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The concepts of economic injury levels and economic thresholds are cornerstones in the foundation of IPM. The chapters by Skold and coworkers represent the state of the art in applying economic considerations to grasshopper management. Chapters show very clearly that chemical control is but one of several available management options and is not universally the most economical tactic. Analyses described in the Skold chapters are an integral part of Hopper, which managers can use to estimate public, private, or total benefits versus costs for either public, private, or cooperative rangeland grasshopper control projects.

Clearly, the decision to control or not control rangeland grasshoppers is not simple. Also, the general public rightfully expects a high level of technical competence within the decisionmaking process. This section of the GHIPM User Handbook represents a concerted effort to equip managers with a complete list of definitive questions as well as the means to obtain accurate answers to those questions. Adherence to the suggestions and guidelines in this section will help managers avoid blunders, mistakes, and errors—and will help support rational pest management on public and private rangelands.

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Hopper, which is described in section VI.2, can be freely copied. All third-party software used in Hopper can be distributed royalty free.

## **Hopper Disclaimer**

Hopper has been tested as much as possible with the available data and experts and has performed satisfactorily. However, the rangeland ecosystem is very complex and unpredictable. In addition, Hopper does not have any control over the data entered by each user. Therefore, the results derived from Hopper cannot be guaranteed. The following disclaimer applies:

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## VI.2 Hopper, Version 4.0, Users' Guide: Decision Support System for Rangeland Grasshopper Management

James S. Berry, William P. Kemp, and Jerome A. Onsager

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### Preface

**The Users' Guide Is a Teaching Tool.**—The goal is to present you with the most critical information and the most likely scenarios you will encounter using Hopper and Hopper Lite. In this way, you can learn the program fast and be free of the documentation soon.

**Use the Guide Even If You Can Run Hopper Without It.**—Initially, you should follow this Users' Guide, even if you intuitively understand how the programs work. The Users' Guide presents you with the options and situations under which you would use Hopper and Hopper Lite and provides background information to help you understand the data and results.

Hopper and Hopper Lite are simple and intuitive, but the data they require are *not*. Ranching economics and rangeland ecology are complex. Consequently, while the data are easy to enter, they are sometimes hard to collect and understand. The Users' Guide provides useful background information and hints to help you learn and use the system correctly. Used properly, Hopper and Hopper Lite will improve the reliability of your treatment decisions.

### Acknowledgments

Hopper was developed for the Grasshopper Integrated Pest Management (GHIPM) Project, a multiyear research and development effort that ended in 1995. Many individuals contributed to Hopper over the life of the Project. We wish to acknowledge the following for their support:

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#### **Hopper Implementation Team (Special Advisory Committee):**

Gary L. Cunningham, USDA, APHIS, Plant Protection and Quarantine (PPQ)

Robert Averill, USDA, Forest Service  
Bob Brittingham, USDA, APHIS, PPQ (retired)  
Nelson Foster, USDA, APHIS, PPQ  
J. Bruce Helbig, Plant Health Director for South Dakota, USDA, APHIS, PPQ  
J. Dan Kail, PPQ Officer for Nevada, USDA, APHIS, PPQ  
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John Larsen, Plant Health Director for Wyoming, USDA, APHIS, PPQ  
David Legg, Department of Plant, Soil and Insect Sciences, University of Wyoming (Extension Service representative)  
Melvin Skold, Department of Agricultural and Resource Economics, Colorado State University  
B. Barte Smith, Plant Health Director for Nebraska, USDA, APHIS, PPQ  
Larry Zaleski, Instructional Design Specialist, USDA, APHIS, Recruitment and Development (R&D)

#### **Original Hopper Users' Guide:**

Jim Berry, APHIS, PPQ, Phoenix, AZ  
Larry Zaleski, R&D, Frederick, MD

### Introduction

There are two versions of the Hopper Decision Support Software, "Hopper" and "Hopper Lite." Hopper Lite is for the infrequent user and could be used without consulting a printed manual. Hopper provides more features and flexibility than Hopper Lite. Consequently, Hopper is more complex and not as simple to use. However, Hopper and Hopper Lite use the same analyses and produce the same results. Each time you start Hopper, you will be asked whether you would like to use Hopper or Hopper Lite.

**What Is Hopper?**—Hopper and Hopper Lite will allow you to evaluate the validity and cost effectiveness of treating outbreaks of rangeland grasshoppers to protect rangeland in western North America. These analyses are based on the best scientific knowledge currently available. This knowledge represents more than 40 years of research and practical field experience of scientists and field personnel.

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Hopper is designed around a menu system that you use to select the options and features you need. On the other hand, Hopper Lite will guide you step-by-step through the treatment selection process. Hopper and Hopper Lite are designed for experienced agriculturalists and resource managers who must make informed treatment decisions. Hopper and Hopper Lite cannot be used to evaluate land enrolled in the Conservation Reserve Program (CRP) or protection of crops adjacent to rangeland. In addition, the economic analysis is based on the value of rangeland forage as a food source for free-roaming cattle. Other values, such as long-term resource protection, wildlife, or social impact, are not considered. Hopper does provide some information that a land manager can use to evaluate some of these factors. For example, forage yield may be useful to big-game managers. The analysis allocates reserve forage to be left after grazing (determined by the proper use factor and the Peak Standing Crop parameter). Grasshoppers consume nonreserve forage according to their need. Any remaining nonreserve forage is available to cattle.

**Why Use Hopper?**—You should use Hopper or Hopper Lite to assist with and improve the reliability of your treatment decisions. Treating grasshopper outbreaks is costly and complicated; you don't want to waste time and money treating when treatment is *not* needed.

Treatment decisions are serious business. On the one hand, unneeded treatment wastes money. But failure to treat when treatment is needed may damage the local ranching economy.

Consequently, you want to make the right decision, and you need reliable information to do so. Hopper provides reliability by evaluating your data scientifically.

**What Hopper Does.**—Hopper and Hopper Lite provide you with a list of treatments and an estimate of cost effectiveness. To provide this information, Hopper asks you for data about your site. Then Hopper analyzes your data using computer models. These models evaluate factors that are critical for making treatment decisions, including many that are otherwise too time consuming for field personnel to consider.

Hopper gives you a benefit–cost ratio (BC) that you can use to help make your decisions. The BC replaces the

static treatment thresholds used previously. The BC depends on many factors that change over time and locations (see appendix A, “How Hopper Works and Why”). The BC is based on the benefits and costs incurred during a single year's operation. The single-year BC does *not* account for multiyear effects, such as the effect of reduced egg deposit on next year's grasshopper population density. Hopper can calculate a multiyear BC, compounded from the single-year BC. Also, Hopper does not account for environmental costs or benefits, value of beneficial species, and other nonforage-related values.

In summary, Hopper's economic evaluations include only the value of forage for livestock consumption in a single season. However, there are many other factors that a rancher may consider in addition to possible multiple-year benefits. One factor is maintenance of the brood herd and long-term survivability and profitability of the operation. A 1-year loss may be acceptable over a 10-year cycle of 9 profitable years.

When the BC is 1.0 or more, treatment is economically justified, and you would treat the outbreak to protect forage. But when the BC is less than 1, treatment is economically unjustified, and you would *not* treat the outbreak just to protect the current forage crop. The final decision to treat or not depends on Hopper's analysis and any other factors important to the ranching community and general public.

Thus, by using Hopper, you can include cost effectiveness in the decisionmaking process.

**When To Use Hopper versus Hopper Lite.**—New users, infrequent users, and managers who need only to evaluate normal treatment scenarios should use Hopper Lite, at least initially. These managers include USDA, APHIS, PPQ personnel. Hopper Lite will direct you, step by step, through Hopper's essential features to evaluate a potential treatment scenario. The most needed features of Hopper are provided, such as input screens for treatment cost and efficacy and grasshopper information. After becoming familiar with Hopper Lite, frequent users will probably find Hopper easier to use because of its increased flexibility. Also, Hopper provides the opportunity to determine an economic threshold, change additional economic information, create hard-copy data-entry

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forms, print graphs, configure attached printers, and run a generalized simulation of rangeland grasshoppers. If you need any of these features, you must choose Hopper. However, remember that the analysis in Hopper Lite is the same as Hopper. There is no reason to use Hopper unless you need its additional features.

## Getting Started

**System Requirements.**—Hopper will run on an IBM™ compatible computer with at least 640 kilobytes (KB) of memory. (A central processing unit 80386, –486, or higher is strongly recommended.) Hopper will probably run with less memory, but the absolute lower limit is not known. Your computer must be running DOS version 3.1 or higher. A VGA monitor is required to view the hazard maps and graphs of the grasshopper and forage simulation results but is not required for other parts of Hopper. To save and print graphs of Hopper's simulations for dot matrix and laser printers, 512–1024 KB of expanded memory (EMS) is required. (See the Installation section of your DOS or MS–Windows™ manual to modify your `config.sys` file with the `emmm386.exe` driver.) You can use a mouse to make selections from menus, but the mouse is not required.

A hard drive is required, and there must be at least 3.5 megabytes (MB) free disk space before Hopper is installed. A math coprocessor will speed the simulations in the economic analysis module by almost a factor of 10. However, the math coprocessor is only recommended, not required.

**Installation.**—There is a simple program (`INSTALL`) supplied with Hopper that will guide you through the installation process and install Hopper on your computer's hard disk. `INSTALL` will also identify the computer's hardware so you can verify system requirements. To install Hopper and Hopper Lite, put the Hopper disk in the floppy disk drive. Then type the letter of the floppy disk drive, a colon, and `INSTALL` (e.g., `A:INSTALL`); do not type any blank spaces; then press the enter key `<ENTER>`. Then follow the directions on the screen. Hopper is supplied in an archived format to save diskette space. `INSTALL` will unarchive the files and copy them to your hard disk. **Note:** Hopper cannot be installed by simply copying the files to your hard disk. You must use the installation program.

If you have previously installed an older version of Hopper in the `\Hopper` directory, you may want to erase the old Hopper files from your hard drive (**Note:** Data files from previous versions and data files (`*.fct` and `*.ec3`) are not compatible with the current version). Removing outdated files will free some disk space for future use. You can keep the old version of Hopper, but you will need to specify a directory other than `\Hopper` when you are prompted by `INSTALL`. If you attempt to install Hopper into a directory where any files exist, `INSTALL` can erase the files for you after prompting you for permission. In this case, all previous information you have saved in that directory will be lost.

If you have at least 2 MB of memory on your computer, you can make some of that memory available to Hopper for creating graphs. To add expanded memory for saving and printing simulation graphics for dot matrix and laser printers, add the following line to your `config.sys` file after the `HIMEM.SYS` line (if present) or on the first line.

```
device=c:\dos\emmm386.exe 1024
```

Hopper's default graphic printer (HPGL/2) does not require this line to be added.

**Starting Hopper and Hopper Lite.**—After `INSTALL` finishes installing Hopper to the hard drive, Hopper is ready for use. Typically, Hopper will be located in a directory called `C:\Hopper`, unless a different drive and directory were specified during installation. Hopper needs to find several of its files while it is running. Therefore, Hopper can be started only from its own directory. To change to the Hopper directory and then to run Hopper, type:

```
cd\hopper <ENTER>
hopper <ENTER>
```

This assumes that Hopper was installed in `C:\Hopper`. If Hopper is started from a menu system, the menu must be programmed to make the Hopper directory the current directory before starting Hopper (similar to the above commands). Each time you start Hopper, you will be asked whether you would like to use Hopper or Hopper Lite.

**The User Interface.**—In this manual, keystroke commands are in pointed brackets such as <>. The keys are:

- <ENTER>...Enter key
- <ESC>...Escape key
- <DEL>...Delete key
- <INSERT>...Insert key
- <PageUp>...Page up key
- <PageDown>...Page down key
- <Down>...Down arrow
- <Up>...Up arrow
- <Left>...Left arrow
- <Right>...Right arrow
- <F1>, <F2>...Function keys.

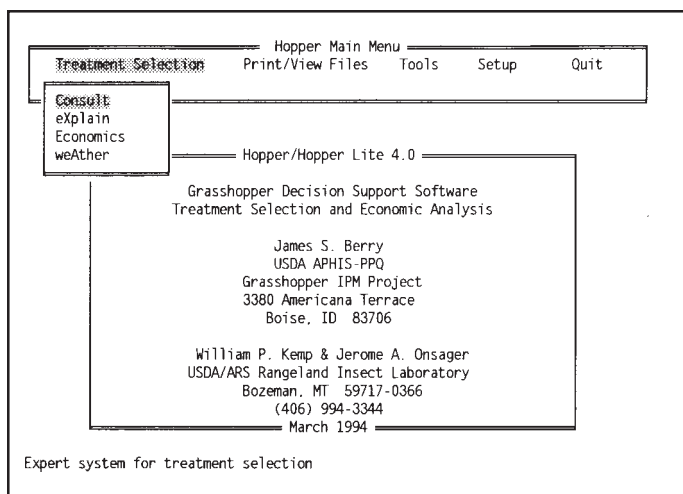
At times, text or numbers must be entered. These will appear in this Users' Guide without brackets (e.g., 23, some text).

When Hopper or Hopper Lite is started (by typing Hopper <ENTER>, or Hopper MONO <ENTER> if you have a monochrome monitor or monochrome liquid crystal display [LCD] screen), a disclaimer appears and waits for any key to be pressed before continuing. Next, the option to select Hopper or Hopper Lite is presented. If you select Hopper Lite, you will be guided through the treatment selection process. Many of Hopper's and Hopper Lite's features and screens are identical. If you choose Hopper, the main menu screen appears (fig. VI.2-1). This screen contains a title win-

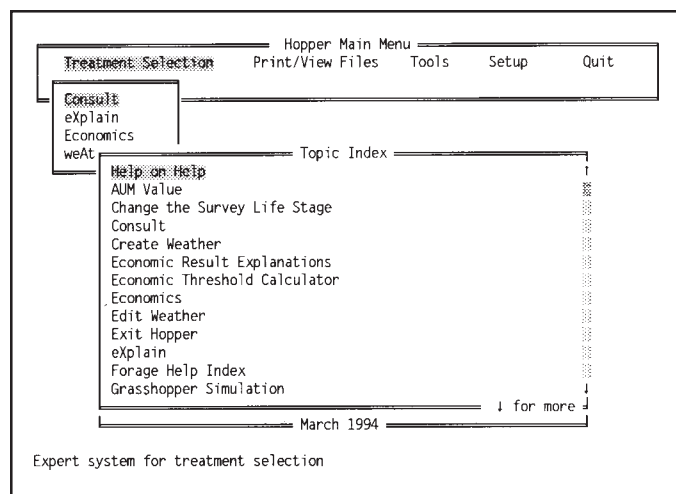
dow in the center of the screen. Across the top of the screen is a list of main menu items available. (In this text, main menu items are printed in boldface type.) Use the arrow keys (or mouse) to move to a main menu item and then press <ENTER> (or left mouse button) to select that item. When you select one of these main menu items, a submenu of items appears. (Submenu items are always printed in italics.) You can leave any menu or submenu by pressing <ESC>. In fact, pressing <ESC> will allow you to jump out of most areas in Hopper or back up one step.

Hopper is operated by using menus, so you do not have to remember complicated commands. Instead, look through the menus to find the desired item and press <ESC> to leave the menu if the item is not found. Also, you can press <F1> at any time to get context-sensitive help information (fig. VI.2-2). Therefore, you do not have to remember commands or syntax. This menu-driven architecture increases the ease of operation of Hopper while maintaining flexibility for you. You are always returned to the main menu after exiting from a submenu.

Some information Hopper needs is entered onto onscreen data-entry forms (fig. VI.2-3). At times you will need to type numbers or dates on a form. Use the tab key <TAB>, <ENTER>, or arrow keys to navigate between the fields on a form. Data within a field on a form can be edited using the delete key <DEL> or arrow keys, and by



**Figure VI.2-1**—Main screen showing the **Treatment Selection** submenu.



**Figure VI.2-2**—Main screen help after pressing <F1> twice to get the Help index.

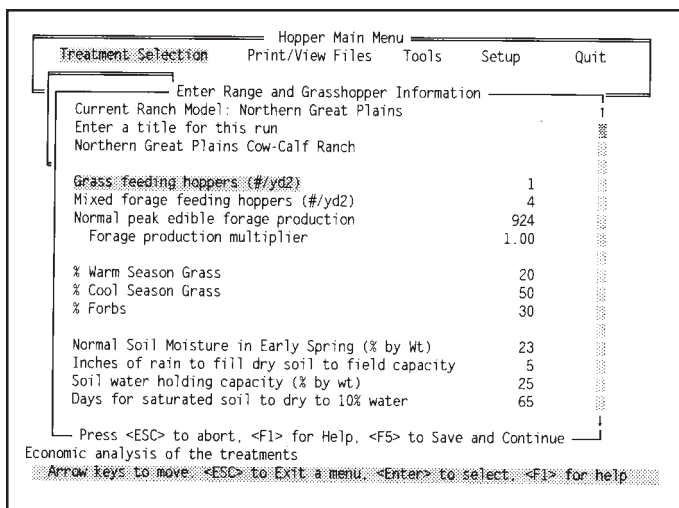


Figure VI.2-3—Example of the fields in an onscreen data-entry form.

typing the desired information. Forms are preloaded with default values so that you often do not need to enter much information. Usually you will just change a couple of values on a form.

A good way to learn Hopper is to explore the menu system and try the various features. Hopper filters your input so that you can enter appropriate information only. Hopper is designed to be robust so that you can easily explore its capabilities as you learn how to use it.

**Technical Support.**—For help in using Hopper or Hopper Lite, contact Jim Berry by telephone at (602) 379-6014 between 8:00 a.m. and 5:00 p.m. (Mountain Standard Time), weekdays. Facsimilies can be sent any time to (602) 379-6005. Send Internet mail to pmdc@xroads.com with “Jim Berry” (minus the quotation marks) in the Subject line.

## Hopper Lite Version 4.0 A Simple Decision Support System for Rangeland Grasshopper Management

Hopper Lite is very easy to use. It asks you questions and controls the whole process to the end. A typical scenario should take about 2 to 10 minutes to complete, depending on the speed of your computer.

**Installation.**—Hopper Lite is installed automatically with Hopper. Hopper Lite is a subset of Hopper and uses the same files as Hopper.

**Operation.**—Make the Hopper drive and directory current (e.g., `cd\hopper`). Then type `Hopper` <ENTER> to start the program. You will be asked if you would like to use Hopper Lite. Enter `Y` to select Hopper Lite. Then enter the information requested at each prompt. The arrow keys can be used to highlight an answer; then press <ENTER> to select that answer. Much of this Users’ Guide is contained on the computer and is available by pressing the <F1> key. This information will often provide additional explanation or help each step of the way. **Note:** To configure your printer or generate hard-copy data-entry forms, you will need to run Hopper.

For the economic analysis, select a data file that corresponds to your situation (e.g., `NPH_CC.ec3` for northern high plains cow-calf operation, or a generic model [files with “.gn3” extension] if no models are available for your area or situation). For more information on economic analysis, see the Economics section.

The economic analysis display at the conclusion of the process shows what treatments were selected and benefit-cost ratio (BC) for each. Remember, these results are the same as those provided by Hopper.

You can change the text printers (default = Hewlett-Packard LaserJet™) or graphics printers (default = HPGL™/2) only in Hopper. In addition, Hopper Lite can only save graphs, not print them. Select **Print/View Files** from the main menu in Hopper to print graphs.

## Overview of Hopper

**Summary of Features.**—There are four items accessible from the main menu. The first is **Treatment Selection**. The submenu provides access to an expert system for selecting appropriate treatments and computer models for economic analyses of those treatments. You can easily try different scenarios to evaluate their economic consequences. The computer simulations for forage production, grasshopper population dynamics, and ranch economic linear programming models in version 4.0 of Hopper and Hopper Lite expand this flexibility for evaluating alternative scenarios.

The second main menu item (**Print/View Files**) will allow you to view on the screen or print any output that

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Hopper or Hopper Lite produces. Outputs include reports and data-entry forms. Graphs you save during the economic analysis of treatments can be printed but not viewed.

The third main menu item (**Tools**) has five submenus. There is an interactive *Tutorial* designed to teach a new user how to use Hopper. Next, there is a generalized simulation model of grasshopper population dynamics and treatment effects (*SimHop*). This is useful for demonstrating the effects of several factors on the overall utility of a control program. *Maps* allows you to select and view rangeland grasshopper hazard maps for several States. These maps are derived, using geostatistical techniques, from surveys of adult grasshoppers in the previous year. Because grasshopper densities are highly correlated with densities 1 year earlier, the maps indicate probable areas of high grasshopper populations. The *Economic Threshold* submenu item will estimate the grasshopper density necessary to produce a benefit–cost ratio you specify. The last submenu item is *Forms*, which will allow you to create hard-copy data-entry forms based on an existing economics data file.

The main menu item **Setup** contains functions to set up printers for text and graphics. Hopper prints graphics indirectly after creating disk files compatible with the graphics printer established in **Setup**. Once you set up both a text and graphic printer, you will not need to set them up again unless you want to use a different printer. The configuration you specify will be used by both Hopper and Hopper Lite.

**Strategy for Use.**—The main use for Hopper is to select a list of appropriate treatments and then evaluate their economic utility. The *Tutorial* in the **Tools** submenu will demonstrate a typical usage of Hopper. The *Tutorial* will work fine when Hopper is first installed but may not work properly after you have modified some of Hopper’s data files. The **Treatment Selection** submenu contains all of the functions for grasshopper control analysis. To develop and evaluate potential treatments, first use the arrow keys to move the highlighted bar to **Treatment Selection** on the main menu and press <ENTER>. *Consult* should then be highlighted in the submenu. Press <ENTER> to select *Consult* and begin the process to develop a list of appropriate treatments. *Consult* will guide you through this process and ask you for informa-

tion along the way. In *Consult*, survey and treatment dates are entered. These are used to determine the average grasshopper life stage in *Consult* as a factor for selecting certain treatments. Note that these dates are also used later in the economic analysis to simulate treatment effect on forage availability for livestock. After *Consult* has been used, the treatment list is available to be used for economic analysis. *Economics* is listed below *Consult* in the **Treatment Selection** submenu.

After you select the appropriate economic data file from Hopper’s list, Hopper presents onscreen data-entry forms that must be completed. You can accept all the default values except grasshopper density. Typically, of all the data requested by Hopper for the economic analysis, only grasshopper density needs to be entered. More experienced users may change treatment cost and efficacy on the Treatment form. There, scenarios for increasing swath width and the resulting decrease in cost and efficacy can be evaluated.

Once data are correct on an onscreen data-entry form, press <F5> to cause Hopper to continue to the next form or function. Most onscreen data-entry forms can just be bypassed by pressing <F5> to accept the displayed values when the form appears.

After all data have been entered, the analysis begins. Graphs of the forage and grasshopper simulations can be displayed and/or saved. The economic analysis uses results from the simulations to calculate the benefits and costs of each treatment. The final results can be saved and are also displayed on the screen. Experimenting (“gaming”) by changing some values, such as grasshopper density or treatment date, can be very useful and interesting.

## The Modules

### Treatment Selection

**Consult.**—The first item in the **Treatment Selection** submenu is *Consult* (fig. VI.2–4). This is the expert system that selects treatments that are valid for a given situation. Select *Consult* by moving the highlighted bar to *Consult* and pressing <ENTER>. The program will ask you relevant questions about the situation and current conditions. Often, *Consult* presents several options on the screen. To select one of the options, use the cursor keys

(arrow keys), or you can use a mouse and click once on the left mouse button to move the highlighted bar to the appropriate option. Press <ENTER> or click once on the left mouse button to make your selection and continue with the consultation (fig. VI.2-5). At times you may be asked for data that you will need to type in from the keyboard (e.g., dates). In these situations, you will not use the cursor keys to select an option. Instead, you will type your response (fig. VI.2-6).

First, *Consult* will require you to select weather data for your site unless you have already loaded weather data. The *Weather* submenu will open and present three items. The most common choice is to create a weather file for the site. *Weather* also allows existing files to be used or

new files to be created in a spreadsheetlike editor. Once Hopper has weather data for the site, Hopper will present an option to load existing facts into memory. If you choose to load existing facts, Hopper will provide a list of available files from which to select. Hopper will take control and guide the treatment selection process. Just answer any questions that are asked. A second window (Current Value Window) at the bottom of the screen will display the information you have entered.

More explanation or help for a question being asked can be obtained by pressing <F1>. These explanations will help you make sure that your answers are appropriate for the way they will be used in the system (fig. VI.2-7).

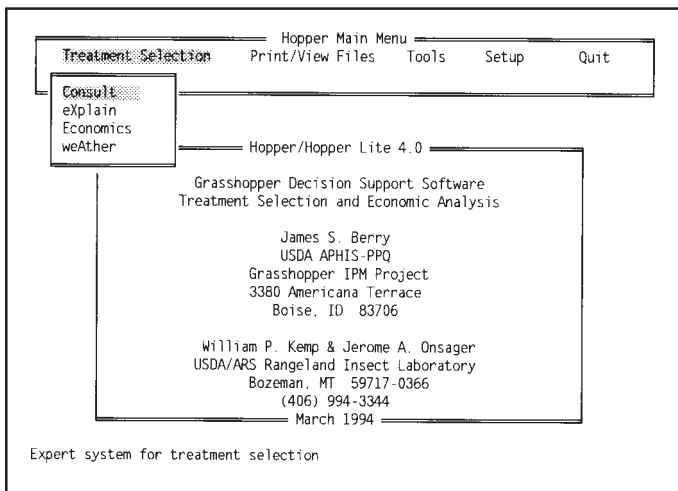


Figure VI.2-4—*Consult* is highlighted and will be selected by pressing <Enter>.

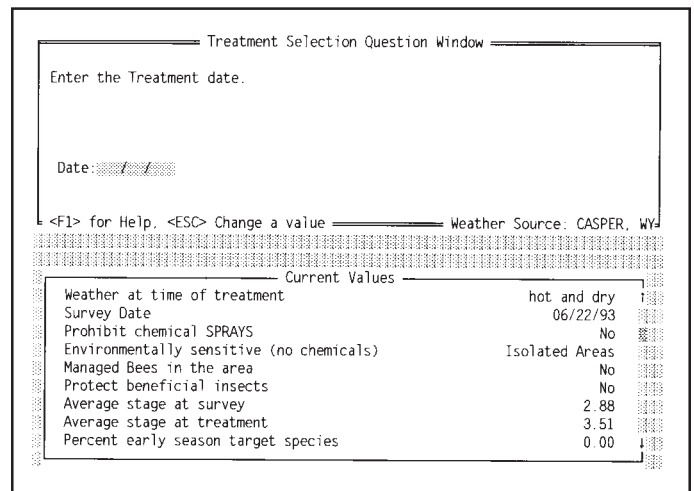


Figure VI.2-6—Typical numeric entry in *Consult*.

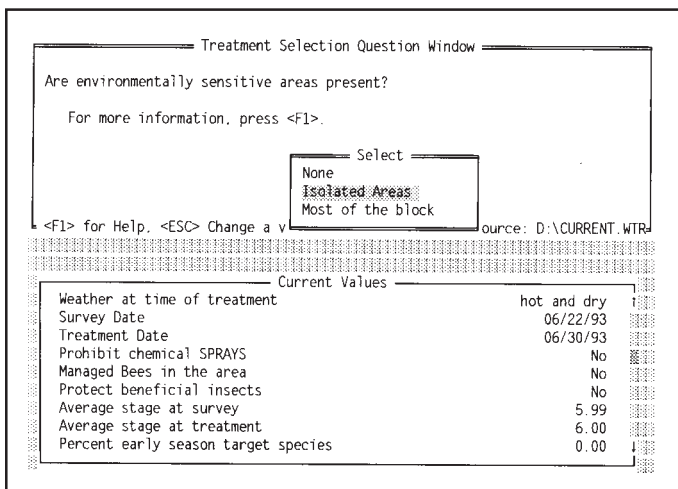


Figure VI.2-5—Typical multiple-choice data entry in *Consult*.

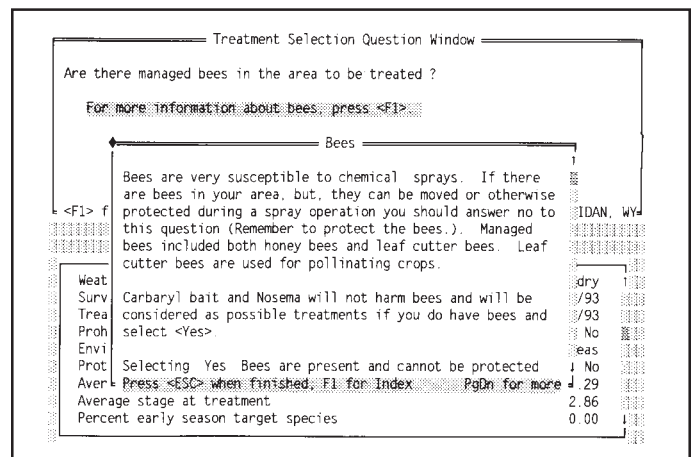


Figure VI.2-7—While entering information in the *Consult* expert system, help and ancillary information can be displayed.



To change or delete a value (e.g., an incorrectly entered value), you can temporarily exit from the Treatment Selection Question Window by pressing <ESC>. The cursor will be placed in the Current Values Window (fig. VI.2-8). There you can see or delete (highlight the value then press <DEL>) any values you have entered. When you are ready to continue with *Consult* again, press <F5>. Only deleted values and any new information needed by the expert system must be entered during the new or continued run with *Consult*. This feature allows you to build treatment lists rapidly from different scenarios. To quit without selecting a treatment and return to the main menu, press <ESC> while the cursor is in the Current Values Window.

**Note:** After *Consult* is finished, the information that was entered by you for treatment selection can be saved to a file. This information can later be retrieved when you begin *Consult* again, as previously described. When asked for a file name to save facts, only the filename (eight or fewer characters in length), without an extension, should be entered (e.g., FACT2).

When *Consult* is finished, a list of treatments with corresponding application dates will be displayed (fig. VI.2-9). In some situations, other information will be displayed to show the outcome of the consultation. You could delete some facts and press <F5> to run another scenario. When you press <F5> without deleting any facts, you will be returned to the **Treatment Selection** submenu. Hopper will retain in memory the list of treatments you obtained from *Consult*. This list

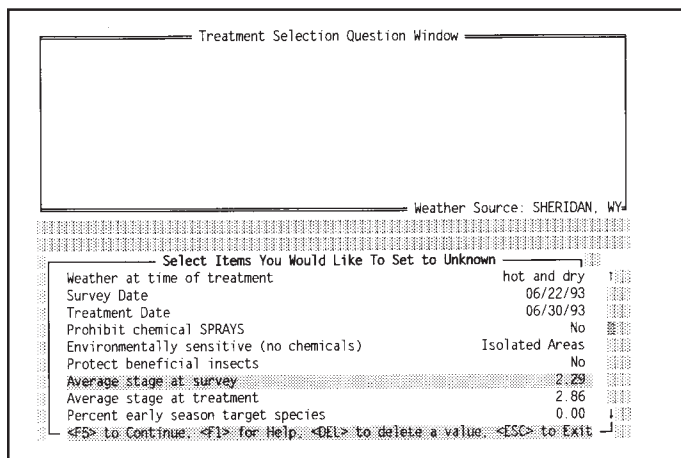


Figure VI.2-8—Screen used to delete data from *Consult*.

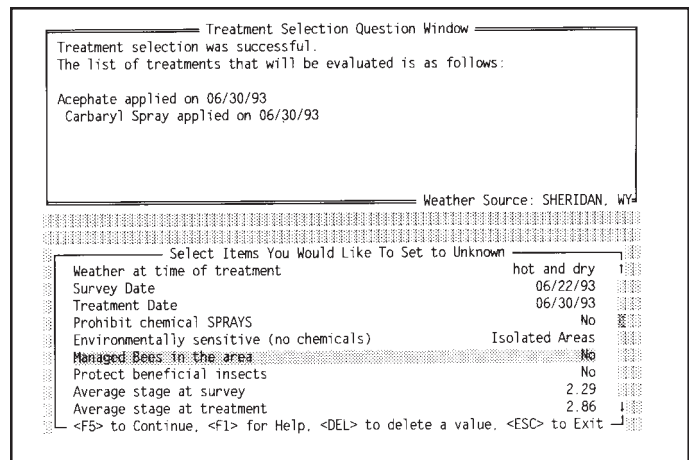


Figure VI.2-9—*Consult* ends by displaying a list of treatments that can be analyzed in the *Economics* module.

will be used each time you select the *Economics* module until *Consult* is run with different data.

**Explain.**—The *eXplain* option tells you why Hopper selected or rejected treatments for a given consultation.

You may either:

1. View the explanation onscreen (Read)

Use <PageUp> and <PageDown> to move around the explanation. After reading the explanation, press <ESC> to return to the main menu.

2. Print the explanation (Print)

Follow the onscreen directions to print the explanation. See **Setup** for information on setting up your printer.

**Economics.**—*Economics* prompts you to enter economic and environmental data about the infested site. Then, Hopper runs the data through simulation models that provide an economic analysis of the treatments selected by *Consult*. By varying the data, you can evaluate the benefit–cost ratio of treatments for various scenarios. This allows you to determine

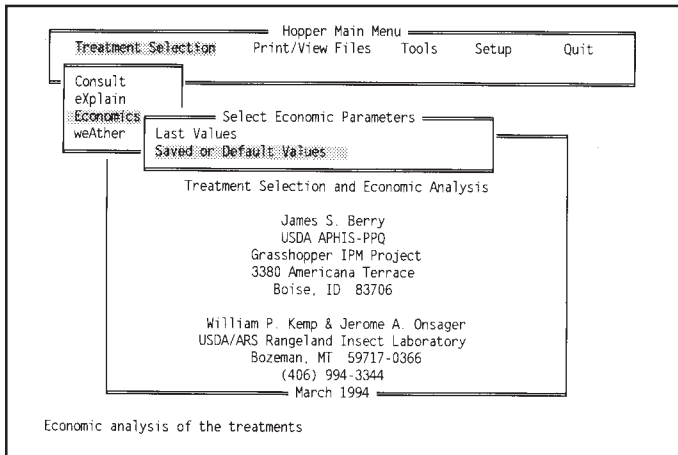
- Whether or *not* treatment is cost effective,
- Which treatment is most cost effective, and
- When to use the treatment for maximum effect.

The *Economics* module gives you access to a virtually unlimited number of scenarios for evaluating the economic robustness of the treatments that were selected by

the *Consult* module (fig. VI.2–9). This flexibility and power come by using forage and grasshopper simulation models. The *Economics* module manages the models and the details of each simulation. Therefore, it is very easy for you to do the economic analyses. In fact, the only way a user even knows that models are being used is that a display indicates when a simulation is active.

After *Economics* is selected from the submenu, you must select an option to load economic data into Hopper (fig. VI.2–10). Information for the economic analysis is stored in files. The last information used by Hopper can be retrieved by selecting “Last Values.” Information for regional economic models provided with Hopper can be selected by choosing “Saved or Default Values.” In addition, any specific economic information you have saved can also be retrieved this way. Press <F1> for descriptions of the economic files. Usually, on the first run for a given area you will select the option for “Saved or Default Values” (existing data file). There are several data files that represent data typical for an area. For example, NGP\_CC.ec3 represents a northern Great Plains cow-calf operation. There is also a generic model available for areas that do not have a specific model. These models use data files that have the extension .GN3 and can be used anywhere in North America. For a description of the economic models and data files currently available, see appendix B of this Users’ Guide or press <F1>.

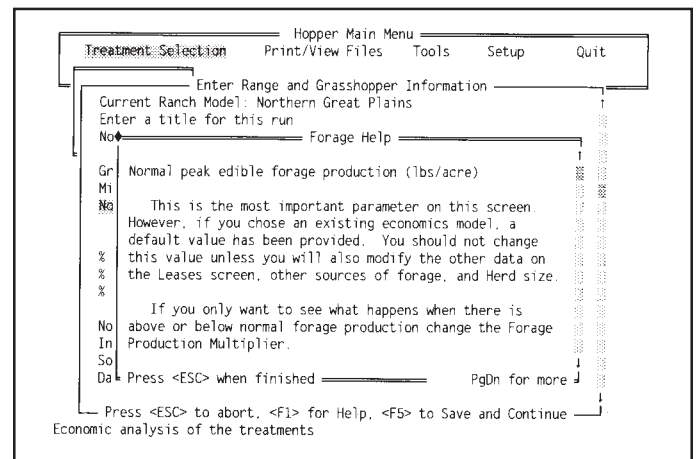
Six data-entry windows are used to get information from you before the simulations are started. **Help and expla-**



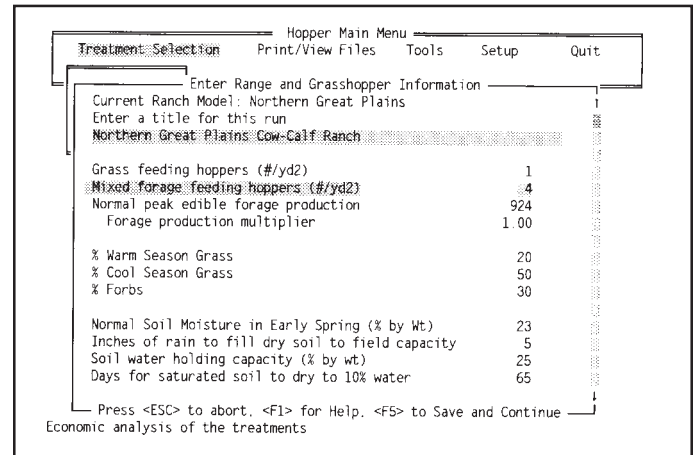
**Figure VI.2–10**—With *Economics* selected, Hopper then prompts for economic parameters file to use.

**nation (press <F1>) are available for most parameters.** See figure VI.2–11. These explanations should be read so that you will be able to enter correct information and understand the potential effects of a variable on the economic analyses. To change a value, use the arrow keys or <TAB> to move the highlight to the value. Type a new value or use <DEL> to edit the value. When you are finished entering information on an onscreen data-entry form, press <F5> to move to the next onscreen data-entry form.

The first onscreen data-entry form (Forage and Grasshopper Models) is for information used to simulate forage growth and grasshopper population dynamics (fig. VI.2–12). Densities of grasshoppers that eat only grass and



**Figure VI.2–11**—Grasshopper and rangeland data entry with help information for peak standing crop displayed.



**Figure VI.2–12**—Grasshopper and rangeland onscreen data-entry form.

those that eat mixed vegetation and, occasionally, a forage-production multiplier should be entered. Remember to press <F1> for more explanation for each parameter (fig. VI.2-11 shows a help screen). The rest of the values are reasonable estimates if you do not have better information. Press <F5> to continue when you are satisfied with the values that are displayed. Percent forbs is calculated by Hopper, based on cool- and warm-season grasses.

The second onscreen data-entry form (Treatment Cost) displays the list of treatments, with their costs and mortalities, selected by the *Consult* module (fig. VI.2-13). The total cost (material plus application cost) and mortality can be entered (press <ENTER> after typing each value) for each treatment except *Nosema* bait. Only cost can be entered for *Nosema* bait because mortality calculations are too complicated for most users. After all the costs have been entered correctly, press <F5> to accept your entries and continue to the next onscreen data-entry form.

The third onscreen data-entry form allows you to indicate the potential for multiple-year benefit from control. Be sure to read the information on the screen (fig. VI.2-14). Multiple-year benefits are calculated only by compounding single-year benefits over the number of years you enter on this onscreen data-entry form. This is the last screen of data presented when a generic model is used.

The fourth onscreen data-entry form (Hay Information) shows data used in the ranch economic model (fig. VI.2-15). Press <F5> to continue when you are satisfied with

the values that are displayed. Only change this information if you have data for a specific ranch or a ranch typical for the treatment block. The values provided by Hopper are for a typical ranch in the area.

The fifth onscreen data-entry form (Herd Size) shows livestock data used in the ranch economic model (fig. VI.2-16). A land manager may choose to evaluate the effect of reduced herd size versus paying for grasshopper control. Press <F5> to continue when you are satisfied with the values that are displayed.

The sixth onscreen data-entry form (Lease Information) shows lease data used in the ranch economic model (fig. VI.2-17). Press <F5> to continue when you are satisfied with the values that are displayed. Only change this information if you have data for a specific ranch or a

Figure VI.2-14—Multiple-year onscreen data-entry form.

Treatment	cost/acre (including application)	mortality (percent)
Acephate	\$2.47	91
Carbaryl Spray	\$3.50	92

Figure VI.2-13—Treatment cost and mortality onscreen data-entry form.

Figure VI.2-15—Hay information onscreen data-entry form and livestock data display.

ranch typical for the treatment block. The values provided by Hopper are for a typical ranch in the area.

Your last entered values for the economic analysis are saved automatically in a file called `Last.ec3`. Before the economic calculations begin, Hopper will ask if you would also like to save in a specific file the information just entered. You could reload and use this information later (fig. VI.2-10).

Then you will be asked if you want to continue with the economic analysis. This process can take several minutes on slow computers without math coprocessors. If `N` is entered, the economic analysis will end and the Treatment Selection menu will be displayed. If `Y` is

entered, the economic analysis will proceed. The progress of the analysis can be monitored in a window in the center of the screen. You can view graphs after each treatment simulation. Then the ranch economic model will run. There is no user intervention required until the analyses are complete (fig. VI.2-18). (However, you can press `<Ctrl-Break>` to interrupt the economic analysis and return the Hopper menus.) The results are automatically saved in a file called `Results.rpt`. You will be asked if you would like to save this information in a specific file. **Note:** The Primal/Dual Degenerate Problem message should be ignored.

The results of a ranch economic analysis (not generic analysis) are displayed in a window (fig. VI.2-19). The

**Figure VI.2-16**—Livestock herd-size onscreen data-entry form. Yearlings and sheep are not in the model.

**Figure VI.2-18**—Working screen for the ranch economic model.

**Figure VI.2-17**—Range lease onscreen data-entry form.

**Figure VI.2-19**—Final results from the economic analysis.

top few lines describe some general results of the analyses. The yields from the simulations are dependent on the scenario you described (Forage and Grasshopper Parameters Window) and on the weather scenario. The yield with grasshoppers accounts only for grasshopper consumption since the survey date or date of average fourth instar, whichever is earlier. The acres to be treated are calculated from the total Animal Unit Months (AUM's) grazed on the ranch, normal production of peak edible forage, and the proper use factor for each lease and total deeded land. [An AUM represents the average amount of forage consumed by one cow and one calf in 1 month—about 800 lb.] Therefore, the acres to be treated represent the total acres grazed by the ranch, except distant pastures on the Hay Information Screen (fig. VI.2–15). The eggs deposited per square yard is an estimate of the density of grasshopper eggs deposited by the end of October. The number of later instar grasshoppers that will be produced next year by these eggs depends on winter survival of the eggs and spring survival of the young instars.

The simulation results from the individual treatments (includes treatment mortality) and their corresponding application dates are listed in tabular form. The dollar return is total return for the ranch and is calculated from the value of an AUM (determined by the ranch economic model or entered by you in the case with the generic economic models), the cost of control, and the AUM's gained from control.

In some situations, the monetary value of forage saved from a treatment does not justify the application of that treatment for short-term economic reasons. However, there may be carryover benefits for the coming year that cannot be quantified economically. For example, the number of eggs deposited may be reduced, possibly preventing continued high densities of grasshoppers during the next growing season. Eggs deposited per square yard are shown for each treatment in the last column. These densities can be compared to the densities simulated for the untreated grasshopper populations (shown at the top of the window). In this way, relative effectiveness of the treatments (and application dates) for reducing next year's potential population can be evaluated. The return is the gain for the ranch if the treatment is applied. Cost is the total cost to treat the ranch (all AUM's on the lease data-entry form, fig. VI.2–17). The benefit–cost ratio

(BC) shows if the benefit is greater than the cost ( $BC > 1.0$ ). Two BC's are displayed. The first is for a single year. The second is combined for a single year plus the number of subsequent years shown. In the example, figure VI.2–20 shows the current year and 2 subsequent years. Although Hopper provides for benefits to be calculated for up to 10 years, 4 or 5 years is more realistic. See Help <F1> for additional information about multiple-year benefits. If current BC (single-year) is less than 1.0, the treatment may still be cost effective if you think you will get as much benefit in subsequent years (multiple-year effects BC).

The results from a generic economic analysis are very similar to the results from the ranch models. A difference to note is the acres to be treated. The generic analysis always shows 1.0 acre, whereas the ranch models show the number of treated acres associated with a ranch. The cost and return for the generic model are also for 1.0 acre, not for an entire ranch. In addition, the forage model is not used by the generic model. Therefore, yield is the normal peak edible forage production times the forage production multiplier minus the estimated forage consumption by grasshoppers (from the grasshopper model). In other words, the generic model calculates potential forage consumption by grasshoppers, but the ranch models calculate yield based on the interaction of forage growth with concurrent grasshopper forage consumption.

Hopper's recommendations are derived from the best scientific and field data available (including your own responses). However, remember that there is great

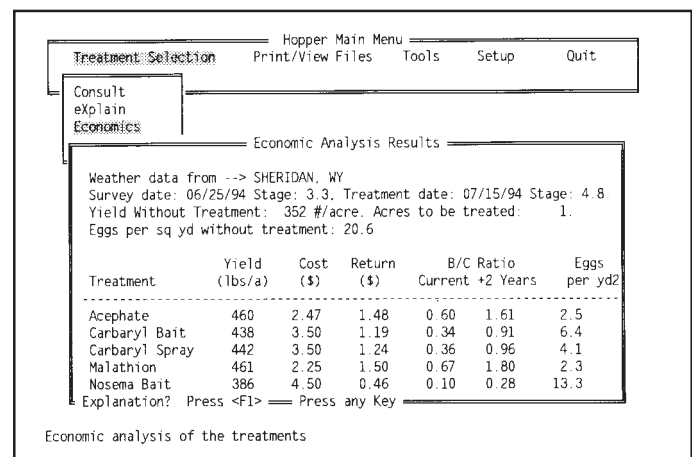
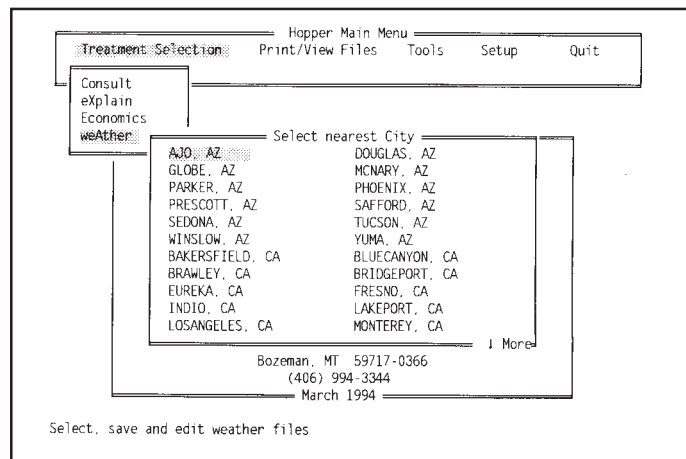


Figure VI.2–20—Final results from the generic economic analysis.

variability in any biological system. Also, future events, such as drought or changes in the cattle market, cannot be quantified accurately and are not included here. Therefore, you should evaluate the strength of your decision by running Hopper and changing some of the values you enter. For example, decrease the grasshopper density by 20 percent. If BC is greater than 1.0 (assuming it was greater than 1.0 in the first run), then you can have greater confidence in the decision to use the specified treatment. However, if BC drops below 1.0, you should suspect that a decision to use the given treatment is not very robust (not a decision that can be made with much confidence). Gaming with the program in this way can be very informative and is one of the strengths of using computer models.

**Weather.**—Hopper uses simulation models to predict forage production and grasshopper phenology and oviposition. These models use temperature and precipitation information to make the predictions as accurate as possible. The *Weather* module allows you to retrieve, modify, and save temperature data that are used by Hopper. Currently, precipitation and temperature are generated and stored in a file. Both can be edited or updated for each day of the year in the Temperature Editor provided in the *Weather* module.

You can create average weather (using the weather generator provided with your copy of Hopper, fig. VI.2–21) or provide your own weather files. The files may have any filename but must have *.WTR* as the *file extension*



**Figure VI.2–21**—Weather generator submenu to select the weather station nearest your site.

(e.g., *mytemps.wtr*). For example, *mytemps.wtr* might look like this:

1	14	–5	0.110
2	13	–3	0.090
3	17	0	0.000

etc.

Column 1 is day of the year (where 1 is January 1, 365 is December 31), column 2 is maximum temperature (°F), column 3 is minimum temperature (°F), and column 4 is precipitation (inches). Incomplete data sets are accepted (whole days can be missing). There must be at least one space between each column. In the Northern States, Hopper uses temperatures from April 1 through October 8. Make sure you have good data for these dates before running the *Consult* or *Economics* modules.

A spreadsheetlike Weather Editor is provided to allow you to edit temperatures and precipitation from several sources (average from sites in your area, created by the weather generator; weather files that you have previously edited or assembled using a text editor; or temperature data that are currently loaded into Hopper). Often you may want to evaluate the effect of generally warmer, cooler, wetter, or dryer conditions. The Weather Editor allows you to increase or decrease temperatures or precipitation for the entire year all at once. When you are finished editing, you may press <F5> to update the current temperatures in Hopper and, optionally, to save your changes to a file on the disk. Any file you save may be reloaded later for use by Hopper and/or more editing.

### Print/View Files

**Graphs.**—The *Graphs* option will allow you to print any graphs that were saved during an economic analysis. Note that your graphics printer must have been configured correctly at the time the graphs were created. Your graph will not print correctly if it was created for a printer different than the one you would like to use to print the graph (see **Setup** for more information on graphics printer setup, page VI.2–16).

**Reports.**—All of the information needed to duplicate a scenario is stored in Hopper’s reports. The *Reports* option includes information entered in the *Consult*

module and the *Economics* module and identity of the source of weather data. Hopper always saves the last run in the file `results.rpt`, even if you declined to save the results when prompted in the *Economics* module. Print Reports will display any report file on the screen or print it to the current printer (see **Setup** for more information on text printer setup, page VI.2-16).

**Forms.**—You can create hard-copy data-entry forms that you can use to collect input data for Hopper. The forms contain default values from Hopper or values from any data you have saved during an economic analysis. These files have the ending `.ec3`. You can view the forms on the screen or print them. To create a form, see *Forms* in the **Tools** section, page VI.2-16.

## Tools

**Tutorial.**—An automated *Tutorial* will show you a typical run through Hopper. After you modify some of the data files that arrived with Hopper, the tutorial may not run correctly. This problem happens because Hopper may require a different response based on the data that are entered. The tutorial cannot adjust to these changes in advance.

**SimHop.**—*SimHop* will simulate the general pattern of grasshopper development, forage consumption, and treatment mortality. This is useful for teaching or explaining why it may be too late or too early in the year to treat. The effects of long-lasting (long residual) treatments and timing of treatments can be demonstrated. Text and graphics are used to show the results (fig. VI.-22).

There are two modes of operation. First, a grasshopper population can be simulated from before spring egg hatch (preseason) to the end of season (fig. VI.2-23). You can set the timing, length and size of the hatch period. Second, *SimHop* can begin after egg hatch (midseason). In this case you can specify the density of each instar and starting date of the simulation (fig. VI.2-24). For each type of simulation, you can set the timing, length, and total mortality for a treatment. Therefore, via simulation, you can compare results of a slow-acting biological control applied early to results of a short-residual, fast-acting chemical spray applied later.

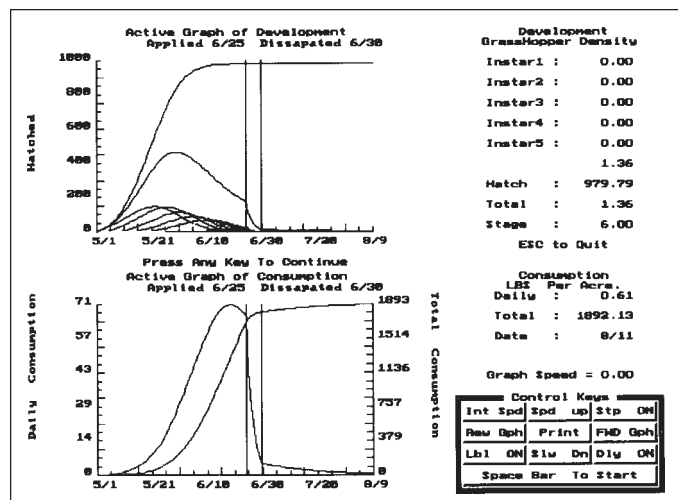


Figure VI.2-22—*SimHop* graphics display screen during a simulation beginning before egg hatch.

```

Grasshopper Population Simulation
Hatch Pre(Y) Post(N)
instar1 % : 0 instar2 % : 0
instar3 % : 0 instar4 % : 0
instar5 % : 0 instar6 % : 0
Life Stage Duration (days) : 5
Daily Survival (%/day) : 95
Starting Date : 6/01/00
Treatment
Do you want Use a treatment (Y/N) : Y
Application Date : 6/25/00
Mortality (Total %) : 90
Duration (days) : 5
Model Performance
Speed Reduction (0 = Fast) : 0
ESC:Exit F1:Help F5:Run Model
  
```

Figure VI.2-23—Postegg-hatch onscreen data-entry form for *SimHop*.

```

Grasshopper Population Simulation
Hatch      Pre(Y) Post(N) :  Y
Median Hatch Date      5/20/00

Start Hatch Date      5/ 1/00

Total Expected Hatch (Eggs/yd²)  1000

Life Stage Duration (days)      5
Daily Survival (%/day)          95

----- Treatment -----
Do you want Use a treatment (Y/N):  Y
Application Date      6/25/00

Mortality (Total %)          90
Duration (days)            5

----- Model Performance -----

Speed Reduction (0 = Fast)      0

ESC:Exit  F1:Help  F5:Run Model

```

**Figure VI.2–24**—Pre-egg-hatch onscreen data-entry form for *SimHop*.

You can change between the pre-hatch model and the post-hatch model by entering **Y** or **N** in the first field. The data-entry screen will switch so you can enter data for the model you chose. The last value on the screen is to slow the simulation so that the graph and data can be viewed in more detail. Press **<F1>** for more information on any current data value (where the cursor is flashing). Change any information on the screen; then press **<F5>** to run the simulation.

While *SimHop* is running, control keys in the lower right corner of the simulation results screen (fig. VI.2–22) can be used to slow, stop, reverse, or increment (step by step) the simulation. The layout of these keys represents the numeric keypad to the right on the computer keyboard. To use the numeric keypad during *SimHop*, turn off the Num-Lock. You could stop a simulation by pressing **<SpaceBar>** and then reverse the simulation by pressing the numeric keypad “4.” **<SpaceBar>** will start and stop a simulation.

This tabulation explains the definitions of 1–9 on the numeric keypad:

<b>Int Spd (7)</b> Initial Speed	<b>Spd Up (8)</b> Increase speed	<b>Stp On (9)</b> Toggles step mode
<b>Rev Gph (4)</b> Reverse graph	<b>Print (5)</b> Print current screen to a file	<b>Fwd Gph (6)</b> Forward direction for graph
<b>Lbl ON (1)</b> Toggle numeric output to screen	<b>Slow Dn (2)</b> Decrease graph speed	<b>Dly ON (3)</b> Toggle delay for graph

The consumption rates used in *SimHop* are based on laboratory measurement for *Melanoplus sanguinipes*. Therefore, *SimHop* should be used to help with general understanding of grasshopper population dynamics, not to make precise estimates of forage loss.

**Maps.**—*Maps* allows you to select and view grasshopper hazard maps for several States. To select a State, move the highlighted bar to the State desired and press **<ENTER>**. When you are finished viewing the map, press **<ENTER>** to continue. To exit the *Maps* module, press **<ESC>** at the State selection submenu.

**Economic Threshold.**—Hopper can estimate the density of grasshoppers for a specified BC ratio. This estimate is also dependent on grasshopper life stage and species composition and current economic variables. The grasshopper density that corresponds to the BC ratio can be considered an economic threshold. In some situations, you might specify a BC ratio that cannot be achieved—one that is either too high or too low. Hopper will inform you when this situation occurs.

The *Economic Threshold* calculator will first run *Consult* to develop a list of treatments and then allow you to select one of those treatments and enter a BC ratio. Remember that BC ratios greater than 1.0 indicate a treatment profit for the single-year analysis. Next, an economic analysis will begin similar to the analysis in the **Treatment Selection** module. Generic models cannot be used for the *Economic Threshold* calculator. You can enter or modify any of the data to match your situation.



Hopper will run the analysis several times to find the economic threshold. This may take 3 minutes on a 486 computer. However, no intervention is required until the final results are presented. Results can be saved to a report file.

**Forms.**—You can create and print hard-copy data-entry forms that you can use to collect input data for Hopper. The forms will contain default values from Hopper or values from any data you have saved during an economic analysis. These can be a handy way to prepare to run Hopper because you will have at hand all the information Hopper requests. Select *Forms* and a submenu of items will be presented. You can create, view, or print a form. When you select “Create,” a list of economic data files in your Hopper directory is displayed. These files have the ending .ec3. Highlight a file and press <ENTER> to create the form for those data. Next, you could view the new form on the screen or print it.

## Setup

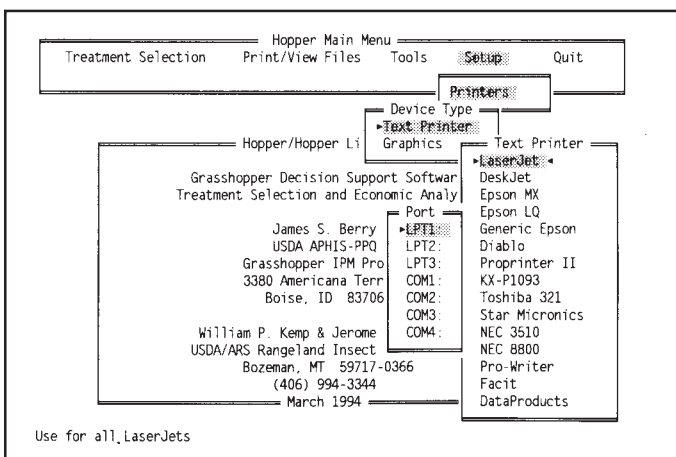
**Printers.**—Hopper uses the printer type (text and graphics) you select here to format properly the documents it prints. The printer information is stored in a file. Therefore, you need only select a printer once, unless you change printers. Select both a text printer and a graphics printer.

**Text Printers.**—Hopper will print existing reports and information in *eXplain* to your text printer. With Text Printers highlighted on the menu, press <ENTER> and a list of printers will appear (fig. VI.2–25). Use the arrow

keys to highlight your text printer (or a similar model). If your printer is not listed, check to see if it is compatible with any other printers listed. The Epson printer is very common, and many printers are compatible with it. If your actual printer-model is not listed in Hopper, try selecting Epson instead. The text printer and graphics printer are often the same. However, you need to set up both types of printers in Hopper if the default printers are not acceptable. The text printer must be connected to a printer port (e.g., LPT). If your printer is connected to a COM port, you can place a Mode command in the file `autoexec.bat` to route the printer data through LPT1. For example, if your printer is attached to the serial port COM1, you should place this line in the `autoexec.bat` file:

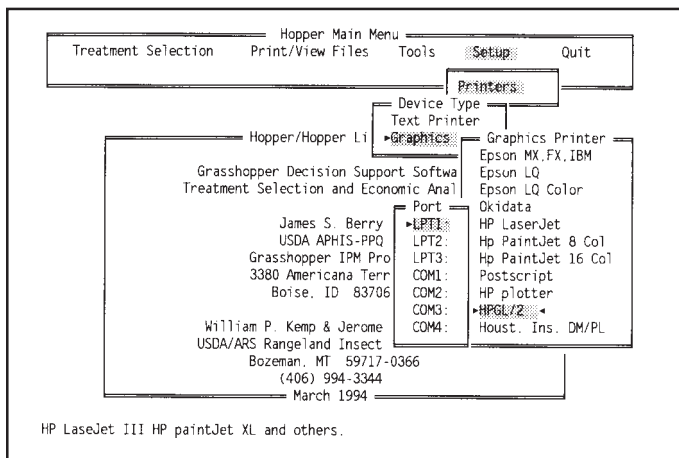
```
mode lpt1=com1
```

**Graphics Printers.**—Hopper does not print graphics information directly to a printer. Instead, graphics are “printed” to a file. The format of the graphics file is determined by the graphics printer you select here. The advantage of having the graphics in a file is that they can be imported into a word processor or graphics software. For example, you can import Hopper’s graphics (from the simulation models and *SimHop*) into your word processor document. The Hewlett–Packard Pen Plotter is the default graphics printer. Graphics files for this graphics printer consist of lines and end points (vector graphics), and the format is HPGL/2. Therefore, with this format, graphics can be reproduced at the maximum resolution of the printer device, and most graphics editors (such as Lotus Freelance™ and Harvard Graphics®) can import and edit them. Laser-printer or dot-matrix printer output cannot be imported into these graphics editors. Hopper prints only graphics from the **Print/View Files** submenu (see Graphs, page VI.2–13). Therefore, the graphics printer port is not used if you will only import graphics files into other software without ever printing directly. **Note:** Remember that if you select a dot matrix or laser printer, you will need at least 512 to 1024 KB of expanded memory (EMS). See the Installation section at the front of this manual for instructions for configuring your computer’s memory.



**Figure VI.2–25**—Setup submenu selected and Text Printer highlighted.

To change the graphics printer, highlight “Graphics” on the menu and press <ENTER>; a list of printers will appear (fig. VI.2–26). Use the arrow keys to highlight your printer (or similar model) and press <ENTER>. If your printer is not listed, check to see if it is compatible with any other printers listed. Again, select “Epson” as first try if your printer-model is not listed. Next, a menu of ports for the graphics printer will be displayed. The normal port is LPT1. Select the correct port; then press <ENTER>. The text printer and graphics printer are often the same. However, you need to set up both types of printers in Hopper if the default settings are not acceptable. **Note:** Some graphics printers (dot matrix and some laser printers) will not work in Hopper unless the computer has about 512 KB of EMS (expanded) memory available.



**Figure VI.2–26**—Setup submenu selected and Graphics selected with the Hewlett–Packard Pen Plotter highlighted (HPGL/2).

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## Software Credits

Borland Pascal 7.0, Borland International, Inc., Scotts Valley, CA. Pascal Compiler.

Object Professional®, TurboPower Software, Scotts Valley, CA. User interface and general programmer's software toolbox for Turbo Pascal.

Turbo Analyst™, TurboPower Software, Scotts Valley, CA. Analytical tools in an integrated development environment, including Pascal formatter, cross referencer, execution timer, execution profiler, program indexer, and program lister.

Tlib Version Control™, Burton Systems Software, Cary, NC. Source code librarian.

PCX Programmer's Toolkit™, Genus Microprogramming, Houston, TX. Routines to display, save, scale, and print PCX images.

BLP88, Eastern Software Products, Alexandria, VA. Linear programming with bounded variables for the IBM-PC, used for the economic analysis.

INGRAF 6.0™, Integrated Graphics Library for Pascal, SutraSoft, Sugar Land, TX. Routines for scientific plotting and graphs.

INSTALIT™, Helpful Programs, Inc., Huntsville, AL. Hopper installation program.

USCLIMAT.BAS, Weather generator, U.S. Department of Agriculture, Agricultural Research Service, Northwest Watershed Research Center, Boise, ID. (Contact: C. L. Hanson.)

RanchMod, Economics Module, M. Skold and R. Davis, Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, CO.

## Appendix A How Hopper Works and Why

By Larry Zaleski

**Why You Should Know How Hopper Works.**—You should know how Hopper works to help accomplish your treatment responsibilities skillfully and accurately.

Whether you're a rancher or government official, professional and financial considerations demand that you work skillfully and accurately. Applying pesticides when *not* needed may threaten the environment and waste money. Conversely, failure to apply pesticides when conditions warrant may jeopardize native rangeland and potentially threaten the local ranching economy.

Hopper helps you decide objectively whether to treat or *not*. But you must use Hopper correctly for good results. And to use Hopper correctly, you must know how the program works.

**What You Should Know.**—You should be familiar with the following:

- How Hopper can save time, improve accuracy, and save money
- What the economic research shows
- How Hopper's components work together
- What the expert system (Consult) does
- What the forage model (RangeMod) does
- What the grasshopper model (HopMod) does
- What the economics model (RanchMod) does
- Your role

As you become familiar with Hopper, you will become more knowledgeable about treatment technology, rangeland ecology, and ranching economics.

**How Hopper Can Save Time, Improve Accuracy, and Save Money.**—Hopper saves time, improves accuracy, and saves money by

- Automating expensive and time-consuming tasks, and
- Using ecological and economic information previously unavailable to decisionmakers.

**Automating Expensive and Time-Consuming Tasks.**—Hopper automates many tasks that require time, money,

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and personnel to accomplish. You still collect information about local conditions, but with Hopper, your treatment decisions are greatly *improved* with little additional effort. To understand the value of automation, you should know

- What Hopper does automatically,
- How Hopper automates tasks, and
- How automation improves treatment decisionmaking.

**What Hopper Does Automatically.**—Hopper automatically

- Estimates the average instar of a grasshopper population (for integration with field data);
- Estimates the effects of precipitation on forage production;
- Estimates forage production and, then, forage loss to grasshoppers;
- Chooses treatments based on local conditions; and
- Determines if treatment is cost effective.

Without automation and computer simulation, many of these tasks are impractical or more likely to be completed with errors.

**How Hopper Automates Tasks.**—Hopper automates tasks by integrating an expert system with simulation and economic models (Berry et al. 1991, 1992).

Hopper's expert system is rule-based. Rule-based expert systems are computer programs consisting of rules.

These rules are the same as those used by human experts, but the expert system uses the computer's ability to apply logic, instead. For example, an expert system program for reacting to a *traffic light* might look like this:

IF THE LIGHT IS RED: Stop and wait for the light to turn green.

IF THE LIGHT IS GREEN: Go on.

IF THE LIGHT IS YELLOW: Slow down, and...

— If the light turns red, stop, wait for it to turn green, then go on.

— If the light doesn't turn red, go on.

The computer runs through the program until it encounters an "if statement" that matches the current condition. Then the program follows the programmed procedure. Hopper's expert system works similarly, but it's designed to select treatments. Hopper asks questions, matches

your answers to its rule base, then lists treatments accordingly.

Models, on the other hand, are mathematical formulas that imitate events in the real world. Models allow you to make predictions and estimates about events in the real world. Previously, such models were too time-consuming and complicated for everyday use. Only scientists could use them. But the personal computer has changed that.

**How Computer Automation Improves**

**Decisionmaking.**—Computer automation improves decisionmaking in two ways. First, automation is comprehensive. That is, Hopper requires that you answer questions needed to make accurate decisions, each time. Critical factors, including those you might *not* ordinarily consider, are routinely considered. Without this prompting, you might ignore some factors to save time or because you don't know how to evaluate them.

Second, automation is consistent. It's consistent because users answer critical questions each time and because Hopper evaluates data the same way each time—something that people seldom do. Consequently, two people independently entering the same data into Hopper achieve the same results each time. Thus, Hopper transforms treatment decisionmaking into a more objective and scientific process.

Simulation, completeness, and consistency result in improved accuracy at roughly the same cost.

**Using Ecological and Economic Parameters Previously**

**Unavailable to Decisionmakers.**—Hopper achieves improved accuracy because it uses parameters and variables that were previously impractical or unavailable (Davis et al. 1992). Even though these parameters were important, they were often not used because they were too costly and time consuming to obtain or because they could not be analyzed fast enough to help. As a result, treatment decisions were based on partial information.

Recently, however, researchers have shown that many of these unused but critical variables can be simulated mathematically. Other variables have been determined by the Grasshopper Integrated Pest Management Project and cooperators.

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**Before Hopper, Treatment Decisions Were Based on Less Extensive Information.**—Hopper estimates critical variables previously unavailable to decisionmakers.

Biologists and economists knew these variables were important, but only well-funded research projects could collect and analyze the data. And the results of their analysis usually came too late to help.

But the economic basis for control of grasshoppers on rangeland depends on several variables, not just grasshopper density (Davis et al. 1992). These critical variables include

- Rangeland productivity,
- Soil moisture,
- Livestock prices,
- Accessibility and cost of alternative forage,
- Effectiveness and timing of treatments, and
- Grasshopper numbers and composition.

These variables, however, are difficult and expensive to measure. Many could not be analyzed quickly. And few scientists, ranchers, or government officers could measure and interpret all of the variables. Consequently, no one could integrate the critical variables into a practical decision support system.

**Critical Variables Can Be Estimated Mathematically.**—Recently, researchers demonstrated that many critical variables could be estimated mathematically (Berry and Hanson 1991, Berry et al. 1995, Dennis et al. 1986, Kemp and Onsager 1986). Therefore, for some variables, mathematical simulation provides an alternative to sampling and measurement.

When combined with a personal computer, mathematical simulations provide quick, reliable estimates of difficult-to-measure variables. For the first time, critical variables are routinely available to decisionmakers. What's more, estimated variables can be combined with economic calculations to determine if treatment is cost effective.

**What the Economic Research Shows.**—The economic research reveals three key facts (Davis et al. 1992):

1. Decisionmakers should use an economic threshold as their basis for applying treatment.

2. Economic justification for grasshopper control programs depends on several variables, *not* just grasshopper population density.
3. Economic justification for grasshopper control programs varies from place to place and year to year.

**Decisionmakers Should Consider Economic Threshold in Their Decision About Applying Treatment.**—

Economics is a primary justification for treating grasshopper infestations. So ranchers should treat grasshoppers *not* to reduce their numbers but to improve the profitability of the ranch. Reducing grasshopper numbers is only a tactic for managing the rangeland resource.

From a ranching perspective, even rangeland management—a continuous effort which some use as a justification for grasshopper control—is simply an economic endeavor aimed at preserving rangeland productivity. Preserving productivity preserves profit. To illustrate the profit motive: one way to manage the land and prevent range damage during a grasshopper outbreak is to remove cattle. But this option is unprofitable, so ranchers tend to avoid cattle removal when possible. Generally, ranchers seek more profitable alternatives.

Environmental factors are important, too, and may *prevent* treatment. But in most cases, the basis for your decision to treat or not is economic.

To apply an economic threshold to treatment decisions confidently, you need to understand the concept of the economic threshold and the concept that treatment is an investment.

**The Economic Threshold.**—The economic threshold is the population density of a pest at which the cost of management intervention equals the resulting benefit from controlling it. The economic threshold varies with the benefits and the cost of treatment (Davis et al. 1992).

**When Does Treatment Become Profitable?**—The economic threshold is reached when the benefit–cost ratio equals 1 or more.

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Hopper determines the economic threshold by calculating the benefits of treatment, then dividing the benefits by the cost. This measure is called the benefit–cost ratio (BC):

$$BC = \frac{\text{Benefits}}{\text{Cost}}$$

When the benefits equal the cost, the ratio is equal to 1 and the economic threshold is achieved. For example:

Benefits of treatment = \$5,000

Cost of treatment = \$5,000

$$BC = \frac{\text{Benefits}}{\text{Cost}} = \frac{\$5,000}{\$5,000} = 1$$

BC's greater than 1 are profitable, but BC's less than 1 are unprofitable. The economic threshold (BC = 1) is the break-even point.

The cost of grasshopper control includes wages and the cost of chemicals, baits, and equipment. The benefit of grasshopper control, on the other hand, is equal to the *value* of the forage saved by treating grasshoppers.

**Treatment Is an Investment.**—Treatment is an investment in the agricultural economy. You apply treatment to attain or improve profitability.

Typically, you expect a return on your investments. For example, if you invest \$100 in a savings account, you expect to collect interest, which is a return. If the account pays 5 percent simple interest, then after a year you would have \$105. The BC of your account would be  $\$105 \div \$100 = 1.05$ . Because the BC is greater than 1, the account is profitable.

You would *never* knowingly invest in a savings account that loses money (an account whose BC is less than 1). Investing when the BC is less than 1 is unprofitable, and thus, economically unjustified.

Treatment, too, should show a return. Treating when the BC is less than 1 is unprofitable, and thus, economically unjustified.

**Variables Affecting Economic Justification of Grasshopper Control Programs.**—At least seven variables determine the economic justification for grasshopper control programs on rangeland:

- Rangeland productivity and composition,
- Precipitation and soil moisture,
- Accessibility and cost of alternative forage,
- Effectiveness of treatment,
- Cost of treatment,
- Timing of treatment, and
- Grasshopper population density, life stage, and species composition.

Put simply, these variables determine the *value* of the forage grasshoppers eat (the damage grasshoppers cause) and how much damage can be prevented. The interaction between critical variables is complex.

For example, if rangeland produces too much or too little forage, you cannot economically justify treatment. If *excess* forage is produced, there is enough to feed both grasshoppers and livestock, so you cannot justify treatment. On the other hand, if too little forage is produced, there is no forage to protect, so again, you may not be able to justify treatment purely based on forage value.

Consequently, the effects of the variables below assume that there is forage to protect, but *not* too much or too little. Otherwise, some of the following information would contradict. In practice, Hopper accounts for the effects of forage production automatically.

**Rangeland Productivity and Composition.**—On *highly productive* rangeland, you can economically justify treatment at lower grasshopper population densities than you can on less productive rangeland (Davis et al. 1992). This is true because treatment saves more forage per acre on highly productive rangeland.

The more forage you save per acre, the lower the cost per unit of forage saved and the greater your benefit for a given per-acre treatment cost. Consequently, on productive rangeland, you can treat *fewer acres* and still get the same per-acre benefit. The fewer acres you treat, the lower the cost.

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In addition, some forage species are more valuable than others. Generally, the more valuable the forage, the easier it is to justify treatment.

**Precipitation and Soil Moisture.**—During *dry years*, you can economically justify treatment at lower grasshopper population densities than in years of normal or high precipitation.

Precipitation is the most important factor affecting rangeland productivity (Berry et al. 1991). Obviously, if it doesn't rain or snow, forage won't grow. When forage is scarce, its value increases because you must supplement it by buying hay or leasing additional land. Remember that, although the value of the forage may increase in dry years, the amount that will be protected by controlling grasshoppers is reduced. Hopper considers both of these factors.

In contrast, during normal and wet years, when forage is plentiful, there is often enough forage to feed both livestock and grasshoppers—even at high grasshopper population densities.

Hopper evaluates the effect of precipitation by calculating soil moisture.

**Accessibility and Cost of Alternative Sources of Forage.**—When alternative sources of forage are *expensive* or *inaccessible*, you can justify treatment at lower grasshopper population densities than when prices are low and forage accessible. This is true because when alternative sources of forage are expensive, you pay more to supplement or replace your existing forage. Therefore, your existing forage is worth more, and you can justify paying more to protect it.

**Effectiveness of Treatments.**—Other things being equal, when treatment is highly effective, you can justify treatment at lower grasshopper population densities than when treatment is ineffective. The more effective treatments are, the greater their value, and the higher the benefit–cost ratio.

**Cost of Treatment.**—When treatment is inexpensive, you can justify treatment at lower grasshopper densities than

when treatment is expensive. Several factors influence the cost of treatment, including the price of pesticides, biological control agents, equipment, and personnel. In addition, the cost of treatment varies with demand. In years with lots of spraying, sprayers demand higher fees. Clearly, you need higher grasshopper densities to justify treatment at \$4 per acre than you do at \$2.25 per acre.

**Timing of Treatment.**—Timing influences the effectiveness and value of treatment. If you treat too early or too late, you reduce effectiveness. If you treat too early, many grasshopper eggs are still unhatched and will be unaffected. And if you treat too late, the forage is already eaten and next year's eggs are laid. In either case, the benefits are reduced.

**Grasshopper Population Density and Composition.**—Clearly, you can more readily justify treatment at higher grasshopper population densities than you can at lower grasshopper population densities. The higher their population density, the more forage grasshoppers eat. If the grasshopper density reaches the economic threshold, then grasshoppers literally eat up your profits.

In addition, species composition is important. Some grasshopper species do more harm than others. You can justify treating more-harmful species at lower densities than less-harmful species.

But as you've seen, several factors, in addition to grasshopper population density and composition, determine the economic threshold.

**The Economic Justification for Grasshopper Control Varies From Place to Place and Year to Year.**—Because the variables affecting the cost effectiveness of treatment vary from place to place and year to year, the economic justification for grasshopper control varies, too.

Conditions vary from place to place. For example, one pasture is more productive than the next, or one county has normal precipitation, while another is dry. Consequently, you may treat grasshoppers profitably at 1 location when densities reach 18 per square yard but not at another location until they reach 25 per square yard.

Similarly, conditions vary from year to year. Over time, a ranch may experience fluctuating precipitation, live-stock prices, and lease costs. In 1 year grasshoppers may be worth treating at 30 per square yard; the following year, grasshoppers may be worth treating at 20 per square yard.

Normal variation of ranching conditions demands a flexible response to grasshopper treatment. Hopper provides flexibility by accounting for differences in conditions that vary with location and time.

**How Hopper's Programs Work Together.**—Hopper uses three kinds of software technology to assist you in making treatment decisions (fig. VI.2-27):

1. An expert system—to select treatments,
2. Simulation models—to estimate difficult-to-measure variables, and
3. An economic model (ranch model)—to determine if treatment is cost effective.

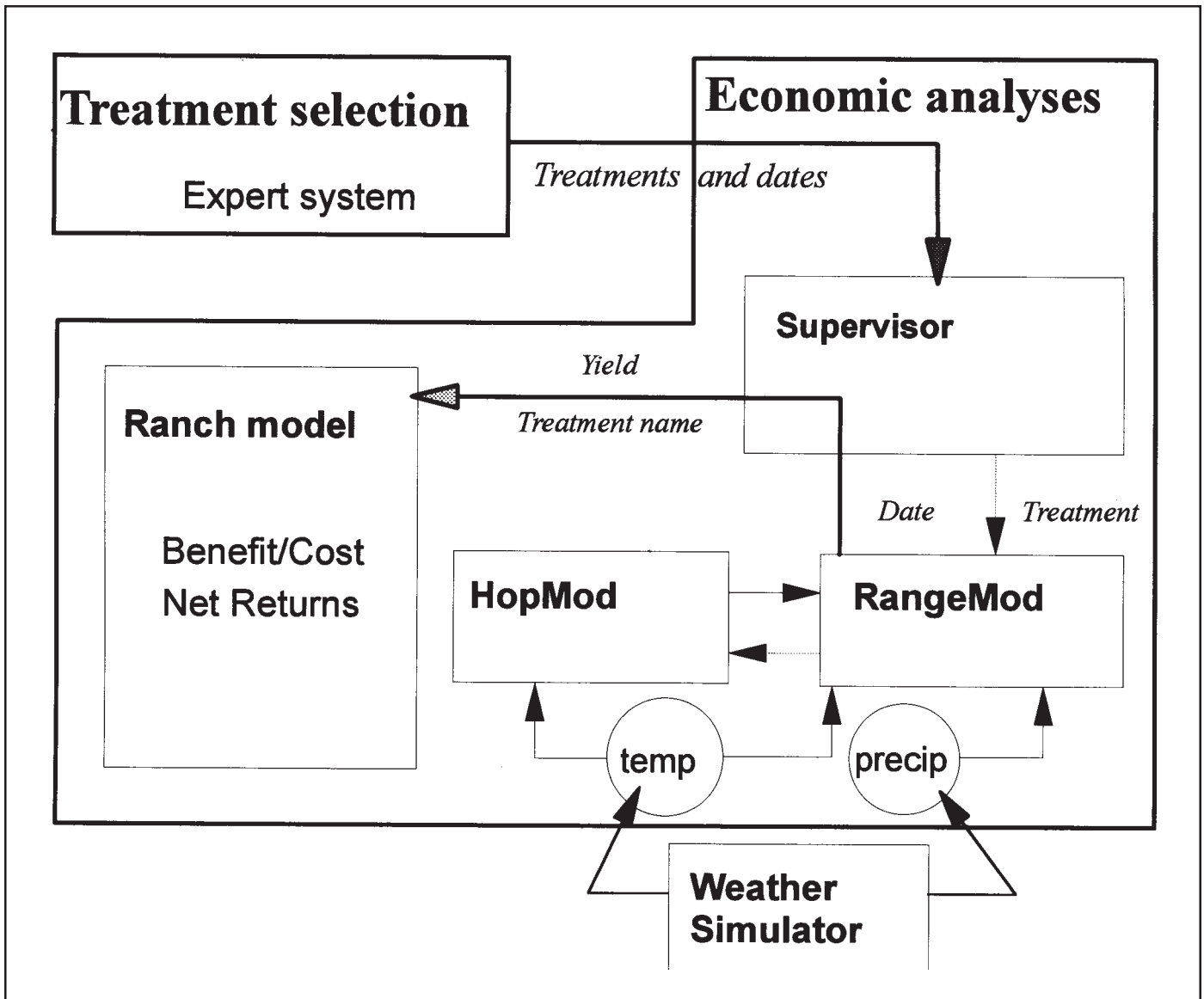


Figure VI.2-27—Overview of Hopper user interface and internal modules.



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These technologies work together to provide decision support. Below is an overview of each class of technology. As each technology is introduced, you'll learn how it works with the others.

**The Expert System.**—The expert system (Consult) helps you choose grasshopper treatments as accurately as an expert. It does this by asking questions about the site, giving some of this information to simulation models to estimate grasshopper life stage, evaluating the data against an internal set of rules, and then providing you with a list of suggested treatments appropriate for the situation (Berry et al. 1991).

**The Simulation Models.**—The simulation models (HopMod and RangeMod) calculate values for critical variables that would otherwise require additional sampling and analysis.

Hopper uses simulation models to estimate the effects of precipitation, forage production, treatment mortality, grasshopper species composition and life stage (Berry et al. 1995). Information from the simulation models is used by the expert system and economics model.

Simulation models allow Hopper to respond to factors that change over time, like grasshopper life stage and forage production (Berry et al. 1991).

**The Economics Model.**—The economics model (RanchMod) is a linear programming model that does two things. First it determines if treatment is cost effective. Second, it determines which of the treatments listed by Consult is most cost effective. The economics model uses information from the expert system and simulation models to determine a benefit–cost ratio.

Hopper's models work together to provide reliable decision support. As a result, you can be more confident in your treatment decisions.

**What the Expert System Does.**—Hopper's expert system (Consult) provides you with a list of treatments appropriate for the conditions you specify. Consult uses internal rules to decide which treatment(s) to list (Berry et al. 1991). In addition, only treatments approved by the

Environmental Protection Agency and the Environmental Impact Statement for the Cooperative Rangeland Grasshopper Program are considered.

**Where Consult Gets Its Information.**—Consult uses information from three sources. First, Consult asks you the following:

- Location?
- Species composition?
- Grasshopper census date?
- Treatment date?
- Presence or absence of managed bees?
- Should treatments harmful to beneficial insects be eliminated from consideration?
- Do conditions prohibit the use of toxic chemicals?
- Vegetation thickness?
- Current weather conditions?
- Percent of the hopper population already hatched (if known)?

Second, Consult uses Hopper's own weather model to enter weather data for the site.

Third, Consult uses the grasshopper model (HopMod) to calculate the average life stage at the time treatment will be applied and number of grasshopper eggs that will be deposited during the current year. This allows Consult to decide if it's too early or too late to treat the infestation economically.

**What Consult Does With the Information.**—Consult evaluates the information supplied against an internal set of rules. These rules allow Consult to choose treatments appropriate for local conditions.

Consult selects from five treatments approved by the Environmental Protection Agency and the final Environmental Impact Statement for use against grasshoppers on rangeland:

- Acephate spray,
- Carbaryl spray,
- Malathion spray,
- Carbaryl bait, or
- *Nosema locustae* bait (a pathogen of grasshoppers and Mormon crickets).

Depending on the conditions you specify, Consult may recommend none, one, or all of the treatments for economic evaluation. Carbaryl bait, for example, might be recommended when the presence of commercial bees or endangered species prohibit spraying in the area. *Nosema locustae* may be recommended for use near bodies of water, where chemicals are prohibited.

Consult considers species composition and development in making treatment recommendations because:

- Some species *don't* take baits, so you can't use baits.
- Some species *won't* eat the predominant local forage, so you *don't* have to control them.
- Some species develop faster or slower than the bulk of the population, so you should adjust treatment timing.

By accounting for these factors, Consult can alter its treatment list and, ultimately, the decision whether and when to treat.

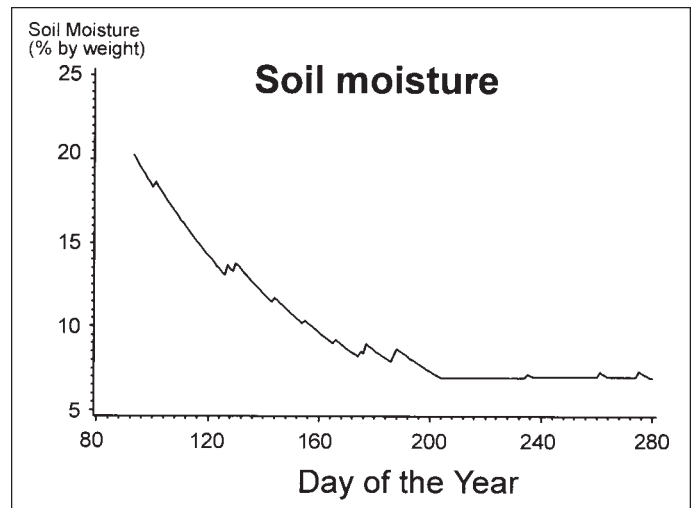
#### **What the Forage Model (RangeMod) Does.—**

RangeMod simulates growth of cool- and warm-season grasses and forbs on rangeland during a single growing season (Berry and Hanson 1991). Important features of the model include the following:

- Forage production depends on soil moisture and projected peak standing crop.
- Temperature starts and ends plant growth.
- Forage production occurs logistically (forming an S-shaped curve).

***Forage Production Depends on Precipitation and Peak Standing Crop.***—RangeMod determines forage production based on daily precipitation and an estimate of peak standing crop. The model uses either known precipitation averages from nearby cities or precipitation data that you supply. Forage consumption by wildlife is *not* estimated or considered by Hopper.

Precipitation directly affects soil moisture, which RangeMod calculates as a function of dry days (consecutive days without precipitation). The model causes soil to dry exponentially (quickly when wet but more slowly as moisture decreases—fig. VI.2–28) down to a minimum of 3 percent by weight. For comparison, the permanent wilting point for plants is reached when soil moisture is 10 percent (Berry and Hanson 1991).



**Figure VI.2–28**—The effect of drying with occasional precipitation on soil moisture content. This pattern is typical for northern latitudes in the West.

#### ***Temperature Starts and Ends Plant Growth.***—

RangeMod uses a threshold temperature to begin growth in the spring, and to end growth in the fall. The model starts calculating growth when the temperature (the average of the daily high and low) exceeds 32 °F for 5 consecutive days. Growth occurs if daily minimum temperature is above the threshold for the plant type—44.6 °F for forbs and cool-season grasses, and 50 °F for warm-season grasses (Berry and Hanson 1991).

In RangeMod, temperature is *not* a factor in forage production except for its role in starting and ending growth (Berry and Hanson 1991).

***Forage Production Occurs Logistically.***—When graphed, forage production forms a logistic (S-shaped) curve (fig. VI.2–29). The logistic curve simulates forage production in pounds per acre over time. RangeMod simulates forage production for forbs, cool-season grasses, warm-season grasses, and total production, producing a logistic curve for each.

The *exact* shape of the logistic curve varies with precipitation and forage consumption by grasshoppers. Hopper simulates grasshopper forage consumption in the grasshopper model, HopMod.

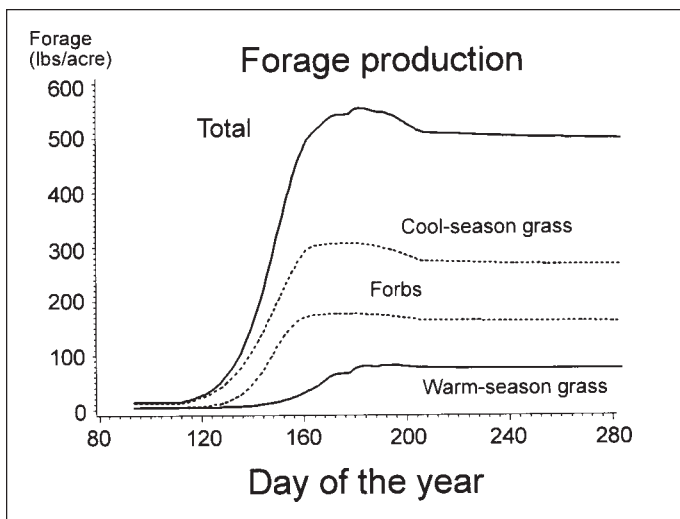


Figure VI.2-29—The logistic growth of forage appears S-shaped.

**What the Grasshopper Model (HopMod) Does.—**

HopMod determines forage loss caused by grasshoppers and determines the loss that you can prevent by applying treatment (Berry et al. 1991).

HopMod simulates grasshopper development through time. Predicting development is important because the amount of forage eaten by grasshoppers per day varies greatly for each life stage. Early instars eat less than later instars. And because the proportion of each instar in the population changes daily, forage consumption changes daily, too.

HopMod’s simulation of grasshopper development, in conjunction with the forage and economics models, allows you to decide whether or not to treat at a given time in the grasshopper’s growing season.

To understand HopMod, you must understand the following:

- What the grasshopper phenology (growth and development) model does,
- How HopMod determines population size,
- How HopMod calculates forage consumption,
- How HopMod determines oviposition, and
- How accurate HopMod is.

**What the Grasshopper Phenology Model Does.—**Phenology is the study of the relationship between climate and recurring biological events, such as grasshopper life

stage. The grasshopper phenology model estimates the proportion of the grasshopper population in each life stage on any given day as a function of time and temperature (fig. VI.2-30).

A proportion is a percentage divided by 100. For example, the proportion “0.8” is derived as follows: 0.8 = 80 percent ÷ 100. Most people use proportions frequently for various routine calculations.

*How Development Is Calculated.—*The model determines grasshopper development based on time and temperature, called development time (Kemp and Onsager 1986). Grasshopper development is controlled primarily by temperature, so development time is measured in degree-days.

*Degree-Days Are Accumulated Heat.—*A degree-day is a measure of accumulated heat. Degree-days accumulate in HopMod when the air temperature is between 40 °F (4.4 °C) and 100 °F (37.8 °C) (Berry et al. 1995).

For example, when the daily minimum and maximum temperatures are between 40 °F and 100 °F, HopMod calculates degree-days like this: If the air maximum temperature is 70 °F and the minimum is 40 °F, then there are 70–40 = 30 degree-days of development.

HopMod averages degree-days over a day–night cycle. The program adds degree-days when the temperature is

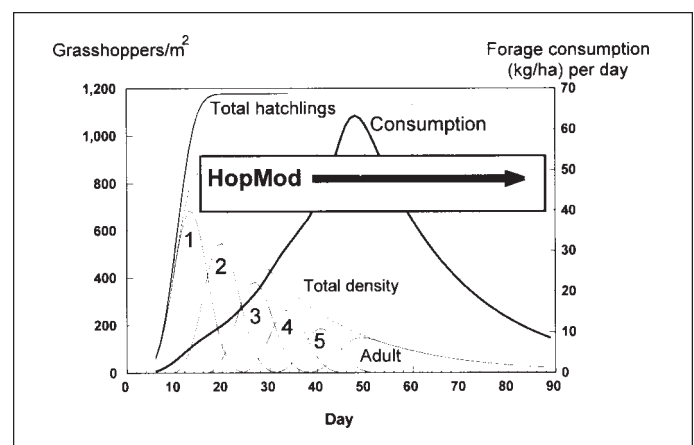


Figure VI.2-30—General progression of a grasshopper population during the spring and summer. HopMod begins when the population has peaked and egg hatch has finished.

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within the thresholds. HopMod uses a modified sine-wave formula to adjust and accumulate degree-days as the value changes during the day–night cycle. (A sine-wave formula creates a curve similar to the wave pattern you’d see on an oscilloscope. The wave fluctuates above and below a line. In this case, above the line represents daylight; below the line represents night.) In this way, HopMod calculates the average instar, which is displayed in Consult.

When necessary, you can change Hopper’s estimate of the average instar. For example, if you measure an average instar that is different than HopMod’s estimate, you can replace Hopper’s estimate with your measurement, and HopMod will adjust.

*Development Is Based on Accumulated Increments of Development Time.*—HopMod assumes that the development rate of a grasshopper depends on accumulated increments of development time (Kemp and Onsager 1986). The process is defined as the amount of development time that a grasshopper has accumulated by a given actual time.

HopMod uses Hopper’s weather data base to calculate degree-days. Then HopMod calculates grasshopper development for each calendar day of the growing season. The result is a list of proportions for each life stage for each day. For example, on a given day, you might see the following: instar 1 = 0.1 (10 percent), instar 2 = 0.3 (30 percent), and so on. The proportions must add up to 1.00 (representing 100 percent of the grasshopper population) for the day.

*How HopMod Determines Population Size.*—HopMod gets the grasshopper population size from you. For example, you count 20 grasshoppers per square yard and type in that number. HopMod, however, adjusts over time for natural grasshopper mortality itself.

HopMod calculates average natural grasshopper mortality using a density-dependent model. The larger the grasshopper population, the faster grasshoppers die.

HopMod, however, does *not* have an egg-hatch model. Consequently, HopMod *cannot* add newly hatched grass-

hoppers to the population. The program assumes all eggs have hatched by the census date.

***How HopMod Calculates Forage Consumption.***—

HopMod calculates forage consumption in five steps:

1. HopMod determines the *proportion* of grasshoppers in each instar (life stage), each day. For example, instar 1 = 0.1, instar 2 = 0.3, instar 3 = 0.4, instar 4 = 0.15, instar 5 = 0.05. Remember, the total must add up to 1.00, meaning 100 percent of the population. The proportions in each instar change each day but always add up to 1.
2. HopMod determines the *number* of grasshoppers in each instar by multiplying the proportion in each instar by the population density of first grass feeders, then mixed feeders (usually, grass feeders won’t eat forbs, so forbs are protected from grass feeders without treatment). You supply the data on population density and composition.  
  
For example, if the grasshopper population density is 20 per square yard and is 80 percent grass feeders, then—assuming the proportion of instar 2 = 0.4—the number of grass-feeding grasshoppers in instar 2 is:  
 $20 \times 0.4 \times 0.8 = 6.4$  per square yard.
3. HopMod determines *how much* forage each instar consumes by multiplying the feeding rate of grasshoppers in each instar (supplied by Hopper and based on scientific measurement) by the number of grasshoppers in the instar.
4. HopMod determines *total* forage consumption by adding the consumption of each instar for each day of the growing season. This value is passed to RangeMod and subtracted for each forage type from the amount of forage for the day. If conditions are favorable, forage continues to grow, and forage loss is usually less than the total consumption by grasshoppers.
5. Finally, HopMod *repeats* the process (steps 1–4) after applying simulated treatments. For example, if there are 20 grasshoppers per square yard, and the treatment is 92 percent effective (only 8 percent survive), then *after treatment* the population is  $20 \times 0.08 = 1.6$  grasshoppers per square yard.

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HopMod calculates forage consumption by grasshoppers on both treated and untreated rangeland to determine the difference in consumption. This difference is the *benefit* to the ranch.

HopMod repeats the process for each treatment selected by Consult. Available forage is used in the economics model (RanchMod) to determine the benefit–cost ratio for each treatment.

**How Oviposition Is Determined.**—HopMod assumes that grasshoppers lay eggs at a constant rate. The rate is different for grass feeders and mixed feeders. For grass feeders, the rate is 0.6550 eggs/adult female/day; and for mixed grass feeders, the rate is 0.4564 eggs/adult female/day (Berry et al. 1995).

**How Accurate Is HopMod.**—HopMod has been field validated (Berry et al. 1995). HopMod correctly simulates the general patterns of rangeland grasshopper population dynamics within a given year (Berry et al. 1991).

**Comparison of Field Data and the Grasshopper Model.**—Figure VI.2–31 shows a comparison between field data and the phenology model’s plots. As you can see, the calculated values closely match the field values. In addition, the estimates of forage consumption by the different grasshopper instars are based on scientific measurement. Therefore, you can expect HopMod to produce reasonable approximations of grasshopper forage consumption.

**Steps You Can Take To Improve Accuracy.**—You can improve accuracy in two ways:

1. Conduct the grasshopper census as close to the treatment date as possible.
2. Enter actual measurements of the average instar instead of accepting calculated values.

Remember, HopMod does *not* have an egg-hatch model. Consequently, HopMod cannot add newly hatched grasshoppers to the population. As a result, the greater the time between field measurement and treatment the greater the error in estimating average instar and density. So for best results, use current data.

Also, observed measurements are the best estimate of reality. Therefore, whenever possible, enter observed measurements instead of relying on Hopper’s initial life-stage estimates.

**What the Economics Model (RanchMod) Does.**—RanchMod determines the value of the forage. With this information, and with information from the other Hopper models, RanchMod can determine if a treatment is cost effective. In addition, RanchMod compares the cost effectiveness of each treatment listed by Consult, so you can decide which treatment is *most* cost effective. The model reports cost-effectiveness as a benefit–cost ratio.

To understand RanchMod, you must know the following:

- How RanchMod determines the benefit–cost ratio,
- What information you may supply, and
- How reliable RanchMod is.

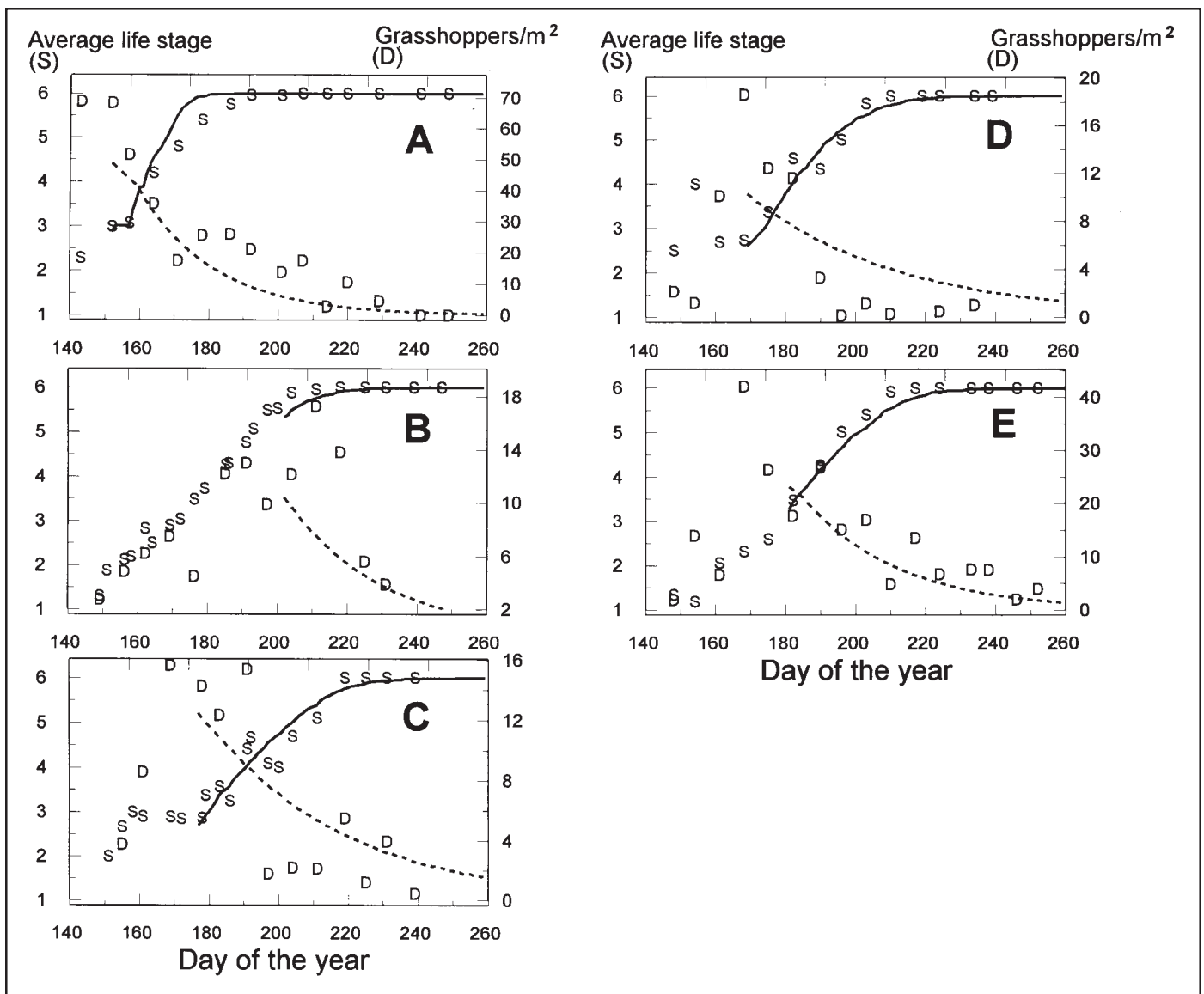
**How RanchMod Determines the Benefit–Cost Ratio.**—Using the forage and grasshopper models, RanchMod estimates the *value* of forage consumed by grasshoppers when treatment is applied and when treatment is *not* applied. The difference is the damage avoided by treatment, called the benefit. RanchMod assumes that the forage saved (less the forage set aside by the proper use factor) is available to livestock. The proper use factor is the proportion of the forage that will *not* be consumed by livestock, to prevent overgrazing.

The model divides the *value* of the forage saved (benefit) by the *cost* of treatment to determine the benefit–cost ratio.

RanchMod combines information from the forage and grasshopper models within its economic model to determine the value of forage. The value of forage directly affects the benefit–cost ratio.

**What Information You May Supply.**—The economics model asks you for information on the arrangement, and operation of the local ranch(es). This information includes the following:

- Lease costs,
- Cost and availability of hay,
- Livestock prices, and
- Herd information—size and composition.



**Figure VI.2-31**—Validation runs showing average life stage (S, field data; solid line, model) and density (D, field data; dashed line, model) for GHIPM sites in North Dakota.

Hopper provides default values for most of these variables. Default values are averages. When you don't know the actual value, you can use the default value to get a reasonable approximation.

Do not, however, use default values for grasshopper population size and species composition. These values are so variable that your results will be useless. So, for grasshopper density and composition, always use field data. Supply the best information you can for other values as well.

Remember, Hopper is only as accurate as the information you supply. The closer this information matches reality, the more reliable Hopper's recommendation is. Use default values when you must, but supply the best information you can.

**How Reliable RanchMod Is.**—RanchMod is both reliable and justifiable. RanchMod uses factors previously unavailable to decisionmakers. These factors allow you to account for variation in the ranching environment and to justify your treatment decisions based on economic criteria.

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RanchMod's accuracy depends on the accuracy of the data. The closer the data are to reality, the more reliable the benefit–cost ratio. During average years and on the average ranch, the default values will produce good results. But the more conditions stray from average, the more critical that you enter factual data instead of allowing the program to use default values. With accurate data, expect reliable results.

Remember, RanchMod's results are *not* exact. Rather, RanchMod gives you a “ball-park figure,” an estimate. RanchMod's estimate, however, is more accurate and more reliable than any you get by other means.

**Your Role.**—Your role (the role of ranchers, ranching committees, and government officials) in making treatment decisions with Hopper is twofold:

1. To provide accurate data to Hopper.
2. To make the final decision.

**Providing Accurate Data to Hopper.**—Hopper's recommendation relies on the data you enter. Therefore, to ensure reliability, you must enter the best data available. Collecting this data, however, requires skill, professionalism, and discipline.

Give Hopper the best data you can—it's worth the effort.

**Making the Final Decision.**—You must make the decision to treat or not. Hopper supplies you with benefit–cost ratios and other useful information. You must decide whether to treat based on the benefit–cost ratio, and other factors *not* accounted for by Hopper, that you judge important. Hopper is a decision support tool, *not* APHIS policy.

Remember, under normal circumstances, treating when the benefit–cost ratio is less than 1 is economically unjustifiable. Failure to treat when the benefit–cost ratio is greater than 1 threatens the ranching economy.

Hopper provides support for your treatment decisions based on scientific and economic research. If you use Hopper's benefit–cost ratio to make your decision, you can claim Hopper's support. But if you use another criteria, you cannot.

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## Appendix B Descriptions of Hopper's Ranch Models

By Melvin Skold, Rob Davis, and James S. Berry

Recent definitions of economic thresholds (ET's) and economic injury levels (EIL's) by economists and entomologists have shown that these concepts are dynamic in nature and must be evaluated for each site under consideration for treatment. Key economic parameters to evaluate include ranch type, rangeland productivity, cost of alternative sources of forage for livestock, and nontreatment options available to the rancher. Biological parameters for evaluating an ET or EIL depend on density of grasshopper species, life stage at time of treatment, mix of economic and noneconomic species, and

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presence of beneficial insects. Other factors of importance are proximity to waterways and presence of rare or endangered species.

The Grasshopper Integrated Pest Management (GHIPM) Project has provided economic models for eight important range ecosystems in the Western States. Within these range ecosystems, typical ranches are defined which characterize the predominant ranching practices of the area. Between range types, ranches vary considerably with respect to amounts, types, and costs of forages used. Livestock production and management strategies also differ between range types. An evaluation of these typical ranches through Hopper shows how the economic justification for treating rangeland grasshoppers changes between locations and ranching systems.

#### **List of Existing Model Names and Descriptions**

**(Range Types).**—The range ecosystems included in Hopper are those identified by APHIS, PPQ personnel as having recurring grasshopper infestations. The selected areas characterize seven range ecosystems and eight typical ranch types. For one area, the Northern Highland Prairie, both beef cow–calf ranches and beef–sheep ranches are common; consequently, two typical ranches were defined to analyze the impacts from grasshoppers infestations more fully.

**Generic.**—The generic model can be used for any area in the United States or Canada. This model does not use the detailed economic model nor forage production model. Therefore, you will need to use the default value of a replacement AUM (\$11.00) or enter a different value (calculated in the other, more detailed models). An AUM (animal unit month) is defined as the amount of forage a cow and calf consume in 1 month (about 800 lb of air-dry forage).

**Northern Great Plains.**—The rangeland is located within the Northern Great Plains range type, and about 2.2 to 3.3 acres are required to produce 1 AUM. The grazing season is approximately 8 months long; cattle are placed on grazing lands about May 1 and continue to graze until December 31. About half the forage needed on the ranch comes from public land, a quarter from private grazing lands, and the remaining quarter from hay and crop residue.

Located in western North Dakota on the Little Missouri National Grassland, the typical ranch in this model can be used for all of the Little Missouri National Grassland and extrapolated to eastern Montana with changes to rangeland productivity, herd size, leases, weather-generation models, etc. The rangeland is characterized as a northern mixed prairie and is predominantly cool-season grasses, forbs, and shrubs.

**Northern Highland Prairie.**—About 4 acres are required to produce 1 AUM of forage on this range type. Because elevations in the northern Highland Prairie are somewhat higher than in the northern Great Plains, the grazing season is shorter. Grazing begins about May 1 and continues through early September.

There are two typical ranches defined for this region. The first is a cow–calf ranch that is supplied 23 percent of forage needs by public grazing lands. Hay stocks are produced for winter feeding needs, and private rangeland supplies the balance of forage AUM’s (56 percent) for the livestock. A calf crop of 85 percent is achieved, with the calving season starting in March.

The second ranch has both a cow–calf enterprise and a range sheep enterprise. This ranch receives 41 percent of forage AUM’s from public rangeland, no hay is produced, and private grazing lands supply the balance of forage needs. Lambing begins about May 15; a lambing crop of 122 percent is the norm. The calving season for this ranch starts in March, with a calving percentage of 80 percent.

Located in Johnson County, WY, this typical operation is a large cow–calf ranch; these model parameters can be used for ranches throughout eastern Wyoming, south-central Montana, and possibly northeastern Colorado (assuming the weather, rangeland productivity, herd size, leases, etc., are changed when data are input). This rangeland, is characterized as Northern Mixed Prairie, is predominantly cool-season grasses, forbs, and shrubs.

**Central Great Plains.**—This region is characterized by highly productive rangelands of predominantly warm-season grass species. The typical ranch of about 2,200 acres of grazing land is a cow–calf operation with a 6-month summer grazing season. Grazing land can support



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approximately 1 AUM/acre. Hay is fed in the winter to supplement crop-residue grazing and supplies 14 percent of the total AUM's of forage. Public grazing land is available to only a portion of these ranches. Livestock graze on rangeland owned by the rancher and rangeland leased from other landowners.

This typical ranch is located in western Nebraska, and its parameters can be extrapolated to ranches located in southeastern Wyoming, north-central Colorado, and the Nebraska panhandle.

***Southern Great Plains.***—The typical southern Great Plains ranch has both cow–calf and sheep enterprises. There is an 8-month grazing season, with 34 percent of the total AUM's of forage coming from public rangelands. The typical ranch includes about 15,600 acres. Privately owned rangelands supply 26 percent of total needed AUM's, and raised hay stocks supply the remaining 40 percent of forage needs.

Almost 53 acres are required to produce 1 AUM of forage. The grass and forb species in this area are predominantly warm season, and most vegetative growth occurs in July, when the monsoon rains come.

The typical ranch in this model is located in eastern New Mexico.

***Mexican Highland Scrub.***—The typical ranch for this region is a cow–calf operation. Total forage comes from public grazing land (34 percent), from privately owned grazing land (13 percent), private rangeland (10 percent), and from raised hay stocks (43 percent). The elevation is low, and summers are very hot. Most vegetative growth occurs in late summer, when monsoon rains occur. Almost all plant species present are warm season. The grazing season is 9 months long, and hay is fed to supplement the grazing.

Located in southeastern Arizona, this typical operation is a smaller cow–calf ranch operating in the “hot desert” environment. About 64 acres are required to produce 1 AUM of forage. Results from the Mexican Highland Scrub typical ranch profile can be extrapolated to ranches in southwestern New Mexico.

***Gila Mountains.***—Grazing needs are satisfied for this cow–calf ranch with a year-round grazing season. About 6.5 acres are required to produce 1 AUM of forage. There are no hay stocks produced. The split between public and private grazing lands is about 50–50. The grass species in this region have high percentages of both warm- and cool-season grasses. Most vegetative growth occurs in late July with the onset of summer monsoon rains.

Located in central Arizona in the Chino Valley near Prescott, this typical ranch is a very large cow–calf operation in a transition zone next to a hot desert zone.

***Eastern Intermountain Basin.***—The typical ranch for the southeastern Great Basin region is a cow–calf ranch that receives about 7 percent of its total forage supplies from public rangelands, 32 percent from leased private rangelands, 41 percent from owned rangeland, and 20 percent from hay produced on the ranch. About 12 acres are required to produce 1 AUM of forage. The grazing season is year-round, with hay stocks supplementing the rangeland forage supplies during the winter. Public rangelands are used during the spring months.

This typical ranch is located in western Utah, and results from this ranch profile can be extrapolated to ranches in southern Idaho and eastern Nevada.

***Northern Intermountain Basin.***—A cow–calf ranch was defined for this region. The grazing season starts in mid-April and runs until early November. About 9 to 10 acres are required to produce 1 AUM of forage. Public rangelands supply 44 percent of the total forage needs of the cow herd. Raised hay stocks supply 22 percent of the forage and are used in the winter months. Privately owned rangelands and leased private rangelands supply the remainder of forage needs (34 percent).

Located in Harney County, OR, this typical ranch is a cow–calf operation in the Great Basin Desert, which is dominated by big sagebrush. Results from this ranch profile can be extrapolated to operations in southern Idaho and northern Nevada.

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## Model Names in Hopper

(CC = cow–calf, CS = cow–sheep enterprise)

- NGP = Northern Great Plains (western North Dakota)
- NHP = Northern Highland Prairie (north-central Wyoming)
- CGP = Central Great Plains (southeastern Wyoming, north-central Colorado, Nebraska panhandle)
- SGP = Southern Great Plains (eastern New Mexico)
- MHS = Mexican Highland Scrub (southeastern Arizona, southwestern New Mexico)
- GM = Gila Mountain (central Arizona)
- EIB = Eastern Intermountain Basin (western Utah, southern Idaho, eastern Nevada)
- NIB = Northern Intermountain Basin (eastern Oregon, western Idaho)
- Generic = Any area in the United States or Canada. This model does not use the detailed economic model nor forage model. Therefore, you will need to enter the value of replacement AUM's (calculated in the other, more detailed models). These files will have the extension \*.gn3 (e.g., generic.gn3).