USERS' GUIDE TO FEXPERT: FOREST ECOSYSTEM CLASSIFICATION MADE EASY

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Natural Resources Canada
Canadian Forest Service–Sault Ste. Marie
Great Lakes Forestry Centre

1995

Information Report O–X–443

Canadian Cataloguing in Publication Data

Payandeh, Bijan

Users' guide to FEXPERT: forest ecosystem classification made easy

(Information report, ISSN 0832–7122 ; O–X–443)
Includes an abstract in French.
Includes bibliographical references.
ISBN 0-662-22608-9 Cat. no. Fo46-14/443E

1. Fexpert (Computer file)
2. Forest ecology – Ontario – Classification – Computer programs.
3. Forest site quality – Ontario – Computer programs.
I. Dukes, D.R. (Darren R.)
II. Baldwin, K.A.
III. Great Lakes Forestry Centre.
IV. Title: Forest ecosystem classification made easy.
V. Series: Information report (Great Lakes Forestry Centre); O–X–443.
QH541.5P36 1995 574.5'2642'02855369 C95-980151-0

Catalogue No. Fo46–14/443 E
ISBN 0–662–22608–9
ISSN 0832–7122

Copies of this publication are available at no charge from:
Publication Services
Canadian Forest Service–Sault Ste. Marie
Great Lakes Forestry Centre
P.O. Box 490
Sault Ste. Marie, Ontario
P6A 5M7

Microfiche copies of this publication may be purchased from:
Micromedia Inc.
Place du Portage
165, Hotel-de-Ville
Hull, Quebec
J8X 3X2

Payandeh, B.; Dukes, D.; Baldwin, K. 1995. Users' guide to FEXPERT: Forest ecosystem classification made easy. Nat. Resour. Can., Canadian Forest Service–Sault Ste. Marie, Sault Ste. Marie, Ontario. Inf. Rep. O-X-443. 22 p. + appendix.

ABSTRACT

FEXPERT is a rule based computer program developed to facilitate application of the Northwestern Ontario Forest Ecosystem Classification (NWO FEC) System. At each plot the program guides the user through a decision process in order to classify that stand into one of 38 vegetation types and one of 22 soil types. At any point during the classification process one or more of the previous decisions may be revised to reveal their effect on the final classification for the stand. The factsheet describing any given soil or vegetation type can be retrieved from FEXPERT's extensive help system, which incorporates nearly all of the information contained in the field guides as Hypertext documents. This eliminates the users need for flipping through the manual to find descriptions or illustrations of soil profiles, soil types, and plants, or to find definitions of classification terms.

This manual contains a guide to the installation and requirements of FEXPERT, a tutorial on using FEXPERT, a detailed guide on FEXPERT's commands, and a description of how the NWO FEC keys were converted to the input windows used in FEXPERT.

RÉSUMÉ

FEXPERT est un programme informatique à base de règles qui a été mis au point pour faciliter l'application du système de classification des écosystèmes forestiers (CEF) du secteur nord-ouest de l'Ontario. Il fournit la majeure partie des renseignements contenus dans les guides d'identification sur le terrain, et remplace donc ces derniers. À chaque station, le programme guide l'utilisateur dans un processus de décision le menant à classer le peuplement étudié dans l'un des 38 types végétaux et dans l'un des 22 types de sol. À tout moment au cours de ce processus de classification, on peut examiner une ou plusieurs des décisions antérieures pour évaluer leur effet sur le classement final du peuplement étudié. Le système d'aide très complet donne accès à toutes les fiches techniques qui décrivent les types de sols ou de végétaux. La caractéristique la plus importante de FEXPERT est précisément son système d'aide qui comprend presque tous les renseignements contenus dans les guides d'identification sur le terrain sous forme de documents Hypertext. L'utilisateur n'a donc plus à feuilleter les guides pour trouver la description ou l'illustration des profils de sol ou des plantes, ou encore pour trouver des définitions ou des termes utilisés pour le classement.

Le présent manuel comporte un guide d'installation de FEXPERT, une section sur ses conditions de fonctionnement, un tutoriel et un guide détaillé sur ses commandes, ainsi qu'une description de la façon dont les clefs de classification des écosystèmes forestiers du nord-ouest de l'Ontario sont rendues compatibles avec les fenêtres d'entrée de FEXPERT.

Disclaimer

Natural Resources Canada is the sole owner of FEXPERT. The FEXPERT software was developed at Natural Resources Canada, Canadian Forest Service–Sault Ste. Marie. The purchaser/recipient may not assert any proprietary rights thereto nor make representations to anyone to the contrary.

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How to obtain FEXPERT

FEXPERT may be obtained either on 3½" diskettes (9) or be downloaded directly from the Internet. Users wishing to receive it on diskettes should contact the senior author or the Publications Unit, CFS–Sault Ste. Marie. To download FEXPERT from Internet you may proceed with the following steps or equivalent procedures:

1. Connect to the anonymous FTP server: FTP.GLFC.Forestry.Ca

2. Go to the /pub/fexpert directory and download the (27 MB) file FEXXPERT.EXE (the compressed version of FEXPERT) to a /FEXPERT subdirectory on your PC.

3. At the DOS prompt run FEXXPERT to uncompress the files (it requires 38 MB of disk space to complete uncompressing the files, but 11 MB can be restored by deleting the compressed file).

4. FEXPERT requires 595 Kbytes of free memory, a Microsoft or Logitech compatible mouse and driver installed, a VGA compatible graphics card and monitor, and MS–DOS 5.0 or later version.

5. The simplest way to free sufficient memory for FEXPERT is to make a special boot disk containing only a mouse driver and loading all necessary TSR's and drivers into high memory. If you are not familiar with the necessary TSR's and drivers for your computer system, contact someone who is, or refer to the FEXPERT users' manual.

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INTRODUCTION

An effective characterization of site quality and site condition is very important in ecosystem management; therefore, considerable effort has been devoted to the development of Forest Ecosystem Classification (FEC) systems. The Northwestern Ontario Forest Ecosystem Classification (NWO FEC) has provided a tool for boreal forest site classification. Unfortunately its field application requires considerable expertise and frequent referral to field manuals for determination of soil properties and identification of species of trees, shrubs, herbs, mosses, and lichens.

An "expert" or "knowledge-based" system is one that applies specified facts and rules for inference, enabling the software to exhibit human-like diagnostic abilities in a limited problem domain (Pressman 1992). Expert systems have been used in many fields, including medicine, engineering, agriculture, and forestry. The NWO FEC is essentially a well defined diagnostic tool requiring the user to determine certain soil and vegetation characteristics in order to classify them into specifically defined groups. This makes it suitable for automation using expert system principles.

FEXPERT is designed to facilitate the application of the NWO FEC system by computerizing the essential contents of its field manuals and classification procedures so that the user may have immediate access to the necessary information for quick, consistent, and accurate classification. FEXPERT should prove valuable to the novice by providing extensive help in the form of text, diagrams, pictures, profiles, etc., for proper classification.

GETTING STARTED

This section describes how to install FEXPERT on your computer. To do this you must run the install program provided. The files on the installation disks are in a compressed format, and must be correctly installed before the program can be executed.

System Requirements

FEXPERT requires the following minimum hardware and software for successful installation and execution:

- A personal computer, i.e., an IBM 386 or 486 compatible
- One high density 3.5-inch floppy disk drive
- 40 Mbytes of available hard drive space
- 595 Kbytes of free memory
- A Microsoft- or Logitech-compatible mouse with the mouse driver installed
- A VGA-compatible graphics card and monitor
- MS-DOS 5.0 or a later version (no DOS versions prior to 5.0 have been tested)

The simplest way to free sufficient memory to run FEXPERT is to prepare a special boot disk containing only a mouse driver and then load all necessary terminate stay residents (TSRs) and drivers into high memory. If you are not familiar with the necessary TSRs and drivers for your computer system, contact someone who is. For example, you may try the following steps in preparing your bootable disk:

1. Insert a blank floppy diskette into a bootable floppy disk drive.

2. Change the current drive to one you just placed the floppy diskette in, for example Drive A, and type:

   a: **<ENTER>**

3. Format the floppy disk by typing:

   format a: /S **<ENTER>**

4. Copy the following files from your hard drive (usually c:) to the current drive by typing:

   copy c:\autoexec.bat
   copy c:\config.sys

5. If you have never edited these two files before, it is a good idea to get help for the next steps.

   Edit config.sys file so as to contain ONLY the drivers that are essential to your system. To maximize use of High Memory Area and Upper Memory Block, use HIMEM.sys and EMM386.exe, respectively. Your edited config.sys file should look like the following (assuming your MS-DOS directory is C:\DOS):

   ```
   Rem ************************************
   Rem*** CONFIG.SYS file for FEXPERT ***
   DEVICE=C:\DOS\HIMEM.SYS
   DOS=HIGH, umb
   DEVICE=C:\DOS\EMM386.EXE RAM HIGHSCAN
   BUFFERS=15,0
   FILES=20
   ```

   Next edit your autoexec.bat file on A: to look like the following:

   ```
   Rem ************************************
   Rem *** AUTOEXEC.BAT for FEXPERT ****
   Rem * FEXPERT only requires C:\DOS to be in the path, if you need to extend
   Rem * your path to include other directories then do so.

   PATH=C:\DOS

   Rem * If you did not load a mouse driver in your CONFIG.SYS file
   Rem * then do so now by entering a line similar to the following:
   LH C:\MOUSE\MOUSE.COM
   ```

6. Save all your changes to the config.sys and autoexec.bat files to your newly formatted bootable floppy disk.

   Now, to execute FEXPERT, reboot your computer with this floppy disk in your bootable drive. An optimized memory configuration will be used and the required memory for running FEXPERT should be available.

Installation

To install FEXPERT (if you have successfully downloaded and uncompressed FEXPERT from the Internet, skip this section):

1. Start your computer.

2. Insert the disk labelled "Disk 1" into Drive A or B.
3. Type one of the following at the command prompt:

   a:<**ENTER**>
   or
   b:<**ENTER**>

4. Type the following:

   install c:\fexpert <**ENTER**>

   If you prefer to install the program in a directory other than c:\fexpert, enter the directory name here. For example, to install the program into the directory d:\forest type:

   install d:\forest <**ENTER**>

   Note that the installation program will automatically create the directory in which to place the files.

5. Follow the instructions on the screen from here to install FEXPERT. For the most part, the instructions should be straightforward. If the install program asks you for the "last disk of the backup set" this refers to the disk with the highest number - i.e., if you received an eight-disk set, insert Disk 8 into the drive. If the program asks for the "disk with the batch file" it means Disk 1.

USING FEXPERT

The following tutorial provides a simple, hands-on look at FEXPERT. Work through it by carefully following the instructions.

1. Reboot your computer with your FEXPERT boot disk, then at the DOS prompt, start the FEXPERT program by typing:

   C: <**ENTER**>
   cd \fexpert <**ENTER**>

   If you have installed FEXPERT in a directory other than c:\fexpert, then make that directory your current directory. Now that you are in the directory containing fexpert.exe you should type:

   fexpert <**ENTER**>

2. You are presented with a title screen for FEXPERT telling you to press any key to continue, so press a key now.

3. A help window titled FEXPERT, which contains an introduction for the first time user, is displayed on the screen along with the menu bar. Read through

this and scroll through the document using **<PgUp>** and **<PgDn>**, or click on the **<PgUp>** and **<PgDn>** options on the command bar at the bottom of the screen.

Clicking on the green text will take you to other help screens. Click on the words "<How to Use FEXPERT>" and read the instructions there, again using the **<PgUp>** and **<PgDn>** keys to scroll through the document.

Click on the green "<Sample Graphics>" text to see one of the many graphics available in FEXPERT. Now click on "<Previous>" in the menu bar. You will be returned to the window you've just come from.

Take some time to familiarize yourself with the help menus. Try clicking on various Hypertext links and see where they take you. When you are comfortable using the help window, click on "<Close>" to close the window. You can bring this window back at any time by clicking on Help (in the menu bar at the top of the screen) and then clicking on Introduction in the dropdown menu that appears.

4. From the menu bar click on Classification. A drop down menu will appear. Click on "Vegetation Type Determination". You are presented with a dialogue box that looks similar to the following:

Percent Cover of Hardwood ≤ 2% Yes No Cancel Help

In the NWO FEC the tree species on a site are said to be "Only conifer" if the hardwood cover component is less than or equal to two percent (≤ 2%) in the 10 m x 10 m sample plot. If you were to click on Help at this point, you would be transferred into FEXPERT's help menu, where you could find further help in making this observation.

For now, however, we will assume that you don't need further help, and that the percent cover of hardwood species is ≤ 2%, so select "Yes" from the action menu.

5. A window now appears on the screen. Use the mouse or arrow keys to move this window near the center of the screen, then press **<ENTER>** or click with the mouse. Be sure not to click the mouse button until the window is correctly positioned. Windows users should avoid the temptation to "click and drag". The Conifer Vegetation Type Determination input window appears (*see* Figure 1).

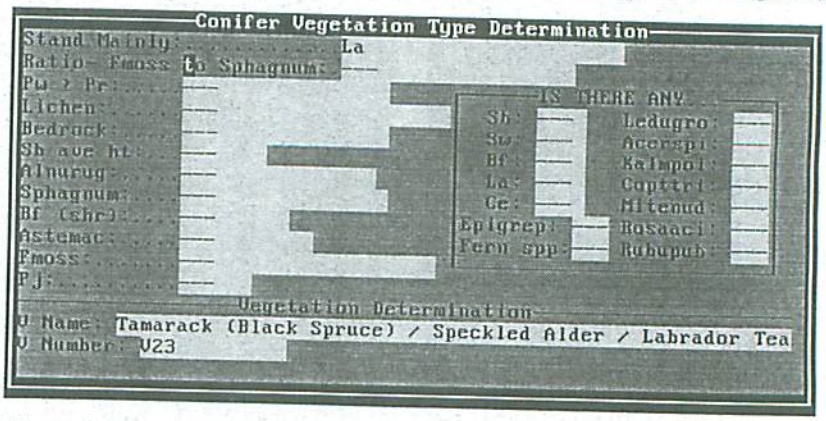


Figure 1. Default input window for the Conifer Vegetation Type Determination.

This input window will determine the vegetation type (displayed on the bottom two lines of the window) based on data you enter in the section above. You will notice that, at the moment, most of the observation fields are marked with three dashes. This indicates that information cannot yet be entered in these fields.

This window, like the Soil Type window you will see later, is designed so that setting values in fields further up will change the available options in the fields below them. It is important, therefore, that you enter information into the window in a systematic way, working from the top row down, and from left to right within each row.

At present, the only valid field in the window is the top field, the "Stand Mainly" field, which contains the default value "La" (*Larix laricina*, i.e., tamarack or larch).

6. Click on the input field (the grey horizontal bar) containing "La". A list menu containing a number of items should appear. At this point, it may not be clear what you are supposed to do for this input field.

7. Press **<ESC>** now to close the list menu again. The **<ESC>** key can be used to cancel and close most boxes, windows, and menus within FEXPERT.

8. Click the right mouse button on the input field containing "La". The right mouse button is used in FEXPERT to call up context-sensitive help screens. In this case, you should see the help menu shown in Figure 2, which provides additional information on the "Stand Mainly" field. It also provides links to other help windows and pictures of trees mentioned in the list menu. Additional help may be accessed by clicking on the appropriate link.

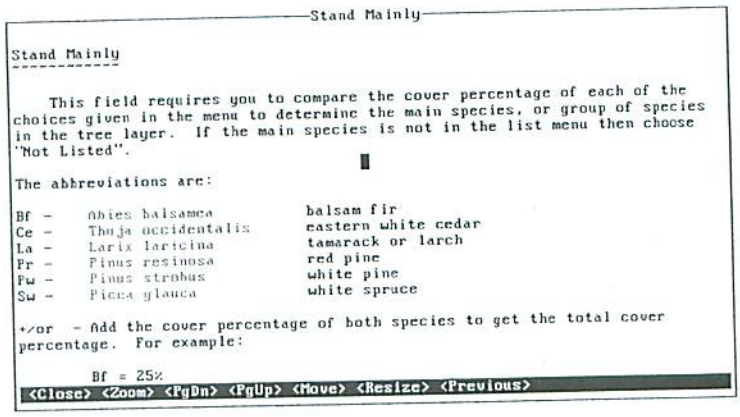


Figure 2. Help window for the "Stand Mainly" input field.

9. Once you are familiar with inputting information for this field press **<F6>** (the Switch Active Window key) several times until the input window becomes visible again, or, if it is already partially visible, click on it to make it completely visible. Move the input window to the top right corner of the screen by clicking on the title bar of the window (i.e., the bar at the top of the window that reads "Conifer Vegetation Type Determination") and dragging the mouse pointer to the upper right corner of the screen. Then move the help window to the bottom left corner of the screen either by clicking and dragging on its title bar, or by clicking on the "<Move>" option in the command bar at the bottom of the screen. This will allow you to read information in the help window while inputting your observation in the input window.

10. If "La"constitutes the greatest cover percentage of any of the conifer species in the stand, then the vegetation type would be V23 as shown in the V number field at the bottom of the input window. For a more generalised example click on the "Stand Mainly" input field (the grey bar containing "La") again. For this example we will assume that the main conifer species in the stand is Ce (*Thuja occidentalis* or eastern white cedar). Click on "Ce" from the list menu.

11. The "Stand Mainly" input field is now red to indicate that you have made the required observation i.e., FEXPERT has provided you with a possible diagnosis on vegetation determination. There are now five other input fields available for use (fields not containing "—"). You should check to see whether they agree with your observations for those fields (*see* Figure 3).

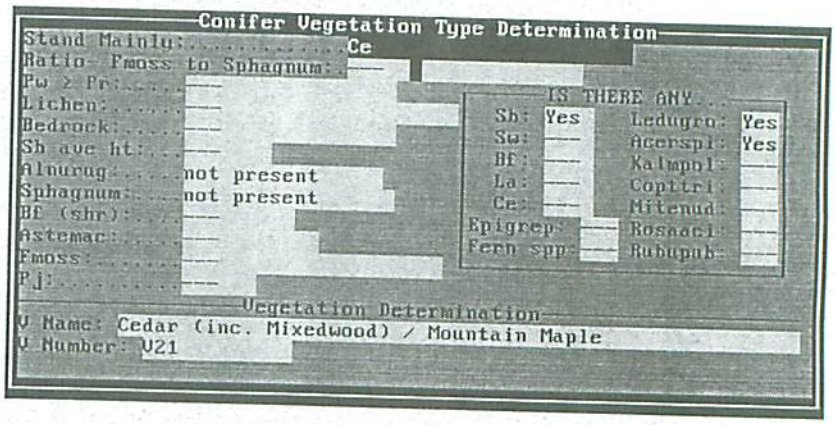


Figure 3. Input window for the example run with the "Stand Mainly" observation entered.

As mentioned above, you should work your way down the rows of input fields to avoid making unnecessary observations.

Next the "Sb", "Ledugro", "Acerspi", "Alnurug", and "Sphagnum" input fields should be set in this order. Before selecting an item from the list menu for each field you should click on the various input fields with the right mouse button to get additional information on their requirements. Once you are certain about making the correct observation for a field, enter the appropriate item from the input field's list menu.

12. For this example select the following values from the list menus for each input field. For:

    Sb select "Yes"
    Ledugro select "No"
    Acerspi select "No"
    Alnurug select "1% to 9%"
    Sphagnum select "not present"

    You will notice that several of the fields above already contained the correct entry. Nevertheless, it is a good idea to click on the entry and actively select "Yes". Doing this will cause the field to be displayed in a different color, thereby allowing you to see at a glance which fields contain data that you have entered and which merely contain default settings.

You may also have noticed that the "V number" and "V name" fields changed while you were inputting the above observations. Now the "V number" and "V name" fields should be "V22" and "Cedar (inc. Mixedwood) / Speckled Alder / *Sphagnum*", respectively. All the input fields that don't have "—" in them are red.

13. You may now view the factsheet to determine if the vegetation type determined by FEXPERT accurately describes your stand classification. To do this use the right mouse button to click on the "V number" field containing "V22". A help window is now opened with the title "V22"; this is the factsheet for the vegetation type. In actual field application of FEXPERT you would compare the contents of the factsheet to the stand around you to determine if the factsheet accurately describes the stand. If it doesn't and there were some borderline decisions involved (i.e., the percent cover of "Pw +/or Pr" was the same as "Ce") you could close this help window factsheet and change your observation in the input window. This may result in a change of vegetation type to one that more closely resembles the stand.

    Classifying soil types uses the same process as used above, help is available at every step to get you to a soil type as quickly and consistently as possible.

A GUIDE TO FEXPERT COMMANDS

This section provides a guide to FEXPERT's dialog boxes, list menus, search boxes, menu bar, help windows and pictures, input windows, and some shortcut keys (or hot keys) that can be used. Most of the components listed above can be used with either a mouse or the keyboard. Both methods are explained here.

Dialog Boxes

Menu commands followed by ellipses (...) will open a dialog box such as the following:

Sample dialog box prompt: Optional Input Field OK CANCEL HELP

The dialog box may contain three items:

1. A prompt illustrated above by "Sample Dialog Box Prompt:". This will indicate what kind of response the dialog box is asking for.

2. An optional input field illustrated above by the "Optional Input Field". This may be used for entering textual information such as a file name.

3. An option or action menu illustrated above by "OK", "CANCEL", and "HELP". These are usually in response to the prompt or in reference to the input field. Selecting an item will result in immediate action.

One may navigate within the dialog box via the arrow keys or a mouse as follows:

- If there is an input field, pressing < ↑ > and < ↓ > will give you control of the input field and action menu, respectively.

- When an item in the action menu is highlighted pressing < → > and < ← > will allow you to choose among options; pressing **<ENTER>** will select the command currently highlighted.

- Pressing **<ENTER>** while inputting information is the same as selecting the first item in the action menu (e.g., "OK").

- Pressing **<ESC>** will cancel whatever command was used to open the dialog box and then close the dialog box.

- A mouse can be used to select an action menu command by clicking on that command.

List Menus

Figure 4 is a typical list menu:

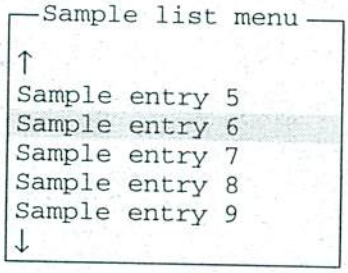


Figure 4. Typical list menu.

The arrows (↑ , ↓) in the list menu appear only when there are items above or below that are not shown. You can select an item as follows:

- Press < ↑ > or < ↓ > to move the highlight bar up or down and scroll through the list. The **<PgUp>** and **<PgDn>** keys will also scroll your view to the items above and below the present view, respectively. Pressing **<ENTER>** will select the item that is highlighted.

- Clicking on an item with the mouse allows it to be selected. Clicking on the up (↑) or down (↓) arrow in the list will scroll the list up and down.

Search Box

The search box is used to find topics in FEXPERT's help system with the Help|Search command. A typical search box is shown in Figure 5.

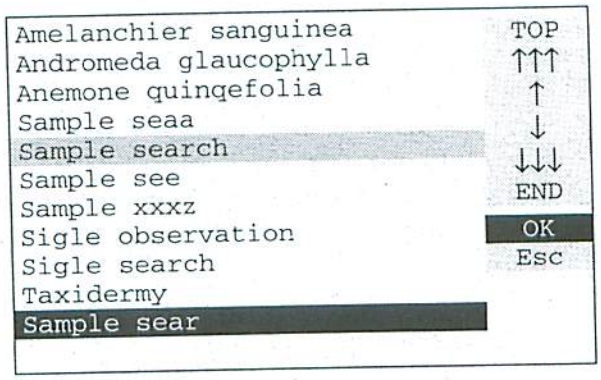


Figure 5. Typical search box.

A search box uses a list menu without the arrows at the top and bottom to display the possible help window or picture titles that will satisfy the search. A highlighted bar shows the current selection. The bar can be moved using the following methods:

- The < ↑ > or < ↓ > keys move the bar up or down by a single item; **<PgUp>** or **<PgDn>** scrolls your view to the items above or below the present view; **<Ctrl>+<PgUp>** or **<Ctrl>+<PgDn>** moves the highlight bar to the top or bottom of the list.

- With the mouse, clicking on " ↑ " or " ↓ " moves the bar up or down by a single item; clicking on " ↑ ↑ ↑ " or " ↓ ↓ ↓ " scrolls your view to the items above or below the present view; clicking on "TOP" or "END" moves the highlight bar to the top or bottom of the list.

- If you type the name of the topic for which you want to search, the highlight bar will be moved automatically to the item that best matches what you are typing. The example shows "Sample sear" as the letters typed in and the search box has automatically highlighted "Sample Search" in the list menu. Note that the highlight bar is moved and the list adjusted with every letter you type. In the example, typing "S" moves the highlight bar to "Sample seaa", the first entry beginning with "S". If you then typed "I", the highlight bar would move to "Sigle observation", the first entry beginning with "SI". This feature means that, in most cases, you need type only a few letters of a topic's full name in order to move directly to that topic.

To select the item the highlight bar is on, click on "OK" or press **<ENTER>**. This will open the help window for that item. You can close the search box and cancel the command that opened it by clicking on "Esc" or pressing **<ESC>** at any time.

The Menu Bar

Figure 6 is a diagram of FEXPERT's menu bar. It shows the menu titles with their respective menus.

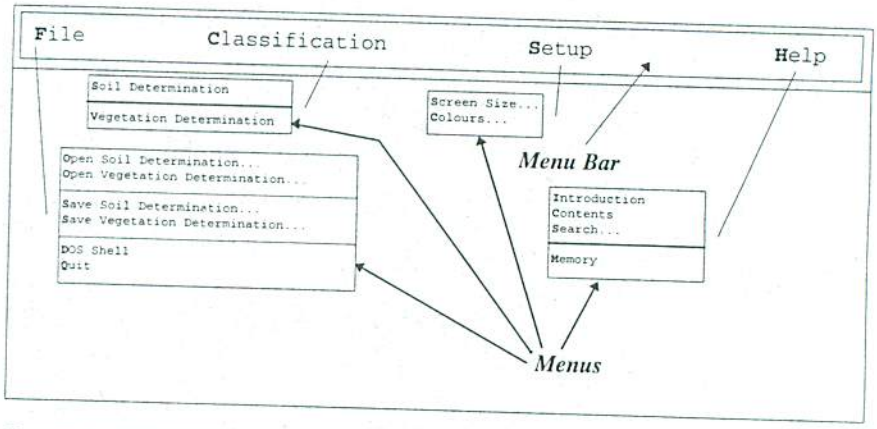


Figure 6. FEXPERT's menu bar and associated menus.

The methods used to select a menu command adhere to the Common User Access command set made popular by Microsoft Windows programs.

To select a menu command:

- If the menu bar is active (one of its items is highlighted), press the first letter of the desired item (f for **F**iles or c for **C**lassification, etc.), then use the < ↑ > and < ↓ > keys to select a command.

- If the menu bar is active, press < ← > or < → > to move the highlight bar left or right and press **<ENTER>**, or the down arrow when the menu title you want is highlighted, then use the < ↑ > and < ↓ > keys to select a command from the menu.

- From almost anywhere in FEXPERT (except from a dialog box, list menu, search box, or a pull-down submenu) press **<Alt>** and the first letter of the menu title simultaneously.

- Using the mouse, click on the menu title to open the menu, then click on the desired command.

Menu Commands

All of the titles in the menu bar invoke menus of commands. Some of the commands are followed by an ellipsis (...); choosing one of these commands opens a dialog box. If the item has no ellipsis then the action occurs as soon as the command is chosen. The following is a description of each of the menu titles and related menu commands:

File Menu

Open Soil Determination

The Open Soil Determination command can be used only if no soil determination input window is currently open. It will display a dialog box prompting for a file name to open. The escape key (**<ESC>**) may be pressed at any time to cancel opening a file. You can do any of these:

Type in a complete file name and press **<ENTER>** to open the classification with that file name.

Type in a file name with wildcards (i.e., * or ?), which filters the files in the directory to match your specifications. All matches are displayed in a list menu; choosing one of them will open that file.

Open Vegetation Determination

The Open Vegetation Determination command is similar to the Open Soil Determination command, but it opens a vegetation determination file instead of a soil determination file.

Save Soil Determination

The Save Soil Determination command may be used only if a soil determination input window is open. It will display a dialog box prompting for the file name of the soil determination to be saved. **<ESC>** may be pressed at any time to cancel saving a file. You can do any of these:

Type in a complete file name and press **<ENTER>** to save a classification to that file name.

Type in a file name with wildcards (i.e., * or ?) then press **<ENTER>** or simply press **<ENTER>** to list the files in the current directory with the default .SOL extension or in a specified directory that matches the name entered. You can then choose to overwrite one of these file names by clicking on it, or select it with the arrow keys and pressing **<ENTER>.** In order to prevent files from being overwritten inadvertently, FEXPERT will ask you whether you are sure you want to overwrite the existing file before saving.

Save Vegetation Determination

The Save Vegetation Determination is similar to the Save Soil Determination command, but it requires that a vegetation determination input window be open. It will save the information in that window to a vegetation determination file.

DOS Shell

The DOS Shell command lets you temporarily exit FEXPERT to enter a DOS command without losing any information you may have entered. To return to FEXPERT type:

exit **<ENTER>**.

Since FEXPERT requires a large amount of memory, you may find that there is not enough memory to execute this command. If this is the case, closing some of the open help windows or saving and closing current soil or vegetation determination files should help.

Do not use the DOS print command or install any TSR programs while in a DOS shell because memory may be misallocated.

Quit

This command will leave FEXPERT. If any soil or vegetation classification input windows are open you will be prompted to save them before quitting.

Classification Menu

Soil Type Determination

The Soil Determination command will open a dialog box to determine the soil depth according to the criterion "Mineral or Organic Soil Depth ≥ 100 cm". Choosing "Yes" or "No" will open the "Deep Soil Determination" or "Shallow Soil Determination" input windows, respectively. Selecting "Cancel" or pressing **<ESC>** will cancel the opening of any input windows and return to the main menu. Selecting "Help" will provide help on how to make this decision.

Vegetation Type Determination

This command will open a dialog box to determine the stand cover type based on the criterion: "Stand is Only Conifer". Choosing "Yes" or "No" will open the "Conifer Vegetation Determination" window or the "Mainly Hardwood / Conifer Mixedwood Vegetation Determination" input windows, respectively. Selecting "Cancel" or pressing **<ESC>** will cancel the opening of any input windows. Selecting "Help" will provide help on how to make this decision.

Setup Menu

Screen Size

The Screen Size command will open a list menu containing several screen sizes. FEXPERT is configured for the VGA screen size by default. Any changes to the screen size will be saved when exiting FEXPERT.

Colors

The Colors command will allow you to set the menu bar color and the background color. Changing colors will close all the open windows so be sure you change the colors before making a classification. Any changes to the colors will be saved upon quitting FEXPERT.

Help Menu

Introduction

The Introduction command opens the introduction help window titled FEXPERT that is active when you begin FEXPERT.

Contents

The Contents command opens the table of contents help window for FEXPERT's help system.

Search

The Search command will open a search box for finding topics in FEXPERT's help system. You should keep in mind that the search utility is context sensitive; most topics start with capital letters, so beginning your search with capital letters is the quickest way to find the topic you want.

Memory

Since FEXPERT currently requires a large amount of memory, the Help/Memory option will display the amount of free memory.

Help Windows

Help windows are used to give you instructions on every aspect of a classification. Figure 7 is a sample help window.

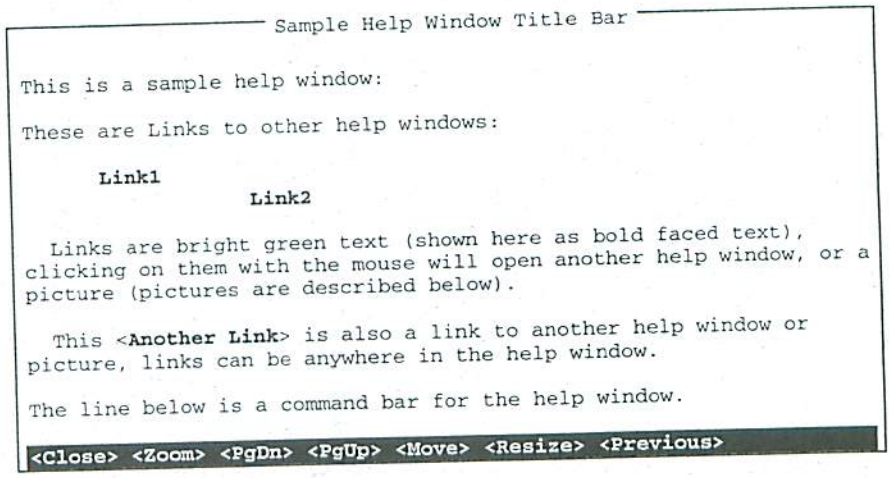


Figure 7. Example Help Window from FEXPERT's Help System.

The command bar at the bottom of the help window has seven commands on it. Clicking on each of the commands will have the following effect:

<Close> Closes FEXPERT's help system.

<Zoom> Enlarges the window to the entire screen size. Clicking on it for a second time will return the window to its previous size.

<PgDn> Scrolls the text in the window down by one full screen.

<PgUp> Scrolls the text in the window up by one full screen.

<Move> Allows you to move the window with the mouse or the arrow keys. To place the window in the new location press enter or left click.

<Resize> Allows you to resize the window with either the arrow keys or the mouse. To restore the window at the new size press **<ENTER>** or click the left mouse button.

<Previous> Closes the current help window and opens the previous help window or picture.

Besides clicking on a command on the command bar you may use the mouse to do the following:

- Resize the window by holding down the left mouse button on the bottom right corner of the window and moving the mouse to size the window. Releasing the button will leave the window at the new size.

- Move the window by holding down the left mouse button on the title bar and moving the mouse. Releasing the button will place the window at the new location.

- Close the help system by clicking on the top left corner of the window.

A link to a picture looks the same as a link to a help window, but when you click on it a graphics screen is opened like the one in Figure 8. In addition, the mouse cursor turns into a white arrow.

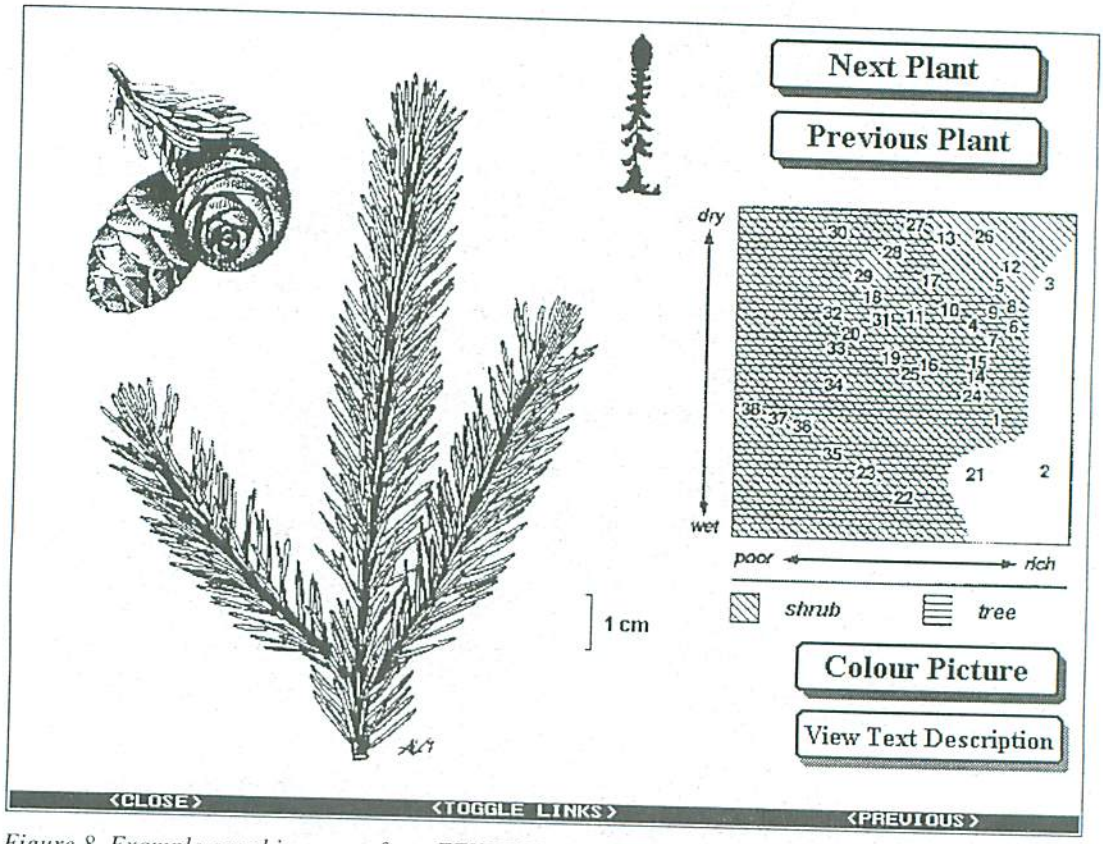


Figure 8. Example graphic screen from FEXPERT's help system.

Figure 8 is a picture of a plant from the plant guide, and its associated habitat diagram. The boxes on the right are links to other pictures and to a description of this plant. The command bar along the bottom of the screen offers the following commands:

<Close> Closes FEXPERT's help system.

<Toggle links> Shows all the links to other help windows, or pictures, as dashed rectangles. For example, the area inside the shadowed boxes on the right hand side of the screen are links to the next and previous plants in the plant guide, a color picture of the plant, and a description of it. This is a useful feature since links may be anywhere on the screen. For example, if the habitat diagram required some sort of explanation, clicking on "Toggle links" might place a rectangle around it to show a link to another help window or picture explaining how to use the diagram.

<Previous> Closes the current help picture and opens the previously open help window or picture.

Input Windows

Input windows provide an easy way of inputting data into FEXPERT. Figure 9 is a sample input window.

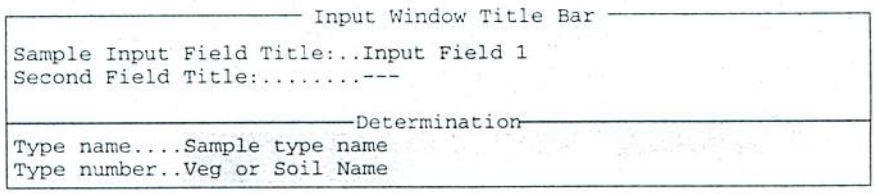


Figure 9. Sample input window.

Each window displays input field titles (e.g., "Sample Input Field Title") and default values in its gray input fields (e.g., "Input Field 1"). Clicking on the input field value opens a list menu containing the possible values for that field. Clicking on a value in the list will display it in the field and highlight the background in red to show that an observation was made. Pressing the escape key before a value is chosen will close the list menu and make no changes to the field. Nonessential fields are dashed out as shown above by "—"; left clicking on these fields will have no effect. FEXPERT continuously updates the information fields and soil or vegetation types. By making observations that highlight all of the fields not containing dashes, a soil or vegetation type is completely diagnosed, and a factsheet is available for viewing by using the right mouse button to click on the soil or vegetation type number (i.e., "Type number" input field). You can move and close an input window the same way as you move and close a help window by undertaking the following:

- To move an input window hold down the left mouse button on the title bar and drag the window to the desired location. Releasing the button will restore the window.

- To close an input window, click on the top left corner of the window.

Hot Keys

<ESC>	Cancels and closes any dialog box, search box, list menus, pull-down menu, or help window
<Alt>+<C>	Opens the **C**lassification menu
<Alt>+<F>	Opens the **F**iles menu
<Alt>+<H>	Opens the **H**elp Menu
<Alt>+<S>	Opens the **S**etup Menu
<F1>	Opens a help window for the current input field in a classification
<F5>	Opens a help window to the full screen size
<F6>	Switches the active window

About FEXPERT

In the Field Guide to the Forest Ecosystem Classification for Northwest Ontario, the NWO FEC system is described as a system that can be readily applied to a forest ecosystem in Northwestern Ontario by individuals with some basic knowledge or training in plant identification and field description of forest soils. There is a two-stage allocation process:

Step 1. A forest stand is allocated to one of 38 vegetation types (V-Types) via keys based on general overstory description, and modified by the presence, absence, or general abundance of a few important understory plants.

Step 2. The soil is allocated into one of 22 soil types (S-Types) via keys based on moisture regime, parent material texture, and depth to bedrock (Sims et al. 1989).

FEXPERT has been modelled after the NWO FEC keys for soil and vegetation classification. It uses a collection of observations made by the user about soil and vegetation, and rules represented by the keys relating the observations, to form a "rule based" system to infer a conclusion, i.e., classify a site as one of the 38 vegetation and 22 soil types. Each of the four keys - Deep Soil, Shallow Soil, and the two halves of the vegetation key for Conifer vegetation types (NWO FEC Vegetation Key, Part B) and Mainly Hardwood /Conifer Mixedwood vegetation type (NWO FEC Vegetation Key, Part A) - were converted into a set of rules that used information fields containing the user's observations to determine the classification.

Each classification key is composed of a number of nodes or decision points. At each node, one or more observations on either soil characteristics or vegetation characteristics must be made to determine the next decision point. Many of the decision points in a classification require information on common topics. For example, the deep soil key has eight decision points that require information on soil texture. Such information was combined into one information field called "Texture of C Horizon" as shown in Figure 10.

The soil moisture regime was classified to <4 (i.e., Dry to Fresh) or _4 (i.e., Moist to Wet) by combining the "Depth of Mottles/Gley" and "Texture of C Horizon" fields as summarized in Table 1 indicating valid ranges for the variables involved. Tables 2 and 3 show the possible values for each of the fields in the deep and shallow soil keys, respectively. Figure 11 shows the groupings made for the shallow soil key.

The vegetation type keys require more than one type of observation at a decision point. Groupings of similar observations at various decision points resulted in Figure 2. Tables 4 and 5 show the possible values for the fields designated in Figure 2.

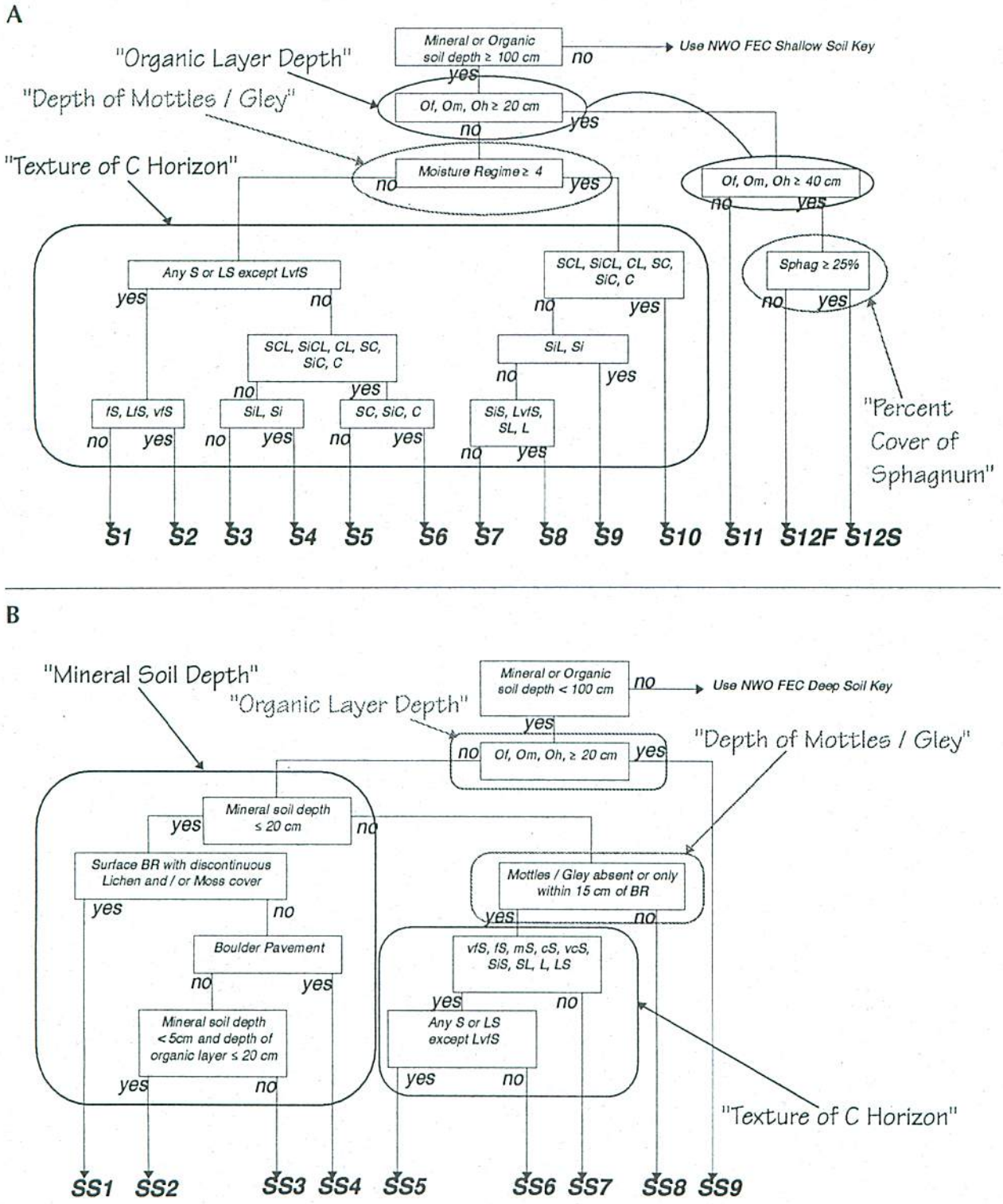
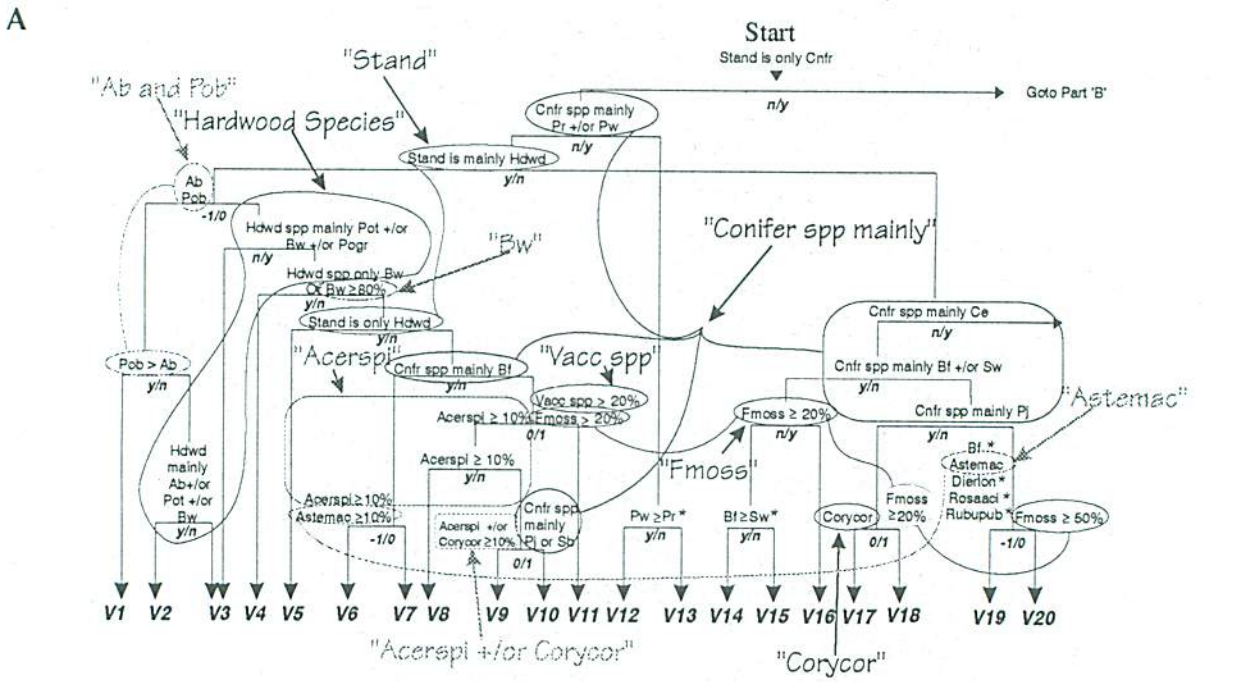
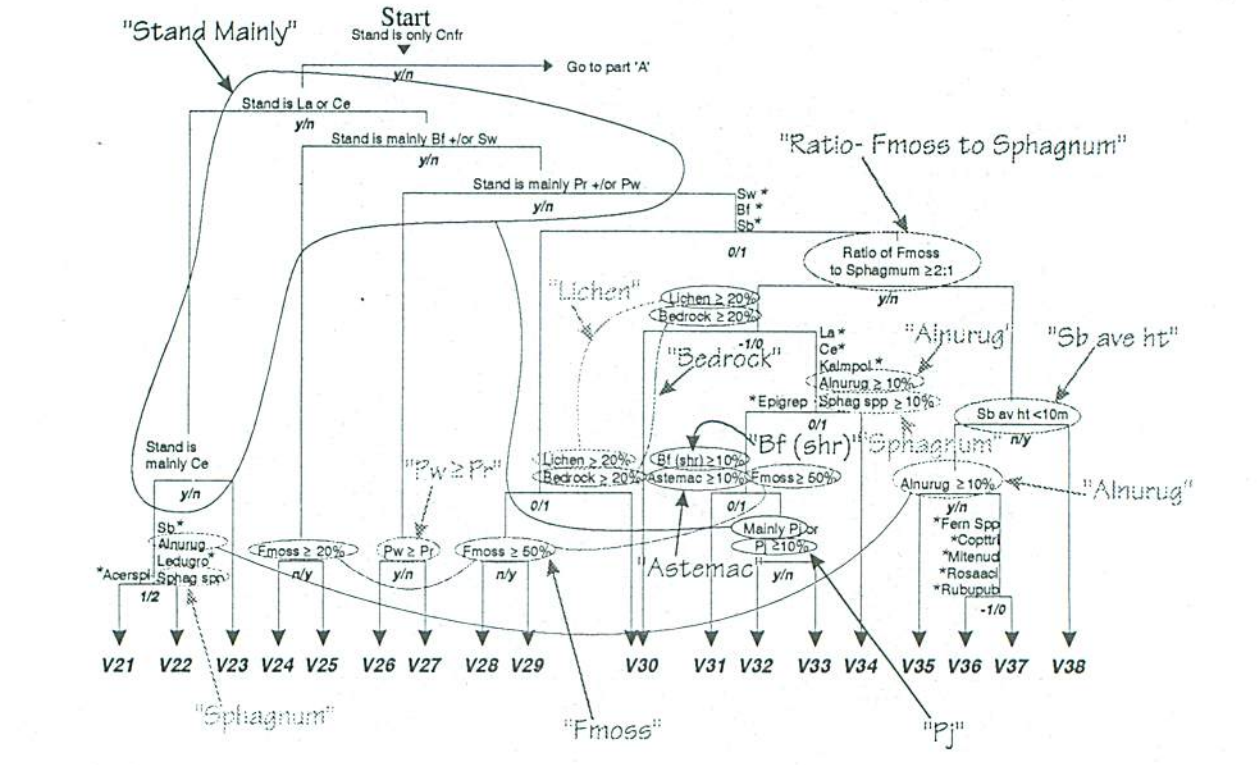


Figure 10. Deep (A) and Shallow (B) Soil Keys for the NWO FEC with groupings used in FEXPERT. Source: Sims et al. (1989).



The group name and the term beside the asterisk (*) are the same



The group name and the term beside the asterisk (*) are the same

Figure 11. Mainly Hardwood/Conifer Mixedwood (A) and Conifer (B) Vegetation Keys for the NWO FEC with groupings used in FEXPERT.
Source: Sims et al. (1989).

Table 1. Relating Moisture Regime to Depth of Mottles/Gley and Texture of C Horizon.

	Moisture Regime	
	<4 (Dry to Fresh)	≥4 (Moist to Wet)
Texture of C Horizon	Depth of Mottles/Gley (cm)	Depth of Mottles/Gley (cm)
vcS, cS, LvcS, LcS, SivcS, SicS, mS, LmS, SimS*	g≥51 or G≥91	g≤50 or G≤90
fS, LfS, SifS	g≥61 or G≥121	g≤60 or G≤120
SL, vfS, LvfS, SivfS	g≥61 or G≥151	g≤60 or G≤150
L, SiL, SCL, SiC, C, Si, SiCL, CL, SC*	g≥61	g≤60

G: Depth of grey Gley color
g: Depth of Mottles

Table 2. Valid fields and values for the Deep Soil key.

Field	Valid values and range
Organic layer depth	<20 cm 20 - 39 cm ≥40 cm
Percent cover *Sphagnum*	<25% ≥25%
Texture of C Horizon	Any SC, Any SCL, Any SL, C, CL, cS, fS, L, LcS, LfS, LmS, LvcS, LvfS, mS, Si, SiC, SiCL, SicS, SifS, SiL, SimS, SivcS, SivfS, vcS, vfS*
Depth of Mottles/Gley	This depends on the texture of C Horizon, *see* Table 1

Table 3. Valid fields and values for the Shallow Soil key.

Field	Valid values and range
Organic layer depth	<20 cm ≥20 cm
Mineral soil depth	>20 cm 5 cm – 20 cm 1 cm – 4 cm BR with discontinuous lichen / moss Boulder or pavement
Texture of C Horizon	Any SC, Any SCL, Any SiS, Any SL, C, CL, cS, fS, L, LcS, LfS, LmS, LvcS,* LvfS, mS, Si, SiC, SiCL, SiL, vcS, vfS*
Depth of Mottles/Gley	G, g: <15 cm from bedrock, or absent G, g: ≥15 cm from bedrock

* Soil/vegetation abbreviations. Source: Sims et al. (1989) "Field Guide to the Forest Ecosystem Classification for Northwestern Ontario". *See* Appendix A for definition of abbreviations.

Table 4. Valid fields and values for the Conifer Vegetation Determination.

Field	Valid values and ranges
Stand Mainly	La, Ce, Bf +/or Sw, Prl +/or Pw, Pj, Not Listed
Ratio - Fmoss to *Sphagnum*	≥2:1, <2:1
Lichen	≥20%, <20%
Bedrock	≥20%, <20%
Sb average height	<10m, ≥10m
Alnurug	not present, 1% to 9%, ≥10%
Sphagnum	not present, 1% to 9%, ≥10%
Bf (shr)	<10%, ≥10%
Astemac	<10%, ≥10%
Fmoss	<20%, 20% to 49%, ≥50%
Pj	<10%, ≥10%
Sb, Sw, Bf, La, Ce, Epigrep, Fern Spp, Ledugro, Acerspi, Kalmpol, Copttri, Mitenud, Rosaaci* Rubupub	Yes (Some present) No (None present)

Table 5. Valid fields and values for the Mainly Hardwood/Conifer Mixedwood Vegetation Determination.

Field	Valid values and ranges	
Stand	Only hardwood, mainly hardwood, mainly conifer	
Hardwood species	*When Ab ≥ Pob:*	*When Pob and Ab are absent:*
	Mainly Ab +/or Pot +/or Bw	Mainly Pot +/or Bw +/or Pogr
		Only Bw
	Not Listed	Not Listed
Conifer spp mainly	*When stand is mainly conifer:*	*When stand is not mainly conifer:*
	Bf +/or Sw	Pr +/or Pw
	Ce	Pj or Sb
	Pj	Bf
	Pr +/or Pw	Not Listed
	Not Listed	
Bw	≥80%, <80%	
Ab and Pob	Pob > Ab, Ab ≥ Pob, neither present	
Acerspi	≥10%, 1% to 9% , not present	
Astemac	≥10%, 1% to 9%, not present	
Vacc spp.	≥20%, <20%	
Fmoss	≥50%, 20% to 49%, <20%	
Acerspi +/or Corycor	≥10%, <10%	
Pw ≥ Pr	Yes (True)	
	No (False)	
Bf ≥ Sw	Yes (True)	
	No (False)	
Rosaaci, Dierlon, Bf, Rubupub, Corycor*	Yes (Some present)	
	No (None present)	

* Soil/Vegetation abbreviations. Source: Sims et al. (1989) ; "Field Guide to the Forest Ecosystem Classification for Northwestern Ontario" . See Appendix A for definition of abbreviations.

Once all the fields and valid facts were established, the rules that encapsulate the structure of each of the keys were developed. The rules are of the form:

Soil Type is S11F - IF:
Organic Layer Depth = "0 to 39 cm''

Soil Type is S12F - IF:
Organic Layer Depth = "≥40 cm"
and
Percent Cover *Sphagnum* = "<25%"

(This is an example from the Deep Soil key; all other keys use similar rules.)

This example indicates that some of the information fields were not always required for a classification. For this reason, another set of rules was developed to determine when additional information was required, for example:

"Organic Layer Depth" Required

"Texture of C Horizon" Required - IF:
"Organic Layer Depth" = "<20 cm"

"Depth of Mottles/Gley" Required - IF:
"Organic Layer Depth" = "<20 cm"

The "Organic Layer Depth" is always required since it is the first node in the Deep Soil key. The valid values for the "Texture of C Horizon" are straightforward, and presented in Table 2 for the deep soil key, but the valid values for the "Depth to Mottles/Gley" are determined by the value associated with the "Texture of C Horizon". Therefore another set of rules was constructed to determine values of the Depth of Mottles/Gley field:

"Depth of Mottles/Gley" valid values = "g≥51 or G≥91" and "g≥50" or "G≥90"
IF:
"Texture of C Horizon" = "vcS" or "cS" or "LvcS" or "LcS" or "SivcS" or "SicS" or "mS" or "LmS" or "SimS"

"Depth of Mottles/Gley" valid values = "g≥61" or "G≥121" and "g≥60" or "G≥120"
IF:
"Texture of C Horizon" = "fS" or "LfS" or "SifS"

"Depth of Mottles/Gley" valid values = "g≥61" or "G≥151" and "g≥60" or "G≥150"
IF:
"Texture of C Horizon" = "SL" or "vfS" or "LvfS" or "SivfS"

"Depth of Mottles/Gley" valid values = "g≥61" and "g≥60"
IF:
"Texture of C Horizon" = "L" or "SiL" or "SCL" or "SiC" or "C" or "Si" or "SiCL" or "CL" or "SC"

(g = Depth to mottles, G = Depth to grey gley colors. All measurements are in cm.)

Similar rules were developed for each of the soil and vegetation keys. These rules were then written in PROLOG, and entered into their respective database. Input windows were created for each key containing the fields defined in Tables 2 through 5.

CONCLUSIONS AND RECOMMENDATIONS

FEXPERT encapsulates the necessary information from the NWO FEC Field Guides for easy and guided access during a classification. By avoiding redundancies, it provides the quickest route to arrive at a consistent diagnosis. FEXPERT also gives instant access to factsheets so that immediate verification of the classification can be made. In the case of misclassification due to doubtful observations, one may return to the input window to revise input information on soil or vegetation types.

The present version of FEXPERT requires a great deal of free memory to execute. This may not be a problem if a suitable data-logger is available. An MS-Windows version of FEXPERT may solve the memory requirements as well as lead to a suitable data-logger. A pen-based portable computer (i.e., pen tablet) would eliminate the use of a keyboard and mouse or trackball in the field, while providing an operating system (such as MS-Windows) that would handle FEXPERT's memory requirements.

ACKNOWLEDGMENTS

The authors would like to thank Richard Sims of Canadian Forest Service–Ontario for scientific and technical assistance, and Steve Rossi of the University of Western Ontario, for the design and programming of the FEXPERT prototype on which the present version is based. We would also like to thank Pia Papadopol for her help in preparing the user's manual.

LITERATURE CITED

Pressman, R. A. 1992. Software engineering: A practitioners approach. McGraw Hill Inc., Toronto, ON. 793 p.

Sims, R. A.; Towill ,W. D.; Baldwin K. A., Wickware G. M. 1989. Field Guide to the Forest Ecosystem Classification for Northwestern Ontario. Ont. Min. Nat. Res., Northwestern Ont. Forest Tech. Development Unit, Thunder Bay, ON. 191 p.

Racey, G. D.; Whitfield, T. S.; Sims, R. A. 1989. Northwestern Ontario Forest Ecosystem Interpretations. Ont. Min. Nat. Res., Northwestern Ont. Forest Tech. Development Unit, Thunder Bay, ON. Tech. Rep. 46. 90 p.

Baldwin, K. A.; Sims, R. A. 1989. Field Guide to the Common Forest Plants in Northwestern Ontario. Ont. Min. Nat. Res., Northwestern Ont. Forest Tech. Development Unit, Thunder Bay, ON. 344 p.

APPENDIX 1. GUIDE TO ABBREVIATIONS

From "Field Guide to the Forest Ecosystem Classification for Northwestern Ontario" (Sims et al. 1989)

Soil Texture Abbreviations

C	clay	Si	silt	S	sand
SC	sandy clay	SiS	silty sand	vfS	very fine sand
SCL	sandy clay loam	SiL	silt loam	fS	fine sand
CL	clay loam	SiC	silty clay	mS	medium sand
SiCL	silty clay loam	cS	coarse sand	L	loam
vcS	very coarse sand	SL	sandy loam	LS	loamy sand

Vegetation Abbreviations

Spp	species (plural)	+/or	and/or	≥	greater than or equal to
Cnfr	conifer	>	greater than	≤	less than or equal to
Hdwd	hardwood	<	less than		

Tree Species

Abbreviated name	Scientific name	Common name
Ab	*Fraxinus nigra*	black ash
Bf	*Abies balsamea*	balsam fir
Bw	*Betula papyrifera*	white birch
Ce	*Thuja occidentalis*	eastern white cedar
La	*Larix laricina*	tamarack or larch
Pj	*Pinus banksiana*	jack pine
Pob	*Populus balsamifera*	balsam poplar
Pogr	*Populus grandidentata*	large-toothed aspen
Pot	*Populus tremuloides*	trembling aspen
Pr	*Pinus resinosa*	red pine
Pw	*Pinus strobus*	white pine
Sb	*Picea mariana*	black spruce
Sw	*Picea glauca*	white spruce

Shrub Species

Abbreviated name	Scientific name	Common name
Acerspi	*Acer spicatum*	mountain maple
Alnurug	*Alnus rugosa*	speckled alder
Bf(shr)	*Abies balsamea*	balsam fir (shrub)
Corycor	*Corylus cornuta*	beaked hazel
Dierlon	*Diervilla lonicera*	honeysuckle
Epigrep	*Epigaea repens*	trailing arbutus
Kalmpol	*Kalmia polifolia*	bog laurel
Ledugro	*Ledum groenlandicum*	Labrador tea
Rosaaci	*Rosa acicularis*	prickly wild rose
Rubupub	*Rubus pubescens*	dwarf raspberry
Vacc spp.	*Vaccinium angustifolium*	blueberry
	Vaccinium myrtilloides	blueberry
	Vaccinium vitis-idaea	mountain. cranberry

Herb Species

Abbreviated name	Scientific name	Common name
Astemac	*Aster macrophyllus*	large-leafed aster
Copttri	*Coptis trifolia*	goldthread
Fern spp.	any species of fern	
Mitenud	*Mitella nuda*	naked mitrewort

Moss and Lichen Species

Abbreviated name	Scientific name	Common name
Feather moss	*Hylocomium splendens* *Pleurozium schreberi* *Ptilium crista-castrensis*	feathermosses
Sphagnum spp.	any species of *Sphagnum* moss or *Sphagnum*	
Lichen	any species of ground lichen e.g., *Cladina mitis* *Cladina stellaris* *Cladina rangiferina*	