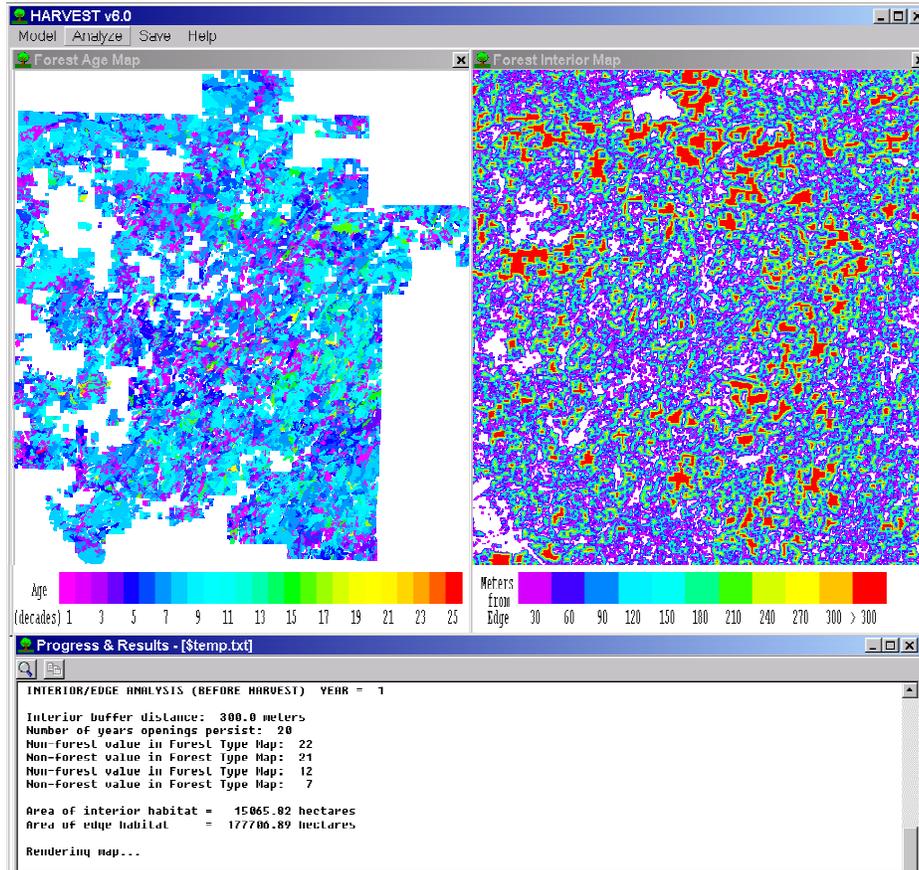# HARVEST for Windows

Timber Harvest Simulation Model

Version 6.0

User's Guide

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Description

HARVEST was designed as a strategic research and planning tool, allowing assessment of the spatial pattern consequences of broad timber management strategies. The model is well suited to evaluate alternative strategies, providing comparable predictions about how the alternatives affect the age (or successional stage) distribution of the forest, the spatial distribution of forest interior and edge habitats, and the patch structure of the resulting forest landscape. With HARVEST, the object is not to find a scheduling solution (i.e., determining the order in which individual stands should be harvested), but to assess the spatial pattern consequences of general management strategies. HARVEST has been shown to generate patterns similar to those produced by timber management (Gustafson and Crow 1999).

HARVEST simulates harvest practices that reset the age of forested sites to zero. This includes even-aged timber harvest techniques (e.g., clearcutting, shelterwood, seed tree techniques) and uneven-aged group selection. It is not capable of simulating single tree selection because these treatments do not predictably change forest age.

HARVEST allows the user to interactively simulate harvest by forest type and Management Area. Management Areas are relatively large, multi-stand areas that are to be managed by specific objectives. The user specifies harvest parameters (such as harvest size, rotation age, green-up interval), for a Management Area and forest type. The process may be repeated for multiple time steps.

HARVEST 6.0 provides a Windows interface and includes a number of features not available in previous versions, including the ability to specify cutting guidelines by multiple Management Areas and forest types, harvests with more irregular shapes, adjacency constraints, and analyses of landscape pattern. These rules include the size distribution of timber harvest openings, the total area harvested, the minimum age that can be cut (planned rotation interval), the spatial dispersion of harvested areas (whether harvested stands will be clumped or dispersed), the green up interval if adjacency restrictions are to be applied, and the width of buffers to be left between harvests and riparian areas.

HARVEST can conduct several analyses of the spatial pattern of the landscape both before and after simulated harvest. The patch structure (patches defined by stand age) can be analyzed for the entire mapped area, or by individual Management Areas. The amount of forest interior and edge habitat can be calculated and displayed according to the definition of interior given by the user. Analysis results of simulations can be saved spatially as GIS maps and in tabular form as a text file.

HARVEST was written in Fortran 95 using the Winteracter Windows libraries by Eric Gustafson and Luke Rasmussen. Address comments and questions to:

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The most recent version of HARVEST and its documentation may be obtained from the North Central Research Station Web site: http://www.ncrs.fs.fed.us/4153/Harvest/v60/v6_0.htm

This guide has been formatted for double-sided printing and insertion into a loose-leaf binder.

Installing HARVEST 6.0

Save Harvest60.zip to your hard drive. This may be a new directory, or one in which you wish to use HARVEST.

Uncompress the file. This can be done using PKZip, WinZip, or other decompression software.

The following files should be found following this operation:

Harvest60.exe	The Harvest program
Viewer.exe	A utility program used to view Erdas 7.4+ GIS map files
Help.txt	Online help file
Harv60 User.doc	The file you are now reading
Rgb.dat	Color table for the Harvest program
Rgb192.dat	Color table for the Viewer program
Defaults.sys	File to store User Preferences

Note: Files with a .sys extension may be hidden to your file management program.

To run Harvest, double click on the file *Harvest60.exe*.

Preparing input files

HARVEST operates on a grid-cell (raster) representation of the landscape. HARVEST requires a set of 4 input map files to simulate harvest activity: forest age map, forest type map, Management Area map, and a stand ID map. These maps are typically prepared using a GIS, and exported for use by HARVEST. Each input map file in the set must be of the same area, and have the same cell size and number of rows and columns. These files must be in an Erdas v7.4+, 8- or 16-bit GIS file format, typically with a *.gis* extension. Many common GIS programs can export this format. To create an Erdas v7.4+ format file from an Arc grid (ESRI Arc/Info), use the GRIDIMAGE command at the **arc:** prompt (not the **grid:** prompt).

Forest Age Map file: This map contains cells whose values represent the age (in years) of the forest on each cell. This map is used by HARVEST to determine if cells meet the age constraints for harvest. This map is typically prepared from a GIS stand map, assigning values based on the age attribute, or calculated from the year of origin of the stand. Cells with a value of zero are assumed to be areas that will never be harvested (land owned by others, inoperable, permanently reserved from harvest, etc.)

Assigning zeros here is one way to exclude parts of the mapped area from harvest. Another is to designate Management Areas (see below) in which you never specify any harvest activity. As you generate the forest age map, stands (forested cells) that have an actual age of zero (recently cut) should be assigned an age of 1. Negative numbers are not supported in the Erdas file format, and should not be used.

Forest Type Map file: Each cell in this map contains a user-assigned integer code value (between 0 and 255) denoting a specific forest type. This map is used by HARVEST to apply harvest rules to the correct forest type. HARVEST also uses this map when leaving uncut buffers (typically riparian buffers), and to identify the non-forest land when calculating the amount of forest interior and edge habitats. HARVEST does not attach labels to the map values, so users must remember the values representing each forest or land cover type. This map is typically produced in a multi-stage process. First, the forest types are gridded from the forest type attribute in a GIS stand map. You may wish to aggregate types to match the types relevant to silvicultural treatments to reduce the number of harvest specifications you must make when simulating with HARVEST. For example, you may wish to aggregate 3 aspen species into an aspen type. Secondly, you may want to overlay the land cover types that you will wish to leave uncut buffers around (e.g., streams, lakes, and maybe even roads.) Lastly, you may want to mosaic this map with land cover information for the parts of the age map that are coded with zeros (e.g., outside your ownership). This may be information derived from a satellite image classification (e.g., USGS GAP program) or other land cover data (e.g., USGS LUDA data.) The minimum information required for the parts of the map where there are zeros in the age map is 2 classes: forest and non-forest. Providing this information will allow you to generate forest interior/edge maps for the entire image, rather than just where there are non-zeros in the age map. This last step is optional. Again, HARVEST does not allow you to attach labels to the integer values in this map, so you must keep their meanings clear as you reference these values when using HARVEST.

Management Area Map file: Each cell in this map contains a user-assigned integer code value denoting the Management Area in which that cell falls. A Management Area is a multiple-stand area in which all the stands will be treated with similar, specific management practices. *Management Areas with the same value need not be contiguous.* This map is used by HARVEST to apply the harvest strategies you specify to the correct Management Area. If you do not wish to distinguish separate Management Areas, then produce a Management Area map with a single value for all cells.

Stand ID map file: This is a map of stand ID numbers, where each stand ID value is a unique integer ≤32,767. This map is used by HARVEST to track harvest activity in stands. It is often produced from the stand age map by passing the age map through a GIS clumping algorithm (e.g., REGIONGROUP in Arc GRID, CLUSTER in EPPL). HARVEST reads the maximum stand ID value (*n*) from the file header, and assumes that stand ID values start at 1, and that there are no missing integers between 1 and *n*. Cells with the same ID value must be contiguous (stands may not be fragmented into noncontiguous parts.) This map of stand IDs remains constant throughout a simulation of multiple time periods.

Figure 1 shows examples of each of these maps for a hypothetical landscape.
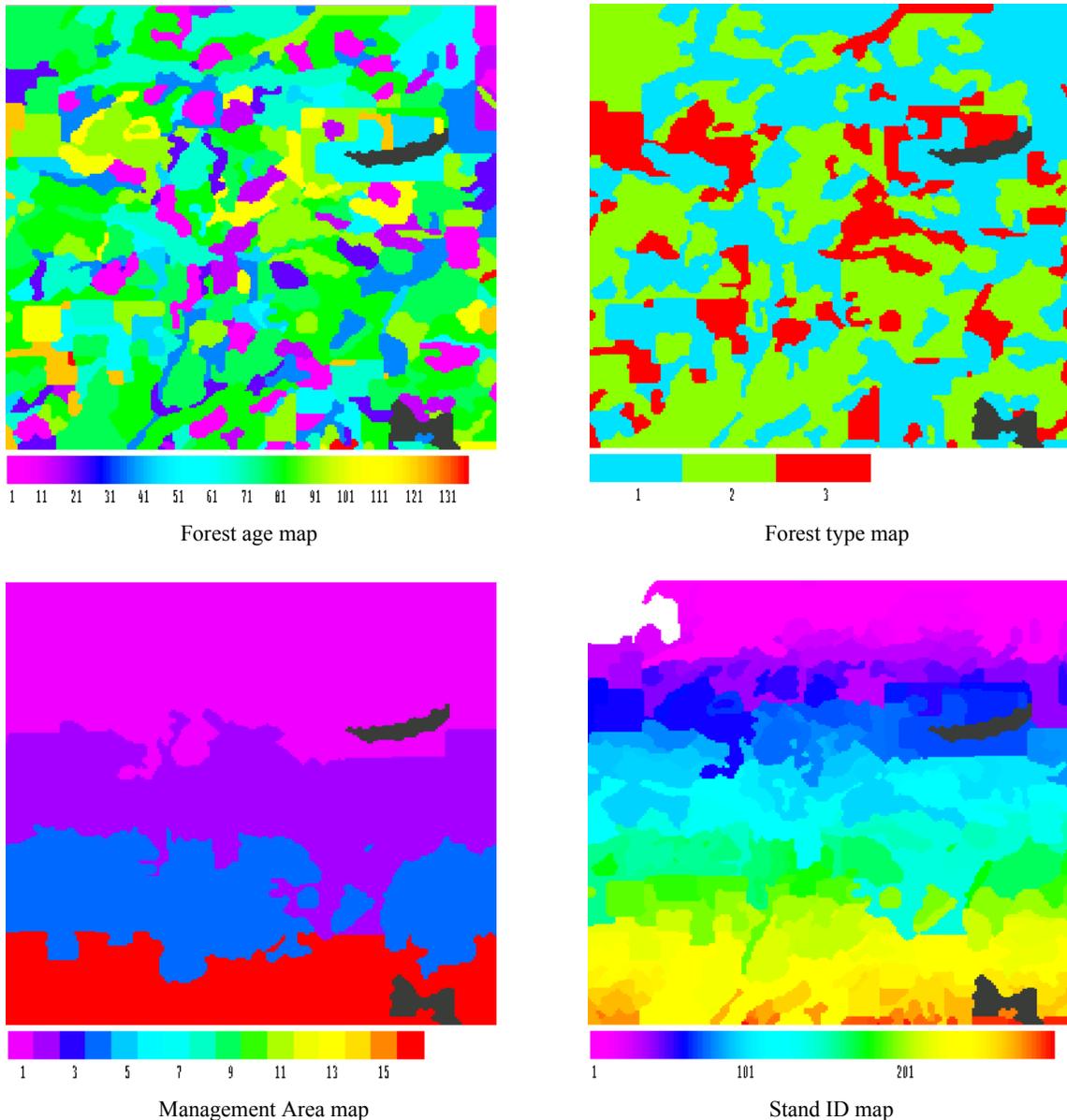
Figure 1. Hypothetical examples of the four input maps required by HARVEST. The color bars show the values associated with the colors for each map. The Management Area map contains values of 1, 2, 4 and 16. The Stand ID map has 292 stands, and many adjacent stands are difficult to distinguish with only 255 colors.

Simulating Harvests Using HARVEST 6.0

HARVEST provides guidance for new users through context-sensitive "helper dialogs." To turn this feature on, select 'Preferences' under the *Save* menu item. Check the "Show helper dialogs" checkbox. After you become familiar with the operation of HARVEST, you may turn this feature off by clearing this checkbox (click on the checkbox to clear it).

MODEL

This menu item contains the controls for the simulation part of HARVEST.

Load map set

This command allows you to select the 4 map files on which HARVEST operates. A standard Windows File Selection dialog box will open, allowing you to choose the files you wish to use. The input files must be in ERDAS v. 7.4+, 8- or 16-bit format, and will typically have a .gis extension. The first map requested is the forest age map. HARVEST will report when maps have completed loading. If some of the map information needed by HARVEST is not present in the map header (e.g., cell width or unit of area), or if the map's units are different from the default units that you have defined (explained more under the Preferences menu item), HARVEST will prompt you to supply this information. After you select the age map, it will be displayed on the screen. You will then be prompted for a forest type map. If some of the map information needed by HARVEST (for this and subsequent map files) is not present in the map header, HARVEST will offer to use the information from the age map. You will notice a check box that will cause HARVEST to update this missing information in these maps so you will not have to do it each time you load these maps. You will next be prompted for a Management Area map. Lastly you will be prompted for a stand ID map.

Maps other than the stand age map are not displayed. If you wish to view these maps, there is a utility program supplied with HARVEST (viewer.exe) that can be used to view ERDAS .gis files.

If you wish to use Harvest to calculate patch metrics only, loading the last 2 maps is optional (press *Cancel* when prompted for those maps). If you do not load the Management Area map, you will not be able to calculate patch metrics by Management Area.

In addition to a map window, a text window will also appear. This window will allow HARVEST to communicate results and progress to you. All of the information appearing in this window is also recorded in a log file that you may save for future reference (see Save menu item below).

Execute

This option will cause HARVEST to initiate the simulation of harvesting on the currently loaded input maps. If you have already simulated some harvests, the age map you see on the screen is the current age map, and additional harvests can be simulated on it by selecting *Execute*. The forest type, Management Area, and stand boundary maps are never changed by Harvest, so the maps you last loaded will be used. HARVEST will allow you to simulate multiple harvest strategies on various Management Areas and forest types in a given time step. When you finish simulating all harvest activity for a time step, HARVEST will let you proceed to the next time step to repeat the process, or to quit harvesting. You may view an updated age map at any time during this process by clicking on the *Update Maps* button.

When you invoke *Execute*, you will be prompted for a **random number seed**. This must be an integer between 0 and 2147483647. Selecting 0 (zero) will cause HARVEST to generate a random number seed using the system clock. HARVEST is a stochastic model, meaning that it relies on a random number sequence to simulate harvesting activity. The random number seed is used by the computer to initiate the sequence of random numbers. Model runs using the same input parameters and random number seed will be identical, but a change in the random number seed will produce a somewhat different result. This is a realistic approach for timber harvest simulation, because different project planners will implement the same forest management plan in different ways.

You will then be prompted for an **Institutional Memory file**. This file is used to store information about harvest activities in each stand, such as when a harvest event occurred in a stand, what type of harvest it was, and when the stand is to be treated again (if applicable). This file also contains information about each stand in the map. Each stand will be associated with a single Management Area and a single forest type. In the event that a stand overlaps multiple forest types and Management Areas, only the dominant forest type and Management Area will be associated with the stand. You will specify a new file if this is

the first time step, and select an existing file to continue a simulation run begun previously. HARVEST will create the file if it does not exist.

You will then be prompted for the **length of the time step** (in years) that will be used throughout the simulation. At each time step, HARVEST increments the non-zero values in the forest age map by the (integer) value you enter here, representing the aging of stands during the period. The time step interval cannot be changed within a HARVEST simulation run. The default value is 10.

The final question you will be asked before specifying harvest parameters is: **Do you want to create a list of all log output (spreadsheet format)?** The contents of the *Progress and Results* window are a log of your HARVEST session. Because the log file is verbose, some users find it useful to look at a summary of the input parameters and results in a spreadsheet. If you select the *Yes* dialog button here, you will be asked to enter a file name, and HARVEST will create a comma-delimited file that can be imported into most spreadsheet programs.

The **Harvest Parameters** dialog box will now appear. This dialog allows you to target harvest parameters to a specific forest type within a specific Management Area. Each time you press the Harvest button, HARVEST will simulate harvest activity using the parameters you specified, and then return the *Harvest Parameters* dialog box to the screen. You may then target other harvest activity to another forest type/Management Area combination, advance to the next time step, update the maps so that you can observe the harvests that have been allocated thus far, or exit the Harvesting process. After pressing *Exit*, you may resume harvesting where you left off (beginning with the next time step) by choosing *Execute* again from the *Harvest* menu and selecting the same 'Institutional memory file' you were using for the initial run.

Details of the Harvest Parameters Dialog:

1. Choose the integer value(s) representing the **Management Area(s)** and the value(s) representing the **forest type(s)**. Only values actually found in the maps will be offered (except for map values of zero). You may select more than one Management Area and/or forest type if the harvest parameters are applicable to multiple Management Area-forest type combinations. To select multiple values, click on the first value, and then select the additional value(s) while simultaneously holding down the Ctrl key on your keyboard. Harvests will be simulated only in stands of the specified forest type(s) located in the specified Management Area(s).

2. **Average harvest size and standard deviation**. These values specify a normal (bell-shaped) distribution of harvest opening sizes. HARVEST will randomly select harvest opening sizes from this distribution. You can expect that 95% of the randomly selected sizes will fall within 2 standard deviations of the mean. If you wish to truncate the tails of this size distribution so that sizes are not selected that are less than some minimum or greater than some maximum, enter those limits in the appropriate fields. If you do not wish to impose such limits, simply enter zeros. If you want all harvests to be exactly the same size, enter a standard deviation of 0.0. This will cause the minimum and maximum fields to be disabled, since their values will equal the mean.

Note that the ability to specify harvest size allows you to change the scale of patchiness of your landscape (when defining patches by age of seral stage.) When HARVEST allocates a cut that is smaller than the stand, some cells are left uncut. These cells may be cut at a later time step, especially if the stand is being managed on a rotation. Alternatively, if the size of the harvest is larger than the stand, HARVEST will attempt to achieve the requested size by cutting in an adjacent stand, provided it meets forest type and age requirements, and if cutting the adjacent stand would not otherwise violate adjacency constraints (i.e., ignoring the obvious violation caused by the spillover cutting.)

If you do not wish to specify the harvest size distribution, but instead require harvest units to follow existing stand boundaries, check the *Fill Stands* box. This will disable all of the harvest size fields. HARVEST will sequentially harvest stands of the specified forest type in the specified Management Area until the target harvest amount has been cut. HARVEST will rarely cut exactly the target amount (see

section 5 below). HARVEST may fall considerably short of the target if all remaining, suitable stands are larger than twice the amount needed to meet the target. Note: because group selection places numerous openings within the boundaries of a stand, the *Fill Stands* option is not available when group selection is activated.

3. **Dispersion method**. HARVEST will choose locations for harvests using one of 4 algorithms:

   a. The *dispersed* method randomly selects stands (of the designated forest type within the Management Area) for harvest independently of each other. HARVEST continues to select stands until the target acreage has been harvested, or until all the stands older than the minimum age for harvest have been cut.

   b. The *clumped* method randomly chooses a focal stand, and then attempts to harvest the stands that are neighbors of its neighbors (potentially creating a ring on harvested stands, one stand removed from the initial stand.) However, these stands may not always be eligible for harvest because they may be a different Management Area or forest type, or too young. HARVEST attempts to harvest these nearby stands, and then selects a new focal stand and repeats the process until the target acreage has been harvested, or until all the stands older than the minimum age for harvest have been cut.

   c. *Group selection* randomly chooses stands and then harvests small openings (groups; patches) within those stands. When group selection is chosen, you must also specify the proportion of the area of each stand to be removed during each entry into the stand. The default is one-sixth of the stand. This will be used to calculate the total area of the stand that will be turned into harvested openings (cut) during each entry into the stand. If you imagine a stand as a piece of Swiss cheese, this proportion is analogous to the proportion of the surface of the cheese that is holes. HARVEST continues to select stands until the target acreage has been harvested, or until all the stands older than the minimum age for harvest have been cut.

   d. *Oldest first* selects from the stands of the designated forest type within the Management Area in the order of decreasing age. HARVEST continues to select stands until the target acreage has been harvested, or until all the stands older than the minimum age for harvest have been cut.

For each of these methods, you may specify a re-entry interval (in years). This allows HARVEST to cut stands on a set rotation. When you press the *Harvest* button, HARVEST will record for each stand cut the harvest parameters, and the time step when the stand should be cut again. When that time step arrives, HARVEST will automatically cut those stands again, using the same harvest parameters used when the stand was first cut. It will also automatically schedule the next re-entry time step. If you do not select the Re-enter stands check box, harvested stands will again be eligible for selection for harvest when they become old enough. When a re-entry interval is specified, the timing of subsequent harvests in a stand is deterministic; when a re-entry interval is not specified, the random selection process of the dispersion methods described above determines the timing of subsequent harvests. Not checking the re-entry checkbox for group selection may be useful to simulate certain patch-cutting harvest methods.

Under all methods, stands must always meet minimum age requirements and other specified constraints (e.g., adjacency constraints) before they can be harvested.

4. **Minimum age for harvest**. This is comparable to a minimum rotation interval. Forested cells must be at least this old before they can be harvested. Keep in mind that the number of years represented by the length of the time step is added to the age of each cell *before* HARVEST simulates any cutting. To harvest stands on a strict rotation basis, also use the re-entry interval described above. An alternative specification for the age constraint is *Minimum time since last harvested*. This is relevant only for time steps after the first, since HARVEST only uses information found in the Institutional Memory file about previous harvests that may have occurred in a stand. HARVEST will round the number you enter here to the nearest multiple of a time step.

5. **Amount to harvest**. HARVEST requires an area (which it converts to a number of cells) as a target for cutting. This area can be specified by the user in one of three ways: 1) as a percentage of the area of

the forest type in the Management Area, 2) as a percentage of the area of the forest type in the Management Area that also satisfies all constraints (amount of *available* forest type), or 3) as an area entered by the user. If entered as a percentage, HARVEST will quickly scan the age map (by Management Area and forest type) to determine the area available. If you selected multiple Management Area-forest type combinations, HARVEST will take their combined area into account. This area will immediately be reported in the 'Area to be harvested' field below the 'Percent' field whenever you change the percent, the Management Area or the forest type. HARVEST will attempt to harvest the area specified. It may actually cut more or less, usually within an amount less than half of the mean harvest size specified. HARVEST may not find enough cells to fully allocate your request in every decade. Usually this happens when stands are not completely cut (including riparian buffers). This leaves cells that HARVEST thinks may be available, but the stand history or riparian buffers preclude harvests there. The area actually cut each decade is shown in the text output window and recorded in the log file.

Specifying area for Group selection is not always straightforward. HARVEST expects you to specify the area of the stands to be treated with group selection. However, because only a fraction of the stand area is cut (openings created) in each time step, the area actually cut is always less than the area you specify.

6.   **Adjacency constraints**. Check this box if you wish to enforce an adjacency constraint. This constraint prevents HARVEST from cutting a stand that is adjacent to a stand that is younger than the *'green-up interval'* you specify here. The green-up interval typically is understood to be the length of time it takes for a stand to regenerate sufficiently to no longer be considered a newly-harvested opening.

7. **Provide riparian buffers**. Check this box if you wish to prevent cells from being harvested that are within some distance of riparian areas. When this box is checked, you must also select the *value(s) found in the forest type map* that represents riparian areas (or some other class you wish to buffer, such as roads). To select multiple values, click on the first value, and then select the additional value(s) while simultaneously holding down the Ctrl key on your keyboard. Also specify the minimum distance from these areas that harvests are allowed. HARVEST will round the number you enter here to the nearest multiple of the cell width. HARVEST does not allow you to specify different buffer widths for different classes (e.g., water and roads) in the forest type map.

Buttons:

Harvest: Simulate harvesting using the current harvest parameters and return to this dialog. All harvest openings simulated will be targeted to the specific Management Area(s) and Forest Type(s) you selected in the Management Area and Forest Type fields of the dialog. When the dialog reappears, you have the option of specifying additional harvests in this, or more likely, other Management Area/Forest Type combinations.

Go to Next Time Step: End this time step and go to the next time step. Select this button when you have finished simulating harvests in all relevant Management Area/Forest Type combinations for the current time step. When HARVEST advances to the next time step, the first thing HARVEST does is to re-enter any re-entry stands scheduled for the current time step. HARVEST finds this information in the 'Institutional memory' file, and implements re-entries based on the re-entry interval specified when each stand was first cut.

Update maps: This option will re-draw the stand age map when you wish to see the results of harvests simulated since the last map update. HARVEST maintains the age map in memory, but to save time the map is only updated on demand, or when *Exit* is pressed from the *Harvest parameters* dialog. *Also use this button if the map windows become corrupted. Window corruption should only occur if the program is minimized or some other window covers a map window during the map drawing process.*

Exit: Quit harvesting and return to the main HARVEST program. **Note**: you cannot return to the current time step after exiting. If you resume simulation by choosing *Execute* and selecting an existing Institutional memory' file, your simulation will resume at the time step following the one you were in when you pressed *Exit*.

Program Harvest Script

This option will behave like the 'Execute' option, but instead of running simulations, it will save the parameters and rules you specify in a script (text) file, so that you can run the simulation later. This is useful if you want to produce a replicate of a simulation, or wish to modify some parameters for experimental purposes, without having to go through the manual process of inputting all the parameters.

A dialog will ask you to name the script file or, if you wish, select an existing script file. HARVEST can either overwrite the existing script, or append new script to the previous contents. This behavior can be set in the *Save Preferences* dialog located under the *Save* menu (see the *Save* section for more information).

A preliminary dialog box appears with the following check boxes:

a. *Save age map each time step*? If you wish to have a series of age maps automatically saved at the end of each time step, check this box and enter a base filename. The time step number (e.g., 01, 02) will be appended to this name, and saved with a .gis extension. These maps can later be viewed or analyzed for their spatial pattern (load into HARVEST and use *Analyze* functions, or use other analysis software such as Fragstats (McGarigal and Marks 1993)).

b. *Allow manual harvests after script completes*? Check this box if you wish to manually continue the simulation run after the programmed part is finished. The harvest parameters dialog will appear and the time step will not advance from the last time step simulated by the script file.

c. *Create results table file (spreadsheet format)*? Check this box if you want HARVEST to create a comma-delimited file of the input parameters and results that can be imported into most spreadsheet programs.

The script file (which has an .hsc extension) can be edited to expedite minor modifications to a simulation. Some users may want to specify all simulations in *Program* mode, because errors can be edited before executing. HARVEST does **not** have an *Undo* option when running in normal *Execute* mode.

Execute Harvest Script

This option will run a previously created script. You will be prompted for the name of the script file, and asked if you would like the harvest parameters written to the log file. An answer of *Yes* will cause HARVEST to display the parameters contained in the script file to be written in the *Progress and Results* window as the simulation proceeds. The simulations will then proceed without further input from you. If you selected the *Allow manual harvests after script completes* option, the Harvest parameters dialog box will appear when the script has finished executing. You may simulate additional harvest activity as if you had selected *Execute* from the *Model* menu. The time step will not advance from the last time step simulated by the script file. If you wish to begin additional harvesting in the subsequent time step, select the *Go to Next Time Step* button.

Clear log file

This option will clear the contents of the *Progress and Results* window. You will be given the option to save the contents of this window before it is cleared.

Exit

This option will close the HARVEST program. You will be reminded to save files, should you desire to do so.

ANALYZE

This menu item causes HARVEST to conduct an analysis of the patch structure of the current forest age map, or to analyze the amount of interior and edge habitat found in the current forest age map.

Patches

This option will calculate a number of measures of landscape patch structure including the age distribution, the length of linear edge between patches (forest stands) of different ages, the average size of patches of similar age, and the distribution of patch sizes by age class. There are two ways that you can perform patch analysis: either for the Current Map or for Multiple Maps. For all analyses conducted, patches are identified based solely on stand age - information from the forest type map is not used. You will be given the option of calculating patches for the entire map, or by specific Management Area(s). Patches are calculated based on 10-year age classes by default. You may alternatively enter user-defined age classes (two to five classes). To do this, check the 'Define age classes' box, select the number of age classes you wish to define, and enter the age ranges for each class. You may modify the labels for each age class that will be printed in the resulting output. The results of these analyses are reported in the *Progress and Results* window and can be saved as a log file.

If you choose to perform patch analysis for multiple age maps, you will be given a Windows dialog to select the first file in the map series, followed by a dialog to select the last map in the series. All of the maps in the series must have the same base name, and must be sequentially numbered from the first map to the last map selected (i.e. Map01.gis, Map02.gis…Map15.gis). You will also be asked to enter a filename where the tabular output will be stored in a comma-delimited format. The parameters dialog will be shown the same as for single-map analysis, and will be applied to each map in the series. Results for each map will be displayed in the log window.

Interior

This option will calculate the amount of interior and edge habitat, and the length of linear edge between forest and openings, considering both harvested cells and the non-forest types in the forest type map to be forest openings. There are two ways that you can perform interior analysis: either for the Current Map or for Multiple Maps. For all analyses conducted, information from both the stand age and forest type maps is used.

You will be prompted to enter an Interior buffer distance. This is the distance that edge effects extend into the forest, and should be selected based on the ecological process(es) that are of interest. (You may wish to conduct several analyses at various buffer distances.) HARVEST will convert the distance you enter to the nearest number of pixels, so the actual value used will be a multiple of the pixel width. This information is recorded in the running log.

You will also be asked to enter the number of decades that harvested openings persist. When analyzing forest interior and edge, any stand less than or equal to this age will be considered a forest opening. Stands older than this age are assumed to have returned to a closed canopy condition. This value must be a multiple of the length of the time step, and should be selected with knowledge of the local forest regeneration rates, and the ecological process(es) of interest.

You will also be prompted for the value(s) representing non-forest in the forest type map. Cells having this value will also be considered openings when calculating forest interior. All other values will be considered forest. To select multiple values, click on the first value, and then select the additional value(s) while simultaneously holding down the Ctrl key on your keyboard.

The results of this analysis are reported in the *Progress and Results* window and can be saved as a log file. The interior map may also be saved as a .gis file.

If you choose to perform interior analysis for multiple age maps, you will be given a Windows dialog to select the first file in the map series, followed by a dialog to select the last map in the series. All of the maps in the series must have the same base name, and must be sequentially numbered from the first map to the last map selected (i.e. Map01.gis, Map02.gis…Map15.gis). You will also be asked to enter a filename where the tabular output will be stored in a comma-delimited format. The parameters dialog will be displayed just as it is for single-map analysis, and the parameters will be applied to each map in the series. Results for each map analysis will be displayed in the log window.

Query Stand

Select this option to investigate the characteristics of specific stands in the stand age map. Using the left-click button on the mouse, select a cell within a stand. A dialog box will appear showing the following information about the cell and the stand it is in: Stand ID number, stand size, average age of the cells in the stand, the Management Area the stand is in, the forest type of the stand, year last treated, treatment code, and revisit interval. The treatment code will be 255 for group selection harvests, and 1 for all others. In some cases the actual stand boundaries will not be evident from the ages of the cells, because the stand ID map is not shown. When you are finished, press the *Close* button.

SAVE

This menu item allows you to save the results of your simulations and analyses.

Age map

You may save the simulated age map after a simulation run. The map will be saved in an ERDAS 7.4 format, which can be used as input to other HARVEST runs, or loaded into many common GIS systems. Note that once you load a new map set, all previous maps are cleared from memory, so remember to save maps prior to loading another map set.

Interior map

You may also save the current interior map at any time. This map is also saved in an ERDAS 7.4 format. The map you see on the screen is the map that will be saved. Once you conduct a new analysis of interior (or load a new map set), any prior interior maps are cleared from memory and cannot be retrieved later.

Log file

A running log of your HARVEST session is maintained by HARVEST and displayed in the *Progress and Results* window. This log records the input files and the parameters you used, and the results of any analyses you conducted. If you conduct multiple analyses (including the use of many different interior calculation parameters, these will all be appended to this running log. The running log is cleared when you load (or re-load) a map set. You may save this log at any time, although it is cleared by saving, and when a new map set is loaded.

Preferences

You may set the defaults that appear in several of HARVEST's dialog boxes. You also can turn the *Helper dialogs* on or off. The *Helper dialogs* provide context-sensitive instructions to new users. As you become experienced using HARVEST, they will become unnecessary, and may be turned off as a preference setting. Here is a description of the preferences that you can modify and save:

Time step default (years): The value appearing here will be used as the default value in the *Time Step* dialog.

Show helper dialogs: If this box is checked, HARVEST will advise you on your options for running the program at each step of the process. This is useful for new users. To turn this feature off, clear the check box.

Only apply adjacency constraints to same Management Area: If this box is checked, HARVEST will only apply adjacency constraint checks to stands that have the same Management Area as the stand being cut. If this is unchecked, adjacency constraints will apply to any stand.

Path where HARVEST is installed: Provides the directory path where you first installed HARVEST. This is used so HARVEST can find the help and system files if you should move HARVEST to another directory.

Map Units: Define the default map units that HARVEST should use (e.g., feet, meters, acres, hectares). When an age map is loaded, and its units differ from the defaults, you will be asked if you would like to change the map units and save the changes to the ERDAS file.

Scripts: Select the option for generating script files. This controls how script information is added to an existing script file. *Append* - additional script information will be appended to the end of the existing script information; *Overwrite* - all existing script information in the file will be erased.

Group parameters: These values will appear as defaults for Group selection in the *Harvest parameters* dialog.

Harvest parameters: These values will appear as defaults in the *Harvest parameters* dialog.

Interior analysis parameters: These values will appear as defaults in the *Interior definitions* dialog.

HELP

The help menu provides access to an online version of the document you are now reading. You may also determine the version of HARVEST you are using by selecting *About*.

Exporting output files

MAP FILES

The output maps produced by HARVEST are saved in an ERDAS 7.5 file format. To import these files into Arc GRID format, use the IMAGEGRID command at the **arc:** prompt (not the **grid:** prompt).

COMMA-DELIMITED FILES

If you choose to create a list of all log output for export to a spreadsheet, HARVEST saves the data as a comma-delimited file. Most spreadsheet programs provide capabilities to import such data. You may have to specify the delimiter (in this case a comma ","), and the spreadsheet program should automatically import the data, including the column headings.

Common Problems and How to Fix Them

Problem: HARVEST warns me that there are not enough colors available.

Fix: Go to the Windows Control Panel and select 'Display'. Set colors to 'High color (16-bit)'. You may need to re-start your computer for this change to take effect.

Problem: I get the error message, 'File sharing is not loaded, requested ACTION not available, FILE=defaults.sys, UNIT=11'

Fix: HARVEST only allows one instance of itself open at a time. This error is probably caused by trying to open a second instance of HARVEST.

Using HARVEST for research or strategic planning

REPLICATES

Because HARVEST is a stochastic simulation model, you will get a somewhat different result each time you run a given set of parameters on the same set of maps. However, this is also true in real life, where you will get different management plan implementations if you give different project-level planners the same task. Remember that the purpose of HARVEST is to simulate the project-level (stand-level) implementation of a strategic-level plan. This will provide an expected landscape spatial pattern given the management strategy simulated.

To understand an expected outcome requires statistical methods and replicated observations. It is mandatory that simulation replicates be generated whenever data are produced to support a decision or a research finding. A simulation replicate is a repeated simulation run where **only** the random number seed is changed. The question of how many replicates are required depends on how much variation exists among replicates. A minimum of 3 replicates should be produced to assess the between-replicate variation in measures of spatial pattern (e.g., amount of interior, mean patch size.) Consult with a statistician to determine the number of replicates required.

ALTERNATIVE SCENARIOS

HARVEST is a powerful tool to compare the spatial pattern expected under alternative management scenarios. These alternatives may differ in the boundaries and objectives of Management Areas, the intensity of harvest (area cut), the size of harvest units, the dispersion of openings, or some combination. Furthermore, the strategies may change over time in various ways. To see some examples of such comparisons, see Gustafson and Crow (1996), Gustafson (1996), Gustafson and Crow (1998), and Gustafson (1998).

HARVEST is not a tactical planning tool

HARVEST is a strategic-level planning and research tool. It should not be used to support project-level planning except as a heuristic (what-if?) device. To make HARVEST easy to use for strategic, coarse-filter evaluation of management alternatives, many simplifying assumptions were made to reduce data requirements and processing time. Because HARVEST ignores many forest conditions and constraints that are critical in tactical planning, it cannot be expected to provide guidance on the specific location of individual timber sales.

ASSUMPTIONS

A number of key assumptions were made in the development of HARVEST to maintain its ease of use as a strategic planning and research tool. Users of HARVEST should keep these in mind as they interpret and apply the results from simulations.

1. *Forest age is used as a surrogate for merchantability.* It is assumed that the likelihood of harvest of a stand of a given forest type within a Management Area is related solely to the age of the

stand. However, we know that stocking density, size class, site conditions, accessibility and operability are all factors that influence stand growth and harvest decisions in reality.

2. *HARVEST randomly selects suitable stands.* When HARVEST does not select stands using the *Oldest First* method, stands are selected at random from those stands that satisfy age and adjacency constraints. Over a time period of a decade or more, this mimics the pattern found on real managed forests (Gustafson and Crow 1999). For shorter time periods this may not be the case.

3. *Forest type does not change, even over long time periods.* This may be unrealistic for certain forest types under even-age management. However, if the treatment types targeted to forest types by the user are compatible with those types, then this will not be a problem. If the user is interested in how forest composition might change under alternative management strategies, then HARVEST is not the tool to use.

4. *Stand boundaries do not change*, even when the harvest boundaries are significantly different than the original stand boundaries. The original stand boundaries are maintained solely for bookkeeping purposes. This normally does not create problems, but has the potential to create a logistical limit to harvest activity if simulated harvests are generally much smaller (or somewhat larger) than the original stands.

5. *HARVEST adds the length of the time step to the age of each cell prior to simulating any harvest activity.* This means that all stands that will become old enough for harvest at some time during the time step are considered to be old enough at the beginning of the time step. This procedure does not affect the spatial pattern of harvest openings.

INTERIOR

Analysis of forest interior and edge habitat requires the user to provide information to define what is to be considered forest interior. Interior conditions are generally not so much a physical phenomenon as an ecological phenomenon that arises from the perception of habitat quality by organisms. Microclimate edge effects usually extend into the forest only a few tens of meters. However, many bird species avoid habitat within several hundred meters of a forest edge. The user must have a specific ecological question in mind when requesting an interior analysis, and define interior conditions accordingly. In some cases, several analyses using different definitions of interior may be conducted to provide estimates of interior conditions relevant to different species or ecological communities.

PATCHES

Patches are defined as a collection of contiguous cells, connected edge-to-edge or diagonally, whose ages are all in the same age class (e.g., 1-10, 30-60). HARVEST allows the user to define the age classes. Forest type is not considered in the patch delineation process.

LINK TO SPECTRUM

A utility program was developed to convert output from the harvest-scheduling program *Spectrum* into a script file that can be used as input to HARVEST. This allows *Spectrum* schedules to be simulated in a spatial context. For more information on this utility program and its use, contact Eric Gustafson, or visit the HARVEST Web site (http://www.ncrs.fs.fed.us/4153/Harvest/v60/v6_0.asp).

References

Gustafson, E.J. 1996. Expanding the scale of forest management: allocating timber harvests in time and space. Forest Ecology and Management 87:27-39.

Gustafson, E.J. and T.R. Crow. 1996. Simulating the effects of alternative forest management strategies on landscape structure. Journal of Environmental Management 46:77-94.

Gustafson, E.J. 1998. Clustering timber harvests and the effect of dynamic forest management policy on forest fragmentation. Ecosystems 1:484-492.

Gustafson, E.J. and T.R. Crow. 1998. Simulating spatial and temporal context of forest management using hypothetical landscapes. Environmental Management 22:777-787.

Gustafson, E.J. and T.R. Crow. 1999. HARVEST: linking timber harvesting strategies to landscape patterns. *In* Spatial modeling of forest landscapes: approaches and applications*,* Mladenoff, D.J. and W.L. Baker (eds). Cambridge University Press, Cambridge, England.

Gustafson, E.J. 1999. HARVEST: a timber harvest allocation model for simulating management alternatives. *In* Landscape ecological analysis: issues and applications, Klopatek, J.M. and R.H. Gardner (eds). Springer, New York.

McGarigal, K., and B. J. Marks. 1995. FRAGSTATS: spatial pattern analysis program for quantifying landscape structure. Gen. Tech. Rep. PNW-GTR-351. USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon, USA.

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