnerability (such as behavioral traits which make the age class more or less secretive.) Effort values can be measured on any relative scale you choose. It is common to use 1.0 for "normal" effort, less than 1.0 to achieve a lower harvest rate and greater than 1.0 to achieve higher harvest rates.

Suppose age class one males had an effort value of 2.0 and age classes two and above males had effort values of 1.0. This would indicate that the yearlings' harvest rate would be approximately twice that of the older males.

Effort values that differ widely between age classes may lead to undesirable results in otherwise poor simulations. It would be rare to have widely differing values unless there is a really good reason. By checking the Simulation Details, you can see exactly how many animals are being taken from each age class. The specific formula for calculating the harvest for each sex and age class is:

$$H_{a,s} = \frac{N_{a,s} \cdot E_{a,s} \cdot T_s}{\Sigma_a (N_{a,s} \cdot E_{a,s})}$$

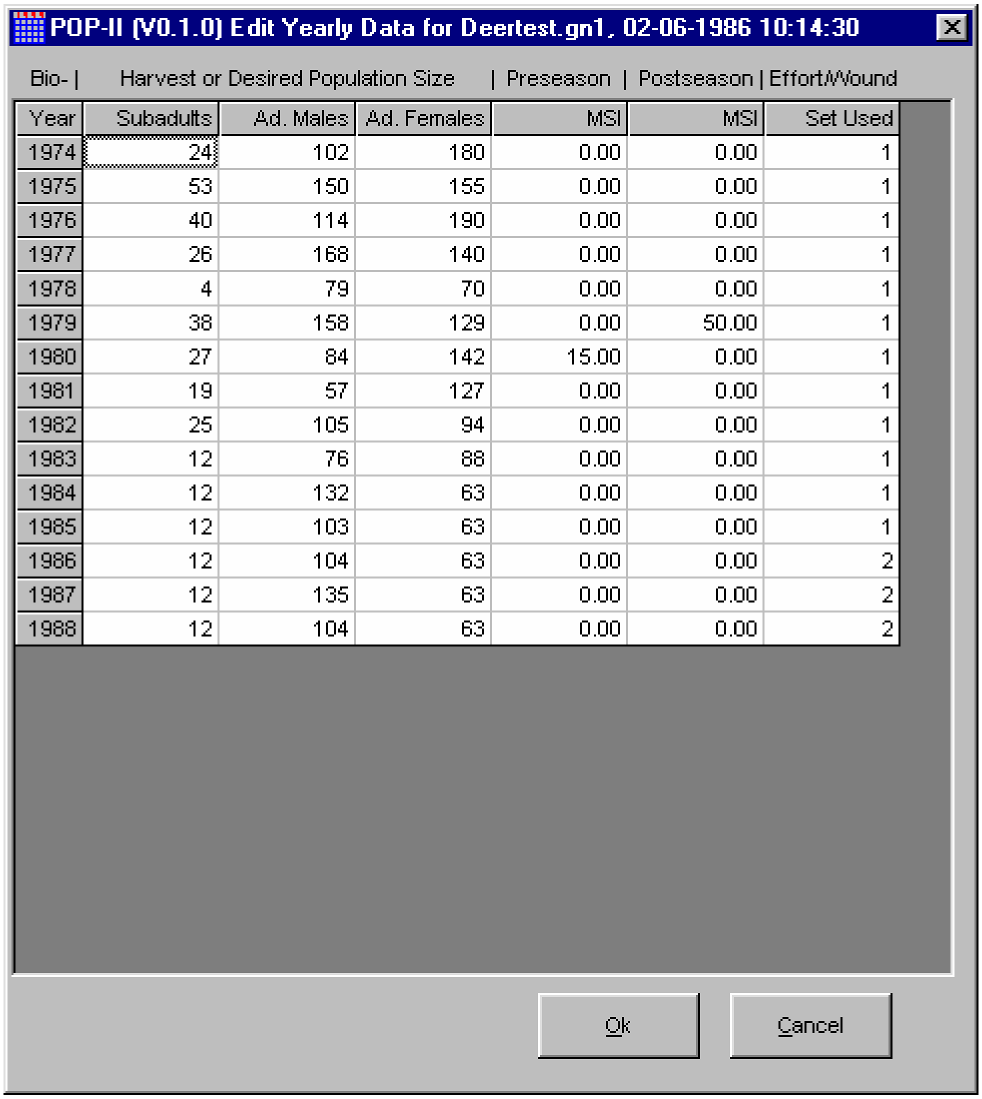
where $H_{a,s}$ = Harvest for age **a** and segment **s**
$N_{a,s}$ = Preharvest number of animals in age **a** and segment **s**
$E_{a,s}$ = Effort value for age **a** and segment **s**
T_s = Total harvest for segment **s**
Σ_a = Sum over all age classes within each segment

What if your hunting regulations have changed through time, perhaps from a population controlling either sex harvest strategy to a trophy producing, age-restricted harvest? During data entry, you will be asked for two sets of effort values, labeled **Set 1** and **Set 2**. You will also be asked on another screen for annual values of a switch to control which set of effort values are used in each year. If you enter a 1, the first set will be used; if you enter a 2, the second set will be used. You may also enter a zero, in which case the effort values will all be set to 1.0, as if there is no selectivity or vulnerability. Using a zero is a good way to experiment with the effect of equal effort values.

TIP: You may set the effort values for certain age classes to zero to eliminate harvest on those ages.

2.4.3 Yearly Data

There are actually two screens for entering data that vary annually. The first, containing harvest values, mortality severity indices and the switch for choosing effort sets, is shown below.


POP-II (V0.1.0) Edit Yearly Data for Deertest.gn1, 02-06-1986 10:14:30

Bio- Year	Harvest or Desired Population Size: Subadults	Ad. Males	Ad. Females	Preseason MSI	Postseason MSI	Effort/Wound Set Used
1974	24	102	180	0.00	0.00	1
1975	53	150	155	0.00	0.00	1
1976	40	114	190	0.00	0.00	1
1977	26	168	140	0.00	0.00	1
1978	4	79	70	0.00	0.00	1
1979	38	158	129	0.00	50.00	1
1980	27	84	142	15.00	0.00	1
1981	19	57	127	0.00	0.00	1
1982	25	105	94	0.00	0.00	1
1983	12	76	88	0.00	0.00	1
1984	12	132	63	0.00	0.00	1
1985	12	103	63	0.00	0.00	1
1986	12	104	63	0.00	0.00	2
1987	12	135	63	0.00	0.00	2
1988	12	104	63	0.00	0.00	2

Ok Cancel

Harvest/Desired Population Size

Harvest or Desired Population Sizes are entered for each biological year. Harvest values are entered as the number of animals for each of the three population segments: subadults, adult males, and adult females. What if there are not enough animals to support the harvest you requested? In this case, you will be given an informative message, but the simulation will continue until the end of the biological year. Then the simulation will stop, even if you requested the program to simulate for several more years, and print an error summary.

If the *Desired Population Size* Option is in effect for that biological year, the values entered in the three columns will be used as postseason population size targets for the three population segments instead of harvest values. Should any population segment be below your desired goal, harvest for that segment will be set to zero, there will be no informative message, and the simulation will continue.

Note: If you are using a yearling male wounding loss that is significantly different than the wounding loss for the rest of the male segment, the desired population size option will not exactly achieve the requested target, but it will be close.

Mortality Severity Indices (MSI)

Pre- and Postseason Mortality Severity Index (*MSI*) values are entered for each year of data. There are two ways to implement the mortality severity indices, as curvilinear multipliers or as linear multipliers. The curvilinear multiplier is an adaptation of a method developed in California, and represents the hypothesis that subadults are more strongly influenced by severe weather or other stressful events than are adults. This curvilinear MSI formulation is strictly empirical and has no theoretical basis as far as I am aware. However, it seems to work well. The linear multiplier is just what it sounds like – a direct multiplicative factor times the natural mortality rates entered on **the Age Class Data** screen. The initial "default" MSI values are zero if you are using the curvilinear formulation; the defaults are 1 if you are using the linear formulation.

The Curvilinear MSI is on a scale from 0 to 99, with 99 being the worst possible mortality, 0 the best. The natural mortality rates you enter will generally be estimates of minimum mortality. You may increase these favorable mortality rates by increasing the MSI from 0 (where the multiplier equals one) to some larger value. The only difference for the linear mortality is that the lower limit is 0 with no effective upper limit. In no case will effective natural mortality rates computed during the simulation be allowed to exceed 100% or be less than zero.

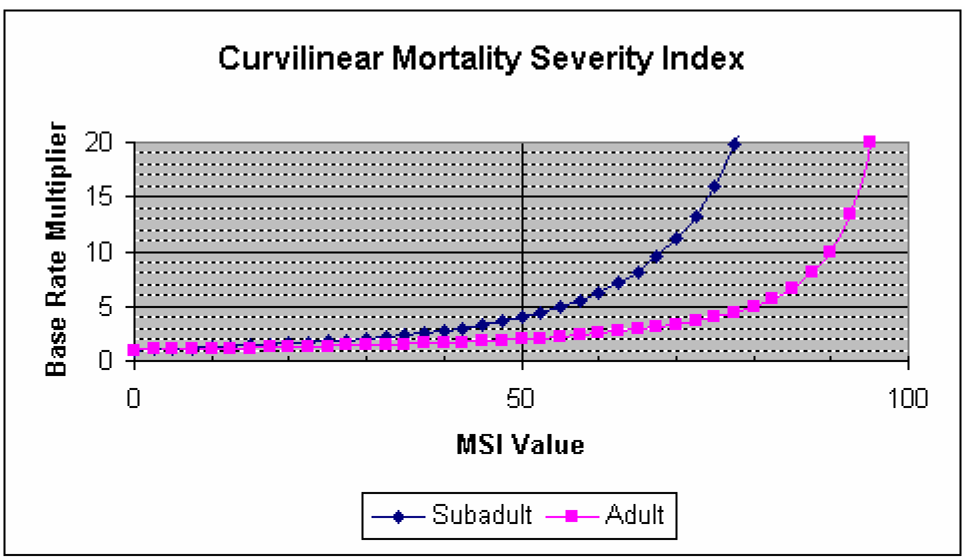


Figure 2. MSI Multipliers for Curvilinear Option

As mentioned, the curvilinear MSI operates differently for subadults than for adults, being more severe for the subadults. Experience will help guide judgement here as there is no intuitive analogy. To really understand the curvilinear MSI, you should study the graph above, the formulae below, and work out some examples for yourself.

For subadults, the yearly preseason mortality rate is divided by:

$$\frac{(100\text{-MSI})}{100} \bullet \frac{(100\text{-MSI})}{100}$$

For adults, this factor would be:

$$\frac{(100\text{-MSI})}{100}$$

As you can see, the relative severity is much greater for subadults due to squaring the factor. Figure 2 serves to re-emphasize this relationship.

TIP: The influence of the MSI values may be effectively eliminated by setting its values to 0 if you are using the curvilinear index, or to 1 if you are using the linear index.

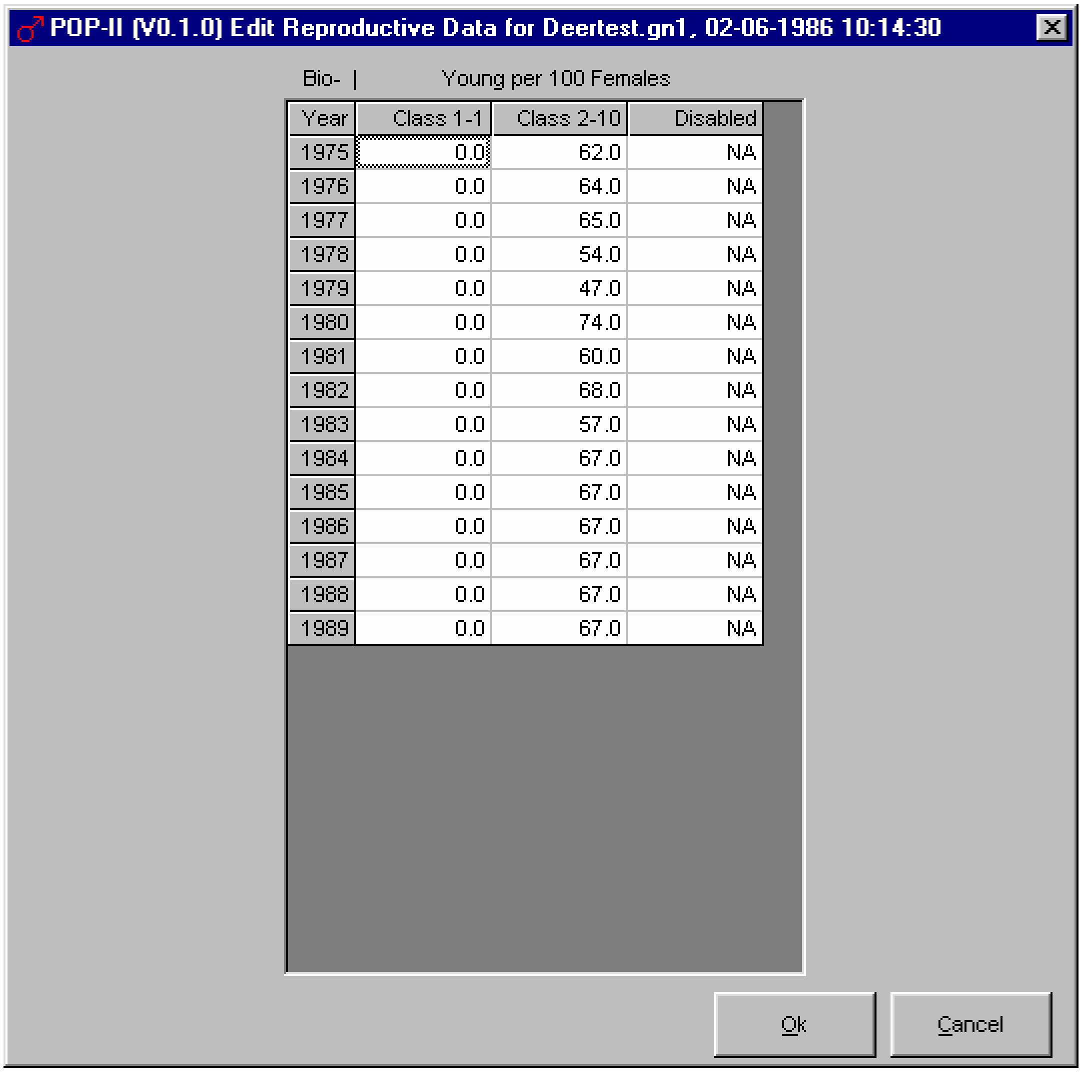
NOTE: Be careful switching back and forth between the MSI options as the values are not comparable. If you switch options, you must edit the values accordingly. In particular, values less than zero are illegal for a linear MSI.

Effort and Wounding Loss Set

The last column of values controls which set of effort and wounding loss values to employ on an annual basis. As you might expect, a value of one (1) uses the first set and a value of two (2) uses the second. As a special case, you may enter a zero (0) in which case the effort values will all be considered equal, effectively giving you three sets of effort values to use. If zero is used, the first set of wounding loss values will still be used.

2.4.4 Reproductive Data

The second screen of annual values includes solely the reproductive rate data.



Year	Class 1-1	Class 2-10	Disabled
1975	0.0	62.0	NA
1976	0.0	64.0	NA
1977	0.0	65.0	NA
1978	0.0	54.0	NA
1979	0.0	47.0	NA
1980	0.0	74.0	NA
1981	0.0	60.0	NA
1982	0.0	68.0	NA
1983	0.0	57.0	NA
1984	0.0	67.0	NA
1985	0.0	67.0	NA
1986	0.0	67.0	NA
1987	0.0	67.0	NA
1988	0.0	67.0	NA
1989	0.0	67.0	NA

Reproductive Rates by Group

Enter the appropriate annual reproductive values for each of the female age groups that were defined on the **Control Data** entry screen. The columns should be labeled with the chosen age groups. The rates you enter will apply to the entire group of females in a way that baffles some people but is actually straightforward. Suppose, for example, that any individual adult female only breeds and gives birth to a single offspring every other year, but each year approximately half of the population of adult females are active breeders. Entering a rate of 50% is appropriate since this represents the pregnancy rate. Now suppose that each pregnant female always gives birth to twins. In this case, entering a reproductive rate of 100% is appropriate since this represents the combined pregnancy and parturition rates. If you were to count young per 100 adult females after birth, you would find 100 young for each 100 adult females.

Or should I say "adult-looking" females? This brings up another point that must be thoroughly understood. Often our field counts include not only adult females who did not give birth, but also young of the previous year females who did not participate in the previous breeding season. Nonetheless, they may be indistinguishable from other adult females at the time of the field count and are counted along with other adult females who did breed. These females <u>must</u> be included when you calculate the reproductive rate because POP-II simply sums the adult females in each group and multiplies by the rate for that group. That is, POP-II doesn't know any more than you do which females were pregnant or how many offspring they have, it simply knows how many offspring are produced by females in that group as a whole.

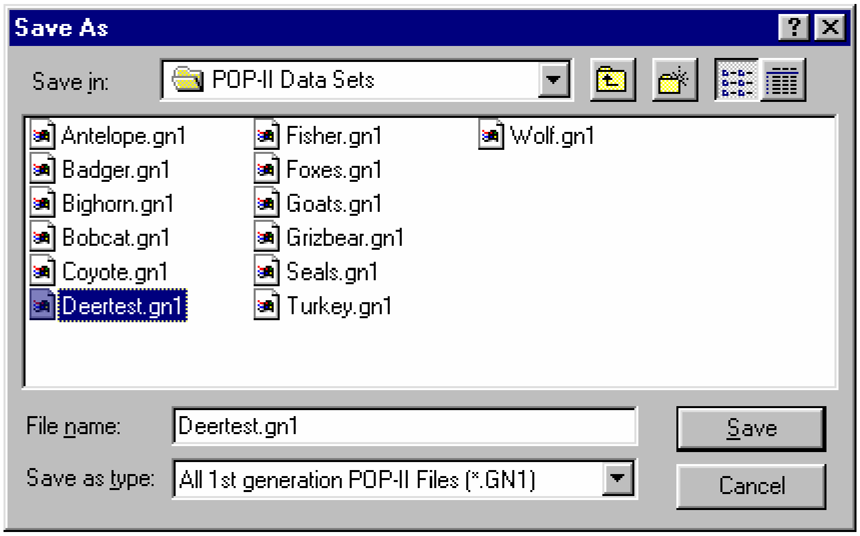
If you do not use the preseason natural mortality period, you may use reproductive rates that represent preharvest young per 100 females. Otherwise you may use *corpora lutea* counts or back-calculate the beginning-of-year parturition rates.

2.5 Saving Your Data

Once you have finished entering (or editing) a new data set, you should store it to disk for safety's sake. You may also save your data with a new file name at almost any time using the **File|Save As** command.

File names follow standard Windows' naming conventions and by default have a three-letter suffix of **.GN1** for compatibility with previous DOS versions of POP-II. If you wish, you may use the naming scheme of .GN2, .GN3, etc., by choosing *the All POP-II files* from the **Save as type** drop down menu in the **File|Open**, **File|Save**, and **File|Save As** dialog boxes. (**Note** that POP-II no longer manages data generations in this manner.) Observed data is stored in a file with the same name as the data set, but with an **.OBS** extension. Unlike data sets that *may* have multiple extensions, and therefore multiple versions, there is one and only one set of observed data. **This means** that if you move data sets from one folder to another, you will likely want to move the **.OBS** file also.

Usually some organized scheme for creating names will help you keep your data organized, and may help if you regularly share data with others in your organization. For example, some people have used names such as MDDAU198, interpreted as Mule Deer for Data Analysis Unit 1 with 1998 harvest data included.

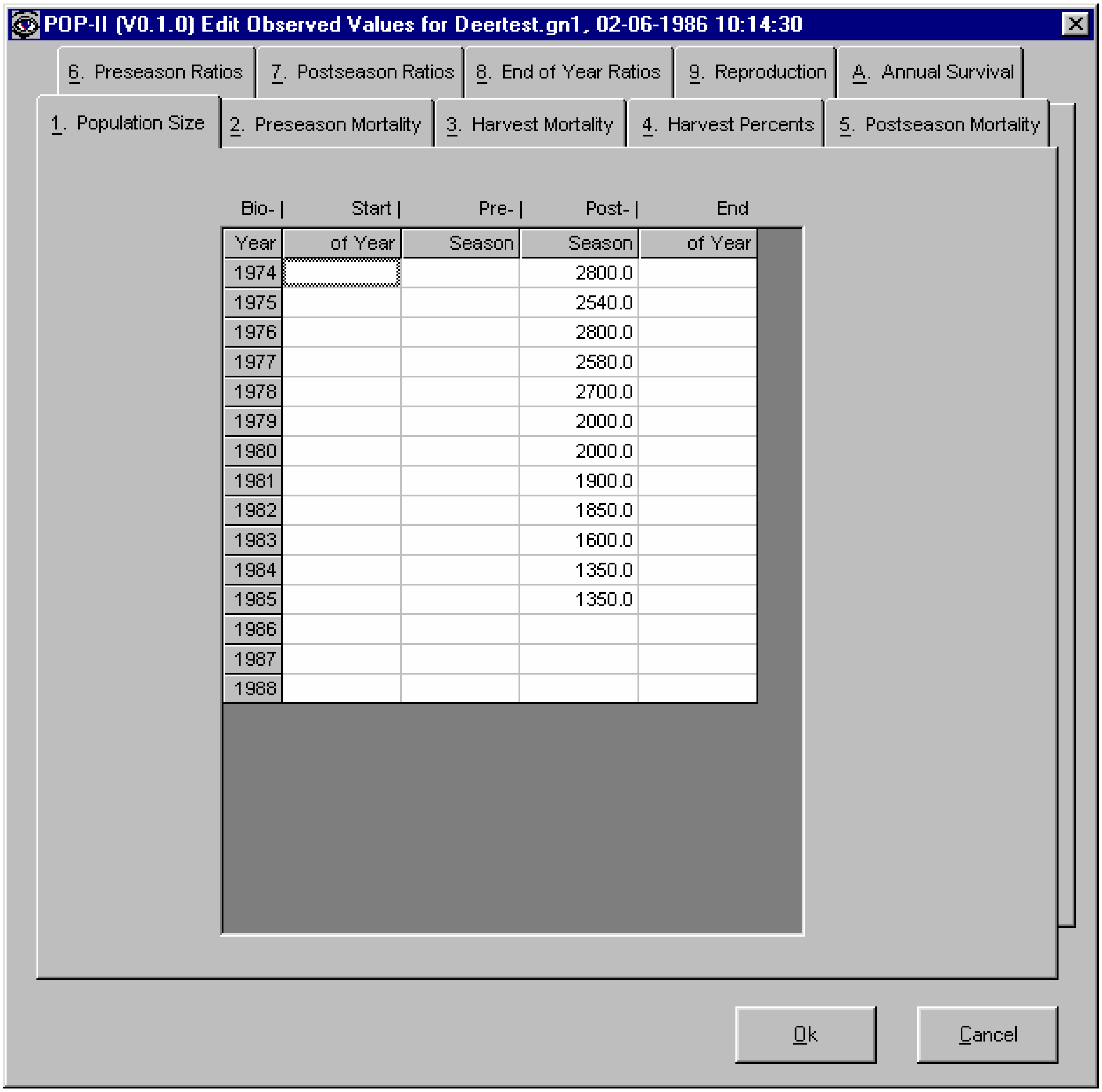


2.6 Data Editing

After using **File|New** to create a data set, or **File|Open** to load an existing data set, you may use the Edit menu or buttons to update its values. The data entry screens are identical to those used during a **File|New** operation. All values changed while editing are permanent as far as the simulation is concerned as soon as the **OK** button is pushed. To be truly permanent, however, the modified data set must be saved on the disk using **File|Save** or **Save As** lest it be lost when your computer is turned off. POP-II will do its best to remind you if edited data have not been saved. Note that pressing **Cancel** when editing does not update your data set.

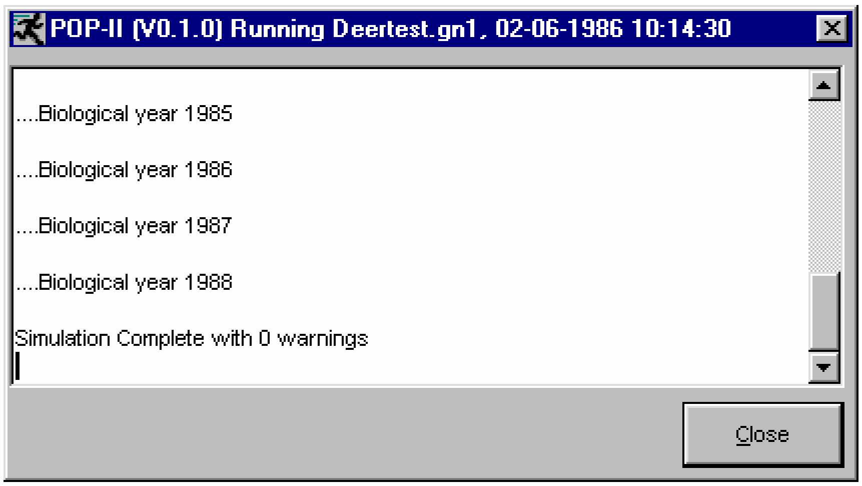
2.7 Observed Data Entry

Edit|Observed will lead you to a section of the program which will allow you to enter or edit a set of observed values which correspond with the graphs you can plot. You must have already **opened** a data set to enter or edit these observed data. Then, if there is not already a corresponding set of observed values on disk, they will be created and a message to that effect given. Initially, all observed data values will be set to *blank* which indicates no observation. The values are found on tabs that correspond to the tables and graphs used to view simulation output. Press a tab to advance to that table and use the editing keys to change values. That's all there is to it.



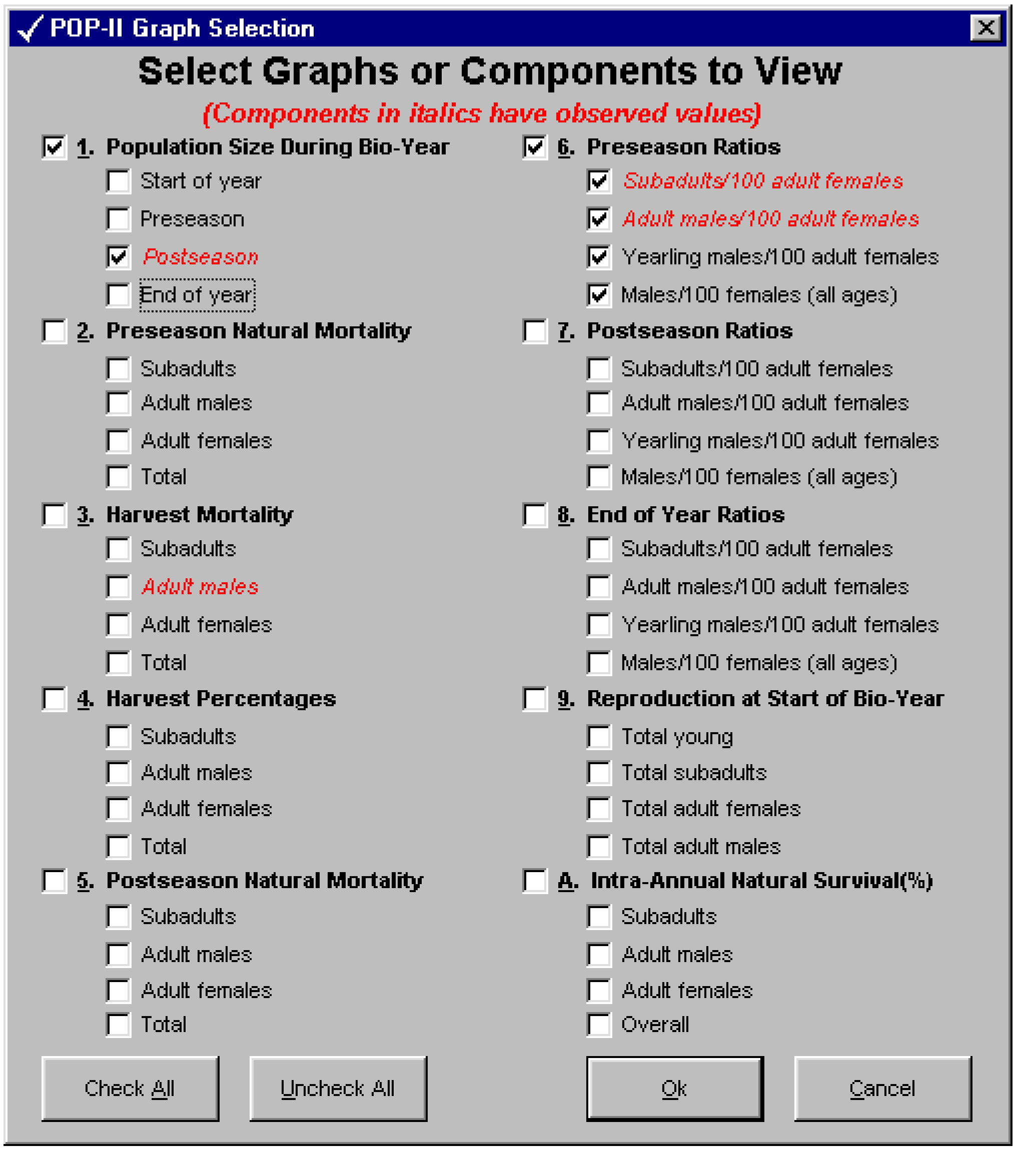
2.8 Running the Simulation

Run|Simulation will begin the simulation. As the biological years march by, they will be printed on the screen along with any informative error messages. Checking the **With Details** switch on the **Run** menu will also generate a detailed listing of the calculations during each simulation year. The **Details** listing can be invaluable for three things. First, it will show you how the bookkeeping cycle of the model works step by step. This ability may be necessary to open the computer's "black box." Second, the **Details** may help you catch your own logic errors that you missed during the data set-up phase. Finally, POP-II's **Details** contains calculations that do not appear on the summary tables and graphs. For example, age structure throughout the simulation year, exact wounding loss values and other **details** may be found here.



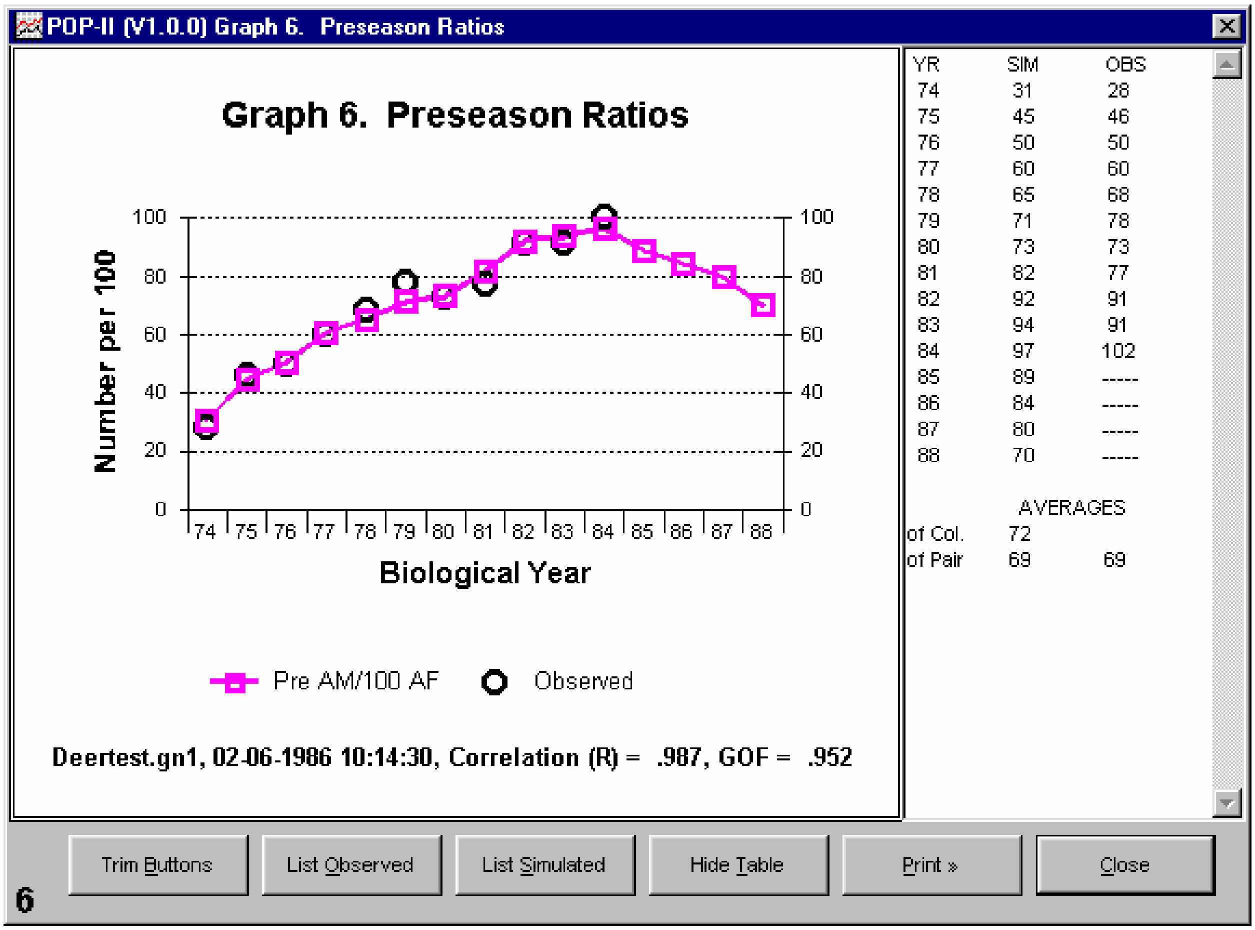
2.9 Tables and Graphs

POP-II's tables and graphs are selected through the **View|Tables** and **View|Graphs** menu items. As you can see from the buttons below, you have your choice of which tables and graphs to look at, or you may select all of them. From a practical point of view, only about six graphs will fit on your screen at once if you have a moderate resolution display. As with the **Edit** screens, pressing **Cancel** will not save your choices.



Once tables and graphs have been selected from the **View** menu, the toolbar buttons for **View Selected Tables** and **View Selected Graphs** will bypass these dialog boxes and give you what you have previously chosen. The tables are viewed in a single text box for easy scrolling or printing, and the graphs are each opened in their own window making it easy to bounce back and forth between them. A button on the bottom of the form allows you to save the group of selected tables to a text file of your choice. See **Keyboard Shortcuts** in Section 2.2 for information on moving data from tables into other applications.

If you have observed values for a particular graph item, that item will appear in *italics* on the selection page. Choosing this one item only for the specific graph will plot the simulation values against the observed values and display the correlation coefficient (R) and goodness of fit statistic (GOF) explained later. You will also have other options available to list/hide the values, either on the graph, in a side-by-side table, or both. The tabular listing will include the average of the numbers in the columns and the average for which pairs when both values are available.



Note: The Sex and Age Pyramid is accessed only from the menu bar or toolbar.

Most tables are relatively self-explanatory. Some notes, however, may be helpful. The date and time that the data set was last modified appear on each table and graph.

In Table 1, the pre- and post-harvest *population sizes* are immediately pre- and post-harvest. If your field counts were made at times much different from these, they may differ from the population sizes due to natural mortality. The *growth rate* is from the start of one year to the start of the next year.

Most of Table 4's *harvest percentages* are the percentage of the population segment, not of the total harvest. For example, if the table lists 2.6% for subadults, that means that 2.6% of the total subadults going into the harvest were removed. The last column, yearling male, is different. This column lists the percentage of the adult male harvest that is composed of yearling males. This item is valuable for calibration.

The columns on Tables 6, 7, and 8 may need some explanation. On Tables 6 and 7, Column 1 refers to Subadults per 100 Adult Females, where subadults and adults are defined per your control data. However, on Table 8, column 1 is Subadults per 100 Adults of both sexes since generally one cannot tell the difference between males and females at the end of the biological year. For all three of these tables, column 2 is Adult (2+) Males/100 Adult Females, where adult males are strictly 2+ omitting the yearlings, but females are all adult females. Column 3 is Yearling (age 1 only) Males/100 Adult Females, with adult defined as before. Column 4 is Adult males/100 Adult Females, such that adult males include yearlings, assuming that adults begin in age class 1. The labels used on the observed and simulated tables as well as the graphs to describe these various ratios are all a bit different due to space considerations, but they are consistent between the set.

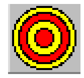
Table A differs from the other tables in that it spans biological years. It displays the *survival* from the end of one harvest period to the beginning of the harvest in the following year. Since the program does not "know" what happens after the last year simulated, Table 8 will always contain one year fewer than all the other tables. Also, because survival in Table 8 covers the time from post-harvest to pre-harvest, young of the year survival for the period from birth pulse to the first harvest season is ignored. This is always true, even if there is more than one age class in the subadult category.

Graphs on which observed values are displayed also show a correlation (R) value, as well as a goodness-of-fit (GOF) statistic. The GOF is a standardized root mean squared error (RMSE) derivative defined as:

$$1 - (\sqrt{(\Sigma(P_i - O_i)^2)/n}) / (\text{mean of the observed values})$$

where P_i is the *i*th prediction, O_i is the *i*th observation, and *n* the number in the set. Like the correlation R-value, the GOF typically ranges from 0 to 1, but can be negative if the difference between the simulated values and the observed values is extreme.

Examples of a full set of tables are given in **Section 4.7 -- Test Data.**

2.10 POP-II's Target Practice Tool 

Introduction

Initial model results almost never agree completely with measured or extrapolated field data. Up until recently, adjusting model parameters was largely a trial and error process, one that was good for learning about the sensitivity of your models, but one that was also potentially quite time consuming. A new tool in POP-II (Version 1.2) helps reduce some of the tedium in model alignment if applied to a model that is in pretty good shape to begin with. This feature, called *Target Practice*, is a way to automatically vary relevant parameters throughout a prescribed range and have the program seek the best fit to a specific ratio like males per hundred females.

Target Practice may be most useful for models that are good, but not great. What I'm getting at is that models that are already well aligned are not likely to improve much, and models that are hopelessly bad aren't either. It's that middle ground where this tool is likely to prove the most useful.

How It Works

Pressing the target icon (or choosing **Tools|Target Practice** from the main menu or Ctrl-P) brings up the selection screen shown in Figure 3.

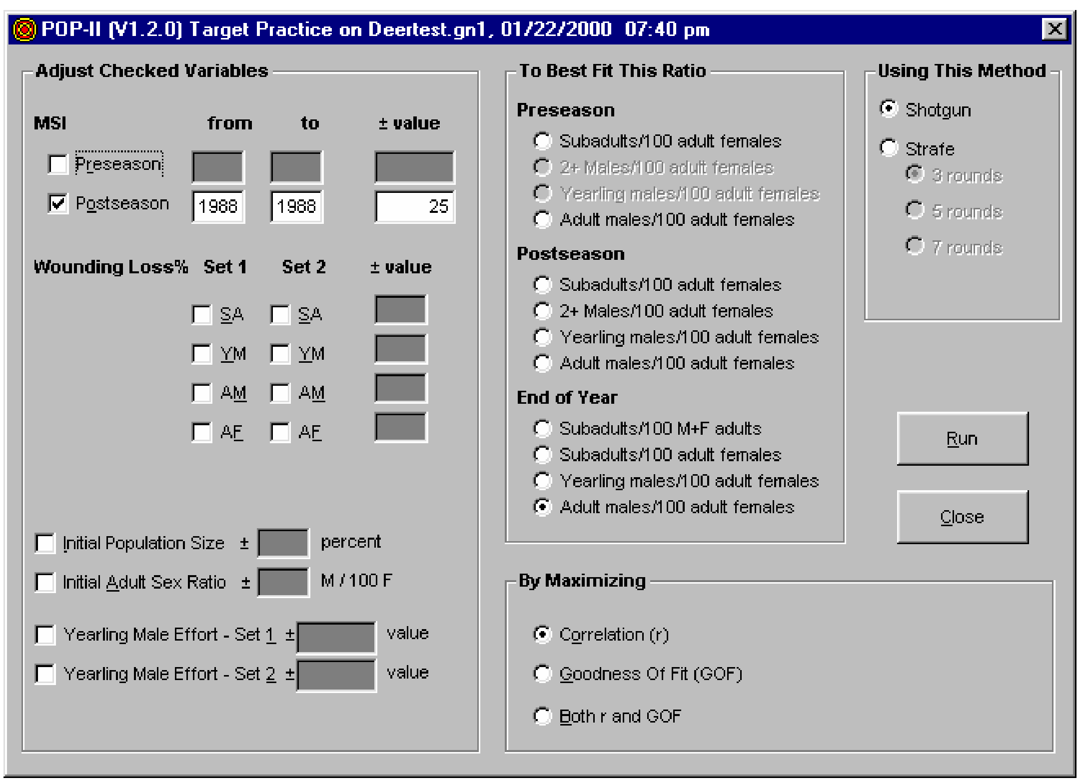


Figure 3. Main Target Practice control screen.

Selections are to be made in four different panels of this screen. Let's go through them one by one to see what they do.

Adjust Checked Variables

The first panel controls which variables may be simultaneously adjusted in a search for good model alignment. As you can see, only selected variables are available: Mortality severity indices, wounding loss, initial population size and adult sex ratio, and yearling male harvest Effort. The pre- and post-season MSI values can be constrained to be adjusted only in certain biological years. Both wounding loss and yearling male effort variables can be chosen from either of the two sets of values normally available for your model. Wounding loss may be selected for subadults (SA), yearling males (YM), adult males (AM), and/or adult females (AF).

Figure 3 shows only the default variable selected, post-season MSI for the last biological year (1988 in this case), but any or all may be chosen by checking the appropriate boxes. Once checked, the *value* boxes become active allowing you to set the allowable search range for each variable. Figure 3 shows that postseason MSI is free to vary plus or minus (±) 25 from its current value. For example, if the current value is 10, *Target Practice* could search from -15 to 35. Of course a value of -15 is not a legal MSI value, so POP-II automatically further constrains the value to be positive, resulting in a legal search range of 0 to 35. All of the other *± values* work the same way except for the one associated with the initial population size. This value works on a percentage basis so that, for example, you may search ±10% from the data set's current initial population size.

Variables sharing a *± value* will always be adjusted in like amount. For example, if Postseason MSI is checked for biological years 1988 to 1998, all of those annual values will be adjusted up or down the same amount for any given simulation. Any pattern in the original data will be retained however. For example, if the original MSI value for 1997 was 10 and for 1998 it was 0, one simulation may add 12.5 to each, resulting in 22.5 for 1997 and 12.5 for 1998. This may mean that *Target Practice* must be run repeatedly for each year or groups of years depending on your circumstances.

Obviously, select only the variables you want to have adjusted. Checking them all may sound fun, but would generally be a lazy and unprofitable maneuver. See the *Warning* below.

To Best Fit This Ratio

Items in the next column correspond to the key ratios found in Graphs (and Tables) 8, 9, and 10. Somewhat like you have seen on the *View|Graphs* menu, only ratios which have a sufficient quantity of observed data will be available for selection, and only one of these ratios can be selected at a time. If you do not have sufficient observed data, at least three years worth for one set of ratios) you will not be allowed to use the *Target Practice* tool.

By Maximizing

You are already familiar with the Correlation (r) and Goodness Of Fit (GOF) values from the discussion of graphing with observed data. You may choose to try to maximize either of these metrics, or by multiplying them together, maximize the pair. To review the general idea, if you are trying to capture the correct *trend* in your data but believe that the data may contain one or more systematic biases, select *Correlation*. If on the other hand, you want to minimize the absolute difference between simulated and measured values, choose *GOF*. If both are true, choose *Both.* See the *Warnings* section below for more on this topic.

Using This Method

The last panel contains two options for conducting the search. *Shotgun* tries different values for all selected variables randomly within the specified ranges. Values are selected from a uniform random distribution and applied over and over until you actively *Stop* the search for the best alignment (or two billion trials, whichever comes first). In contrast, the *Strafe* method is a more systematic search across all selected variables, firing like a Gattling gun at the chosen number of divisions across the ± *value* range (either 3, 5, or 9 "spots") until all possible combinations have been tried, or you stop it by pressing the *Stop* button.

Experience so far suggests that the *Shotgun* method is actually far superior to *Strafe*, but you be the judge for what you want to accomplish.

Running Target Practice

Once all of your selections have been thoughtfully made, pressing the *Run* button begins the search. Your cursor will change to an hourglass and messages will appear in the *Maximizing* frame showing the best values for Correlation and GOF, along with an idea of how many simulations have been run (Figure 4). As mentioned, the *Shotgun* method continues until you press the *Stop* button (same as the *Close* button), and if it has found a better "solution" than for your original data, the program will give you an opportunity to retain these new values. You can watch the improvement in fit, if any, as time goes by to judge whether it's getting significantly better.

The *Strafe* method will simulate until all the possibilities have been tried. Obviously, if several variables have been checked, and 7 divisions are to be evaluated, the number of possible combinations increases geometrically and your wait may be long even though Target Practice has been optimized for speed (break out the Solitaire game). Pressing *Stop* here will give you the opportunity to keep the best solution, if any has been found.

Exiting Target Practice by pressing the *Close* button will give you an opportunity to examine and changes made to your data set by pressing the View|Data button on the 

toolbar.

You should always check to see if the new “improved” values make sense. Retaining the values from *Target Practice* is never permanent until the data set is actually saved.

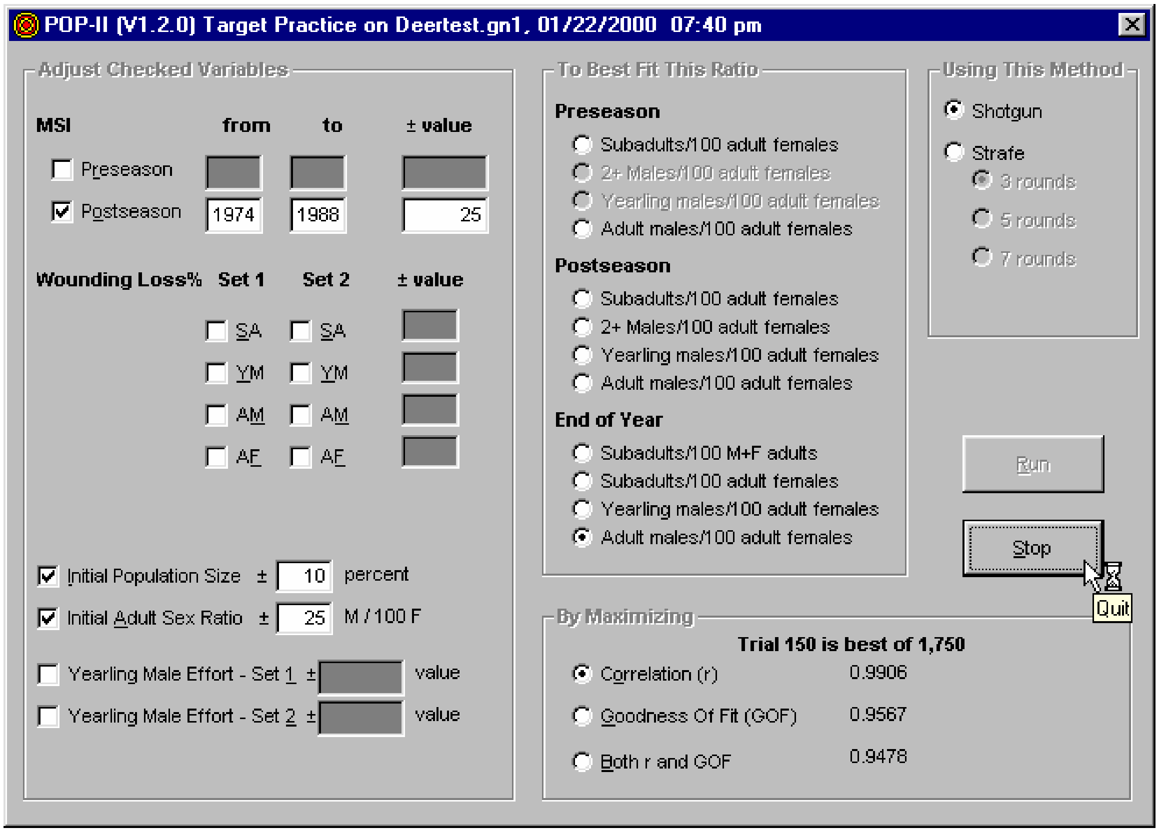


Figure 4. Target Practice screen showing that run number 150 is the best attempt out of 1,750 simulations so far. The fit values for trial 150 are also shown in the frame.

As mentioned briefly above, it may be to your advantage to run Target Practice as a multi-stage process, aligning the first several years using one set of variables you believe may need adjustment, followed by the last years using others. The idea is not to just make it work, but rather to apply good problem-solving skills to your situation.

What Can Go Wrong?

Sounds pretty good doesn’t it? But what can go wrong with Target Practice? Lots of things. In no particular order:

1. Sometimes it is difficult to make improvements in your data set. Depending on the circumstances, it may be hard to influence ratios as much as you might think, within the range of variation you deem reasonable. If you are only adjusting MSI values late in the simulation period, there may be little time to influence the population’s demographic behavior.

In addition, *Target Practice* will do nothing useful if you have chosen some illogical combinations of choices. As an example, if you choose to vary the postseason MSI for the last year of the simulation, but you choose a preseason ratio for alignment, nothing will change. More generally, varying values when there are no observed data to match the simulation's results will do you no good. The program will run and run but never improve.

2. Values chosen by *Target Practice* may have more precision (decimal points) than are easily entered by hand on the editing screens, displayed in tables, or shown in the simulation *Details* report. They may even make no sense, as for example, having a fractional number of animals in the desired initial population size rather than a whole number.

3. There is no provision to weight the two fit measures, correlation or GOF. If you choose *Both*, one of the measures may naturally tend to dominate.

4. Running the *Shotgun* process repeatedly on the same unmodified data set will never generate the same answer twice. The random nature of this technique dictates this behavior.

5. You can only maximize the model fit for one ratio. Doing this may degrade other ratios you also trust. You must choose which is the most important.

6. All the caveats in Tips and Techniques for Modeling with Fuzzy Data still apply.

7. **WARNING!** It is worth repeating that the *Target Practice* tool should not be used as a substitute for judicial thinking. The goal of population modeling is to critically discern the status and trend of wildlife populations and judge the effect of alternative management regimes. *Target Practice* is a means to that end, not an end in itself. Uncritically applied, this routine may easily lull you into believing that your model fits well and thus must be "right". This could be a severe mistake with equally severe consequences to the populations you are, at least in some respects, responsible for. Do not take this responsibility lightly; use it, but don't abuse it!

3.0 INSTALLING POP-II

3.1 **Installation**

If you have a previous Windows version of POP-II installed on your computer, please uninstall it using the *Control Panel | Add/Remove Programs* feature. This removal will not delete any POP-II data files you may have created in these directories -- but this might be a good time to make a backup anyway! In fact, if you are only evaluating the Windows version, be aware that data sets saved in this version cannot be read by the DOS version.

You have been sent a write-protected master copy of POP-II. Insert Disk 1 into your drive and either double-click on SETUP.EXE or type *A:SETUP* from the Windows Run Menu. This will load POP-II. During installation, you may be asked to re-boot your computer. If so, please do as advised and then again perform the installation procedure.

You may find it to your advantage to create a Windows desktop shortcut icon for POP-II. See your Windows manual or help files for more information on how to do this. Likewise, refer to your manual for information on how to *uninstall* POP-II. Normally, this function will be found in the *Control Panel* under *Add/Remove Programs*. Similarly, you may wish to “register” POP-II’s default data file extension, “.GN1”, with Windows so that double-clicking on one of these files automatically runs POP-II and opens that file. This is typically done in the Windows *Open With* dialog accessed by right clicking on one of the .GN1 files. Then choose *Other* and browse to find your POP-II.EXE.

Some users with HP DeskJet or other printers may find that they get an extra blank page feed when they first start POP-II. This may be remedied by changing the printer driver settings. Though each printer driver is potentially unique, the general technique would be to select *Start|Settings|Printers* from your Windows task bar. Then right click your default printer driver and select *Properties|Details|Spool Settings*. Then choose the option for *Start printing after last page is spooled*.

4.0 EVERYTHING ELSE YOU MAY WANT TO KNOW

4.1 Tips and Techniques on Modeling with Fuzzy Data

Modeling with any simulation program is almost an art. It is impossible in one or two pages to convey the range of methods one might use or the kinds of trouble one might get into. However, a few things can be briefly stated.

Let's review a couple of points that were made earlier in the document. First, when just starting a new model, it is best to stop the simulation in the last year of "real" data until the model is satisfactorily calibrated. Then extend the simulation to run another few years. This keeps the "future" behavior of the model from influencing your opinion about the quality of the "historical" simulation. Second, try to gather the data to run for at least as many years as you have age classes in the population. This allows an entire generation to be cycled through the model and reduces the effect of any bias in the initial conditions.

Procrastination should be avoided. It is easy to postpone trying to simulate a population because you think that you do not have enough "good data." You will not know what **enough** data really means until you try. Similarly, **good** is always in the eye of the beholder. Part of the modeling game is to test your data -- use the model as a lie detector. So stop arguing and beating around the bush; put together a test case to see what happens. If you wait until your data are **TRUE**, you will be waiting forever. Besides, if your data are excellent, you probably do not need a model at all. Models help most in cases where your data are only **fair**.

Some special situations may at first make you think that the structure of the POP-II program will not meet your needs. At times, the words used or description of parameters will not seem to fit your special case. You may, however, create your own flexibility in many cases by bending the rules or interpreting the program in a new light. So if at first you don't think POP-II will work, sit back and think how you can turn a problem into an opportunity.

You should arrange your data in order of reliability. In other words, list the types of data you are working with and then order that list by how much you believe in the truthfulness of that data. Typically harvest values will be at the top of the list and natural mortality or wounding loss will be at the bottom. However, each set of data may be different. Use this list to help guide values you adjust, but don't be afraid to modify it.

Make your best guesstimate for your model's input data and try to simulate the population's history. Initially, the model probably will not act as you anticipate. The appropriate things to look at are population size trend, sex ratios, percent yearlings in the harvest and age structure of the population. You will want to compare the simulation's output with any observations you may have.

The graphing section will print out the correlation coefficient (R) if there are more than two observed values. However, please use restraint and do not rely too heavily on simple correlation. First of all, if you concentrate on maximizing the correlation coefficients you may too easily overlook other key features of the simulation that indicate an untrustworthy model. Second, using the correlation coefficient is not statistically valid. Statistical correlation theory assumes that the samples are independent and that the observed values are measured without bias. We are violating both of these assumptions because any series of population measurements are auto-correlated and our observed data are certainly biased.

In the best of all worlds, calibration should endeavor to maximize both the R and GOF values, but it does depend on the situation. If all you have is trend data, only the correlation is meaningful; but if you have actual measurements, then both are useful. The GOF essentially measures the relative error between the two curves (simulated and observed). I believe that the R-value is the more important of the two, and one should not sacrifice R to get a larger GOF value.

The appropriate next step is to alter the least reliable data in your list. Vary it through what you consider a reasonable range. If you are able to make the model better mimic what you believe accurately reflects the history of the population, then you are on the right track. Often, you will need to retreat to the "next level of unreliability." Vary the next worst data throughout its reasonable range. Then ask yourself if you have a satisfactory simulation. You get the idea. This is the process of alignment by parameter calibration.

You should keep in mind that events early in the chronology of the simulation have a more profound effect on the population than do events in later years. You should pay particular attention to the initial population size. One piece of wisdom learned through many years of population modeling is that most people underestimate their population's size by at least 10%. Other things like a surge in reproductive rate or a bad winter early in the simulation can have similar "momentum."

Modeling is an experimental approach in itself. You should be encouraged to try different things when problems arise. Make a small list of the problems you see in the simulation results. Ask yourself which model parameters adjusted in what way should improve your simulation. Which of these changes might have adverse consequences? Then adjust a parameter and see what happens. Often you will be surprised by the results of your change. Ask yourself why things worked out as they did. Only after experimentation will you begin to learn the ropes. Modeling is open-ended. There is **No One Way** to do it.

Being experimental also implies being attuned to model sensitivity. Data collection and research dollars are scarce in today's management agencies, so fully appreciating which values are sensitive for a population and which are not provides guidance for investing wisely in more efficient and effective data collection efforts.

Look for balance in how your simulation matches the data you have for comparison. Do not try to mimic the history of the population to the nth degree. Though in some situations it is possible to get closer and closer to the observed data, you are probably fooling yourself. Remember that your data, no matter how good you believe them to be, contain biases. The model, too, is by no means perfect. Trying to pin things down **exactly** may be counter-productive. Balance is more important.

If you cannot get a good fit between simulated and observed values, you should review the basic assumptions of the model. A common problem with models like POP-II is the assumption of negligible net migration to or from the population. If you cannot satisfy this assumption, then you may need to reorganize your data by aggregating populations into a larger set where this assumption can be met. In any event, POP-II only contains selected components from the ecological setting and may not be appropriate for your situation.

If you can get a good fit between simulated and observed values you should be relentless in making sure how good you think the simulation is. It is prudent to look at the **Details** to see if the details reported agree with your expectations. In particular, look at the age distribution of the harvest. These should agree with your data or expectations. If they do not, try further adjustments. If they do agree, proceed to the next step. Don't be a lazy modeler!

Next, review the simulations from several different populations. Are there any **major** differences in the parameters? If so, why? Maybe there is a good reason, maybe not. Remember that any previous models may be in error. Does this simulation make you want to re-evaluate prior models you have built?

I have not mentioned how you can tell what is good enough. I don't know how to tell you that. Although various statistical techniques can go part of the way, they fall short of providing any single, reliable measure of quality. Therefore, what you really want to do is not prove how valid your model is, but instead, how invalid it is. Put your model at risk. See if next year's incoming data can throw the whole simulation into disarray. If it does, you should question everything and start over. If it doesn't, you are on the way to building some confidence in the model.

What about the predictive simulations you might make? Of course, there is no way to predict what the winters are going to be like or whether there will be a change in the reproductive rate. What you can do is to create plausible, and sometimes not so plausible, scenarios to get a feel for what a range of conditions might bring. In this way, you can be better prepared for whatever might come along. You will get a feel for the risks you assume when you must make a harvest recommendation. With a little imagination, you can put together a **worst-case scenario** to test in the model. Also, see the POP-III model for more information; contact Fossil Creek Software for more information on POP-III.

Finally, show your simulation to others who are in a position to be critical of your model. You can learn a lot by trying out their ideas about how the population might be working. Compare and contrast to see if you can come up with a reasonable compromise, or need to present your respective alternative simulations to the next higher decision-maker.

4.2 Inside POP-II

For those interested, here are a couple of points. First, POP-II does not use integer math. That is, animals are always retained as fractional animals. This is not as realistic (or as appropriate) as an integer model, especially for small populations (less than about 500 animals), but has the advantages of simplicity and the ability to handle extremely large population sizes in a microcomputer. Output from the program will typically only show whole numbers of animals, but you can be assured that they are rounded. Second, POP-II is completely deterministic. There is no random (stochastic) component to the model. This does not provide the realistic variability some modelers prefer, but again, it is simple and not as demanding on small computers. Stochastic models are more appropriate in research; however, they have advantages for the assessment of future risk. Please refer to the POP-III model for more information on population modeling using Monte Carlo techniques.

And, by the way, POP-II is Y2K compatible (and has been since 1984)!

4.3 Hardware and Software Requirements.

POP-II is not a demanding piece of software by today's standards. Disk space requirements are minimal and depend on what you already have installed on your computer. At the most, POP-II will require about 6 megabytes of hard disk space. The program runs under Windows, but has not been fully tested under each Windows operating system. Not all features of Help would be available under 3.1. It is recommended that your display monitor have a resolution of at least 640x800, with 1024x768 preferred. Though a printer is not required, it will be quite helpful.

Software may only be a problem for international users. Make sure that your decimal symbol is set to a decimal point (.) in the *Regional Settings* portion of the **Control Panel**.

4.4 POP-II's Temporary Disk Files

POP-II uses temporary disk files that may be of some advantage to advanced users. **Temp.SIM** contains temporary simulation results from which the tables and graphs are assembled. **Temp.DET** contains the details if the simulation Details switch has been used. **Temp.TAB** contains the currently selected tables. **Temp.LST** contains the formatted input data listing, and **Temp.SEX** contains the sex and age pyramid. These files are stored in the default program folder.

4.5 Warning and Informational Messages

Warning or informational messages may appear in the small simulation window as the simulation progresses or from time to time, as you are editing your data. Here's what they mean.

POP-II works best with a screen resolution of at least 800 x 600. Your display seems to be *X* **by** *Y*. – The screen forms for POP-II have been designed for a certain screen size. Running the program at other resolutions may work, or may be awkward, depending on your specific settings.

Tried to harvest too many.... in bio-year ____, harvest reset to take all - simulation continues - - You have called for the harvest of more animals in a population segment than are available for that biological year. POP-II will remove the whole segment, continue to the end of the biological year, and then stop.

Unable to remove enough _____ due to skewed effort values -- Extreme arrangement of the effort values may result in the programs inability to remove enough animals during the harvest to satisfy the requested harvest or desired population size goal. For example, suppose you had effort values of zero for age classes zero through four and 1.0 for classes five and above. You may have done this to simulate a trophy harvest situation. If the modeled population became so young that all remaining animals were in the first five age classes (0 to 4), no harvest could be removed from the trophy segment even though there may be plenty of animals in total to satisfy the known harvest.

WARNING -- Since you changed the first biological year of data, you must make sure that all other yearly values correspond as they should. Otherwise, unexpected results may occur. -- Be careful!

WARNING -- Since you changed the number of age classes, you must make sure that all age-specific values correspond as they should. Otherwise, unexpected results may occur. -- Be careful!

WARNING -- Changing this option means that you will need to edit your MSI values accordingly. If you do not, unexpected problems may occur. -- Be careful! Think about the difference between these options.

Incompatible version of POP-II observed data. Program will reinitialize values. -- The data set you are trying to use is pre version 6.

Observed values for *dataset* not found on disk. Initializing all observed values. -- No problem, just an information message.

Data Too Old -- POP-II data must be at least version 6.x. Please convert or re-enter your Version *number* data. -- Version 7 requires version 6 or newer data.

You have encountered an unanticipated error. Please report error *number* to Fossil Creek Software. -- If you get this message, I really want to know about it.

NOTE: Any other warning messages should be self-explanatory. Let's hope they are.

4.6 Recent Changes to POP-II

None. This is the first Windows version – it's all new!

Known Deficiencies

For known problems with this version of POP-II, please check the on-line Help file under "What's New in this Version of POP-II" for an up to date list. I'd appreciate notice of any problems encountered.

4.7 TEST DATA SETS

The following pages record a set of tables and graphs that result from the listed data set. This data set is on the file DEERTEST on the diskette distributed with the program. You should be able to duplicate these results. DEERTEST provides an example of using alternate effort values to test a spike restricted harvest season.

In addition to DEERTEST, there are several other data files for you to examine which illustrate the use of certain features of POP-II. They are:

BIGHORN	- Example of effort values for a trophy harvest situation
GRIZBEAR	- Example where subadults are more than one age class
SEALS	- Example of using very crude parameter estimates for a simulation
TURKEY	- Example of desired population size; note table heading
WOLF	- Example of differing reproductive rate by age category

Finally, there are other data files just to illustrate differing population characteristics. They are: ANTELOPE, BADGER, BOBCAT, COYOTE, FISHER, and FOXES.

Note: POP-II may complain somewhat about the reproductive age categories if you load data sets created with some previous versions of the program, including some of the test data sets packaged with the Windows version (since they too are old). The program may beep as you tab the cursor over the age values and change them, or it may beep when you first press the **Ok** button on the editing screen. In such cases, please double check that you are getting the behavior you want by examining the **Details** carefully before proceeding. It is my expectation that all will be well, but sometimes I'm wrong.

Input Listing

Data Set: Deertest.gn1 02-06-1986 10:14:30 Page 1

EXAMPLE SHOWING USE OF ALTERNATE EFFORT VALUES FOR SPIKE RESTRICTION
Data from 1974 to 1988 Simulation from 1974 to 1988

Age Class	Init Pop. Male	Prop. Female	Presn Male	Mort. Female	Postsn Male	Mort. Female	Effort Set 1 Male	Female	Effort Set 2 Male	Female
0	646.0	646.0	40.0	40.0	12.0	12.0	1.00	1.00	1.00	1.00
1	270.0	288.0	1.0	1.0	2.0	2.0	1.10	1.10	0.10	1.00
2	125.0	257.0	1.0	1.0	2.0	2.0	1.00	1.00	1.00	1.00
3	60.0	234.0	1.0	1.0	2.0	2.0	1.00	1.00	1.00	1.00
4	25.0	213.0	1.0	1.0	2.0	2.0	1.00	1.00	1.00	1.00
5	5.0	192.0	5.0	5.0	2.0	2.0	1.00	1.00	1.00	1.00
6	5.0	171.0	10.0	10.0	2.0	2.0	1.00	1.00	1.00	1.00
7	4.0	138.0	15.0	15.0	2.0	2.0	1.00	1.00	1.00	1.00
8	4.0	100.0	20.0	20.0	10.0	10.0	1.00	1.00	1.00	1.00
9	0.0	70.0	25.0	25.0	30.0	30.0	1.00	1.00	1.00	1.00
10	0.0	37.0	30.0	30.0	100.0	100.0	1.00	1.00	1.00	1.00

Sum = 3490.0 Estimated Sum = 4200 Subadults: Ages 0 to 0

Data Set: Deertest.gn1 02-06-1986 10:14:30 Page 2

MSI Function is Curvi-Linear

Bio-Year	Preseason MSI	Harvest // Des. Pop Size in 9999 Subadults	Males	Females	Postseason MSI	Effort Set Used
1974	0.00	24	102	180	0.00	1
1975	0.00	53	150	155	0.00	1
1976	0.00	40	114	190	0.00	1
1977	0.00	26	168	140	0.00	1
1978	0.00	4	79	70	0.00	1
1979	0.00	38	158	129	50.00	1
1980	15.00	27	84	142	0.00	1
1981	0.00	19	57	127	0.00	1
1982	0.00	25	105	94	0.00	1
1983	0.00	12	76	88	0.00	1
1984	0.00	12	132	63	0.00	1
1985	0.00	12	103	63	0.00	1
1986	0.00	12	104	63	0.00	2
1987	0.00	12	135	63	0.00	2
1988	0.00	12	104	63	0.00	2
Wounding Loss		8 %	12 %	8 %	Yearling Male	12 %
Alt. Wounding Loss		8 %	12 %	8 %	Yearling Male	12 %

Data Set: Deertest.gn1 02-06-1986 10:14:30 Page 3

Bio-Year	Young:100 Fems Age 1 - 1	Young:100 Fems Age 2 - 10	Young:100 Fems Age 11 - NA	Sex Ratio: 50 : 50
1975	0.0	62.0	0.0	
1976	0.0	64.0	0.0	
1977	0.0	65.0	0.0	
1978	0.0	54.0	0.0	
1979	0.0	47.0	0.0	
1980	0.0	74.0	0.0	
1981	0.0	60.0	0.0	

Data Set: Deertest.gn1 02-06-1986 10:14:30 Page 4

Bio-Year	Young:100 Fems Age 1 - 1	Young:100 Fems Age 2 - 10	Young:100 Fems Age 11 - NA	Sex Ratio: 50 : 50
1982	0.0	68.0	0.0	
1983	0.0	57.0	0.0	
1984	0.0	67.0	0.0	
1985	0.0	67.0	0.0	
1986	0.0	67.0	0.0	
1987	0.0	67.0	0.0	
1988	0.0	67.0	0.0	
1989	0.0	67.0	0.0	

Output Listing

POP-II (V0.9.0) Simulation Output Tables for Deertest.gn1, 02-06-1986 10:14:30

Table 1. Population Size During Bio-Year for Deertest.gn1 02-06-1986 10:14:30

Bio-Year	Start	Pre-Season	Post Season	End	%Growth
1974	4200	3442	3108	2904	-6.7
1975	3920	3378	2986	2823	-0.8
1976	3889	3327	2951	2786	-3.2
1977	3764	3238	2871	2711	-7.5
1978	3480	3034	2866	2715	-3.0
1979	3376	2957	2600	2269	-5.7
1980	3183	2504	2228	2112	-14.7
1981	2716	2326	2105	1983	-4.7
1982	2589	2199	1952	1826	-11.9
1983	2282	1960	1767	1647	-6.5
1984	2133	1815	1587	1470	-10.4
1985	1912	1633	1436	1338	-8.4
1986	1752	1497	1299	1208	-9.2
1987	1591	1362	1130	1054	-11.4
1988	1409	1205	1008	947	-9.5

Table 2. Preseason Natural Mortality for Deertest.gn1 02-06-1986 10:14:30

Bio-Year	Sub-Adults	Adult Males	Adult Females	Total	% of Pop
1974	622	8	127	758	18.0
1975	407	12	124	542	13.8
1976	426	14	121	562	14.4
1977	391	20	115	526	14.0
1978	308	27	111	446	12.8
1979	265	41	114	419	12.4
1980	506	55	117	679	21.3
1981	242	55	93	390	14.3
1982	242	63	85	390	15.1
1983	183	62	77	322	14.1
1984	194	57	66	317	14.9
1985	177	46	56	279	14.6
1986	165	39	51	255	14.6
1987	153	31	45	229	14.4
1988	142	21	41	204	14.4

Table 3. Harvest Mortality for Deertest.gn1 02-06-1986 10:14:30

Bio-Year	Sub-Adults	Adult Males	Adult Females	Total	% of Pop
1974	24	102	180	306	8.9
1975	53	150	155	358	10.6
1976	40	114	190	344	10.3
1977	26	168	140	334	10.3
1978	4	79	70	153	5.0
1979	38	158	129	325	11.0
1980	27	84	142	253	10.1
1981	19	57	127	203	8.7
1982	25	105	94	224	10.2
1983	12	76	88	176	9.0
1984	12	132	63	207	11.4
1985	12	103	63	178	10.9
1986	12	104	63	179	12.0
1987	12	135	63	210	15.4
1988	12	104	63	179	14.8

Table 4. Harvest Percentages for Deertest.gn1 02-06-1986 10:14:30

Bio-Year	Sub-Adults	Adult Males	Adult Females	Total	Yearling Males
1974	2.6	17.3	9.4	8.89	56.8
1975	8.7	17.6	8.1	10.60	48.6
1976	6.3	12.7	10.6	10.34	28.6
1977	4.4	16.8	8.5	10.31	27.9
1978	0.9	7.8	4.5	5.04	25.8
1979	9.6	14.8	8.6	10.99	20.2
1980	6.6	9.5	11.7	10.10	11.2
1981	5.2	6.5	11.7	8.73	20.2
1982	6.9	11.9	9.8	10.19	18.3
1983	4.4	9.3	10.1	8.98	19.4
1984	4.1	17.6	8.1	11.40	16.4
1985	4.5	16.0	8.7	10.90	20.4
1986	4.8	18.2	9.3	11.96	2.3
1987	5.2	26.9	10.0	15.42	2.5
1988	5.6	25.4	10.8	14.85	2.9

Table 5. Postseason Natural Mortality for Deertest.gn1 02-06-1986 10:14:30

Bio-Year	Sub-Adults	Adult Males	Adult Females	Total	% of Pop
1974	109	10	85	203	6.5
1975	66	14	82	163	5.5
1976	72	17	77	165	5.6
1977	67	17	76	160	5.6
1978	55	20	76	151	5.3
1979	171	40	120	331	12.7
1980	45	20	50	116	5.2
1981	41	27	54	122	5.8
1982	40	33	54	127	6.5
1983	31	38	51	121	6.8
1984	33	35	48	116	7.3
1985	30	28	39	98	6.8
1986	28	25	38	91	7.0
1987	26	17	32	75	6.7
1988	24	11	26	61	6.1

Table 6. Preseason Ratios for Deertest.gn1 02-06-1986 10:14:30

Bio-Year	Subadults /100 1+F	Ad. Males /100 1+F	Yr. Males /100 1+F	All Males /100 Fems
1974	48.6	30.8	16.8	44.3
1975	31.8	44.6	20.6	52.2
1976	35.8	50.4	13.5	57.9
1977	35.5	60.4	15.7	66.4
1978	29.6	64.9	15.6	69.4
1979	26.6	71.2	13.3	74.6
1980	33.7	73.1	7.6	77.0
1981	33.5	81.6	15.3	84.3
1982	38.0	92.0	15.6	93.3
1983	31.4	93.5	16.8	94.4
1984	37.6	96.7	14.7	97.2
1985	36.5	88.7	16.7	90.4
1986	36.6	84.2	16.2	86.7
1987	36.5	79.8	16.3	82.9
1988	36.5	70.1	16.2	74.7

Table 7. Postseason Ratios for Deertest.gn1 02-06-1986 10:14:30

Bio-Year	Subadults /100 1+F	Ad. Males /100 1+F	Yr. Males /100 1+F	All Males /100 Fems
1974	52.6	27.7	14.9	42.7
1975	31.6	39.3	17.9	47.6
1976	37.7	48.8	12.9	57.0
1977	37.2	54.0	13.8	61.2
1978	30.8	62.2	14.9	67.3
1979	26.3	65.5	12.1	69.5
1980	35.8	74.8	7.6	78.6
1981	36.2	86.7	16.1	88.8
1982	39.4	89.2	14.9	91.0
1983	33.6	94.0	16.7	94.9
1984	39.4	85.1	12.6	87.5
1985	38.3	80.3	14.9	83.5
1986	38.6	74.5	17.6	78.6
1987	38.6	62.5	17.6	68.6
1988	38.7	56.7	17.6	63.8

Table 8. End of Year Ratios for Deertest.gn1 02-06-1986 10:14:30

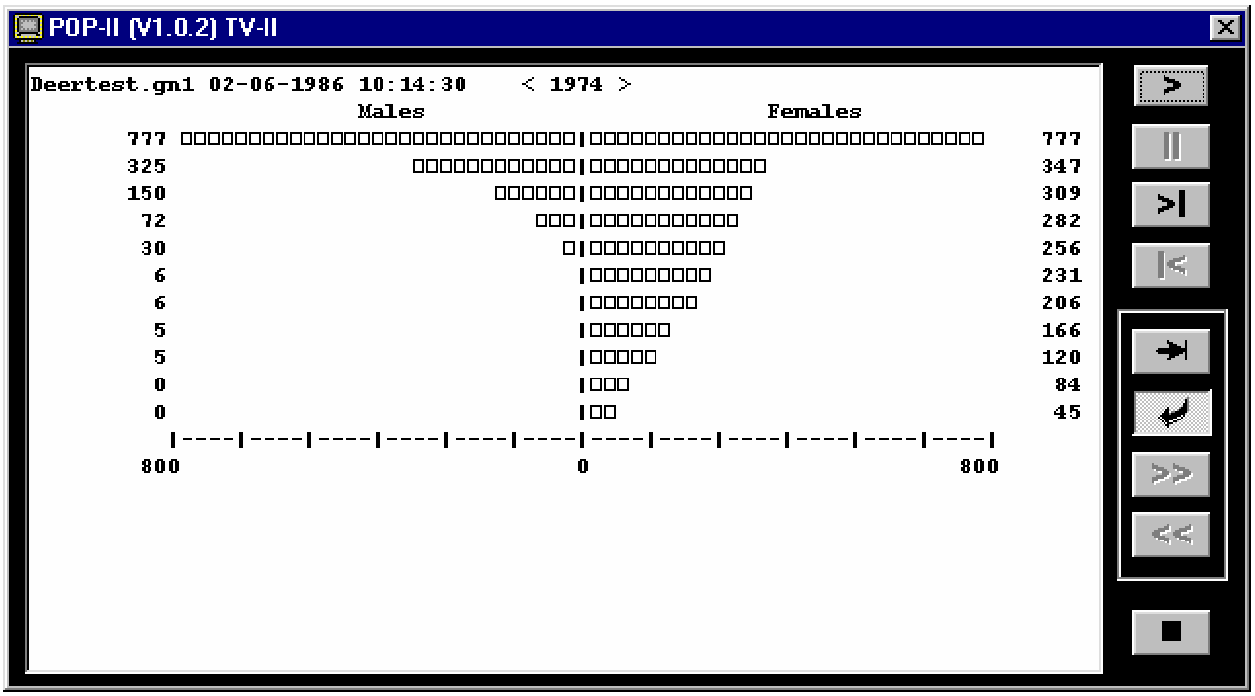
Bio-Year	Subadults /100 1+F	Ad. Males /100 1+F	Yr. Males /100 1+F	All Males /100 Fems
1974	48.7	28.5	15.4	42.5
1975	29.2	40.3	18.4	47.9
1976	34.9	50.2	13.3	57.6
1977	34.5	55.7	14.2	62.2
1978	28.6	64.2	15.4	68.7
1979	15.0	68.6	12.7	70.8
1980	33.1	76.5	7.9	79.9
1981	33.8	89.0	16.8	90.6
1982	37.0	91.1	15.6	92.5
1983	31.6	95.3	17.5	95.9
1984	37.2	86.0	13.3	88.2
1985	35.9	80.9	15.5	83.8
1986	36.2	75.2	18.4	79.0
1987	36.0	63.2	18.3	68.8
1988	35.9	57.5	18.2	63.9

Table 9. Reproduction at Start of Bio-Year for Deertest.gn1 02-06-1986 10:14:30

Bio-Year	Young / 100 AF 1 +	Sub-Ad. / 100 AF 1 +	Total Young	Total Sub-Adult	Total Females 1 +
1974	76	76	1555	1555	2046
1975	50	50	1016	1016	2038
1976	56	56	1066	1066	1908
1977	55	55	978	978	1767
1978	46	46	770	770	1671
1979	41	41	662	662	1609
1980	69	69	914	914	1328
1981	51	51	604	604	1174
1982	58	58	605	605	1041
1983	48	48	456	456	948
1984	58	58	486	486	840
1985	56	56	441	441	781
1986	57	57	414	414	728
1987	57	57	383	383	675
1988	57	57	355	355	625

Table A. Intra-Annual Natural Survival(%) for Deertest.gn1 02-06-1986 10:14:30

Bio-Years	Sub Adults	Adult Males	Adult Females	Overall Survival
1974-1975	87.12	96.28	88.14	89.09
1975-1976	87.12	96.16	88.51	90.01
1976-1977	87.12	95.64	88.04	89.84
1977-1978	87.12	94.86	87.70	89.61
1978-1979	87.12	93.69	87.31	89.34
1979-1980	51.39	89.39	82.55	80.62
1980-1981	87.12	90.70	86.63	88.16
1981-1982	87.12	89.22	85.46	87.19
1982-1983	87.12	87.73	84.88	86.38
1983-1984	87.12	87.06	85.14	86.22
1984-1985	87.12	86.75	85.39	86.21
1985-1986	87.12	87.39	86.46	86.92
1986-1987	87.12	88.04	86.50	87.15
1987-1988	87.12	89.60	87.10	87.88



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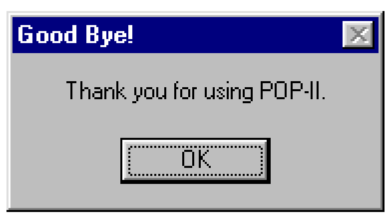

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