Boreal ALFRESCO

ALaska **FR**ame Based **E**co**S**ystem **CO**de

User Guide

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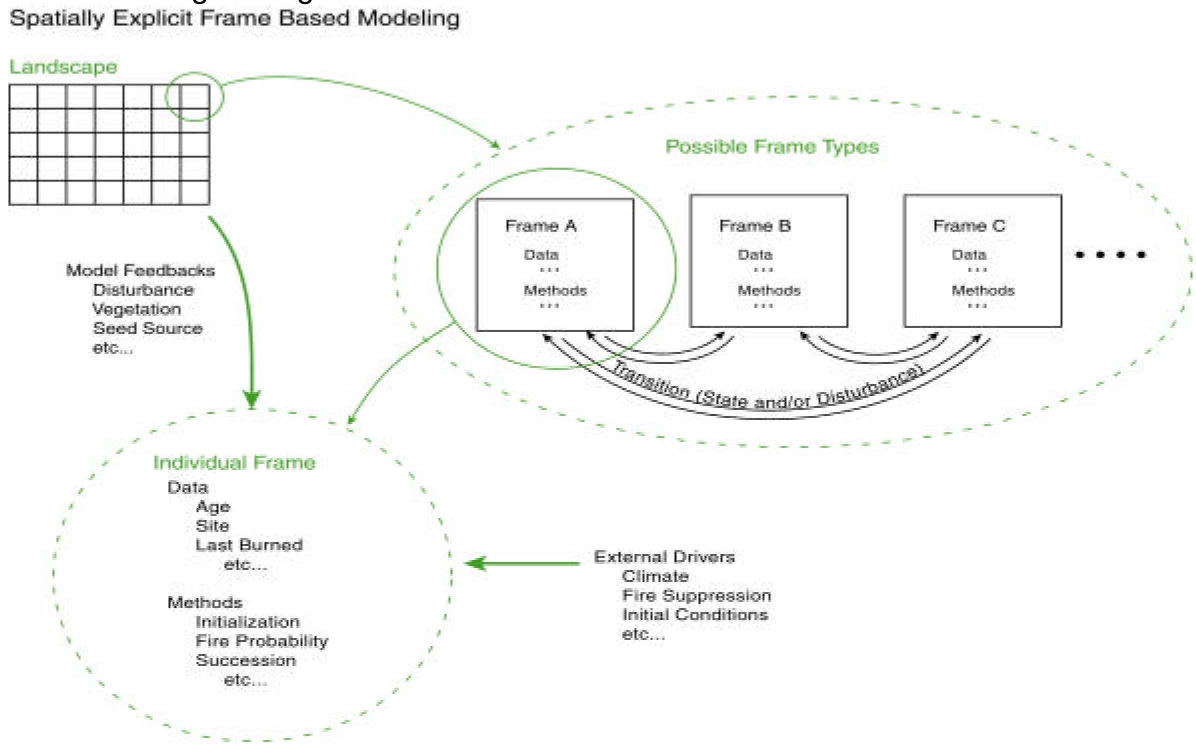
Contents

Introduction

Boreal ALFRESCO is a spatially explicit stochastic ecological simulation model. In its current state, it simulates the landscape dynamics unique to sub-arctic and boreal forest vegetation types – under the assumption that *climate* and *disturbance* are the primary drivers for landscape change in this region.

The Boreal ALFRESCO landscape is composed of frames (cells) of independent sub-models which represent the current *state* of the landscape at that location. Switches from one *state* to another are governed by internal factors unique to each sub-model, as well as interactions with neighboring sub-models thru disturbance factors.



The mechanics of the spatially explicit frame-based design (FRESCO) lends itself well to studying boreal landscapes of various spatial scales, as the internal factors of each sub-model may be calibrated to represent any unique sub-regional landscape characteristics.

Technical Development is currently managed by Richard Howard and Tim Glaser of ASSISI Software, Portland, Oregon.

Front end development and research is currently conducted by the Ecosystem Dynamics Modeling Group of the University of Alaska Fairbanks.

Scott Rupp – Principal Investigator

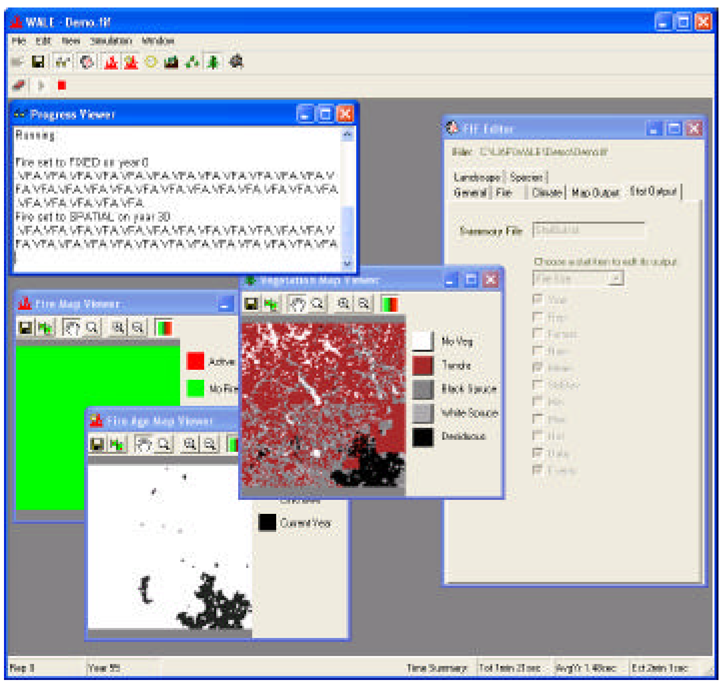
Paul Duffy – Statistician, PhD. Candidate Forest Sciences

Mark Olson – Statistician

Xi Chen – M.S. Candidate Statistics

(Jonathon Henkelman – Programmer)

Running Models

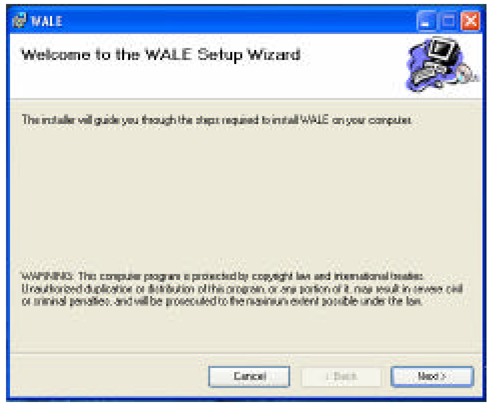


The interface to Boreal ALFRESCO.

Installing the Model

1) Download the folder ‘Setup’ anywhere in your computer.
2) In the ‘Setup’ Folder, open (run):

Setup.exe; the following Setup Wizard should appear. Follow the instructions.



(The Install Wizard will automatically create the working directory C:\UAF\Boreal ALFRESCO.)

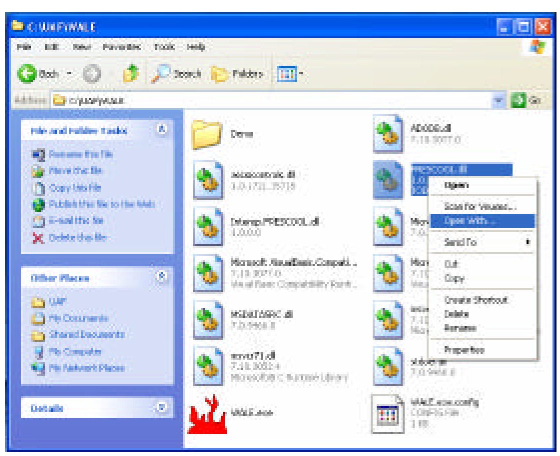
Note: This setup will fail on computers that do not have the updated .NET Framework. If this happens, you will also have to run dotnetfx11.exe (also included in the ‘Setup’ folder). This will install the .NET Framework, and Setup.exe will have to be run again.

3) If installed correctly, the following icon will appear on your ‘desktop’ (skip to 5)).

4) If the icon does not appear, or you get an error message, and dotnetfx11.exe has been installed, try the following:

(Note: This is also common if installing ALFRESCO for the first time.)

a) Navigate to C:\UAF\Boreal ALFRESCO
b) Right click on FRESCOOL.dll. Select the ‘Open With…’ option.



c) Select ‘Browse’ (or ‘Other’ if running Windows 2000)

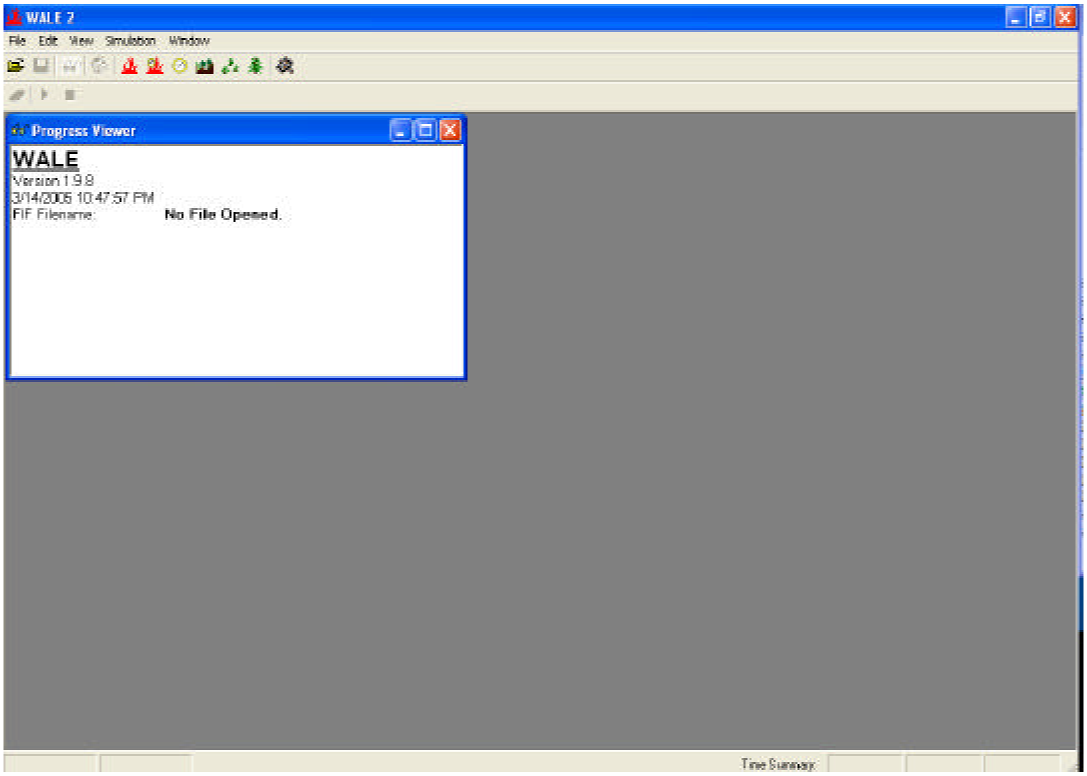
Windows XP:

Navigate to *‘Local Disk (C:)’* => *’WINDOWS’* => *‘SYSTEM32’* => Select regsvr32.exe.

Windows 2000:

Navigate to *'Local Disk (C:)'* => *'WINNT'* => *'system32'* => Select REGSVR32.exe.

5) The program can be run either by selecting the desktop shortcut, or from the working directory by selecting Boreal ALFRESCO.exe . The following screen should appear if the program was installed successfully:



Getting Started

Quick Start

If you are a first time user of Boreal ALFRESCO or need a brief refresher course on how to use Boreal ALFRESCO, this quick overview will teach you how Boreal ALFRESCO is intended to be used.

1. Open Boreal ALFRESCO

Double click the Boreal ALFRESCO shortcut located on your desktop.

2. Open a FIF File

Click the Open… button. A demo FIF file is created during the installation of Boreal ALFRESCO. It is typically located at C:\UAF\Boreal ALFRESCO\Demo\Demo.fif.

3. Make any desired edits

After completing step two, you should now see the FIF Editor (for details see FIF Editor). Navigate through the FIF Editor and make any desired edits.

4. Save the FIF File

Click the Save button. Changes in the FIF Editor will not be enacted in a simulation until they have been saved.

5. Open Desired Viewers

Before running the simulation, you may want to open a few map viewers. Map viewers show color coded maps during a simulation and are updated every simulation year (for details see Map Viewers).

6. Run the Simulation

Click the Run button . To find out what is happening while running the simulation, see the Progress Viewer, the Status Bar, or watch any of the Map Viewers.

The status bar is at the bottom of the Boreal ALFRESCO interface shows the current rep and year as well as a time summary (for details see Status Bar).

If not already opened, the Progress Viewer can be opened by clicking the Progress Viewer icon.

7. Stop the Simulation

If you wish to stop the simulation before it completes, click the Stop button .

8. Resume or Clear to start from beginning

After stopping the simulation, you can either resume the simulation where it was stopped, or you can start the simulation from the beginning again.

To resume the simulation, simply click the Run button .

To restart the simulation, click the clear icon and then click the Run button .

9. View Output Files

After completing the simulation, you can view the various output files created during the simulation. Go to the Output Directory, a subdirectory of the Base Directory. Both of these directories are specified on the General settings tab of the FIF Editor.

Overview

The various buttons and menu items contained within the main Boreal ALFRESCO interface are described in the table below.

Buttons & Menu Items

Open…	Open a FIF file for editing and simulation.
Save	Save changes made in the FIF Editor to the opened FIF file.
Progress Viewer	Open or hide the Progress Viewer.
FIF Editor	Open or hide the FIF Editor.
Clear	Clears a simulation to allow starting a simulation from the beginning.
Run Simulation	Run a simulation using the currently loaded FIF file.
Stop/Pause Simulation	Stop the progress of the simulation. Press the Run button to resume the simulation.
Iterative Ignitions	An iterative ignitions algorithm is used when Simulation|Iterative Ignitions is selected. Otherwise, the original recursive algorithm is used. Both algorithms produce identical output, but the iterative algorithm runs slightly slower, and memory errors may occur when running large landscapes.
Fire Map Viewer	Open the Fire Map Viewer.
Fire Suppression Map Viewer	Open the Fire Suppression Viewer.
Fire Age Map Viewer	Open the Fire Age Map Viewer.
Age Map Viewer	Open the Age Map Viewer.
Site Map Viewer	Open the Site Map Viewer.
Sub Canopy Map Viewer	Open the Sub Canopy Map Viewer.
Vegetation Map Viewer	Open the Vegetation Map Viewer.
Replay Map Viewer	Open the Replay Map Viewer.

FIF Editor

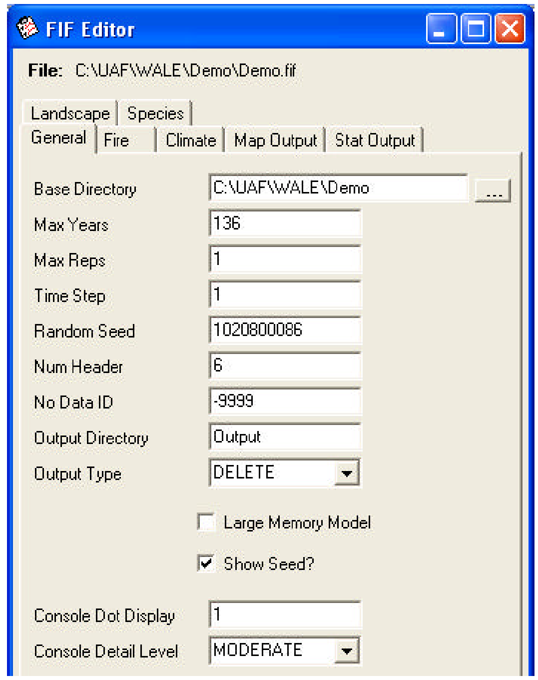
About FIF Editor

The FIF editor provides an alternative to editing FIF files in a text editor. Using the FIF Editor to edit and save FIF files helps ensure the format of the FIF files will remain compatible with Boreal ALFRESCO. Select Edit|FIF Editor or press the FIF Editor button  to open the FIF Editor.

Note

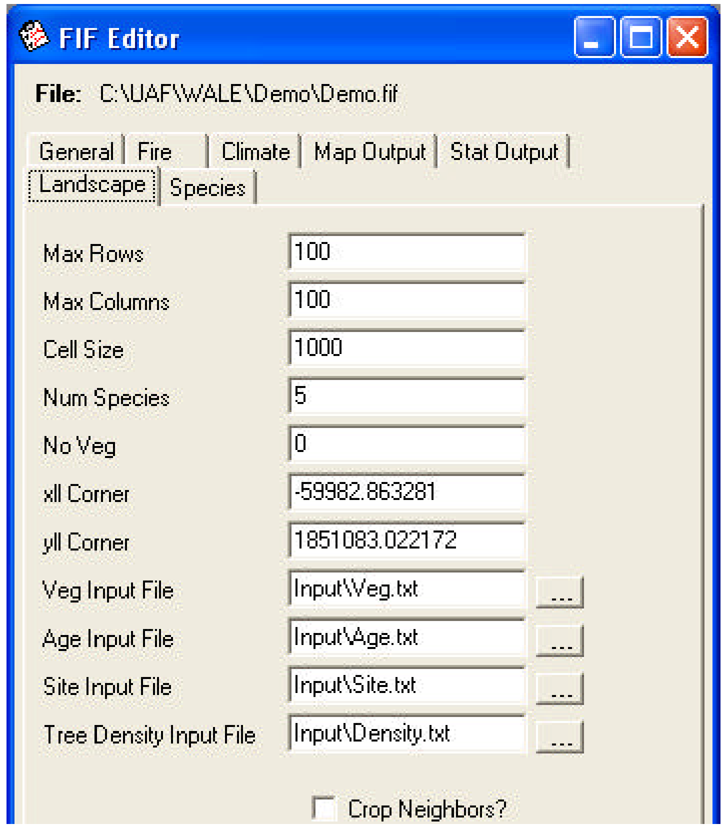
All input file paths should only be entered as subdirectories, because they will be appended to the base directory provided in the general settings tab. For example, if “C:\UAF\ Boreal ALFRESCO \Demo” is provided as the base directory, then “Input\Veg.txt” would be a valid subdirectory file path.

General Settings Tab



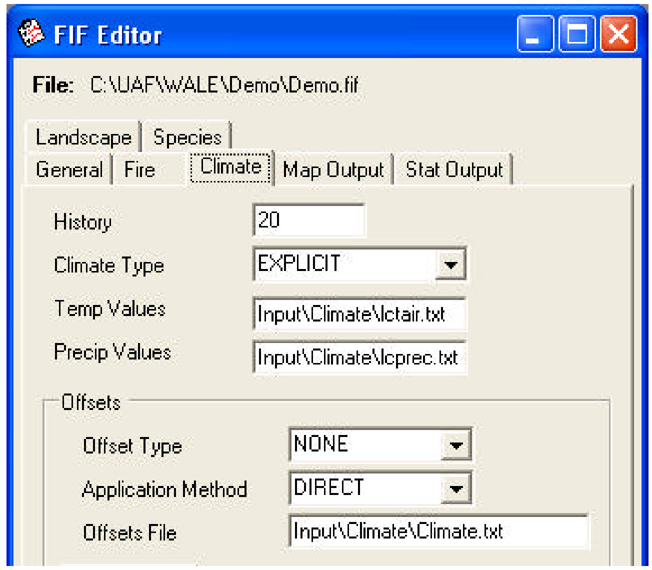
Field	**Description**
Base Directory	Base directory where input files can be found and output will be saved.
Max Reps	The number of replicates to run the simulation (i.e. x replicates total).
Max Years	The number of years to run the simulation (starts at year zero, ends after completing the x'th year)
Time Step	The time step in years. 1 = ANNUAL, 10 = DECADAL
Random Seed	A manually set number used to seed the random number generator. If not set (leave blank), the current time is used to seed the random number generator.
Num Header	The number of header rows in the input files. This is generally = 6 if using ArcGIS to process input/output maps.
No Data ID	No Data value specified by ArcGIS.
Output Directory	Sub directory of base directory where output files will be found. Current date and time will be appended to the name given here.
Output Type	**DELETE**: Delete current output directory. **OVERWRITE**: Overwrite any existing output files. **APPEND**: Append date on to output directory.
Console Dot Display	The frequency to display simulation progress in the Progress Viewer. i.e. once every x years
Show Seed?	Should the program display the random seed to the Progress Viewer?
Console Detail Level	This setting controls the amount of detail displayed in the Progress Viewer. **MINIMAL**: Show only run progress. **MODERATE**: Show some interim calculations along with run detail. **MAXIMUM**: Show maximum detail along with run detail.
Large Memory Model?	Should all data be loaded and stored into memory during setup? TRUE = Read in all Historical fire and Explicit climate maps at beginning of run. (Uses more memory) FALSE = Read in Historical fire and Explicit climate each year.

Landscape Settings Tab



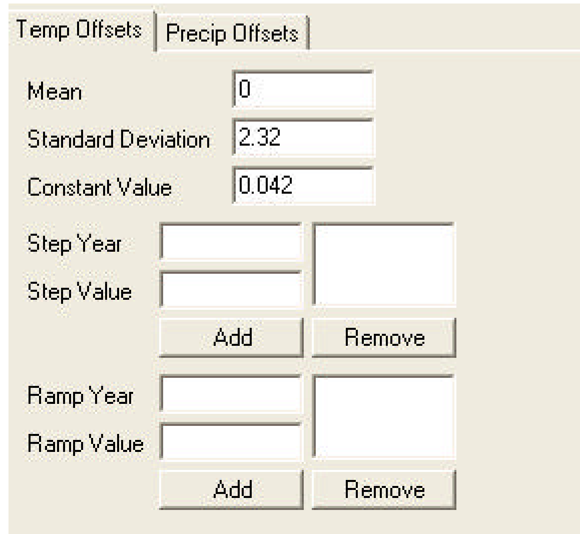
Field	Description
Crop Neighbors?	TRUE = Neighbors are defined as cells within a circular distance from a sample cell. FALSE = Neighbors are defined as cells within a square boundary with side equal to the Fire.SpreadRadius Setting. **(Note: Usually set to FALSE.)**
Max Rows, Max Columns	The total number of rows and columns in the landscape.
Cell Size	The size of each cell in meters (e.g. x by x).
Num Species	The number of landscape species present in the model (including the NoVeg type)
No Veg	ID of the no vegetation cell type (e.g. mountains, water). Flammability for these cells = 0.
Xll Corner	X Corner specified by ArcGIS.
Yll Corner	Y Corner specified by ArcGIS.
Veg Input File	Path (relative to *Base Directory* (General Settings) and filename of initial input vegetation map.
Age Input File	Path (relative to *Base Directory* (General Settings) and filename of initial input age map. Note: If left blank, the model will generate random ages for each cell.
Site Input File	Path (relative to *Base Directory* (General Settings) and filename of initial input site (aspect) map.
Tree Density Input File	Path (relative to *Base Directory* (General Settings) and filename of initial input tree density (canopy) map.

Climate Settings Tab



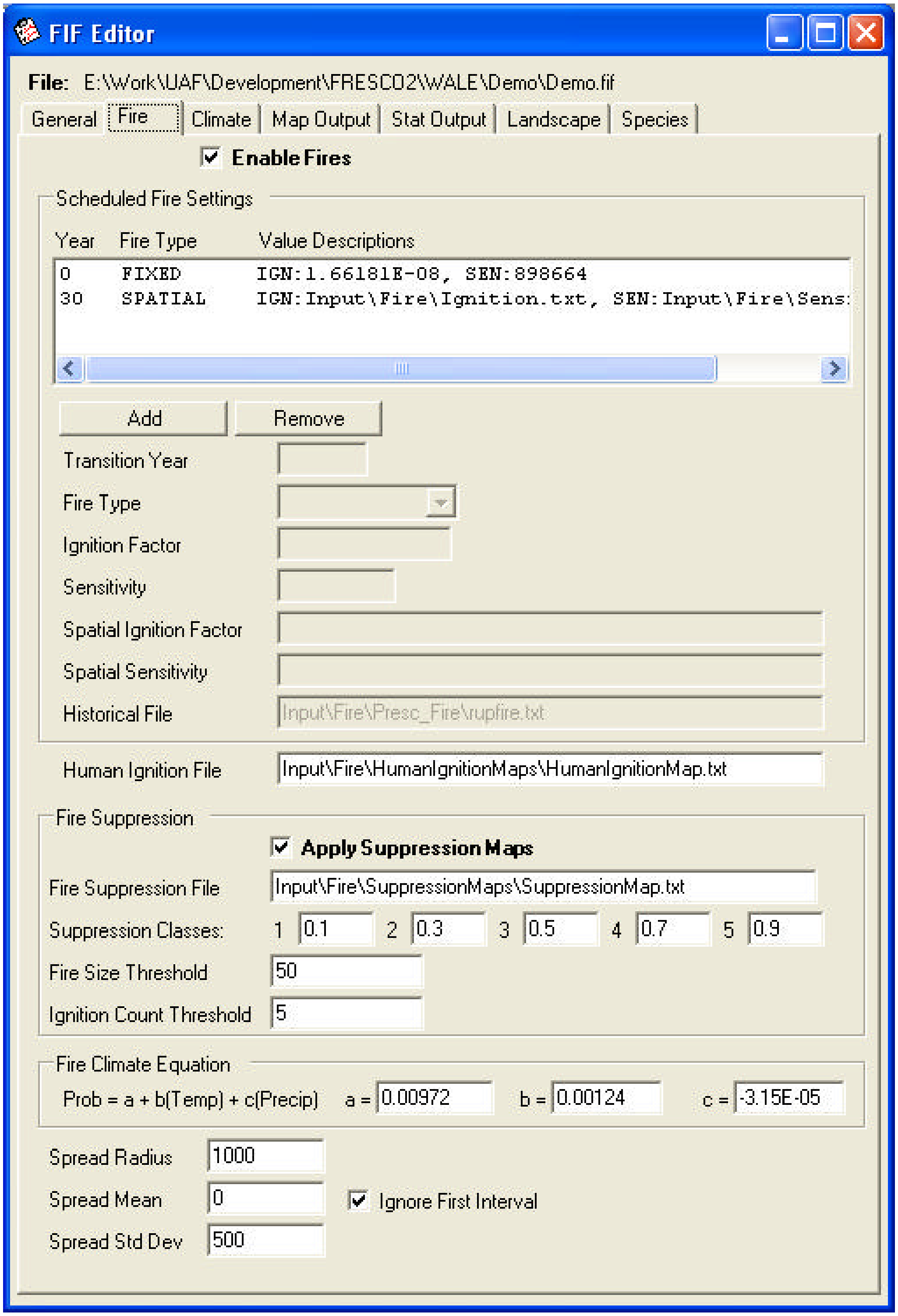
<table>
<tr><th>Field</th><th>Description</th></tr>
<tr><td>History</td><td>The number of years to remember climate history.</td></tr>
<tr><td>Climate Type</td><td>CONSTANT: Single temp and precip value used for every cell in all years and reps.
SPATIAL: Read in spatially unique temp and precip values from a map file. Reuse it each year and rep.
EXPLICIT: Read in spatially unique temp and precip values from a different file each year. Year is appended as _YR</td></tr>
<tr><td>Temp Values
Precip Values</td><td>Specifies the path (relative to the Base Directory) and filenames of the climate information. These files can take on a variety of forms depending upon the selection of Climate Type:
<table>
<tr><td>Climate Type</td><td>Description</td></tr>
<tr><td>CONSTANT</td><td>A single value to use for temperature and precip.</td></tr>
<tr><td>SPATIAL</td><td>Path and filename to single temp and precip maps.</td></tr>
<tr><td>EXPLICIT</td><td>Path and <u>Base</u> filename of temp and precip maps. Note: The sequence of input maps must be in the form [BASE_Year], beginning with Year 0. ALFRESCO will automatically append (and increment) Year onto this base filename while running.</td></tr>
</table></td></tr>
<tr><td><u>Offsets</u> - Offset Type
(Determines how temporal offsets are calculated.)</td><td>NONE: No offsets applied.
CONSTANT: Single temp and precip offset used for all cells over all years and reps.
FILE: Offsets are read in from a file. (Note: This file must be formatted as an ASCII .txt file containing a 2 column matrix (years = rows, no header). Temp = 1st col., Precip = 2nd col.
RAMPED: Offsets are calculated using stepping and ramping (see below).</td></tr>
<tr><td><u>Offsets</u> - Application Method
(Determines how offsets are applied.)</td><td>DIRECT: Offsets applied directly to climate values.
STOCHASTIC: Offsets applied stochastically to climate values each year and rep (see below).
REPLICATED: Offsets applied stochastically to climate values each year but repeated each rep.</td></tr>
<tr><td><u>Offsets</u> - Offsets File</td><td>Path (relative to the Base Directory) and filename when Offset Type = FILE.</td></tr>
</table>

Climate Settings Tab (Stochastic offsets, Steps/Ramps)



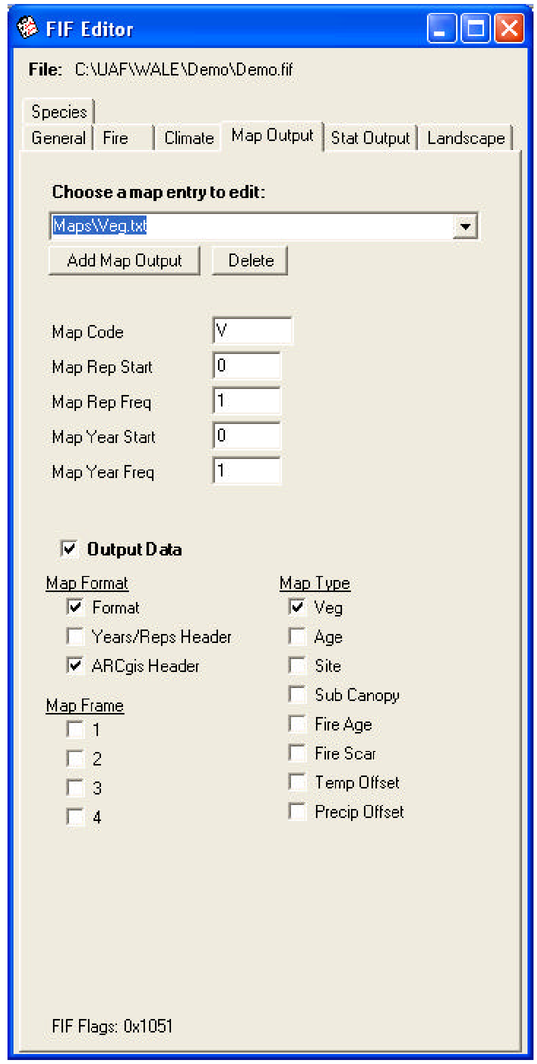
Temp and Precip Offsets The following settings exist on both the Temp Offsets and Precip Offsets tabs.	
Mean	The mean of climate temperatures or precipitation (depending on the focused tab). Expected to be 0, because the mean difference from the mean for that cell should be 0.
Standard Deviation	The standard deviation of the offset from mean climate temperatures or precipitation (depending on the focused tab). For offset type = **STOCHASTIC** (or **REPLICATED**) offsets are generated from a random Normal(User specified Mean (above), Standard Deviation).
Constant Value	The offset used for **CONSTANT** offset type scenarios.
Offset Steps An offset step is a sudden increase in an offset. On a given step year, an offset can be shifted by a step value. Create a list of offset steps by pressing the Add button.	
Step Year	The year that steps occur. Must be a multiple of Time Step (under General settings) to occur.
Step Value	The amount of step that occurs in the corresponding step year.
Offset Ramps An offset ramp is a steady increase of an offset over a range of years starting at Ramp Year and ending when a new Ramp Year occurs. Create a list of offset ramps by pressing the Add button.	
Ramp Year	The year that offset ramps change i.e. the new ramp is applied if the year is > the specified year.
Ramp Value	The ramp (amount per year) that starts in the specified year.

Fire Settings Tab



Field	Description
Transition Year	The year in which a fire type transition occurs.
Fire Type	**FIXED**: Single ignition and sensitivity factor used. **SPATIAL**: Read ignition and sensitivity factors from files. **HISTORICAL**: Burns are scheduled across the landscape.
Ignition Factor	Fire ignition multiplier.
Sensitivity	General fire sensitivity parameter.
Enable Fires	Enable the fire model - usually set to true.
Spatial Ignition Factor Spatial Sensitivity	Path (relative to *Base Directory*) and filenames for spatially explicit ignition and sensitivity maps. Each entry corresponds to a year in Fire.TypeTransitionYears.
Historical File	Path (relative to *Base Directory*) and *Base* file name of historical fire maps. For example, a setting of "Fires/Fire.txt" will cause Boreal ALFRESCO to use maps of fires in the "Fires/" subdirectory rather than calculate an internal fire probability. The maps should be named as Fire_year.txt".
Human Ignition File	*Base* file name for human ignition maps (See Input Files) relative to *Base Directory*. For example, a setting of "Fires/HumanIgnitions.txt" will cause Boreal ALFRESCO to use maps named as "HumanIgnitions_<year>.txt"
Apply Suppression Maps	When checked, suppression maps are applied to fire spread calculations.
Fire Suppression File	*Base* file name for suppression maps (See Input Files) relative to the *Base Directory.* File format similar to Human Ignition file above.
Suppression Classes 1-5	Values for each suppression class. Suppresses a cell's sensitivity to fire spread when a suppression map is applied. Values should be on the interval [0,1] with 0 = Total Suppression, and 1 = No Suppression.
Fire Size Threshold	The number of cells that can burn within a given simulation year before the suppression map stops being applied for that simulation year.
Ignition Count Threshold	The number of ignitions that can occur within a given simulation year before the suppression map stops being applied for that simulation year.
Fire Climate Equation	The fields labeled a, b and c are numbers used in the fire climate equation as follows: $P_{clim} = a + b(Temp) + c(Precip)$ The equation expresses a relationship between fire probability and climate and is the result of a regression analysis.
Ignore First Interval	Ignore the first fire interval for a cell when calculating statistics - used to help eliminate startup bias in statistical calculations.
Spread Radius	The maximum distance fire can spread (meters). If *Crop Neighbors* is set to false and this is less than *Cell Size*, fire will spread to adjacent cells only.
Spread Mean	The mean to use when spreading fire - in meters.
Spread Std Dev	The std dev to use when spreading fire - in meters.

Map Output Settings Tab



Field	**Description**
Map Entries	Path and base names for the output maps.
Map Code	The code to output to the Progress Viewer so the user knows this map has been written.
Map Rep Start	The first replication that outputs maps. (Note: 0 = First Replicate)
Map Rep Freq	The year frequency to output maps.
Map Year Start	The first year that outputs maps. (Note: 0 = First Year)
Map Year Freq	The year frequency to output maps.
Output Data Flag	TRUE = data is output. FALSE = no data is output.
Map Format Flags	Format: Output the data so it is conducive to read it in into a stats package for analysis (e.g. matrix w/ no header). Years/Reps Header: Tack a header onto the output with the number of years/reps for reference purposes. ArcGIS Header: Attach a header to the output file to facilitate import into ArcGIS.
Map Type Flags	The types of data to be output.
Map Frame Flags	The map frames to be output. Output data is dependent upon implementation of that particular frame (facilitates additional map outputs not listed in Map Type Flags).

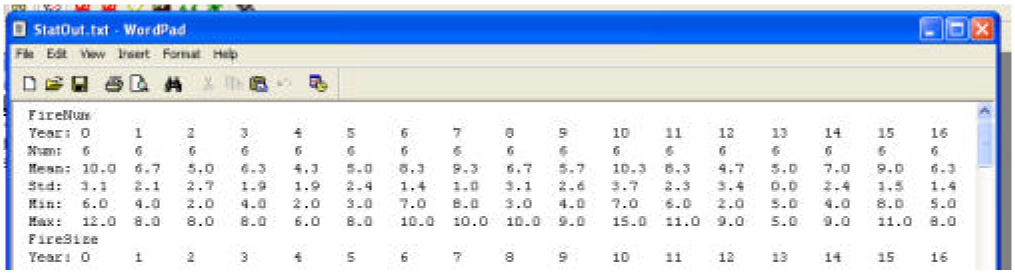
Statistical Output Settings Tab

The Stat Output tab specifies the types of statistical data that will be output to the file specified in the Summary File field. There are three formats for the statistical output:

Stat Summary File

The stat summary file holds summaries of the various stats including Sample Size, Mean, Min, Max, Standard Deviation, and a histogram option. Simulation results can be summarized across replicates or across years.

By Year (Averaged across Replicates):


StatOut.txt - WordPad

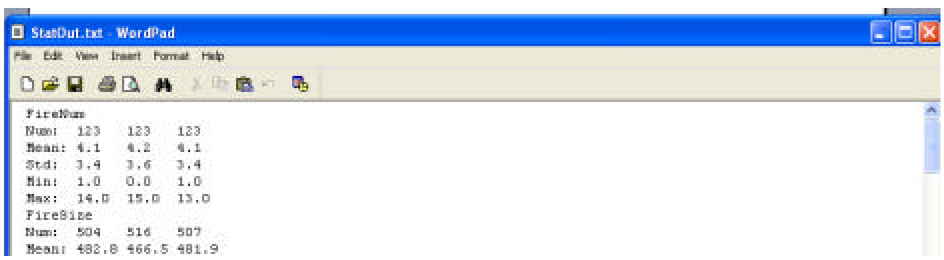
FireNum

Year:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Num:	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Mean:	10.0	6.7	5.0	6.3	4.3	5.0	8.3	9.3	6.7	5.7	10.3	8.3	4.7	5.0	7.0	9.0	6.3
Std:	3.1	2.1	2.7	1.9	1.9	2.4	1.4	1.0	3.1	2.6	3.7	2.3	3.4	0.0	2.4	1.5	1.4
Min:	6.0	4.0	2.0	4.0	2.0	3.0	7.0	8.0	3.0	4.0	7.0	6.0	2.0	5.0	4.0	8.0	5.0
Max:	12.0	8.0	8.0	8.0	6.0	8.0	10.0	10.0	10.0	9.0	15.0	11.0	9.0	5.0	9.0	11.0	8.0

FireSize

Year:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

By Replicate (Averaged across Years):


StatOut.txt - WordPad

FireNum

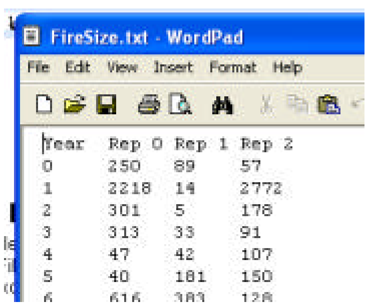
Num:	123	123	123
Mean:	4.1	4.2	4.1
Std:	3.4	3.6	3.4
Min:	1.0	0.0	1.0
Max:	14.0	15.0	13.0

FireSize

Num:	504	516	507
Mean:	482.8	466.5	481.9

Data Files

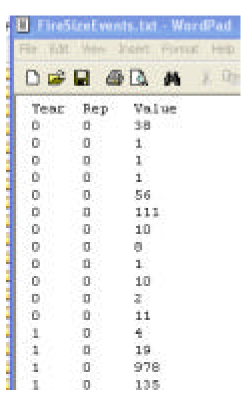
Data Files hold the sample data used to determine the values in the summary file. These (and the Event Files below) are a useful format for exporting the stat output into other computing platforms (e.g. Excel, SAS, R).


FireSize.txt - WordPad

Year	Rep 0	Rep 1	Rep 2
0	250	89	57
1	2218	14	2772
2	301	5	178
3	313	33	91
4	47	42	107
5	40	181	150
6	616	383	128

Event Files

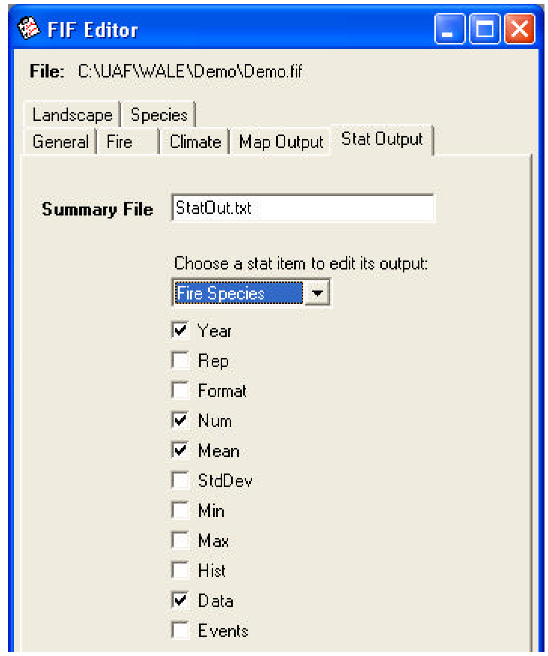
Event Files hold the values from individual events. These are particularly useful when analyzing Fire Sizes and Fire Intervals (The Data Files for these two stat options represent sums; whereas the Event files provide the raw data.)


FireSizeEvents.txt - WordPad

Year	Rep	Value
0	0	38
0	0	1
0	0	1
0	0	1
0	0	56
0	0	111
0	0	10
0	0	8
0	0	1
0	0	10
0	0	2
0	0	11
1	0	4
1	0	19
1	0	978
1	0	135

(Note the Sum of [Year 0|Rep 0] fires = 250.)

FIF Settings



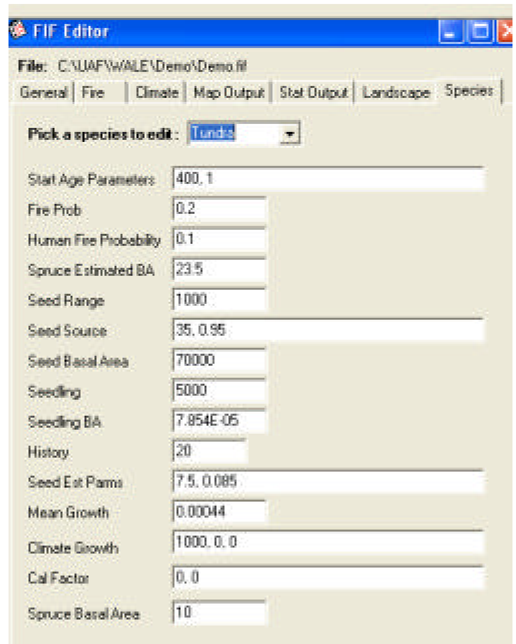
Field	Description
Summary File	The name of the statistical data output file (it will be created in the output directory specified under the General settings).
Stat selection box	Selects the statistical output category to be displayed and edited. The categories are: **Fire Number** – tracks the # of ignitions on the landscape **Fire Size** – # of Cells (Frames) burned / ignition **Veg Distribution** - # of Cells (by species) on landscape **Veg Residence Times** – By species tabulation of the average length of time a species remains in it's current state on the landscape (e.g. the time a species remains on the landscape before succeeding to another species). This accounts for both climate and disturbance induced transitions. **Fire by Species** – Fire Sizes (by species) **Fire Interval** – By species tabulation of the time between fires for each cell. No data will be output for a category without any options selected.
Year	Output the data averaged by year.
Rep	Output the data averaged by replicate.
Format	Show row titles in output. IE "Year", "Mean", "Min", "Max", etc.
Num	Output the number of samples.
Mean	Output the mean of the data.
StdDev	Output the standard deviation of the samples.
Min	Output the minimum of the samples.
Max	Output the maximum of the samples.
Hist	Output a histogram of samples.
Data	Output the sample data for the statistic. Note that sample data may already be an average or sum of event data. For example, FireSize sample data is the sum of all fires in a given rep and year.
Events	Output the event data for the statistic. Event data is a record of individual events rather than an average or sum.

Species Settings Tab

Each species has its own set of fields that can be displayed by selecting the species from the dropdown box.

Tundra

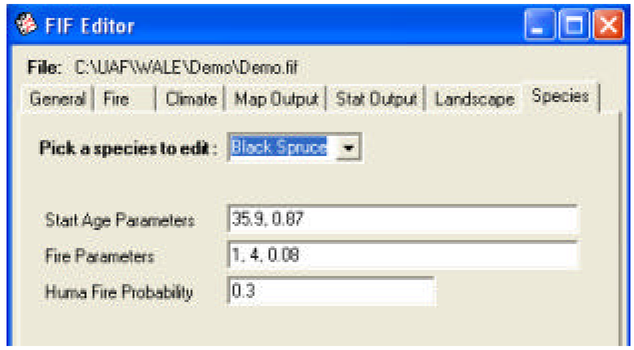
(Species Number = 1)



Field	Description
Start Age Parameters	Parameters for the starting age function. If one parameter is specified assume a constant distribution. Otherwise, parameters are the lifetime and shape parameters for a Weibull distribution.
Fire Prob	Probability of this species type burning.
Human Fire Probability	Human Ignition probability for this species type.
Spruce Estimated BA	Estimate of the basal area of mature forest - used to calculate seed dispersal for the initial BA assignment routine.
Seed Range	Distance to the maximum seed source in meters.
Seed Source	Two parameters: The mean travel distance (meters) and the fraction of thin tail (1-fraction fat tail) in the distribution kernel.
Seed Basal Area	The number of seeds/Ha produced per unit basal area (m2/Ha).
Seedling	Seed to seedling ratio including viability factor.
Seedling BA	Initial basal area of a seedling (m2) - based on a 5mm diameter
History	The number of years of climate that a deciduous frame uses to make decisions. Includes the current year.
Seed Est Parms	Seedling establishment parameters - cutoff temp, avg degree days/year cutoff.
Mean Growth	Mean spruce growth (m) - this discounts the known trend in growth through time.
Climate Growth	Three coefficients (Int Temp Precip) for the relative growth factor - from a regression against climate.
Cal Factor	Calibration factors to move from cohort growth model to exponential growth model - growth seed set
Spruce Basal Area	Basal area at which tundra transitions to spruce (m2/Ha). A mature spruce stand is assumed to be about double this.

Black Spruce

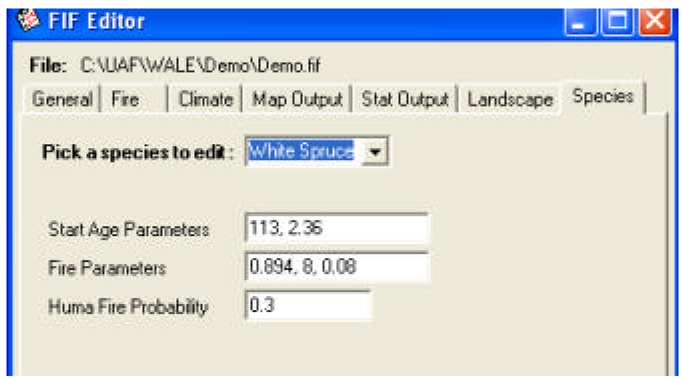
(Species Number = 2)



Field	Description
Start Age Parameters	Parameters for the starting age function. If one parameter is specified assume a constant distribution. Otherwise, parameters are the lifetime and shape parameters for a Weibull distribution.
Human Fire Probability	Human Ignition probability for this species type.
Fire Parameters *	Parameters for the fire age function : k Max Fire Factor a Age Coefficient (Age = a/b) b Slope Coefficient.

White Spruce

(Species Number = 3)

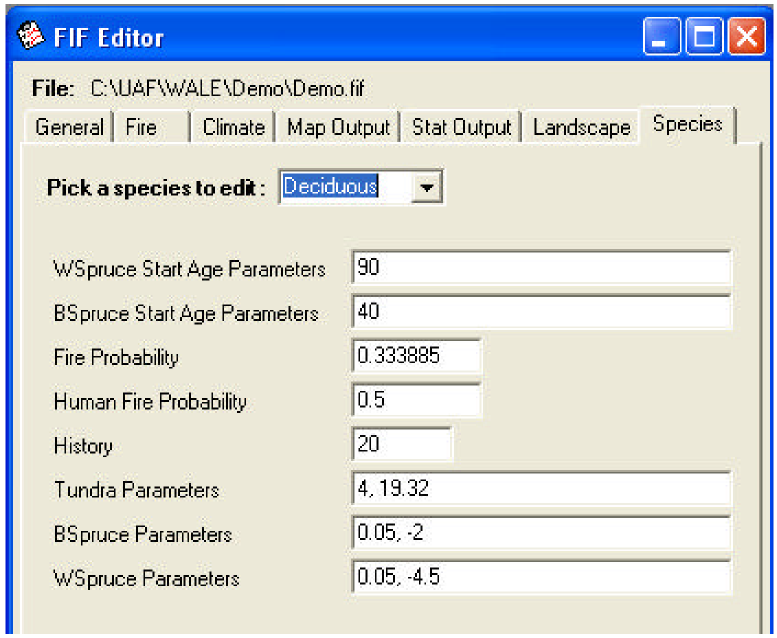


Field	Description
Start Age Parameters	Parameters for the starting age function. If one parameter is specified assume a constant distribution. Otherwise, parameters are the lifetime and shape parameters for a Weibull distribution.
Human Fire Probability	Human Ignition probability for this species type.
Fire Parameters *	Parameters for the fire age function : k Max Fire Factor a Age Coefficient (Age = a/b) b Slope Coefficient

*** Note: The Age dependent flammability function is currently disabled in the model. Spruce flammability (respectively) factors are assumed constant, and are represented by the first parameter listed (k).**

Deciduous

(Species Number = 4)



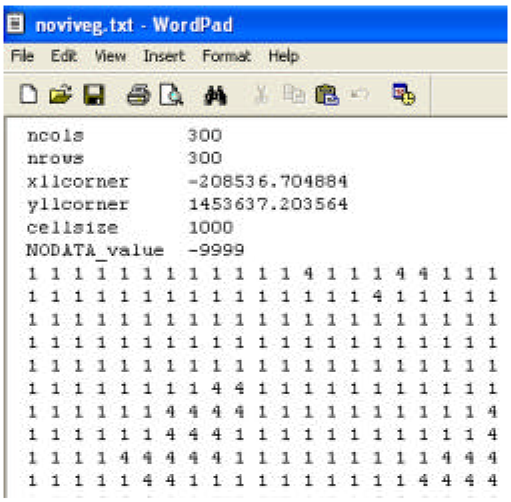
Field	Description
WSpruce Start Age Parameters	If the age of a deciduous land cell is not specified, its sub canopy's start age parameters will be used in the starting age function. A constant distribution is used if only one parameter is specified. Otherwise two parameters should be specified: the lifetime and the shape parameters for a Weibull distribution.
BSpruce Start Age Parameters	If the age of a deciduous land cell is not specified, its sub canopy's start age parameters will be used in the starting age function. If one parameter is specified assume a constant distribution. Otherwise parameters are the lifetime and shape parameters for a Weibull distribution.
FireProb	Probability of this species type burning.
Human Fire Probability	Human Ignition probability for this species type.
History	The number of years of climate that a deciduous frame uses to make decisions. Includes the current year.
Tundra Parameters	Degree-years are integrated from base A (i.e. temp < A). A transition occurs if the integrand exceeds B*(The maximum number of steps i.e. History/TimeStep).
BSpruce Parameters	Two coefficients used in a linear function relating age to the probability of transitioning to BLACK spruce: A*Age + B
WSpruce Parameters	Two coefficients used in a linear function relating age to the probability of transitioning to WHITE spruce: A*Age + B

Input Files

About Input Files

There are numerous input files for Boreal ALFRESCO. Some are always required, others are only required if using certain options. Map input files are ASCII text files generally in an ArcGIS format. Maps should be of appropriate size for the landscape being used in a simulation (same row and column count).

Typical vegetation input map with 6 line ArcGIS header:



Spatial Ignition Factor Map / Spatial Sensitivity Map

These maps are used to spatially define the fire calibration factors *Landscape Sensitivity* and *Landscape Ignition* (See Inner Workings). There is no inherent utility to recognize a <year> appended to these maps. Therefore, in conjunction with Fire Transitions (ie incorporate temporal changes to the spatial allocation of these factors) all maps will require a unique *Base* file name.

Historical Fire Maps

These maps are used to override the fire algorithm in the model. They can represent either historical fire scar maps, or future prescribed burns. The path to and *Base* file name is specified in the FIF editor, and maps should be formatted as *Base_<year>.txt* in their respective folder. Note, the appended years must remain consistent with the simulation time scale. For example, a transition to Historical Fire at simulation year 72 will read *Base_72.txt* as its first map.

Cell Values

Cell Value	Description
0	A fire has not occured.
1	A fire has occurred in this cell during this simulation year.

Human Ignition Maps

A human ignitions map shows which land cells might ignite by human causes.

Filenames for human ignition maps must be in the following format: *Base_<year>.txt*. This should be the case where "year" is the simulation year on which a map will start being applied and where *Base* name is provided in the Human Ignitions File field (located on the Fire tab of the FIF Editor).

Each human ignition map is applied starting on its specified simulation year and continues to be applied each year until the next human ignition map is applied.

Human ignition maps are not required.

Cell Values

Cell Value	Description
0	A human ignition cannot occur.
1	A human ignition might occur. Each species has a Human Ignition Probability field in the Species tab on the FIF Editor. These fields provide the probability of a human ignition occurring on a human ignition map cell with a value of 1.

Fire Suppression Maps

A fire suppression map identifies the level of fire suppression applied to each land cell. There are five suppression levels. Each can be adjusted on the Fire tab on the FIF Editor. Similar to Human Ignition maps, these maps must be formatted as *Base_<year>.txt* and the path to and *Base* name are specified in the FIF Editor. Each map is applied starting on its specified simulation year and continues to be applied each year until the next suppression map is applied.

Note: For both Human Ignition and Suppression maps, if transitioning to No Suppression or Human Ignitions midway thru a simulation (once they have been activated), a "dummy" map of all zero's must be created for the year in which the transition is to occur.

Cell Values

Cell Value	Description
0	No Suppression is applied.
1 – 5	Calls the level of suppression to be applied from the respective values specified in the FIF editor.

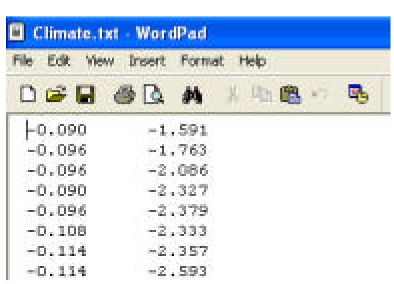
Climate Temperature File(s) / Precipitation File(s)

These are spatially explicit climate maps. For *Climate Type* = **SPATIAL** (FIF Editor), these maps are of the form *Base.txt*. For *Climate Type* = **EXPLICIT**, these maps must be formatted as *Base_<year>.txt*.

Note: ALFRESCO always begin at 'Zero'.

Climate Offsets File

This file is read when *Offset Type* = **FILE** (FIF Editor). This file requires no header, and must be formatted as an ASCII .txt file with Temperature values in the first column, and Precipitation values in the second column. The number of rows = length of simulation.



Vegetation File

This map is the initial vegetation coverage for the model, and is generally derived from a satellite coverage classification of the study area. Simulation outputs may also be used as input maps to subsequent simulations.

Cell Values

Cell Value	Description
0	No Veg
1	Tundra
2	Black Spruce
3	White Spruce
4	Deciduous

Age File

The Age Input file generally cannot be derived from satellite imagery. Spin Up simulations can be performed to generate this map, for which the Age output map can be used as input to subsequent study simulations. If an Age map is not specified, the model has the utility to generate species specific random start ages.

Site File

These maps represent the aspect of each cell (0 – 360 degrees) derived from satellite classifications for each study area. The model uses this information to determine White Spruce and Black Spruce successional trajectories.

Tree Density File

These maps are binary representations of whether a Tundra cell has any white spruce canopy present or not (See Inner Workings).

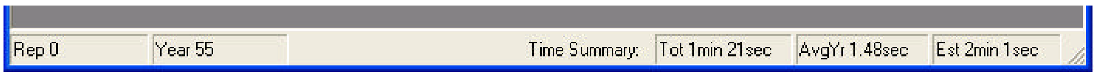
Cell Values

Cell Value	Description
0	No Canopy.
1	Canopy present.

Status Bar

About Status Bar

The status bar provides useful information that is updated every simulation year. The status bar is located at the bottom of the Boreal ALFRESCO application.



The status bar is located at the bottom of the Boreal ALFRESCO interface.

Year/Rep Status

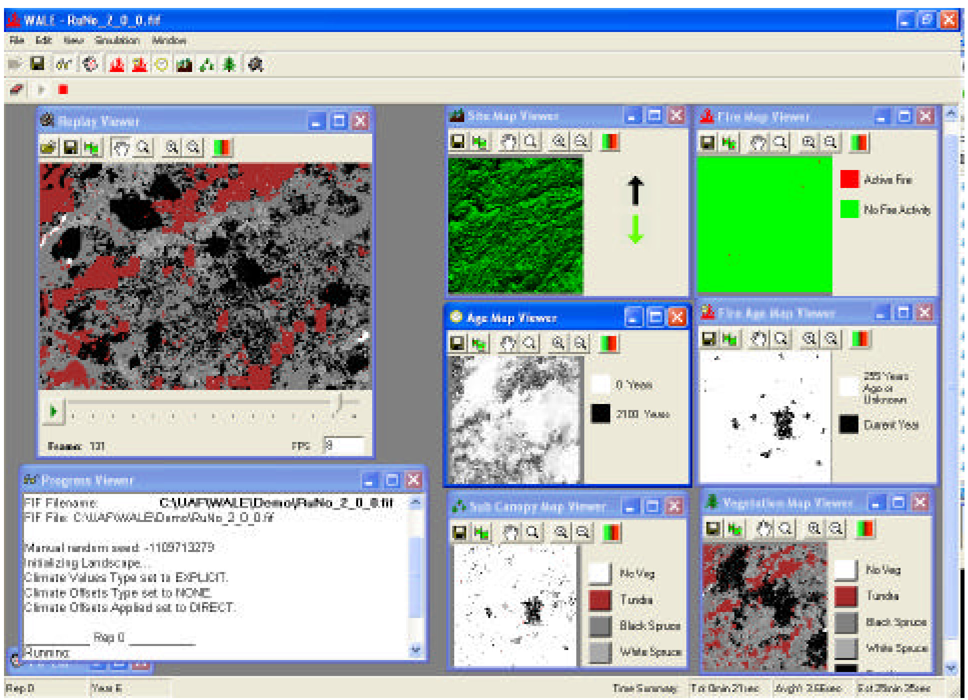
The current simulation year and rep are displayed at bottom left.

Time Summary

A summary of the elapsed simulation time and an estimate of the remaining time are located at bottom right. The three summaries items are as follows:

Label	Description
Tot	Total running time of a simulation. Timing starts on the first year and ends after the last year.
AvgYr	The average running time per simulation year.
Est	An estimate of the remaining time.

Viewers



Progress Viewer

About Progress Viewer

The Progress Viewer is the first window you will see after starting Boreal ALFRESCO. Select View|Progress Viewer or press the Progress Viewer button to open the Progress Viewer.

The Progress Viewer.

The Progress Viewer displays messages including simulation progress, confirmation of important settings (random seed value, fire type, etc.), and can also include error messages.

Map Viewers

About Map Viewers

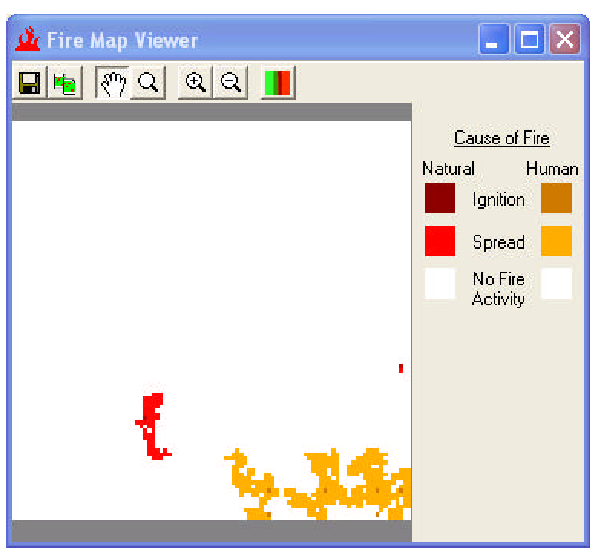
Map viewers are used while executing a run to monitor the data produced in FRESCO. Each map viewer displays unique data in a color coded visual map. Every pixel in a map image represents a land cell. The map images can be saved in bitmap form for later replay using the Replay Viewer. See Replay Viewer for more.

Buttons & Fields

Save	Choose a directory in which the images will be saved when displayed.
Copy	Copy the displayed bitmap to the operating system's clipboard.
Move Mode	Put the mouse cursor in Move Mode. When in Move Mode, the mouse can be used to drag the image into a desired position.
Zoom Mode	Put the mouse cursor in Zoom Mode. When in Zoom Mode, the mouse can be used to zoom in and out. A Left click zooms in, a right click zooms out.
Zoom In	Zoom in.
Zoom Out	Zoom out.
Smooth Pixels	Toggle between normal and smooth pixel rendering. Saved and copied images will always remain in normal pixel mode.

Fire Map Viewer

The Fire Map Viewer shows fire activity for the current simulation year. Select View|Fire Map or press the Fire Map Viewer button to open the Fire Map Viewer.

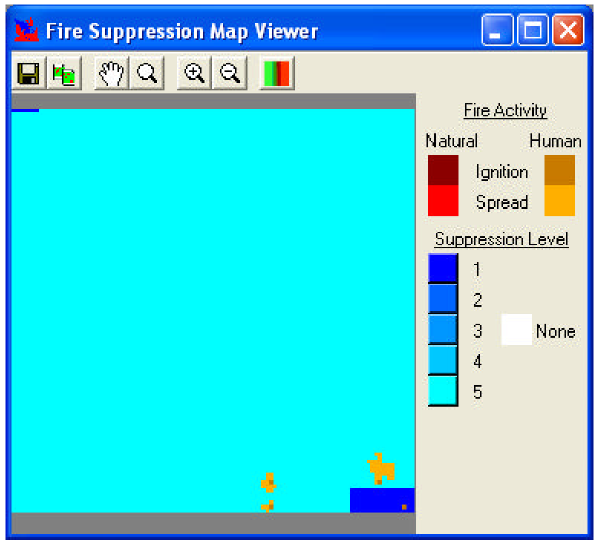


The Fire Map Viewer displaying a large fire in the bottom right.

Shades of red represent fires of natural cause and shades of orange represent fires of human cause. Dark red or dark orange represent an ignition (start of a fire spread). Bright red or bright orange represent fire spread. White pixels represent land cells where no burning occurred.

Fire Suppression Map Viewer

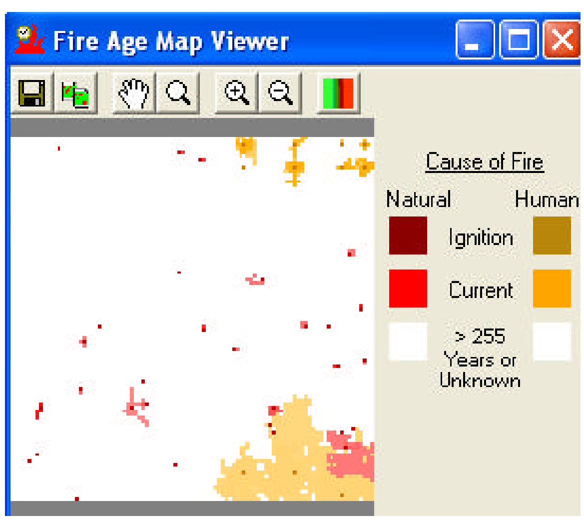
The Fire Suppression Map Viewer shows the level of suppression applied to the landscape and overlays fire activity for the given year. Select View|Fire Suppression Map or press the Fire Suppression Map Viewer button to open the Fire Suppression Map Viewer.



Fires are represented as on the Fire Map Viewer. By default, each suppression level is shown as a different shade of blue. The suppression colors can be customized by clicking on their color box in the key.

Fire Age Map Viewer

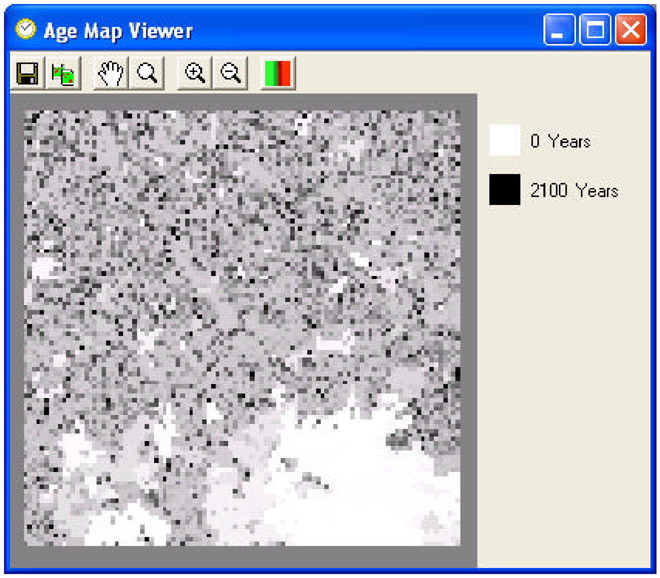
The Fire Age Map Viewer shows the age of fires that occur during the simulation. Select View|Fire Age Map or press the Fire Age Map Viewer button to open the Fire Age Map Viewer.



The age of the last burn on a given cell is shown as white or as shades of red or orange. Shades of red represent fires of natural cause and shades of orange represent fires of human cause. Dark red or dark orange represent an ignition (start of a fire spread). Bright red or bright orange represent new fire spread. A fire spread will fade to white as simulation years pass. White pixels represent land cells where either the last burn occurred at least 255 years ago or the fire history is unknown.

Age Map Viewer

The Age Map Viewer shows the amount of time passed since the last succession per land cell. Select View|Age Map or press the Age Map Viewer button to open the Age Map Viewer.

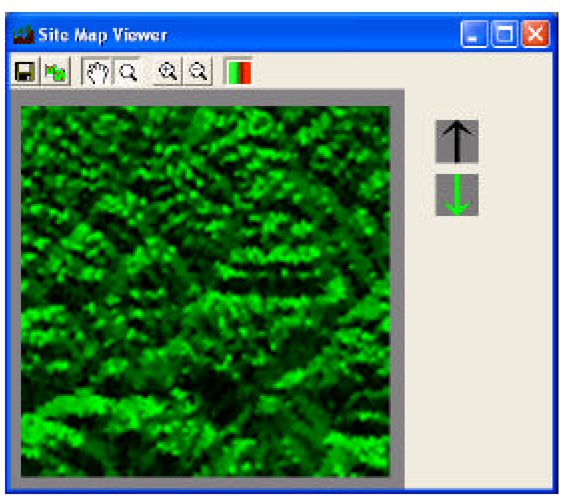


Recent successions shown in white, older successions become darker.

The age of the land type on a given cell is shown as black, white, or a shade of gray. A succession that occurred during the current simulation year is shown as a white pixel. As simulation years pass, that same pixel will turn to shades of gray and become darker until it is eventually black.

Site Map Viewer

The Site Map Viewer shows the aspect of each given land cell. Select View|Site Map or press the Fire Age Map Viewer button to open the Site Map Viewer.



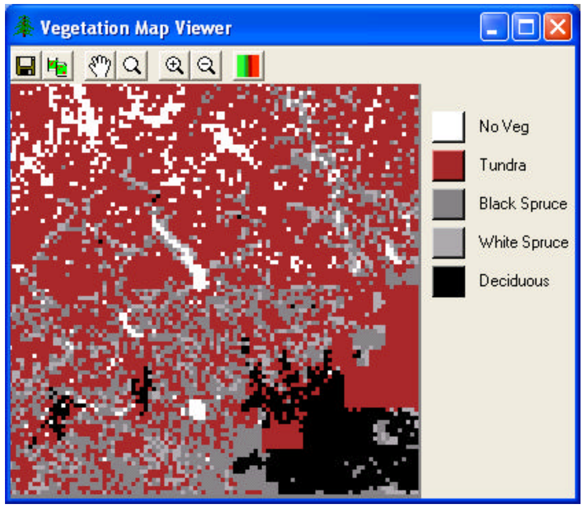
A sample display of the Site Map Viewer.

The colors range from bright green to black. The brightest green regions indicate slopes facing south (or site=180). The darkest regions indicate slopes facing north (or site=0).

It is easy to mistake the site map as a topographical map, but it never indicates the steepness of a slope. Rather, it only indicates the direction in which a slope faces, regardless of the severity of the slope.

Vegetation Map Viewer

The Vegetation Map Viewer shows the distribution of vegetation types. Select View|Vegetation Map or press the Vegetation Map Viewer button to open the Vegetation Map Viewer.

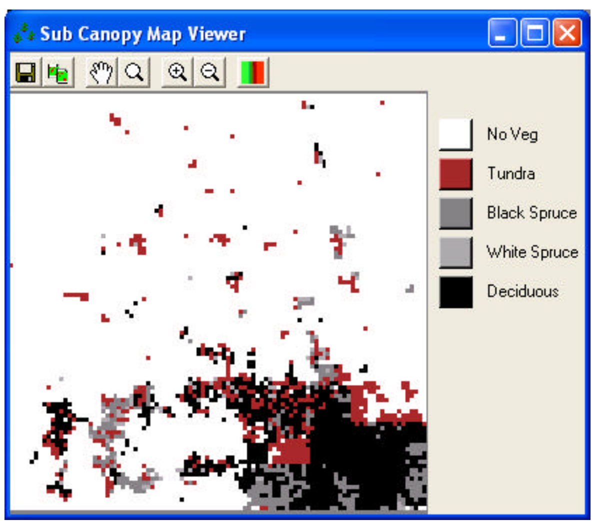


A sample display of the Vegetation Map Viewer.

The color coding can be customized for the Vegetation Map Viewer. Each of the color boxes on the legend are buttons. Push one of these buttons to assign a new color to the vegetation type.

Sub Canopy Map Viewer

The Sub Canopy Map Viewer shows the distribution of sub canopy types. Select View|Sub Canopy Map or press the Sub Canopy Map Viewer button to open the Sub Canopy Map Viewer.



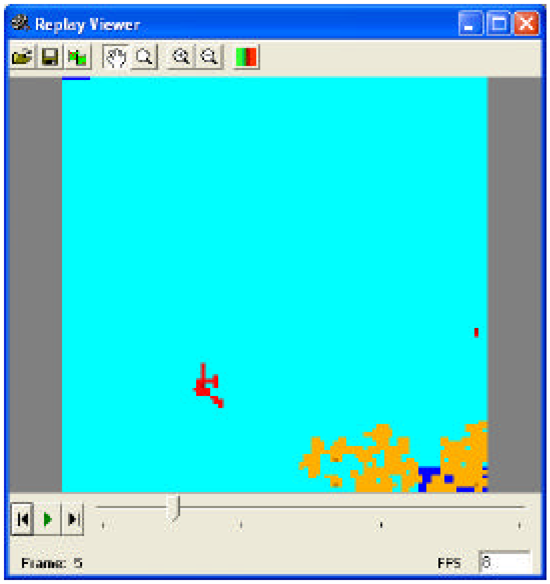
A sample display of the Sub Canopy Map Viewer.

The color coding can be customized for the Sub Canopy Map Viewer. Each of the color boxes on the legend are buttons. Push one of these buttons to assign a new color to the vegetation type.

Replay Viewer

About Replay Viewer

The Replay Viewer is used to view and examine an archived set of map images within a directory. The map images are produced by the various map viewers. See Map Viewers for more.

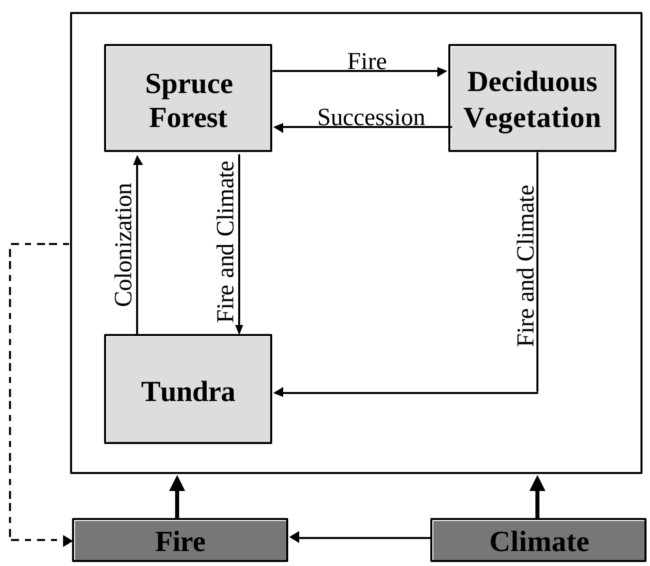


Replay Viewer playing a Fire Suppression Map Viewer output

Buttons & Fields

Open…	Choose a directory that contains archived bitmap images from a map viewer.
Save…	Save the displayed bitmap to a location of choice.
Copy	Copy the displayed bitmap to the operating system's clipboard.
Move Mode	Put the mouse cursor in Move Mode. When in Move Mode, the mouse can be used to drag the image into a desired position.
Zoom Mode	Put the mouse cursor in Zoom Mode. When in Zoom Mode, the mouse can be used to zoom in and out. A Left click zooms in, a right click zooms out.
Zoom In	Zoom in.
Zoom Out	Zoom out.
Smooth Pixels	Toggle between normal and smooth pixel rendering. Saved and copied images will always remain in normal pixel mode.
/	Play and pause the playback.
/	Step to the previous / next frame
FPS	Frames Per Second. The speed of playback. Negative numbers play in reverse order.

Inner Workings



Fire Spread

Landscape Fires

Fires are started by allowing each cell to calculate a probability of burn. This probability is compared with a uniform random number to determine if the cell burns. If burn occurs, that cell is given opportunity to spread its fire to neighboring cells within a certain radius. The probability that a neighboring cell will burn follows a normal function of distance from the currently burning cell.

Fire Probability

Cell Ignition Probability (Natural Ignitions)

The probability that a cell will burn is a function of the cell's internal fire probability, the cell's distance from other burning cells and an overall landscape sensitivity factor.

P = PI * LS * LI
If (UNIRAND<P) Then Burn Cell

Where
P – Burn Probability: Probability that cell will burn.
PI – Probability cell will ignite due to internal factors. (see below)
LS – Landscape Sensitivity. An overall sensitivity to burn calibration factor; can be applied equally across the landscape (Fire Type = FIXED) or spatially explicit across the landscape (Fire Type = SPATIAL).
LI – Landscape Ignition. An overall Ignition calibration factor (see above).
UNIRAND – Uniform[0,1] random number.

Internal Cell Factors

A cell's internal fire probability is a function of the cell's current climate (temperature and precipitation), and current vegetation class flammability.

BSpruce: PI = PC * PDBS
WSpruce: PI = PC * PDWS
Tundra: PI = PC * (PDWS- PDT) * BA/BATS + PDT
Decid: PI = PC * PDD

Where
PI – Probability cell will ignite due to internal factors.
PC – Probability due to climate: temp & precip. (see below)
PD.. – Default probability values for black spruce (PDBS), white spruce (PDWS), tundra (PDT) and deciduous (PDD)
BA – Basal area. Basal changes each year due to seeding and growth.
BATS - Basal area at which tundra transitions to spruce.

Climate Factors

A cell's climate response is a function of the local climate it encounters (temperature and precipitation).

```
PC = C0 + C1*TEMP + C2*PRECIP
Where
PC – Probability due to climate.
C0-C2 – Climate function coefficients.
TEMP – Temperature
PRECIP – Precipitation
```

Cell Ignition Probability (Human Ignitions)

Human Ignitions are modeled as a completely random Poisson process and incorporates large number theory to deduce each cell's species specific probability of ignition. In summary, each cell is treated as Bernoulli trial, the sum of which is a Binomial random variable. For large n and small p, the Binomial converges to a Poisson. This methodology allows for the direct incorporation of the laws of expectation (ie for X~Binom(n,p); E[X] = n*p); where P for each species can be solved:

P(species) = E[Human Igs] / n(species)

P(species) is specified in FIF editor for each vegetation type. Once a Human Ignition occurs, the fire uses the same spread algorithm as natural ignitions. Natural and Human Ignitions are modeled as disjoint events (P[Ignit] = P[Human] + P[Natural]).

```
PH(VegType) = E[# of Ignitions]/n(VegType)
```
If (UNIRAND<PH(VegType) Then Burn Cell

```
Where
PH(VegType) – Species specific Human Ignition probability.
E[# of ignitions] - User Defined Scenario.
n(VegType) – number of that particular VegType on initial landscape
```
UNIRAND – Uniform[0,1] random number

Fire Spread

When a cell ignites, it has the opportunity to spread the fire to neighboring cells within a spread radius of the burning cell. This is done recursively until the fire burns to completion. Fire spread is a function of the cell's internal flammability, overall landscape sensitivity, and the distance from the ignition source cell.

PS = PI * LS * D

If (UNIRAND<PS Then Burn Cell

Where

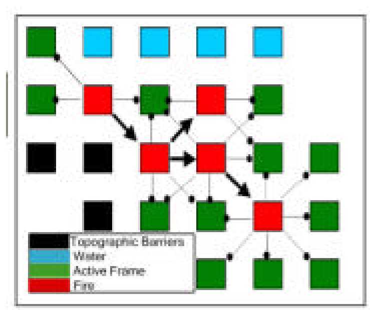
PS – Probability a fire spreads to its neighbor.

D – Distance of current cell from burning cell.

PI – Probability cell will ignite due to internal factors (see above).

LS – Landscape Sensitivity. An overall sensitivity to burn calibration factor; can be applied equally across the landscape (Fire Type = FIXED) or spatially explicit across the landscape (Fire Type = SPATIAL).

Note: The model default spread radius is ½ * (cell size); Thus fire can spread only to a cell's 8 immediate neighbors.



Fire Suppression

The fire suppression multipliers (Class 1-5) are directly implemented in the Fire Spread equation. (Thus they are restricted to values on the interval [0,1])

PS = PI * LS * D*SU(Class)

If (UNIRAND<PS Then Burn Cell

Where

PS – Probability a fire spreads to its neighbor.

D – Distance of current cell from burning cell.

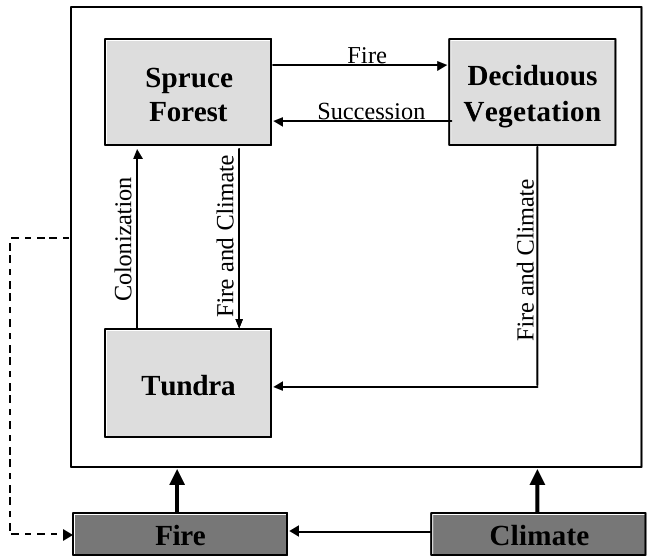
PI – Probability cell will ignite due to internal factors (see above).

LS – Landscape Sensitivity. An overall sensitivity to burn calibration factor; can be applied equally across the landscape (Fire Type = FIXED) or spatially explicit acros s the landscape (Fire Type = SPATIAL).

SU(Class) – Suppression value from FIF editor.

Succession

The ALFRESCO model assumes that Climate and Fire are the primary drivers of boreal forest landscape level change.



Spruce (Black or White) → Deciduous

Following Fire, with the exception of extremely cold temperatures, it is assumed that all Spruce cells succeed to Deciduous. In the case of cold temperatures (calculated as a moving average incorporating the previous 20 year temperature record), Spruce may also succeed to Tundra. This represents the rare case when climate is too harsh for the post-fire germination of deciduous trees.

Spruce (White) → Tundra

Deciduous → Tundra

In the case of cold temperatures (calculated as a moving average incorporating the previous 20 year temperature record), Spruce and Deciduous may also succeed post-fire to Tundra. This represents the rare case when climate is too harsh for the post-fire germination of deciduous trees.

Deciduous → Spruce

Following Fire, Deciduous cells will gradually succeed to Black or White Spruce depending upon their respective trajectory. These trajectories are considered unique by the model. That is, a black spruce cell cannot burn, go thru a deciduous phase, and then return as a white spruce. Cells that are black or white spruce on the initial vegetation map retain that trajectory throughout the simulation. Cells that are initially deciduous utilize an aspect derived trajectory (*Site* input map). The current assumed succession rates in the model are as follows (FIF Editor Species/Deciduous/ (B&W)Spruce Parameters):

Deciduous → Black Spruce

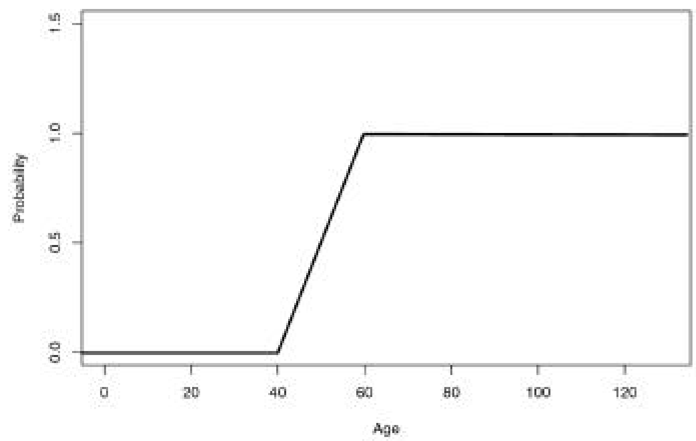
P(D→BS) = .05 * Age – 2.0

If (UNIRAND< P(D→BS)) Succeed to Black Spruce

Where

P(D→BS) – Probability Deciduous succeeds to Black Spruce.

Age – Time Since Last Fire.



Deciduous → White Spruce

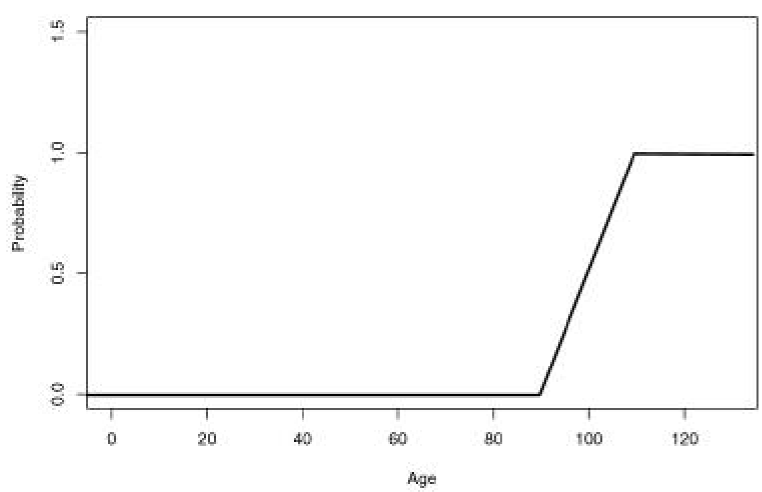
P(D→WS) = .05 * Age – 4.5

If (UNIRAND< P(D→WS)) Succeed to White Spruce

Where

P(D→WS) – Probability Deciduous succeeds to White Spruce.

Age – Time Since Last Fire.



Tundra → Spruce (White)

If climate conditions are favorable, Tundra cells can be colonized by white spruce trees, and eventually succeed to a White Spruce cell. Colonization is a two part process resulting from tree growth and seedling establishment. Seedling establishment is also a two part process consisting of both infilling and seeds dispersed from neighboring cells. The metric the model uses is basal area/unit area (m^2/Ha).

$$BA_t = (G \cdot k_G)BA_{t-1} + \frac{S \cdot K(d)}{M} I \cdot k_S$$

BA(t) = Basal Area at time t
G = mean growth rate (function of Temperature and Precipitation)
S = seed production of a neighboring cell
K = seed dispersal kernel at some distance *d* (neighboring cells)
M = seed to seedling viability ratio
I = hypothesized initial basal area
k(g) and k(s) are empirically determined calibration factors

Appendices

Version History

Version Numbers

Program Version Number

The Boreal ALFRESCO program stores a version number internally to the Boreal ALFRESCO source code. The Boreal ALFRESCO version number is shown at the top of the Progress Viewer. The Boreal ALFRESCO version number follows the following format: MAJOR.MINOR.REVISION.

MAJOR – Incremented after a major re-structuring of interface or code has occurred.

MINOR – Incremented after one or more significant new features are added.

REVISION – Incremented after one or more bugs have been fixed.

Setup Version Number

The setup for Boreal ALFRESCO is a separate executable with a version number separate from Boreal ALFRESCO. The setup version number reflects the program number but adds two additional digits that are incremented as new setups are made. The setup version number follows the following format: MAJOR.MINOR.REVISION + SETUP

MAJOR.MINOR.REVISION – Match the Boreal ALFRESCO version numbers.

SETUP – Increments after a new setup is made.

Boreal ALFRESCO 1.9.1

FRESCOOL

FRESCOOL – FRESCO Object Library is the first COM implementation of FRESCO. It is used by Boreal ALFRESCO and can also be used by any COM programming languages, ie EXCEL & Visual Basic.

Boreal ALFRESCO 2

Boreal ALFRESCO is the first version of Boreal ALFRESCO with a Windows interface. It is built using C# 2003.

Boreal ALFRESCO 1.9.5

Released: 12/?/2004

Latest Release: 1.3.2.11

Start, Stop & Continue

Runs can be stopped then continued from where they were stopped.

Stack Overflow Error

To simulate the spread of fires, FRESCOOL recursively calls burn and spread functions. Recursion demands a larger amount of stack space than non recursive calls. When large fires were processed, the amount of recursion was overflowing the stack and resulting on a program crash. The size of a typical fire was about 1500 cells. Thus when a single ignition spread to over 1500 cells, the program would crash.

This version includes a second programming method of spreading fire that is functionally the same as using recursion. This iterative method creates the same list of fire spreading cells as does the recursive method. However this list is not stored on the stack; it is stored on the heap and therefore does not run out of memory space. The same cells are checked in the same order as the recursive approach so the outcomes are the same. A FIF setting has been added to switch between the two approaches for comparison purposes. The iterative approach is a little bit slower.

Boreal ALFRESCO 2.0

Released: 3/17/2005

Setup Version: 2.0.00

Memory Leaks

Memory leaks within the map viewers have been addressed and no longer exist.

Several other memory leaks not related to map viewers were also fixed. Most of these were only a problem if executing multiple runs without closing the application between runs.

Map Viewers

The following functionality has been added to all map viewers:

- Save the image each year to a file.
- Zoom by pressing the zoom in and out buttons.
- Scroll a map by dragging the image.
- Copy the image to the clipboard.
- Switch between smooth and pixilated rendering.

Site Map Viewer

The Site Map Viewer was interpreting zero degrees and 360 degrees as opposite color values. Now colors are continuous as site values go through the 0/360 mark. The colors range from bright green (facing south or site=180) to black (facing north or site=0).

It is easy to mistake the site map as a topographical map, but it never indicates the steepness of a slope. Rather, it only indicates the direction in which a slope faces, regardless of the severity of the slope.

Replay Viewer

Added a viewer for replaying a series of saved bitmaps. The Replay Viewer can:

- Play in forward and reverse direction at various speeds.
- Zoom in and out.
- Scrolling the image.
- Copy the image to the clipboard.
- Switch between smooth and pixilated rendering.

Progress Viewer

The Progress Viewer now operates in a text wrap mode.

Time Summary Status Bar

Added a status bar that displays:

- Tot – Total running time.
- AvgYr – The average time per simulation year.
- Est – An estimate of how much time remains until completion.

Fire Type Transitions

Added functionality to allow the scheduling of fire type transitions. “Fire.Type” has been replaced by two new FIF attributes:

- Fire.Types – A string array. Each entry is a fire type scheduled for a year found in Fire.TypeTransitionYears at the equivalent array index.
- Fire.TypeTransitionYears – An integer array. Each entry is a simulation year that corresponds with an entry in Fire.Types. An entry for year zero must be present.

The initial fire type and any further fire type transitions can be set on the Fire tab within the FIF editor.

Each transition entry can now have its own set of ignition and sensitivity values.

Notes

The transition takes place prior to processing fire in the scheduled year.

FIF Editor

Map and stat output flags are now displayed and edited with checkboxes instead of textboxes.

Bug Fixes

- Random Seed can now be left blank. If so, a seed will be created automatically by FRESOOL.
- Age Input File can now be left blank without a system crash.
- Fire type transitions now use the correct ignition and sensitivity values.
- Fire type transitions between similar types (FIXED to FIXED) now enabled.
- Various small interface bugs.

Boreal ALFRESCO 2.0.1

Released: 3/30/2005

Setup Version: 2.0.1.5

Human Ignitions

Human ignition features added (for detail see Human Ignition Maps in the Input Files section).

Fire and Fire Age map viewers updated to distinguish between human and natural fires and also to show ignition cells (for detail see Map Viewers).

Fire Scar ID Maps

Fire scar ID ARC features added. A “Fire Scar” data type option was added to the Map Output tab of the FIF Editor. The map shows all the cells of a single fire with the same ID number. The point of ignition is indicated by a negative of the same ID number.

TODO: A map viewer that does not fade any pixels to white so that a full summary can be seen.

Bug Fixes

- Output Type of “APPEND” no longer crashes.

Boreal ALFRESCO 2.0.2

Released: 4/18/2005

Setup Version: 2.0.2.2

Human Ignitions

Human ignition maps are now applied starting on their specified simulation year until the next map is applied.

The Fire Size Events stat output now includes a Cause column where 0 represents natural cause and 1 represents human cause.

Human ignition probability is now species specific. Each species has a Human Ignition Probability field in the Species tab on the FIF Editor.

Fire Suppression

Fire suppression features added (for details see Fire Suppression Maps in the Input Files section).

Fire suppression is only applied to fire spread tests, not ignition tests.

Bug Fixes

- The iterative ignitions algorithm no longer evaluates the last cell of a spread as a possible ignition. It now correctly tests the cell for spread.
- Statistics no longer incorrectly accumulate over reps.
- Iterative Ignitions menu item under Simulation menu now correctly updates its status. Switching between recursive and iterative can be done during a run in progress, but keep in mind that the recursive algorithm has not been updated to use many of the new features such as human ignitions and suppression.
- FireInterval[Species]Events statistics are now being output correctly.

Boreal ALFRESCO 2.0.3

Released: Pending

Setup Version: 2.0.3.0

Replay Viewer

Stepping has been added to enable stepping year by year.

Fire Suppression Viewer

A viewer has been added to show the suppression levels for a landscape along with the fires that occur for the given year.

Fire Saturation Thresholds

A fire saturation threshold for fire size and ignition count has been added. The values can be set on the fire tab of the FIF Editor. A saturation threshold is the number of cells that can burn or ignitions that can occur within a given simulation year before the suppression map stops being applied for that simulation year.

Bug Fixes

- Clearing a run is now only possible after it has been completely stopped.
- Errors in runs with a landscape having fewer rows than columns have been fixed.