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A Pilot Moose Habitat Model for the Mid Boreal Uplands Ecoregion of the Manitoba Model Forest

User Manual

June, 2006

KBM Forestry Consultants Inc.

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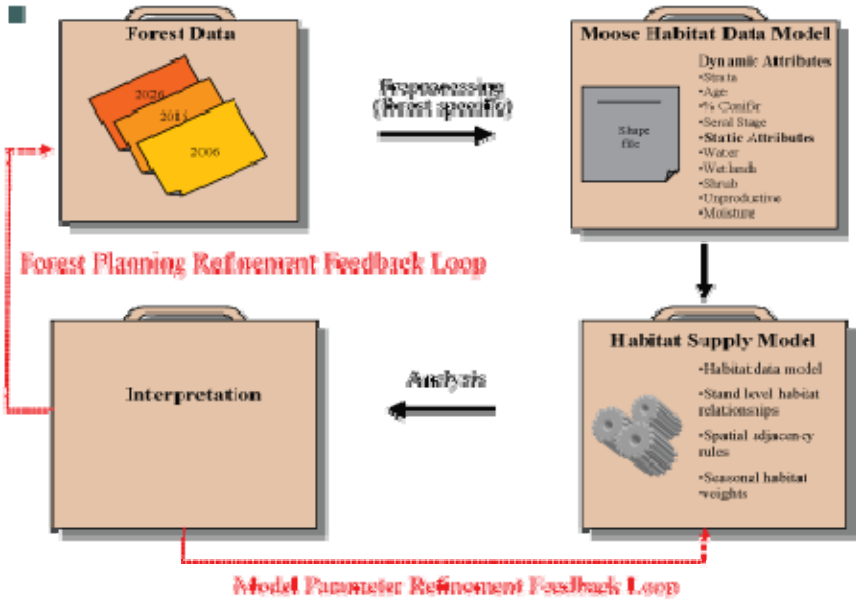
1.0 Introduction

This document describes the Moose Habitat Supply Model (HSM) program and associated sample dataset. The HSM is a program developed to help evaluate the effects of long-term forest management activities on moose habitat. For a complete description of the Moose Habitat Supply Model, users are referred to the following document by McNicol and Rudy, 2006: **A** Pilot Moose Habitat Model for the Mid Boreal Uplands Ecoregion of the Manitoba Model Forest.

The following illustrates the overall work flow and processing components. The four main components are: forest data, moose habitat data model, habitat supply model, and analysis and interpretation.



Forest Data

The forest data component provides the basic forest attributes for the HSM. A Forest Resource Inventory (FRI) GIS layer generally forms the base forest data layer. It should describe general forest conditions such as non-forested and forested areas along with species composition and stand age. The initial forest data may consist of a single time step (i.e., current forest land base) or a series of spatially explicit "snapshots" of future forest conditions. One method of generating future forest conditions is through the use of spatially explicit harvest scheduling and forest growth projection tools.

Moose Habitat Data Model

The moose habitat data model helps maintain a standard data structure. Utilizing a standard data model allows different forest data types with varying levels of detail to be used. The development of the moose data model is a required pre-processing step by the analyst.

The data model is a spatially explicit ESRI shape file containing two basic field attribute categories: static and dynamic. As the first category name suggests, static attributes are attributes that remain constant over time. They are considered stable because natural non-catastrophic changes that may

occur are minimal over the short-term. Static attributes include water, wetlands, non-forested shrub sites, non-forested unproductive sites and a forested sites moisture regime. The following table provides a description of the required static attribute fields.

Attribute (site type)	Field Specifications			Field Description
	Name	Type	Range	
Water	NP_WATER	number	0 or 1	Identifies all rivers, small lakes (< 260 ha) and small bays on large lakes. All water polygons are assigned a code value of 1.
Wetland	NP_WETLAND	number	0 or 1	Identifies all wetland types that represent aquatic feeding sites*. All wetland sites are assigned a code value of 1.
Shrubs	NP_SHRUB	number	0 or 1	Identifies all non-forested sites that support either willow (*salix sp*.) or redosier dogwood (*Cornus sericea*) shrub types. All shrub sites are assigned a code value of 1.
Treed muskeg and treed rock	NP_UNPROD	number	0 or 1	Identifies all treed muskeg and treed rock sites. These areas are not considered to be part of the productive forested land base. Based on the Manitoba Conservation productivity list, these sites fall within the 700 and 710 code series. All identified sites are assigned a code value of 1.
Moisture regime	MOISTURE	character	DRY FRESH MOIST WET VERY WET	Identifies the moisture regime class for forested stands. All forested stands must be assigned a valid moisture regime class label (see field range cell). Forest data sets lacking a moisture regime label can derive a moisture regime class from species composition and site class which are aided by available supplementary data sources such as landform and\or indicator plants
Unique polygon Identifier	HSM_ID	number	1,2,3…n	Unique numeric value assigned to all polygons. For source data derived from coverages, this field can be populated from the coverages internal ID field. For source data derived from a shape file, this field can be populated from the shape files FID field.

* Aquatic feeding sites are locations where moose consume large quantities of emergent and submergent aquatic vegetation (e.g. pondweed {Potamogeton spp.}and yellow pond lily {Nuphar microphyllum}) during summer months.

Dynamic attributes refer to attributes that change over time due to forest succession, forest management activities, or natural disturbances (if modelled). Dynamic attributes only apply to forested stands. Attributes include stand strata, stand age, percentage of conifer species within the stand and its seral stage class. The following table provides a description of all required dynamic attribute fields.

Attribute (site type)	Field Specifications			Field Description
	Name*	Type	Range	
Strata	STRATA_0	character	User Defined	The stand strata label is user defined. The strata label represents a classification scheme based on species composition and reflects stands with similar species types. The strata label is not directly used by the HSM model. It is required for assigning the seral stage label and\or crown closure values. See Appendix 1 for an example of a simple strata classification scheme.
Stand Age (yrs)	AGE_0	number	0 to 999	Identifies the age of each stand.
Percentage of conifer (%)	SWD_0	number	0 to 100	Defines the total percentage of all conifer species within the stand. A pure conifer stand would be assigned a value of 100. A pure hardwood stand would be assigned a value of 0
Crown closure (%)	CC_0	number	0 to 100	Defines the stands crown closure. A mature stand where tree crowns block nearly all sunlight from hitting the forest stand floor would be assigned a crown closure value of 100. Forest datasets lacking crown closure values can be derived from field data (e.g. permanent sample plots) or through expert option. See Appendix II for several crown closure curve examples.
Seral Stage	SSTAGE_0	character	Grass Seedling Sapling Immature Mature Overmature	Defines the stands seral stage class. Each forested stand must have a valid seral stage class label (see field range cell). The seral stage class is derived by defining an appropriate age break point for each strata. See Appendix 1 for an example of age class break points for several forest strata.

* All dynamic field names must contain an integer value to identify its inventory period. An inventory period of 0 (zero), for example, represents the first inventory period or today's forest conditions (e.g., AGE_0). Future forest conditions are designated by the inventory period (e.g., AGE_1, AGE_2, and AGE_3). A user defined HSM model parameter defines the time step for each inventory period (e.g., 5 years).

Habitat Supply Model (HSM)

The HSM generates potential habitat suitability indices for each inventory period along with simple summary statistics and maps for various habitat quality indices and forest parameters. The models graphical user interface (GUI) manages all model inputs within user defined scenario folders. All required parameters are entered or modified through the model's GUI.

The two main model components are: the moose data model (discussed in the previous section) and model input parameters. The moose data model describes the study area's current and future forest conditions. The data model is spatially explicit which allows for an assessment of current and\or future potential moose habitat under various land use planning scenarios. The model parameters for example, relate important forest attributes (e.g., seral stage) to moose habitat suitability, defines the spatial relationships between habitat and their proximity to specific land features (e.g., areas close to water) and home range size (e.g., 2,500 ha). The analyst can modify all model parameters to suit a specific region. The model's default parameter settings are regionally specific to the Mid Boreal Uplands Ecoregion in western Manitoba.

The HSM is raster based and generates suitability index and forest parameter output files formatted as ESRI grids.

Analysis and Interpretation

Most modelling exercises involve multiple simulation runs. Multiple runs result from the two feedback loops shown above: model parameter refinement and forest planning refinement. The model parameter refinement feedback loop occurs during the model validation and calibration stage. It generally involves adjusting specific model parameters (e.g., shifting a crown closure suitability index curve) and is usually linked to a sensitivity analysis. A sensitivity analysis is performed to determine which model parameters are the least sensitive to adjustment. The forest planning refinement loop is related to modifications to your forest management activities. This may involve, for example, an adjustment to your harvest schedule to help maintain a specific level of potential moose habitat in a particular area. Any modification to the forest data model requires the analyst to rebuild the moose data model to rerun the HSM.

1.1 Program Requirements and Structure

The HSM package was designed to run within ArcInfo's workstation environment and is structured around the Arc Macro Language (aml). Users interact with the program through a series of custom menus. It requires Arc/Info Workstation and the associated Grid module to run.

1.2 Program File Structure

Due to the complex set of input and output files, the program maintains a rigid file structure for storing both input and output files. A complete description of all input and output files and their locations are described in later sections.

The HSM program maintains a rigid file program structure. The following table describes the core program file folders:

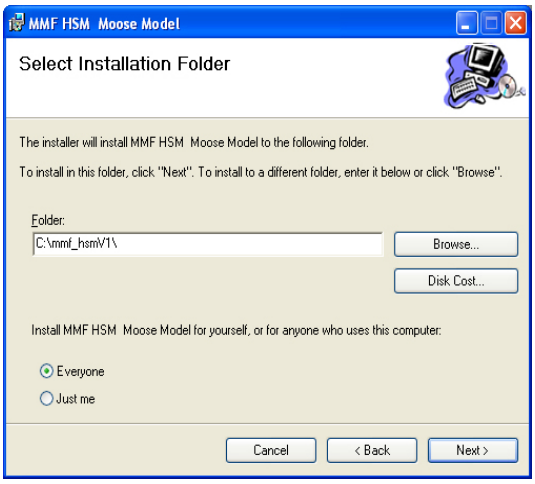
Folder Name	Description
Program	Menu and start-up program file (i.e., hsmMoose.exe).
General	Workspace for all spatial input files.
Shared_Amls	Shared program (aml) files.
Species	Species level program (aml) and input files. Input files are stored within individual scenario folders (e.g., scen0) as sub-folders within the models folder. Once created, a scenario folder stores all required input parameter files.

2.0 Setup

The complete program package and sample dataset for the HSM is included within the main Setup.exe install file. To install:

1) Double click the Setup.exe file.

2) Select all default values unless a different program installation location is required.



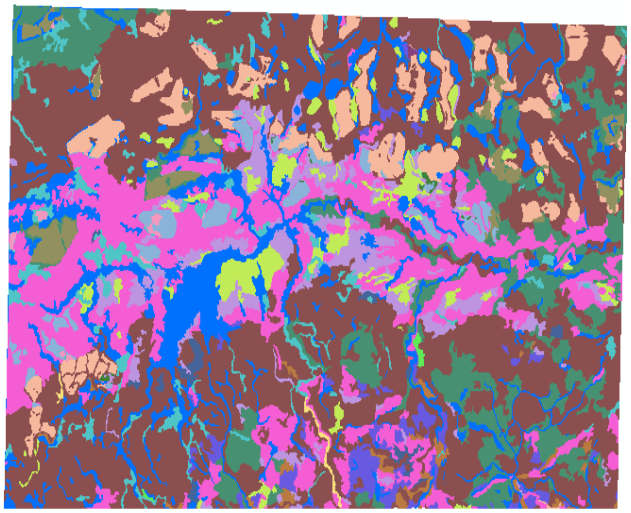
The user should avoid placing the programs root folder in a location that creates a long path string. Long path strings can cause problems when running the model due to limitations within ArcInfo.

To uninstall, use the Add/Remove Programs option on the Control Panel.

Arc 9.1 users will require a patch to fix an ARCPRESS related bug. The patch is included in the programs root folder within the *arc91_arcpress_patch* sub folder or it can be downloaded from the ESRI Support Center website: http://support.esri.com.

Sample Dataset

The sample data model is provided to help users become familiar with the model's standard data structure. It also facilitates the ability to easily execute the model using default model parameters and examine model output and formats.



The sample data model is located within the general workspace (i.e., C:\mmf_hsm\V1\ general\shape.shp).

The data model contains forest projection snapshots every ten years for 150 years. Each inventory period represents a five year planning time step, therefore the planning periods are in increments of two (i.e., planning period 0,2,4,6, etc.).

The following table is a subset of the sample.shp data model to help illustrate the required stand attributes for 6 polygons. Dynamic stand attributes are shown for three of the six polygons for two of the 15 inventory periods. Attributes containing "_0" represent the forests base (current) stand

conditions. Attributes containing "_2" represent the predicted forest conditions for the second inventory period or tenth year (2nd inventory period * 5 yrs planning period). Examining the table indicates the successional trajectory and forest management activities occurring between inventory periods. For example, the sixth stand listing (Strata_0 = NAT_HWD2) shows this stand was cut at the beginning of the second inventory period. As a result, changes to the stands strata, age, crown closure and seral stage class have occurred.

STRAT_0	AGE_0	CC_0	SWD_0	SSTAGE_0	STRAT_2	AGE_2	CC_2	SWD_2	SSTAGE_2	NP_WATER	NP_SHRUB	NP_WETLAND	NP_UNPROD	NP_OWATER
	0	0	0			0	0	0		0	1	0	0	0
	0	0	0			0	0	0		0	0	1	0	0
	0	0	0			0	0	0		1	0	0	0	1
NAT_HWD1	93	60	0	OVERMATURE	NAT_HWD1	103	50	0	OVERMATURE	0	0	0	0	0
NAT_SWD4	91	50	100	MATURE	NAT_SWD4	101	50	100	MATURE	0	0	0	0	0
NAT_HWD2	91	60	0	OVERMATURE	LP_HWD2	0	10	0	GRASS	0	0	0	0	0

Quick Start Tutorial

The following provides a brief overview of the major processing steps using the sample data model. More details are provided in Section 3. The following section assumes you have successfully installed the model and have valid ArcInfo Workstation and Grid licences available.

Step 1: Start program.

- Double click on the MMF Hsm desktop shortcut to open the main Wildlife Species Main menu.

Step 2: Create base grid.

- Click on the Base Grid tab.
- Click the **Select Shape File** button
  - Select the sample moose data model shape file called sample.shp and **Close** form.
- Set the base grid cell size to 25m.
- Click on **Continue** to display the HSM Process Base Grid Window form
  - Click on the **Run** button to begin the shape file to grid conversion process.
  - **Close** the form when the grid processing is completed.

Step 3: Generate moose suitability indices

- Click on the Moose tab.
- Click on the **Set Scenario Folder** button.
  - Expand the moose program folder.
  - Select the default scenario folder called scen0 and **Close** form
- Select inventory periods (year) 0, 10, 20, 30, 40 and 50.
- Click on the **Continue** button to open the Moose Main Menu form
  - Click on the **Select Output Workspace** button
    - Create a new folder on your c drive called quicktour (c:\quicktour) and **Close** the form.
  - Click on the **Select Base Grid** button.

        - Select the sample_g grid you created in Step 2 and click on the **Apply** button to close the form.
    - Click on the **Proximity and Home Range** button.
        - Select the Home Range Zone Matrix tab
        - Select the **4 by 4 (16 zonal layers)** option in the Matrix Size pane.
        - Click on the **Save Parameters** button to save your changes.
        - **Close** the Moose Proximity and Home Range Menu form.
    - Click on the **View Input Files** button
        - Click on the **Home Range** button to view the proximity and home range parameters file contents. Check to ensure the HOME_RANGE_MATRIX variable is equal to 4.
        - **Close** the Moose File Viewer form.
    - Click on the **Continue** button to open the HSM Process Window form.
        - Click on the **Run** button to begin processing. The processing time is dependent on the size of your forest, the number of inventory steps, the home range matrix size and your computers processing speed.
        - **Close** the form when the model simulation has finished processing.
        - **Close** the Moose Main Menu form.
    - Open ArcCatalog and navigate to the output folder (i.e., c:\quicktour).
        - Expand the habitat_grids workspace list. This workspace should contain a series of habitat suitability indices (grids) for years 0, 10,20,30,40, and 50.
        - Highlight one of the suitability index grids for summer cover (i.e., cov_s_0). To view, select the Preview tab.
        - Select the blue i icon on the top menu. Clicking in the preview pane displays the suitability index value within the Identify Results window. A zero value represents unsuitable summer cover habitat. A value of 100 represents suitable summer cover habitat.
        - Close all forms and exit ArcCatalog.

Step 4: Generate moose suitability maps and summary statistics

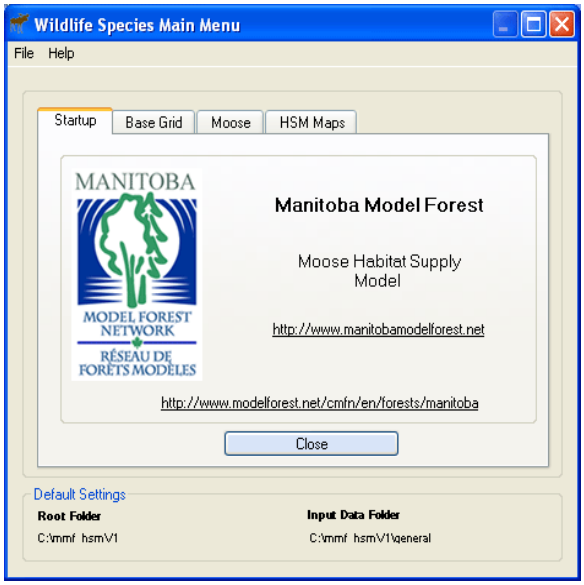
- Click on the HSM Maps tab.
- Click on the **Select Output Workspace** button
    - Select the output folder directory where you have saved your simulation results (i.e., c:\quicktour). Select **Ok** to close form.
- Click on the **Select Base Grid** button.
    - Select the sample_g grid from the Grid file list window and select **Apply** to close the form.
- Click on the **Continue** button to open the HSM Map Window form.
    - Click on the **Run** button to begin possessing.
    - **Close** the form when the HSM map and summary statistics processing has been completed.
- Exit the HSM program
    - Clicking on the **Close** button to exit.
- With Windows Explorer, navigate to your output folder (i.e., c:\quicktour)
    - Two new folders called maps and maps-hi-low have been added to your output folder.

    - Double click on the maps folder to display its contents. Double click on a jpg file to view. Scroll down and double click on the image file called moose_poster.jpg to view a compiled poster of habitat suitability index maps.
- Using Windows Explorer, navigate back to your output folder (i.e., c:\quicktour)
    - Several new habitat suitability and forest parameters summary files (moose_*.dbf) have been added to the output folder. Each file is a summary of the critical habitat elements for the full simulation period.

3.0 Running the Moose Habitat Supply Model

The HSM menu system is initiated by double clicking on the **MMF Hsm** shortcut located on your desktop. The shortcut is linked to the program file located within the \program\bin installation directory.

The program begins by displaying the main Wildlife Species Main Menu form, which appears in the upper left corner of your screen. Each tab provides access to a specific processing task.



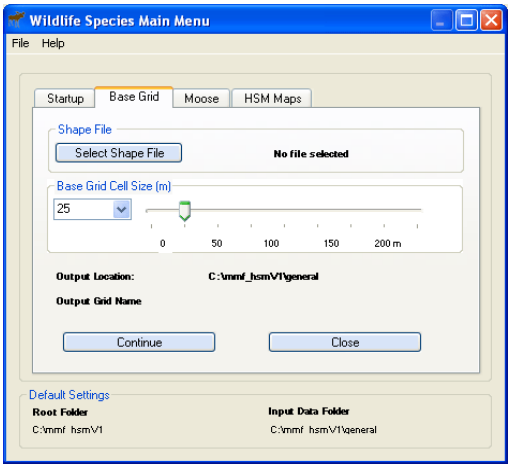
The **Base Grid** tab generates the required base input grid from a user-defined input shape file. The base grid module only needs to be performed once; however, if the input shape file is modified, the base grid must be recreated.

The **Moose** tab provides access to the setup and execution forms for generating habitat suitability indices.

The **HSM Maps** tab generates suitability indices summary statistics and maps from your model outputs.

3.1 Base Grid Tab

The following section describes the **Base Grid** tab form.

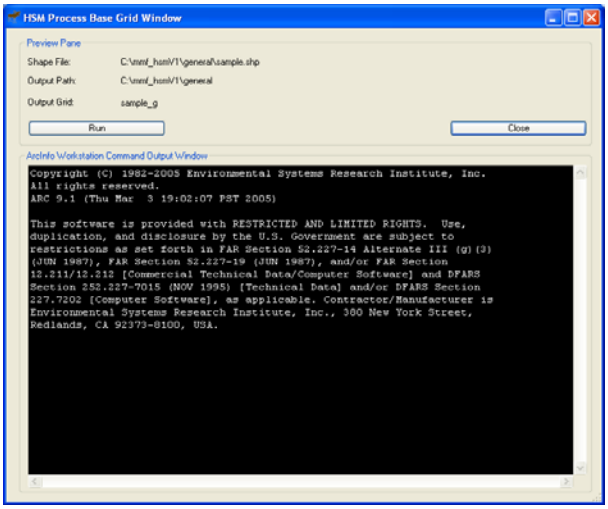


Selecting the **Base Grid** tab displays the Base Grid tab form. The Shape File Input Location pane identifies the input folder location. The input shape file is selected by clicking on the **Select Shape File** button. Set the output grid cell size from the **Base Grid Cell Size** track bar.

The **Output Grid Name** displays the grid file that will be created. The grid file name is limited to 9 characters. If the input shape file contains more than nine characters (e.g., longfilename.shp), the file name is renamed using the first nine characters with an additional "_g" appended to the file name (i.e., longfilen_g).

Selecting **Continue** opens the Process Form menu with an ArcInfo command window viewer. The Process Form contains a preview of the input shape file, the output grid name and its location. Click on the **Run** button to start the base grid processing.

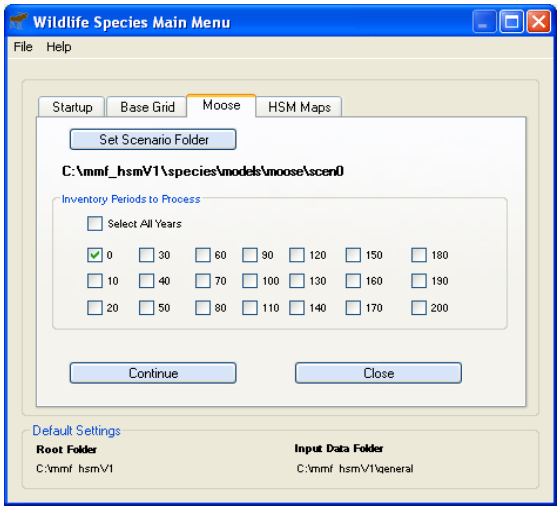
Selecting the **Close** button closes the ArcInfo command window and returns the user back to the Base Grid Attribute menu.



3.2 Moose Tab

The following section describes the **HSM Moose** module menus.

Selecting the **Moose** tab displays the first of several model input parameter forms.



Set Scenario Folder Button

The **Set Scenario Folder** button opens the Browse for Folder form.

All input parameters are stored within a user defined scenario folder. Model parameters for each species are written to text files and stored within a scenario folder. The name of the scenario folder is user-defined and must reside within the moose folder. For example, a scenario consists of a folder located within the moose folder with a user-defined label of scen0 (i.e., C:\mmf_hsmV1\species\models\ moose\scen0) and contains all model parameter files.

Selecting an existing scenario folder will load all model parameters into memory. To create a new scenario folder, highlight the moose folder and click on the **Make New Folder** button. Right click on the newly created folder and select the *Rename* option to assign a new scenario name. Clicking the **Ok** button will populate the scenario folder with all required input files. A Status form is displayed listing the files created and their location. Selecting the **Close** button returns you back to the Wildlife Species Main Menu.

Scenario files can also be loaded from the **File -> Load Scenario** menu. The Scenario Folder File Listing form is displayed (not shown) with a summary of all parameter files loaded into memory.

You can easily create multiple scenarios by first creating a base case scenario from the **Set Scenario Folder** button. With Windows Explorer, copy and rename your base case scenario folder and then reload the newly created scenario folder and modify as required.

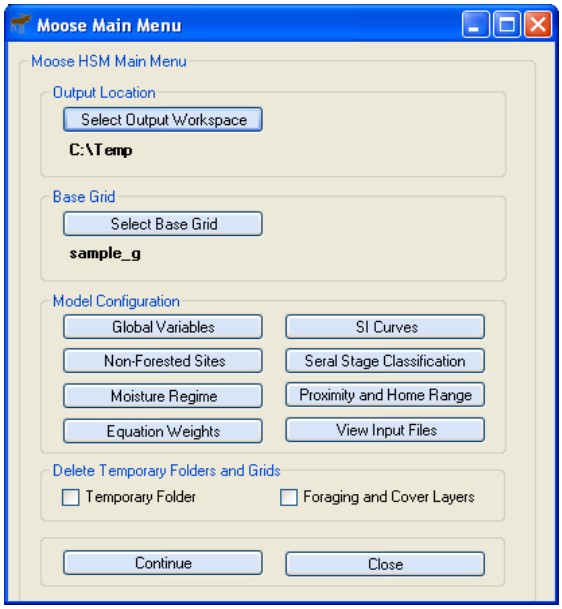
The **Make New Folder** button on the Browse For Folder menu has a quirky behaviour of sometimes not appearing on the form. Closing and reopening the form or restarting the program will usually cause the button to reappear.

Clicking the **Continue** button on the Moose tab opens the Moose Main Menu form.

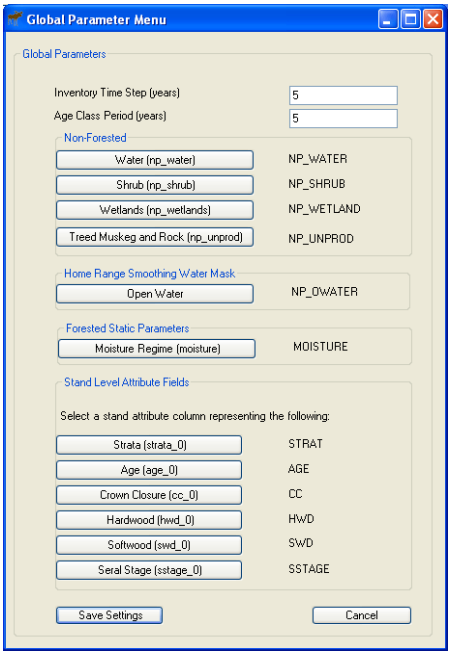
The output folder location is set with the **Select Output Workspace** button. The selected folder path is displayed within the Output Location pane.

The base grid input raster file is set using the **Select Base Grid** button. The Base Grid Selection Menu (not shown) is displayed with a listing of all inventory base grids found within the GENERAL workspace. Readers are referred to the Base Grid tab section, for more information on creating your base grid. The selected grid is displayed in the Base Grid pane.

The **Model Configuration Pane** holds model configuration buttons for accessing the models input parameters and file viewer forms.



Global Variables Button



The Global Parameter Menu displays required fields for the various model components. Except for the *Inventory Time Step* and *Age Class Period parameters*, default field names are displayed in brackets beside each field label. It is recommended you build your initial input layer using the default field names shown here.

Inventory Time Step (years):
The years between each harvest period.

Age Class Period (years):
The period in years that defines the age class.

The remaining parameters access the base grids value attribute table (vat).

Water (np_water):
The field name for identifying water polygons. This field should identify all rivers, small lakes (< 260 ha) and small bays on large lakes. In order to include smaller bays, it's recommended the larger lake polygon be partitioned to allow for the smaller bays to be modelled as distinct zones. Stands adjacent to these water bodies will be assigned a summer food and summer cover bonus suitability value (see section *Proximity to Water Bonus Tab* below for more information).

Shrub (np_shrub):
The field name for identifying non-treed shrub sites that support willow or dogwood as their primary shrub type.

Wetlands (np_wetlands):
The field name for identifying wetlands which support aquatic vegetation.

Treed Muskeg and Treed Rock (np_unprod):
The field name for identifying treed muskeg and rock outcrops. These areas represent treed areas not included within the productive forest land base (i.e., Manitoba Conservation 700 and 710 productivity code series).

Open Water (np_owater):
The field name for identifying all open water polygons. These areas are excluded from the home range smoothing statistic.

Moisture Regime
The field name for identifying moisture regime classes for forested stands.

Strata
Select one of the fields that represent a stand's strata type. For example, **strata** by default, is the prefix that represents fields that identify a stand's strata. Each field containing the prefix strata will also have an associated inventory period (e.g., strata_0). The inventory value represents the inventory period and not the inventory year. To determine the inventory year, multiply the inventory period by the inventory time step (specified above).

Age
Select one of the fields that represent a stand's age. For example, **age** is the prefix that represents the fields that identify a stand's age. Each field containing the prefix age will also have an associated inventory period (e.g. age_0).

Crown Closure
Select one of the fields that represent the stand's crown closure. For example, **cc** is the prefix that represents the fields that define a stand's crown closure. Each field containing the prefix cc will also have an associated inventory period (e.g., cc_0).

Softwood
Select one of the fields that represent a stand's softwood percentage. For example, **swd** is the prefix that represents the fields that identify a stand's softwood percentage. Each field containing the prefix swd will also have an associated inventory period (e.g., swd_0).

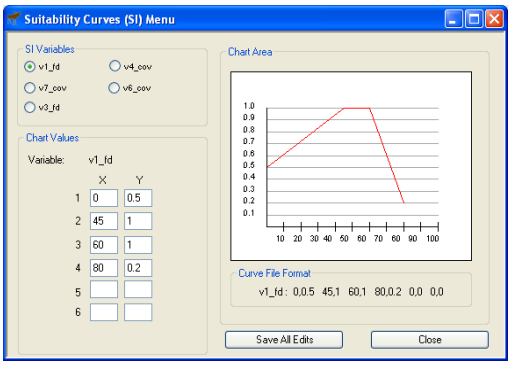
Seral Stage
Select one of the fields that represent a stand's seral stage. For example, **sstage** is the prefix that represents the fields that identify a stand's seral stage. Each field containing the prefix sstage will also have an associated inventory period e.g., sstage_0).

Click the **Save Settings** button to save your changes to the global_parameters.txt file.

SI Curves Button

The Suitability Curves (SI) Menu form defines the reclassification or standardization curves for the following variables:

- Variable 1: Summer and winter forage by percent conifer cover,
- Variable 3: Summer and winter forage by crown closure,
- Variable 4: Summer cover by percent conifer,
- Variable 6: Summer and winter cover by crown closure, and
- Variable 7: Winter cover by percent conifer cover



Selecting an SI variable populates the SI curve inflection point fields. Each curve is defined by a series of x.y points. A maximum of six points are allowed. The model performs a linear interpolation between each point; therefore you only need to enter the main inflection points.

Curve adjustments are made by editing the x and y fields in the Chart Values pane. The curve displayed in the Chart Area and Curve File Format panes is

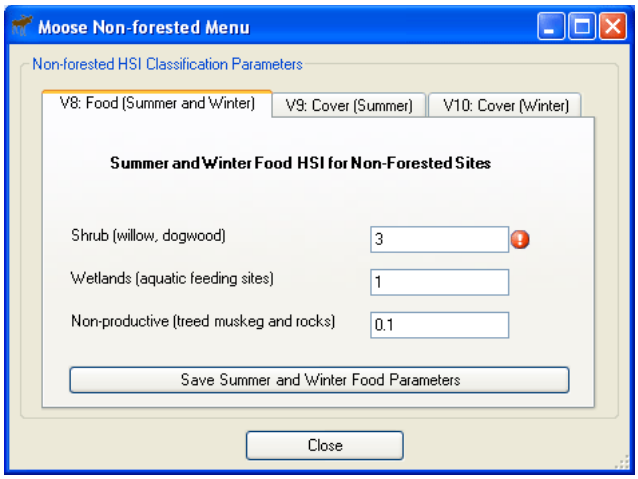
automatically updated to reflect the new value. All numeric values must be greater or equal to zero with no x-values exceeding 100 and no y-values exceeding 1.

Save All Edits Button
Saves all curve edits to the moose.rmp curve definition parameter file. To exit without saving your edits click on the **Close** button.

Non-Forested Sites Button

The Moose Non-forested Menu form sets the non-forested HSI classification parameters for the following variables:

- Variable 8: Summer and winter forage,
- Variable 9: Summer cover, and
- Variable 10: Winter cover



For each variable, enter the suitability index (SI) values for shrub, wetlands and treed muskeg and treed rock sites. The SI values must be greater than or equal to zero and less than or equal to one:

$$0 \leq SI \leq 1$$

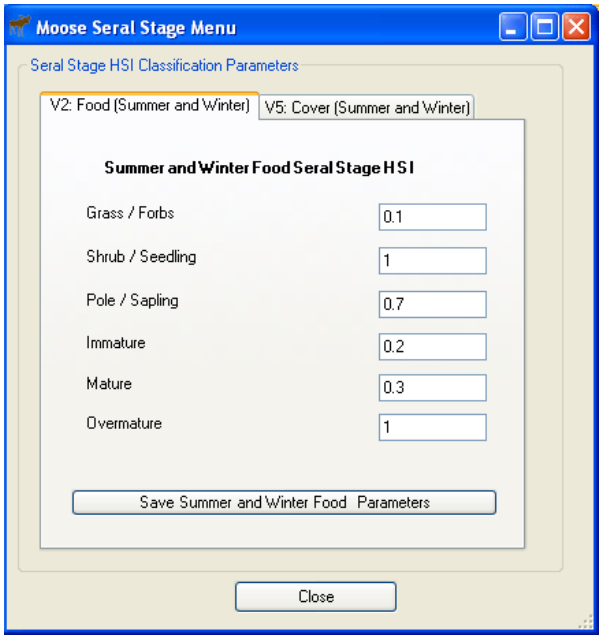
Invalid values are highlighted with an icon. An error is highlighted in the above figure since the value entered is outside the valid range of values. Placing your mouse cursor over the icon will display the type of error (i.e., Numeric value must be between 0 and 1). You should correct all errors before saving since invalid values are still saved to the output parameter file.

Edits are saved by clicking on the **Save** button located on the bottom of each tab. Parameters for each variable are stored within one of the following files: nonprod_cover_ summer.txt, nonprod_cover_winter.txt or nonprod_food.txt.

Seral Stage Classification Button

The Moose Seral Stage Menu form sets the seral stage HSI classification parameters for the following variables:

- Variable 2: Summer and winter forage, and
- Variable 5: Summer and winter cover,



For each variable, enter the suitability index (SI) values for each of the six seral stages. The SI values must be greater than or equal to zero and less than or equal to one:

$$0 \leq SI \leq 1$$

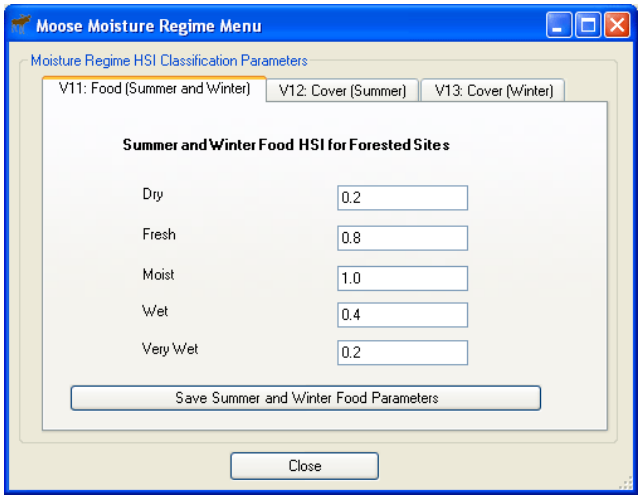
Invalid values are highlighted with an icon. Placing your mouse cursor over the icon will display the type of error (i.e., Numeric value must be between 0 and 1). You should correct all errors before saving since invalid values are still saved to the output parameter file.

Edits are saved by clicking on the **Save** button located on the bottom of each tab. Parameters for each variable are stored within one of the following text files: seral_stage_cover.txt or seral_stage_food.txt.

Moisture Regime Button

The Moose Moisture Regime Menu form sets the moisture regime HSI classification parameters for the following variables:

- Variable 11: Summer and winter forage,
- Variable 12: Summer cover, and
- Variable 13: Winter cover



For each variable, enter a suitability index (SI) value for each of the five moisture regimes. The SI values must be greater than or equal to zero and less than or equal to one:

$$0 \leq SI \leq 1$$

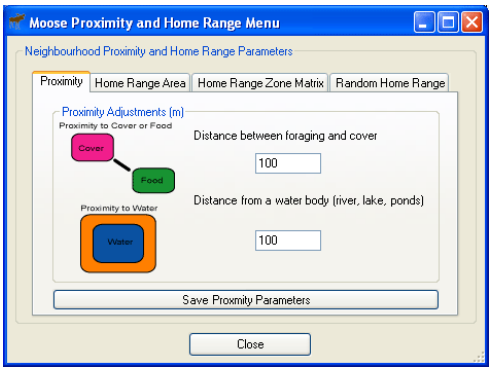
Invalid values are highlighted with an icon. Placing your mouse cursor over the icon will display the type of error (i.e., Numeric value must be between 0 and 1). You should correct all errors before saving since invalid values are still saved to the output parameter file.

Edits are saved by clicking on the **Save** button located on the bottom of each tab. Parameters for each variable are stored within one of the following text files: moisture_cover_summer.txt, moisture_cover_winter.txt or moisture_food_summer.txt.

Proximity and Home Range Button

The Moose Proximity and Home Range Menu form sets spatial parameters related to stand proximity and home range zonal algorithms. All values are stored within the proximity_ distance.txt file.

Proximity Tab



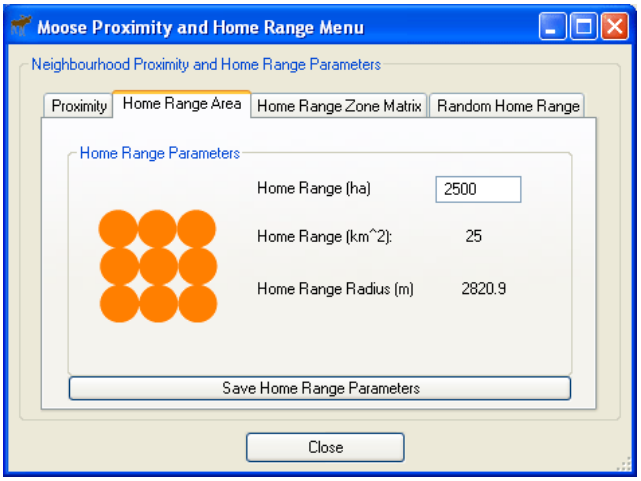
Enter the distance (meters) for the adjustments of SI values based on the proximity between foraging and cover habitats in the *Distance between foraging and cover* box.

This value defines the radius of a circular window used to determine the windows maximum summer food and summer cover SI value.

Enter the buffer distance (meters) to be used around all rivers, small lakes (< 260 ha) and small bays in the *Distance from a water body* box. Both summer food and cover values falling within these zones are assigned a bonus value due to there proximity to water.

For further information on these proximity values, readers should review the **Adjustment of SIs Based on Proximity between Foraging and Cover Habitats** section of the Moose HSM document (McNicol and Rudy, 2006).

Home Range Area Tab

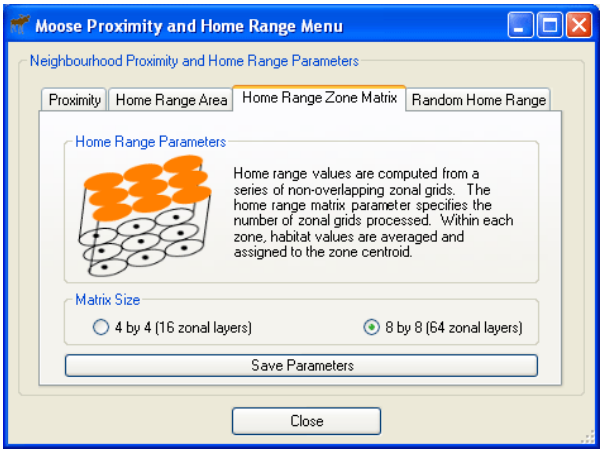


Enter the area of the moose's home range. The home range value is also expressed in square kilometres (km^2) along with its equivalent radius (meters) distance.

This value defines the size of the home range windows used in the home ranging smoothing procedure.

Home Range Zone Matrix Tab

Select if the home range smoothing summary statistics will utilize a 4 by 4 (16 zonal layers) or an 8 by 8 (64 zonal layers) matrix.



Home range values are computed from a series of non-overlapping zonal grids.

An example of a single non-overlapping zonal grid is illustrated in the Home Range Parameters pane. Home range center points are represented by black dots.

For example, by selecting a 4 by 4 matrix, sixteen separate zonal layers will be used in the home range smoothing process. Each layer is slightly shifted resulting in each zones centre points to be offset from center points on the other zonal layers.

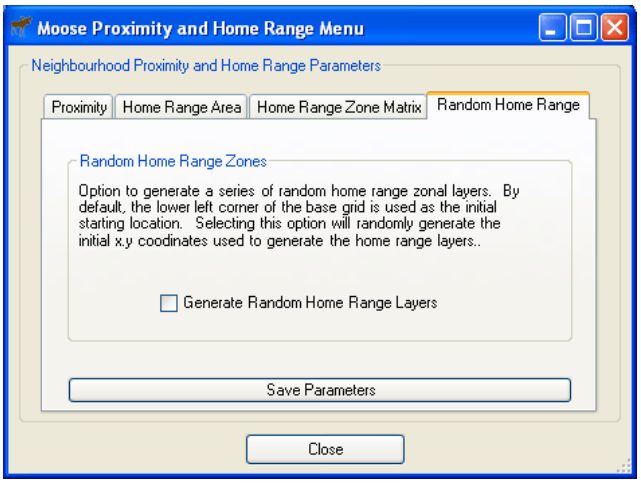
For each layer, the habitat values within each circular home range zone are averaged and assigned to each zones centre point. The centroid values from each of the 16 layers are then combined to create a single layer of the averaged SI values. Selecting an 8 by 8 matrix utilizes more zonal layers (64 layers), which in turn, results in a higher sampling intensity.

The home range smoothing approach selected here performs a systematic sample of locations across the area of interest at the scale of an average moose home range as opposed to calculating an average SI value for each cell.

This approach was selected because the computational time to calculate average SI values for each cell was impractical and moose use their habitat at a much larger scale than that represented by a single cell (i.e. $25m^2$).

Readers are referred to Plate 12 in Appendix 5 of the Moose HSM document for more information regarding the home range smoothing approach used in this model.

Random Home Range Tab



By default, the first initial home range zonal grid is anchored to the lower left corner of the base grid. Each of the home range zonal grids is then shifted from this anchor point. As a result, the same sample points (zone centre points) are used in the home range summary statistics each time the model is run.

The *Generate Random Home Range Layers* option solves this problem by randomly generating a new anchor point each time the model is run. Using static

sample points is useful during model calibration and verification.

> Sample points used in the home range process are stored within a point coverage called \zones\home_rge_pts. Comparing sample point layers from separate simulations, with the Generate Random Home Range layers option enabled, will help illustrate the differences in sample point locations.

Once calibration and verification has been completed, it is recommended this option be enabled. This allows for the replication of a scenario for assessing variations within a scenario and decreases home range smoothing sampling bias.

Equation Weights Button

The Moose Equation Weights Menu form sets the HSM equation and water proximity weights. All values are stored within the habitat_weights.txt file.

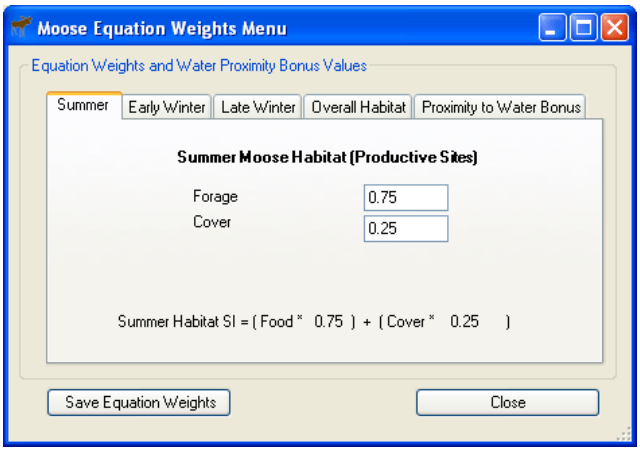
Equation weights are assigned to the following seasonal habitat equations:

- Summer,
- Early winter,
- Late winter, and
- Overall habitat

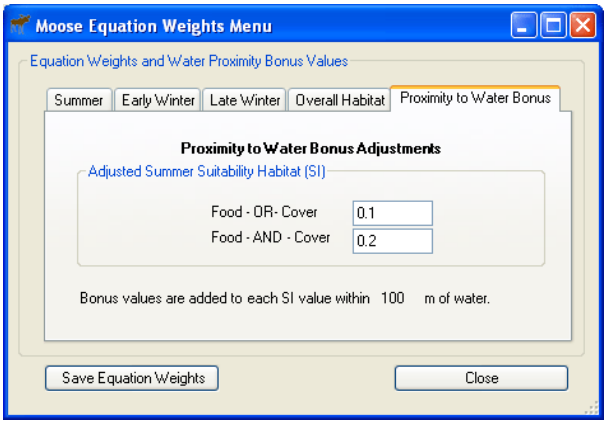
For each seasonal habitat type, enter the appropriate weight value. The weight values must be greater than or equal to zero and less than or equal to one. The sum of the seasonal weight value must equal one.

$$0 \leq \text{Seasonal Habitat Weight} \leq 1$$

Invalid values are highlighted with an icon. Placing your mouse cursor over the icon will display the type of error (i.e., Forage and cover weights must sum to 1!). You should correct all errors before saving since invalid values are still saved to the output parameter file.



Proximity to Water Bonus Tab

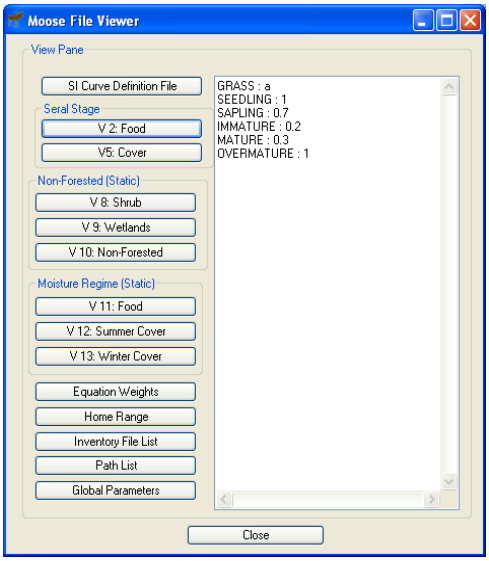


Enter the bonus values to be assigned to areas adjacent to water bodies. Bonus values are assigned to areas within the buffer zones as defined in the Moose Proximity and Home Range Menu.

The SI values must be greater than or equal to zero and less than or equal to one:

$$0 \leq SI \leq 1$$

Invalid values are highlighted with an icon. Placing your mouse cursor over the icon will display the type of error (i.e., Numeric value must be between 0 and 1). You should correct all errors before saving since invalid values are still saved to the output parameter file.



View Input Files Button

Use the Moose File Viewer form to examine all model input parameters and to ensure all values are correct prior to running the model. The file viewer displays all parameter values stored within the currently selected scenario folder.

Selecting the **Close** button returns you to the main species menu.

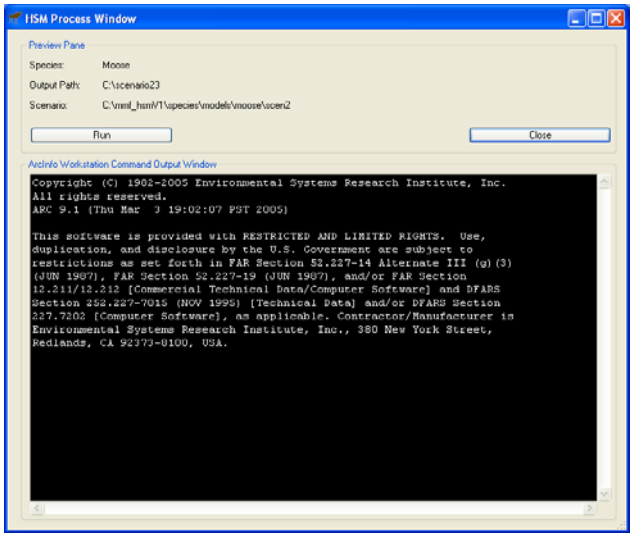
Delete Temporary Folders and Grids Pane

The model creates a temporary workspace (temp_grids) for processing intermediate grid layers. Users have the option to delete the intermediate grids after each model simulation. Many of the intermediate grid layers are stored as floating point grids and require a considerable amount of storage space. If storage space is an issue or intermediate grid files are not needed it is recommended the temporary workspace be deleted.

Once you have edited all required model parameters click the **Continue** button to open the HSM Process Window. The **Preview Pane** lists the species name, output path and the scenario's folder location.

Selecting the **Run** button starts the model process. Model processing results are displayed within the Arc\Info Command Output viewer pane.

Selecting the **Close** button closes the ArcInfo command window and returns the user back to the Moose Main Menu**.**



Selecting the **Close** button on the Moose Main Menu form returns you back to the Wildlife Species Main Menu form.

Moose Model Simulation Results

The model generates a suite of habitat suitability index (HSI) grids for each inventory period modelled. The grid naming convention contains a prefix of the habitat type followed by the inventory year (i.e., cov_s_10). An HSI traditionally consists of values ranging between zero and one with zero suitability values indicating the potential for unsuitable habitat and suitability values of one indicating the potential for suitable or optimum moose habitat. All HSI grids are rescaled to a range between 0 (unsuitable) and 100 (suitable). This rescaling process converts all output grids from a floating grid format type to an integer grid type format which helps to substantially reduce storage space requirements.

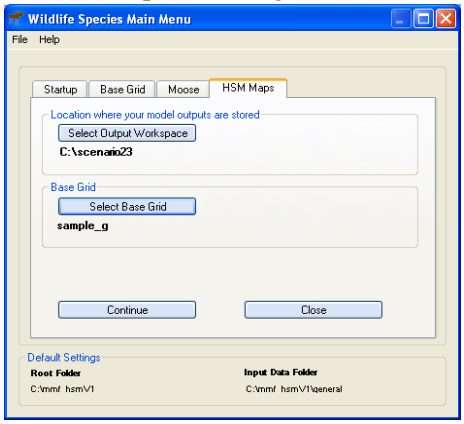
All output is stored within the user defined output folder. The following table lists the content of each subfolder and illustrates all outputs for the tenth simulation year.

Folder Name	Grid Name	Description
habitat_season_grids	moose_10*	Overall moose habitat quality
	home_ear_10	Early winter habitat layer after home range smoothing
	home_late_10	Late winter habitat layer after home range smoothing
	home_sum_10	Summer habitat layer after home range smoothing
	si_ear_10	Early winter habitat prior to home range smoothing
	si_lat_10	Late winter habitat prior to home range smoothing
	si_sum_10	Summer habitat prior to home range smoothing
habitat_grids	cov_s_10	Summer cover habitat
	cov_w_10	Winter cover habitat
	food_s_10	Summer foraging habitat
	food_w_10	Winter foraging habitat
habitat_variable_grids	v1_fd_10	Variable 1: Summer and winter forage by percent conifer
	v2_fd_10	Variable 2: Summer and winter forage by seral stage
	v3_fd_10	Variable 3: Summer and winter forage by crown closure
	v4_cov_10	Variable 4: Summer cover by percent conifer
	v5_cov_10	Variable 5: Summer and winter cover by seral stage
	v6_cov_10	Variable 6: Summer and winter cover by crown closure
	v7_cov_10	Variable 7: Summer cover by percent conifer
	v11_fd_10	Variable 11: Summer and winter forage by moisture class
	v12_cov_10	Variable 22: Summer cover by moisture class
	v13_cov_10	Variable 13 Winter cover by moisture class
zones**	zone#_home	Home range zonal grid. A series of 16 zonal grids are generated when a 4 by 4 matrix is selected. A series of 64 zonal grids are created if an 8 by 8 matrix is selected. Each zonal grid is slightly shifted from the lower left anchor point.
	cent#_home	Home range centroid grid. Centroids are derived from the center point of each home range zone.
	home_rge_pts	Point coverage illustrating the sampling points used in the home range smoothing process. Generated by combining all of the home range centroid grids.

* Calculated from the seasonal home range habitat layers.
** Required for calculating home range statistics.

3.3 HSM Maps Tab

The HSM Maps module generates habitat snapshots and summary posters for a selected scenario.



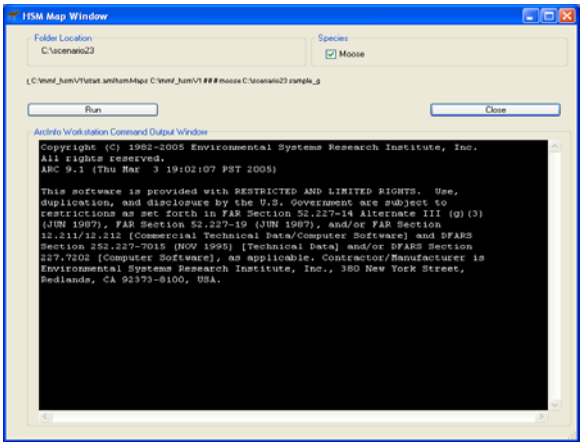
Select Output Location:
Select the folder containing the model outputs from a completed model simulation.

Base grid:
Select the base grid used for the specific run related to the habitat grids you wish to process.

Selecting the **Continue** button opens the HSM Map Window form. The **Preview Pane** lists the folder source path and species name.

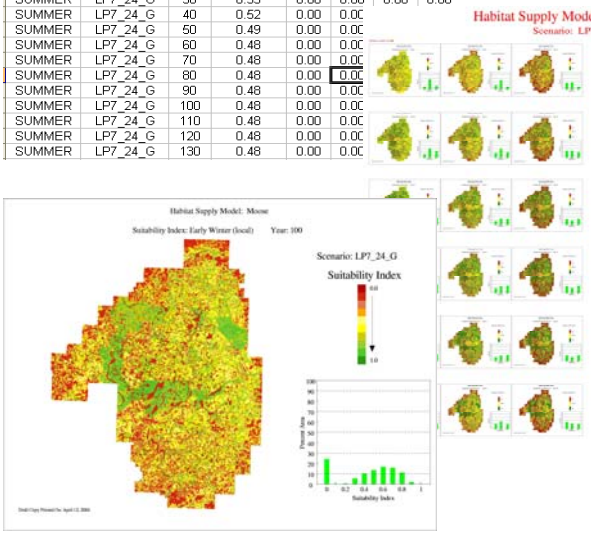
Selecting the **Run** button starts the model process. Model processing results are displayed within the Arc\Info Command Output viewer pane.

Selecting the **Close** button closes the ArcInfo command window and returns the user back to the Wildlife Species Main Menu form**.**



HSM Map Outputs

SI	SCENARIO	YEAR	MEAN_SI	SI_0	SI_1	SI_2	SI_3
SUMMER	LP7_24_G	0	0.47	0.00	0.00	0.00	0.00
SUMMER	LP7_24_G	10	0.51	0.00	0.00	0.00	0.00
SUMMER	LP7_24_G	20	0.53	0.00	0.00	0.00	0.00
SUMMER	LP7_24_G	30	0.53	0.00	0.00	0.00	0.00
SUMMER	LP7_24_G	40	0.52	0.00	0.00		
SUMMER	LP7_24_G	50	0.49	0.00	0.00		
SUMMER	LP7_24_G	60	0.48	0.00	0.00		
SUMMER	LP7_24_G	70	0.48	0.00	0.00		
SUMMER	LP7_24_G	80	0.48	0.00	0.00		
SUMMER	LP7_24_G	90	0.48	0.00	0.00		
SUMMER	LP7_24_G	100	0.48	0.00	0.00		
SUMMER	LP7_24_G	110	0.48	0.00	0.00		
SUMMER	LP7_24_G	120	0.48	0.00	0.00		
SUMMER	LP7_24_G	130	0.48	0.00	0.00		



Summary outputs include a series of 8.5 x 11 image files displaying a suitability index map and frequency histogram chart for the various HSI and forest parameters. A selected set of images are collected together for the creation of a summary poster (24" x 36") for several habitat types or forest parameter variables.

In addition to the map products, a set of tabular summary tables (dBase file format) are generated for each habitat type and forest parameter.

All map images are stored within the user defined output folder. Both map frequency charts and tabular statistics are generated using two different SI interval widths. The first SI interval type is based on ten interval steps. The second interval type is based on three equal interval steps used for defining a high-medium-low SI ranking system. The following table lists the content of the **maps** subfolder and describes all outputs for the tenth simulation year. The **maps-hi-low** subfolder is similar to the **maps** subfolder but is based on the high-medium-low SI ranking system.

Folder	Image file (*.jpg)	Description
maps	moose_10	Overall moose habitat quality map
	home_ear_10	Early winter habitat layer after home range smoothing map
	home_late_10	Late winter habitat layer after home range smoothing map
	home_sum_10	Summer habitat layer after home range smoothing map
	moose_poster	Poster of seasonal habitat types for years 0,10,20,30 40,90,120,150
	si_ear_10	Early winter habitat prior to home range smoothing map
	si_lat_10	Late winter habitat prior to home range smoothing map
	si_sum_10	Summer habitat prior to home range smoothing map
	moose_si	Poster of seasonal habitat types for years 0,10,20,30 40,90,120,150
	cov_s_10	Summer cover habitat map
	cov_w_10	Winter cover habitat map
	food_s_10	Summer foraging habitat map
	food_w_10	Winter foraging habitat map
	moose_forage_cover_poster	Poster of habitat types for years 0,10,20,30 40,90,120,150
	v1_fd_10	Variable 1: Summer and winter forage by percent conifer
	v2_fd_10	Variable 2: Summer and winter forage by seral stage
	v3_fd_10	Variable 3: Summer and winter forage by crown closure
	moose_var_set1_poster	Poster (set 1) of forest variable for years 0,10,20,30 40,90,120,150
	v4_cov_10	Variable 4: Summer cover by percent conifer
	v5_cov_10	Variable 5: Summer and winter cover by seral stage
	v6_cov_10	Variable 6: Summer and winter cover by crown closure
	v7_cov_10	Variable 7: Summer cover by percent conifer
	moose_var_set2_poster	Poster (set 2) of forest variable for years 0,10,20,30 40,90,120,150
	v11_fd_10	Variable 11: Summer and winter forage by moisture class
	v12_cov_10	Variable 12: Summer cover by moisture class
	v13_cov_10	Variable 13 Winter cover by moisture class
	moose_var_set3_poster	Poster (set 3) of forest variable for years 0,10,20,30 40,90,120,150

A set of three summary tables are generated for each interval type and stored with the user defined output folder. The dBase formatted fields are described in the following table.

Files (*.dbf)	Field	Description
moose moose_hab moose_var	SI	Suitability index label (e.g., summer, early, late)
	SCENARIO	Name of the scenario. The base grid name is used as the scenario label.
	YEAR	Simulation year (e.g., 0, 10, 20, 30….).
	MEAN_SI	The overall average SI value.
	SI_0	Percentage of landscape with an SI value between 0 and 9*
	SI_1	Percentage of landscape with an SI value between 10 and 19
	SI_2	Percentage of landscape with an SI value between 20 and 29
	SI_3	Percentage of landscape with an SI value between 30 and 39
	SI_4	Percentage of landscape with an SI value between 40 and 49
	SI_5	Percentage of landscape with an SI value between 50 and 59
	SI_6	Percentage of landscape with an SI value between 60 and 69
	SI_7	Percentage of landscape with an SI value between 70 and 79
	SI_8	Percentage of landscape with an SI value between 80 and 89
	SI_9	Percentage of landscape with an SI value between 90 and 99
	SI_10	Percentage of landscape with an SI value equal to 100
Moose_hilow moose_hab_hilow moose_var_hilow	SI	Suitability index label (e.g., summer, early, late)
	SCENARIO	Name of the scenario. The base grid name is used as the scenario label.
	YEAR	Simulation year (e.g., 0, 10, 20, 30….).
	MEAN_SI	The overall average SI value.
	LOW	Percentage of landscape with an SI value between 0 and 33
	MEDIUM	Percentage of landscape with an SI value between 34 to 66
	HIGH	Percentage of landscape with an SI value between 67 to 100

* Interval ranges are based on an SI range of 0 - 100. All model output was re classed from the standard 0 – 1 SI range to a 0 – 100 SI range to help minimize storage requirements.

Appendix 1: Sample Strata and Seral Stage Age Break Points

Strata	Composition	Seral Stage					
		Grass	Seedling	Sapling	Immature	Mature	Overmature
PTA	80-100% TA, 0-20%softwood	0 - 3	4 - 6	7 - 20	21 - 50	51 - 70	71+
MDE	80-100%TA,BP,WB, 0-20% softwood	0 - 5	6 - 10	11 - 25	26 - 55	56 - 75	76+
NWS	51-79%hardwood,21-49%softwood,Wsor BF or JP	0 - 5	6 - 10	11 - 25	26 - 55	56 - 75	76+
NBS	51-79%hardwood,21-49%softwood,BS and TL	0 - 5	6 - 10	11 - 25	26 - 55	56 - 75	76+
MWS	51-79%softwood,21-49%hardwood,WS or BF or JP	0 - 5	6 - 15	16 - 35	36 - 70	71 - 100	101+
MBS	51-79%softwood,21-49%hardwood,BS and TL	0 - 5	6 - 15	16 - 35	36 - 70	71 - 100	101+
PJP	80-100% softwood, JP leading	0 - 5	6 - 15	16 - 30	31 - 65	66 - 80	81+
PWS	80-100%white spruce, WS or BF leading	0 - 5	6 - 15	16 - 35	36 - 70	71 - 100	101+
UBS	80-100% softwood, BS and TL leading moisture class D,F,M,V	0 - 5	6 - 15	16 - 35	36 - 70	71 - 100	101+
LBS	80-100% softwood BS and TL leading , moisture class W	0 - 7	8 - 20	21 - 50	51-89	90 - 120	121+

Appendix 2: Sample Crown Closure Curves

The following illustrates several sample crown closure curves derived through empirical data interpretation, allometric equations and expert opinion. Each curve represents the change in crown closure over time for a specific stratum.