LANDIS-II Base Harvest v1.3 Extension User Guide

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1 Introduction

This document describes the Harvesting extension ('plug-in') for the LANDIS-II model. Users should read the *LANDIS-II Model User's Guide* prior to reading this document.

The Base Harvest extension described herein generally follows the behavior of the harvest module as described in Gustafson et al. (2000). The extension has been changed significantly to simplify user inputs and maximize flexibility. A user may now match any stand ranking with any site selection method with any combination of stand qualifications. In addition, harvesting events associated with individual prescriptions are now applied in random order. For example, harvesting on a landscape may follow the order: Clearcut, Clearcut, Hardwood Selection, Clearcut, Oak Thinning, etc.

1.1 The Harvesting Landscape

A landscape is divided into a hierarchy of areas for harvesting. These areas are defined prior to landscape simulation.

1.1.1 Management Areas

At the broadest scale, the landscape is divided into management units. Management units define collections of stands to which specific harvesting prescriptions will be applied. Up to 65,000 management units can be defined. Management units need not be contiguous. Management units need not have any harvesting prescriptions implemented, thereby remaining essentially non-active.

1.1.2 Harvesting Stands

At a finer scale, stands are collections of cells and represent typical or average forest management block sizes. Stands must be defined congruent with management unit boundaries – **a stand may not belong to more than one management unit**. Stands consist of multiple cells and up to 65,000 stands can be defined.

1.2 Harvesting Prescriptions

First, a series of **prescriptions** must be defined that describe harvesting criteria and target species cohorts. Prescriptions determine which stands within a management unit qualify for harvest, and define the preferred order that these stands will be selected for harvest

(**ranking**). **Separate prescription rankings are derived for each management unit.** Prescriptions can be shared across management units. More detailed information about prescriptions is provided below. Stands set aside for repeated harvests within one prescription are not available for harvesting by other prescriptions.

1.3 Selecting Prescriptions for Harvest

The implementation of prescriptions is handled separately from the definition of the prescriptions themselves. A **Harvest Implementation** table dictates the target area to which prescription will be applied for each management unit. The target area will ***not*** be achieved if there are not enough qualified stands. The target area may be exceeded if stands are large relative to the management unit: *once a prescription is 'triggered', it will be implemented without regard to the target area for a management unit.*

Prescriptions are stochastically selected for implementation after every harvest event. This process is repeated until all prescriptions reach their target cut size or there are no more stands available to be harvested.

First, a ratio is calculated for each prescription (PS) and management unit (MU), dependent upon the area designated for harvesting:

$$Ratio_{PS,MU} = \frac{TotalAreaToHarvest_{PS,MU} - ActualAreaHarvested_{PS,MU}}{TotalAreaToHarvest_{PS,MU}}$$

Next, these ratios are then converted to a probability ($P_{PS,MU}$) for each prescription by normalizing $Ratio_{PS,MU}$ such that the sum of all $P_{PS,MU}$ is equal to one. A uniform random number is then compared to an interval corresponding to each $P_{PS,MU}$. The interval in which the random number lies determines the next harvest prescription.

Finally, the highest ranked stand for that prescription is harvested. The area of the stand is added to $ActualAreaHarvested_{PS,MU}$. **Stands cannot be harvested more than once per harvest time step.**

The process is repeated until all prescriptions within a management unit have achieved their target cutting area or there are no more stands available (ranking > 0).

Note: *If the user defines many limiting criteria for a prescription and many stands are ranked zero for that prescription, the desired harvest area may not be reached.*

1.4 Version History

1.4.1 Version 1.3

Version 1.3 included several significant bug fixes that ultimately affected Biomass Harvest.

1.4.2 Version 1.2

The behavior of Complete and Partial Stand Spreading was changed such that if the initial stand size ***exceeds*** the desired stand size, then the harvest will begin at a random location within the initial stand and spread internally until the desired size is achieved and stop.

A minimum size was added to Stand Spreading (Complete and Partial) to allow users to more tightly control the area harvested if necessary.

A new optional keyword was added to Prescriptions: **MinTimeSinceDamage**. If this keyword is given, a minimum time since last damage (fire, wind, or harvest) test is applied ***at the site (cell) scale***. The new function will prevent harvesting of recently damaged sites and will provide better control of the area actually harvested. The function will also allow more frequent application of patch cutting as previous patches will not be re-harvested until the minimum time has passed.

A new required log was added: **SummaryLog**. The new log file summarized prescriptions by management area and by year.

In addition, a significant bug in the Repeat Harvest options was fixed.

1.4.3 Version 1.1.3 – 1.1.9

Various bugs addressed.

1.4.4 Version 1.1

Beginning with version 1.1, a Forest Type table must contain zero or greater than one Optional statements. At least one of these must be true for a stand to qualify for harvesting.

1.5 References

Gustafson, E. J.; Shifley, S. R.; Mladenoff, D. J.; Nimerfro, K. K., and He, H. S. 2000. Spatial simulation of forest succession and timber harvesting using LANDIS. Canadian Journal of Forest Research. 30:32-43.

He, H. S., Mladenoff, D. J., Gustafson, E. J., Nimefro, K. K. 2000. LANDIS 3.6 User's Guide. The School of Natural Resource, the University of Missouri-Columbia, Columbia, MO, U.S.A. 66 p.

1.6 Acknowledgements

Funding for the development of LANDIS-II has been provided by the Northern Research Station (Rhinelander, Wisconsin) of the U.S. Forest Service.

2 Basic Inputs

This extension has 3 input files: a text file containing input parameters and 2 input maps (see section 2.3). The text file must comply with the general format requirements described in section 3.1 *Text Input Files* in the *LANDIS-II Model User Guide*.

This first section describes the basic inputs **required for every harvest input file**.

2.1 LandisData

This parameter's value must be `"Harvesting"`.

2.2 Time step

Keyword: `Timestep`

Parameter: The extension's timestep. (Value: integer > 0. Units: years.)

2.3 Input Maps

The extension requires two input maps. It reads the maps after it has finished reading this input file.

2.3.1 Management Areas Map

The extension checks each cell value in the map at an active site on the landscape. Any value that is not in the Management Area column of the harvest implementations table (see section 4) is considered an **inactive** management unit. After reading the management unit map, the extension outputs a list of all the inactive management units that were found.

Keyword: `ManagementAreas`

Parameter: This parameter is the filename of the input map showing where the management units are located on the landscape.

2.3.2 Management Stands

The extension will report an error if any stand belongs to more than one management unit.

Keyword: `ManagementAreas`

Parameter: This parameter is the filename of the input map showing where the harvest stands are located.

3 Harvest Prescriptions

The User may define multiple harvest prescriptions. These prescriptions can be applied to multiple management units over different time periods (see 1.1.1 Management Areas). A prescription describes how stands qualify for harvest, how they are ranked to determine the order in which they are harvested, any optional ranking criteria, how sites (cells) within stands are selected for harvest, and the cohorts to be removed from those sites. The percentage of stands harvested and the time steps of implementation are described under Harvest Scheduling (4 Harvest)

3.1 Prescription Name

This text parameter is the prescription's name. Each name must be unique.

Keyword: `PrescriptionName`

3.2 Stand Rankings

Qualified stands can be prioritized for harvest (ranked) in numerous different ways. The stands with the highest ranking are given priority when stands are selected for harvesting. For most rankings, a value is calculated for each cell and cells are averaged to calculate the stand rank. Unqualified stands receive a rank of zero and will not be harvested during that time step. A stand ranking method must be designated for each prescription. **Stands are ranked within a management unit**, i.e., each management unit will have a separate ranking of the stands within it.

Keyword `StandRanking`

Parameter: Valid inputs are `"Economic"`, `"MaxCohortAge"`, `"RegulateAges"` and `"Random"`.

3.2.1 Maximum cohort age (MaxCohortAge)

Stands in a management unit are ranked in descending order by age, resulting in oldest stands being harvested first. Stand age is computed as the mean of the oldest cohort on each site within the stand.

3.2.2 Economic importance (Economic)

Stands are ranked on an index of economic value. Each species is assigned a relative economic value. The value of each age cohort

within a species is linearly weighted so that older cohorts are more valuable. The economic value of a site is the sum of the weighted value for each age cohort present. The economic value of a stand is the mean of the economic value for each site in the stand. This ranking algorithm requires additional parameters that indicate the relative economic value of each species and the age of economic maturity (minimum age of merchantability) for each species.

If the stands are ranked on their economic value, then a table of economic ranks must immediately follow the StandRanking parameter. Each row in the table has the economic rank for one species.

Requires Species List

Parameters: Species

Economic Rank (Value: 0 < n <= 100, where 100 is the most valuable)

Age (units in years)

3.2.2.1 Species column

The species' name must be one of those listed in the species input file (see chapter 5 in the *LANDIS-II Model User Guide*). The species can appear in any order in the economic rank table. The table does not need a row for every species. Any species that is not in the table is assigned the default economic rank of 0.

3.2.2.2 Economic Rank column

This parameter is the species' economic value (rank). Value: $0 \leq$ integer ≤ 100.

3.2.2.3 Minimum Age column

This parameter is the minimum age at which the species has economic value. Value: integer ≥ 0.

Example:

```
      StandRanking    Economic
>>  Species     Economic Rank   Minimum Age
>>  -------     -------------   -----------
    acerrubr         85             50
```

3.2.3 Regulate cohort ages (RegulateAges)

Stands are ranked such that harvesting over time will produce an even distribution of stand ages across the management unit. The highest

priority is given to stands with sites having the most abundant age classes within the management unit. Stand age is computed as the mean of the oldest cohort on each site within the stand. This ranking attempts to produce an even distribution of age classes within the management unit. The ranking is defined as:

(relative frequency of stands with same maximum age) $e^{(\text{stand-age} / 10)}$

3.2.4 Random (Random)

Stands in a management unit are randomly selected for harvest.

3.3 Stand Qualifications

Before ranking, stands must meet one or more qualifications. If they do not meet the qualification criteia, they will not be ranked or harvested. Each parameter is optional. If two or more of these parameters are present, they must be in the order listed in this section.

3.3.1 Minimum Age

The user may indicate that a stand must reach a **minimum age** before harvesting. The age of a stand is the mean maximum age of all cells within the stand.

Keyword: `MinimumAge`

Parameter: Age (Value: integer ≥ 0. Units: years)

3.3.2 Maximum Age

The user may indicate that a stand **cannot** be harvested after reaching a **maximum age**. The age of a stand is the mean maximum age of all cells within the stand.

Keyword: `MaximumAge`

Parameter: Age (Value: integer ≥ minimum age; if no minimum age specified, then integer ≥ 0. Units: years)

3.3.3 Minimum Time Since Last Harvest

A minimum interval between harvests may be specified. Therefore, in order for a stand to be eligible for ranking, the time since it was last harvested must equal or exceed this parameter. This parameter is useful when the harvest prescription does not change stand age enough

to preclude harvest in subsequent time steps. Within the designated period, the stand is disqualified.

Keyword: `TimeBetweenHarvests`

Parameters: Time (Value: integer ≥ 0. Units: years)

3.3.4 Adjacency constraints

The user may define three parameters which control the adjacency constraints on the stands within a management unit. There are two types of adjacency constraints: StandAge and TimeSinceLastHarvested. Specifying a stand adjacency of X years and the adjacency type of **StandAge** will prevent any stand from being cut if any of its neighboring stands are less than X years old. Specifying an adjacency type of **TimeSinceLastHarvested** will prevent a stand from being cut if any of its neighboring stands have been harvested within the last X years. Additionally, setting the AdjacencyNeighborSetAside parameter at Y years will set aside each neighbor of a stand for Y years. This will prevent stands adjacent to each other from being harvested until Y years have passed.

Keywords `StandAdjacency`

`AdjacencyType`

`AdjacencyNeighborSetAside`

Parameters: AdjacencyType (`StandAge` or `TimeSinceLastHarvested`)

AdjacencyNeighborSetAside (Value: integer ≥ 0. Units: years.)

3.3.5 Forest Type

Prescriptions can be targeted to specific species (forest type). A set of rules are specified to define a forest type. **These criteria are used to disqualify stands for harvesting.**

Each line of the table specifies a species composition condition and inclusion rule that can be either true or false for a stand. The condition is defined by the presence of cohorts within a range of ages for one or more species and a minimum percentage of cells in the stand in which the cohorts must be present. Each rule specifies whether the condition qualifies or disqualifies the stand for harvest.

InclusionRule. Determines how the condition qualifies the stand for harvest. There are three possible values: **Required** = condition must be true. **Optional** = there must be at least two Optional conditions and at least one Optional condition must be true. **Forbidden** = condition cannot be true. A stand will qualify for harvest if all Required conditions (if present) are true AND at least one Optional condition (if present) is true AND no Forbidden conditions (if present) are true. No combination of statements is required although there must be more than one Optional statement if there are any Optional statements.
Species and AgeRange. Presence of cohorts within this species and range of ages is evaluated. Multiple species can be listed, separated by a space. If multiple species are listed, then all listed species will contribute to the percent cells requirement. AgeRange indicates the ages that will be evaluated for the species listed.

PercentofCells. Cohorts within the species and range of ages must exist on at least this percentage of cells in the stand for the condition to be true. Valid values ($0 \leq$ PercentofCells ≤ 100; highest). "Highest" indicates that the species listed has the greatest (or is a tie) number of cells with condition = true of **all** the species found in the stand, and is used to identify the dominant species in the stand. Species not explicitly listed will be evaluated using the age range for the included species.

Examples are provided below.

Keyword: `ForestTypeTable`

3.4 Cell Qualifications

A new optional keyword (**MinTimeSinceDamage**) was added to Prescriptions that enable individual cells within a stand to be qualified or disqualified. A minimum time since last damage (fire, wind, or harvest) must pass before a cell can harvested. The associated function prevents harvesting of recently damaged sites and provides more precise control of the area actually harvested. The function also allows more frequent application of patch cutting as previous patches will not be re-harvested until the minimum time has passed.

Keyword: `MinTimeSinceDamage`

Parameters: Time (Value: integer ≥ 0. Units: years)

3.5 Prevent Subsequent Establishment

New with version 1.3 is the ability to prevent any establishment following a harvest activity. This option is intended primarily for simulating land use change activity, such as housing developments.

Note: *ALL species are prevented from subsequent establishment.*

Keyword: `PreventEstablishment`

Parameter: Yes or No or Y or N

3.6 Site Selection

For each harvest event, the number of sites to be harvested must be indicated. Part of a stand, an entire stand,, or multiple stands may be specified. A single site selection method must be given for each prescription.

Keyword: `SiteSelection`

Parameters: Valid method names are `"Complete"`, `"CompleteStand Spread"`, `"PatchCutting"` and `"PartialStandSpread"`.

3.6.1 Complete Stand

All sites (cells) within a stand are harvested.

3.6.2 Targeted Harvest Size

If the site-selection method is complete stand spreading (`"CompleteStandSpread"`) or partial stand spreading (`"PartialStandSpread"`), then a target harvest size (minimum and maximum) must follow the method's name.

3.6.2.1 Targeted Stand Size – Partial Stand Spreading

Beginning at a random point within a stand, the harvest event spreads until the desired size is reached. A stand may be partially harvested or the harvest event may spread to cells in neighboring stands, depending on the size of the stand relative to the target size. Harvesting spreads to the neighboring stand (a neighbor of any stand already selected for the current event) with the highest stand ranking. A neighboring stand will be completely harvested before spreading to additional neighbors. Therefore, at most only one stand will be partially harvested.
Harvesting may not spread into stands that do not meet the

prescription constraints (e.g., stand qualifiers or ranking = 0) or into neighboring management units. Harvesting will continue until the target size is reached, or the initial stand has no more qualified neighbors.

Parameter 1: Target Minimum Size, in hectares

Parameter 2: Target Maximum Size, in hectares

The minimum size was added with version 1.2, allowing tighter control over the final cut size. If the minimum size is set to zero, this indicates that the user does not require a minimum size. If the minimum size is equal to the maximum size, this indicates that the user wants all harvests to be the maximum size. Minimum size cannot exceed the maximum. **The maximum size must always be a reasonable and appropriate size or there is the risk of a single harvest event harvesting the entire management area.**

3.6.2.2 Targeted Stand Size - Complete Stand Spreading

All sites (cells) within a stand are harvested. If a minimum size has not been reached, **all** cells in a neighboring stand are added until the desired size is reached or exceeded. Harvesting spreads to the neighboring stand (a neighbor of any stand already selected for the current event) with the highest stand ranking. **Harvesting may not spread into stands that do not meet the prescription constraints (e.g., stand qualifiers or ranking = 0) or into neighboring management units.**

Parameter 1: Target Minimum Size, in hectares

Parameter 2: Target Maximum Size, in hectares

3.6.3 Patch Cutting

Randomly selected groups of sites within a stand (often called ‘group selection’) that will be harvested. The User indicates the percentage of cells within a stand to be harvested and the desired patch size (ha). Initial entry sites are randomly selected. From the initial entry site, the patch spreads to neighboring sites until the desired patch size is reached or there are no available neighbors within the stand. If the target percentage of cells in the stand has not been cut, a new entry site within the stand is chosen and the process is repeated. This site selection method may also be used to produce residual patches of uncut sites by specifying a relatively large percentage of the stand.

Keyword: `PatchCutting`

Parameters: Percentage (Value: 0% ≤ number ≤ 100%. Units: percentage of the number of sites in a stand.)

Target Patch Size (Value: number ≥ 0. Units: hectares.)

Example: `SiteSelection PatchCutting 15% 4`

3.7 Cohort Removal List

The User must designate which cohorts are to be removed during each harvest event. A cohort list must be included in each prescription.

Keyword: `CohortsRemoved`

Parameters: There are three options:

"PlantOnly" – No cohorts are removed.

`"ClearCut"` – All the cohorts of all species present at the selected sites will be removed.

`"SpeciesList"` – A list of species that will be harvested follows this parameter.

Examples:
```
CohortsRemoved PlantOnly
CohortsRemoved ClearCut
```

3.7.1 Species List for Cohort Removal

The list has at least one species. Each species is on a separate line. The species do not need to appear in any particular order.

On each line, after the species' name, is either a keyword or a list of cohort ages. The keyword or age list indicates which of the species' cohorts will be harvested.

Valid cohort keywords are:

- `"All"` – All the species' cohorts will be removed.
- `"Youngest"` – Only the youngest cohort will be removed.
- `"Oldest"` – Only the oldest cohort will be removed.
- `"AllExceptYoungest"` – All the species' cohorts except the youngest cohort will be removed. Only the youngest cohort is left.

- `"AllExceptOldest"` – All the species' cohorts except the oldest cohort will be removed. Only the oldest cohort is left.
- `"1/N"` – A fraction of the species' cohorts are removed, by going through the cohorts from youngest to oldest, and removing every N^{th} cohort that is present. N is an integer > 0. No whitespace is allowed in the fraction (i.e., no whitespace is allowed before or after the `"/"` character).

An age list has one or more items separated by whitespace. An item is either an individual cohort age or a range of ages. The format for an age range is "age_{start}-age_{end}" where $age_{start} \leq age_{end}$. Each age in the list, whether individual or the endpoint of a range, is an integer between 1 and 65,535.

The ages and ranges in the list can appear in any order. An individual age cannot be repeated in the list. Also, a range cannot overlap any other range or include any listed individual age.

A species cohort will be removed if the cohort's age is one of the individual ages in the list or if its age lies within one of the ranges in the list.

Example:

```
CohortsRemoved SpeciesList
    >>  Species     Cohorts removed
    >>  -------     ---------
        abiebals    35-100 140 150-160
        acerrubr    AllExceptYoungest
        pinubank    1/3
```

3.8 Plant

The User must also indicate whether a species should be planted after harvest. This optional parameter indicates that which species should be planted at a site after it is harvested. Value: A list of one or more species names separated by whitespace.

Keyword `Plant`

Parameters: One or more species codes

Example: `Plant pinustro acerrubr`

3.9 Repeated Prescriptions

Prescriptions are typically applied at each time step, with stands selected for harvest based on a new ranking at each time step. However, some prescriptions require the same stand to be harvested later in a predictable way. Therefore, prescriptions can optionally specify a predictable repeat harvest in one of two ways: single repeat or multiple repeat. These options can be used in combination with any of the stand qualifiers or ranking procedures given above. However, note that the multiple repeat harvests will only be qualified and ranked **once**.

3.9.1 Single Repeat Harvests

A single repeat is necessary when performing seed tree or shelterwood harvests. For example, most cohorts of a white pine stand may be removed, leaving only the oldest cohort. After a designated interval, allowing enough time for regeneration via seeding, the oldest cohort is also removed. **These stands are re-harvested once after the designated interval.** Although stands are ranked for the initial harvest, **the second harvest will occur automatically without a re-ranking**. A second cohort removal list **must** be provided for repeat harvests. Time-since-last-harvest will be updated after both harvests. However, only the initial harvest of younger cohorts is counted towards the total area harvested.

Keyword: `SingleRepeat`

Parameter: Time (Value: integer > 0. Units: years.)

3.9.1.1 CohortsRemoved and Plant Parameters for Single-Repeat Harvests

In order to specify which cohorts are to be removed during the repeat harvest, a 2nd use of the CohortsRemoved parameter (see section `CohortsRemoved` above) must follow the SingleRepeat parameter.

Also, if the repeat harvest involves the planting of species, a 2nd use of the Plant parameter (see section 3.8 above) may follow the 2nd use of the CohortsRemoved parameter.

3.9.2 Multiple Repeat Harvests

Multiple repeat harvests can be used to mimic selective harvesting, clearcutting, and other silvicultural practices where stands are repeatedly entered to remove specific cohorts. At a regular, specified interval, typically allowing enough time for maturation, the stands are

harvested again. **These stands are only ranked once during the initial harvesting period and are repeatedly (periodically) harvested.**

Keyword: `MultipleRepeat`

Parameters: The interval between the successive harvests of the selected stands. (Value: integer > 0. Units: years.)

4 Harvest Implementations Table

This table specifies which prescriptions are implemented in the various management units. Each row in the table specifies one prescription that is applied to one or more management units. More than one prescription can be applied to a management unit.

4.1.1 Table Name

The table's name is `"HarvestImplementations"`.

4.1.2 Management Area Column

This parameter is the map code of the management unit to which the prescription will be applied. The management unit must contain at least one active site in the landscape. Value: $0 \leq$ integer $\leq 65{,}535$. If a prescription is to be applied to more than one management unit, these should be listed on separate lines.

4.1.3 Prescription Column

This text parameter is the name of the prescription to apply to the management unit(s).

4.1.4 Area To Harvest Column

This parameter is the target percentage of the management unit to be harvested with the applied prescription **within a single harvest time step**. Value: $0\% \leq$ number $\leq 100\%$. Target percent is a fraction of sites within a management unit. Note: non-active sites should not be included in any management unit as this may lead to erroneous results.

4.1.5 Begin Time Column

This optional parameter indicates the year during the model scenario when the prescription should start being applied to the management unit. Prior to the specified year, the prescription is inactive. Value: $0 \leq$ integer $\leq$ end year of the scenario. Units: Year. **If this parameter is not specified, then the prescription starts at the beginning of the scenario.**

4.1.6 End Time Column

This optional parameter indicates the year during the model scenario when the prescription should stop being applied to the management unit. After the specified year, the prescription is inactive. Value:

Begin Time ≤ integer ≤ end year of the scenario. Units: Year. **If this parameter is not specified, then the prescription is active until the end of the scenario.**

Note: this parameter can only be used if the Begin Time parameter is also used. In other words, in order to specify an end time for a prescription, the user must also specify a begin time.

Example:

```
  HarvestImplementations

>>Mgmt Area   Prescription   Harvest Area    Begin Time  End Time
>>---------   ------------   ------------    ----------  --------
  1           RandomClearCut  10%             0           50
  2           RandomClearCut  20%
  3           RedMapleHarvest 8%              50         100
  3           MaxAgeClearcuts 15%
```

5 Output Definitions

This extension generates two types of output files: a) a map of where prescription harvests occurred in each time step, and b) a log of harvest events for the entire scenario.

5.1 Prescription Maps

Each prescription is assigned a number that represents its position in the input parameter file. The first prescription is assigned 1, the second is assigned 2, and so on. The harvest map is labeled 0 for non-active sites, 1 for active and not disturbed sites, [prescription number + 1] for all harvested sites. A map is produced for each harvest time step.

Note: *The user must indicate if the output should be placed in a subdirectory.*

Keyword: `PrescriptionMaps`

Parameters: The template for the names of the prescription output maps (see section **Error! Reference source not found.**). The parameter value must include the variable "timestep" to ensure that the maps have unique names (see section 3.1.8.1 *Variables* in the *LANDIS-II Model User Guide*).

5.2 Event Log File

The event log is a CSV file that contains information about every **harvest event** over the course of the scenario: year, management unit, prescription used, stand affected, that stand's current age, that stand's current rank, total event size (number of sites), number of sites where cohorts were removed, total number of cohorts removed, and harvest prescription name.

Note: *If a stand spreading prescription is implemented, an event will be spread across multiple stands. The **Event ID** column can be used to identify which stands were affected by such a prescription.*

Keyword: `EventLog`

Parameters: The name of the extension's event log file (see section **Error! Reference source not found.**).

5.3 Summary Log File

The summary log is a CSV file that contains information about every **prescription** over the course of the scenario: year, management unit, number of sites where cohorts were removed, total number of cohorts removed, and cohorts removed by species.

Keyword: SummaryLog

Parameters: The name of the extension's summary log file (see section **Error! Reference source not found.**).

6 Table of Parameters

Below is a summary of the aspatial parameters required for Base Harvest (courtesy Caren Dymond, Canadian Forest Service).

Harvest Prescriptions

Required or optional?	Parameter [actual parameter names given above]	Description
Required	Harvest prescription name	
Optional	Minimum age	age in years
Optional	Maximum age	age in years
Optional	Time between harvest	years
Optional	Stand adjacency	years
Optional	Adjacency Type	age or time since last harvest
Optional	Adjacency Neighbor Set aside	number of years to NOT harvest neighboring stands
Optional	Forest Type Table	species composition and ages and inclusion or exclusion rule
Required	Stand Ranking Algorithm	age or economic table or age distribution or random
	EconomicRank	relative economic value of each species and minimum age of merchantability
Required	Site Selection	complete stand or target area partial allowed or targeted area complete stands only or patches
	target area (min and max)	ha
	patches	percent of stand and patch area in ha
Required	Cohorts Removed	ClearCut or SpeciesList
	specieslist	**all** or **youngest** or **oldest** or all

		except youngest or all except oldest or fraction to remove for each species
Optional	Planting List	list of one or more species

Harvest Implementation Table

Required or optional?	Parameter	Description
Required	Management Area	number corresponding to management area input map
Required	Prescription names	string
Required	Area to harvest	percent of management area to be harvested in a single harvest time step
Optional	Begin time	simulation year
Optional, requires a begin time	End time	simulation year

Harvest Output

Required or optional?	Parameter	Description
Required	Prescription output maps	"timestep"
Required	Event log file	

7 Example Inputs

7.1 Example Forest Type Tables

```
ForestTypeTable  << Northern hardwood without hemlock
 >> InclusionRule ageRange    percentCells            species
    Optional      20-200            45                acersacc
    Optional      30-220            45                querrubr
    Forbidden     30-300            10                tsugcana

ForestTypeTable  << Scots pine
 >> InclusionRule       ageRange    percentCells      species
    Required            101-300     highest           pinusylv
    Forbidden           100-450     40                pinusibi
    Forbidden           1-151       60                betupend
    Forbidden           1-131       60                poputrem

ForestTypeTable  << Conifers
 >> InclusionRule       ageRange    percentCells      species
    Forbidden           1-151       60                betupend
    Forbidden           1-131       60                poputrem
    Optional            101-300     highest           piceobov
    Optional            101-211     highest           aibesibi
    Optional            101-380     highest           larisibi
    Optional            101-300     highest           pinusylv

ForestTypeTable  << uneven-aged Siberian larch
 >> InclusionRule       ageRange    percentCells      species
    Required            101-380           50          larisibi
    Optional            1-40              1           larisibi
    Optional            41-80             1           larisibi
    Optional            81-100            1           larisibi

ForestTypeTable   << light conifers (larch or Scots pine) dominate
>>and all conifers together comprise at least 50% of stand.

>>InclRule            ageRange  %Cells   species
 Required             101-380   highest    larisibi pinusylv
 Required             101-380   50         larisibi pinusylv piceobov
 Forbidden            1-151     60      betupend poputrem

ForestTypeTable   << mixed spruce forest
>> (spruce plus at least one other conifer and one deciduous)

>>InclRule            ageRange   %Cells  species
```

```
  Required            101-300    49     piceobov
  Required            101-380    25     larisibi pinusylv piceobov aibesibi
  Required            1-151      25     betupend poputrem
```

7.2 Example Parameter File

The following is an example parameter file, with several prescriptions defined, and later used in the HarvestImplementations table.

```
>>  SAMPLE HARVEST FILE

>>  If a parameter requires SPECIES information, it must be followed by a
>>  table listing a species name, followed by a list of parameters,
>>  as outlined in the documentation.

>>--------------------------------------------------------------------------
>> TYPE OF DATA

LandisData  Harvesting

>>--------------------------------------------------------------------------
>>  TIMESTEP

Timestep    10

>>--------------------------------------------------------------------------
>>  MANAGEMENT AREAS: the .gis file which defines the management units.

ManagementAreas "./management.gis"

>>--------------------------------------------------------------------------
>>  STANDS: the .gis file which defines the stands.  A stand can belong to
>> one and only one management unit.

Stands      "./stand.gis"

>>--------------------------------------------------------------------------
>>  PRESCRIPTION NAME
>>  Each prescription must have a unique name, which can be referenced
>>  later in the HarvestImplementation section.
>>  The data following the prescription name defines the prescription.

    Prescription    RandomClearCut

>>  STAND RANKING METHOD:
>>  The different Stand Ranking methods are listed below.
>>  Some require extra  parameters, which are outlined in the user guide.
>>  Select 1 of the following:
>>  1. Economic         - requires SPECIES information
>>  2. MaxCohortAge
>>  3. Random
>>  4. RegulateAges
```

```
    StandRanking    Random

>>  AGE REQUIREMENTS:
>>  Define a Minimum or Maximum age to limit the prescription stand ages.

    MinimumAge  150
    MaximumAge  325
    TimeBetweenHarvests  40

>>  SITE SELECTION METHOD:
>>  The different Site Selection methods are listed below.
>>  Some require extra parameters, which are outlined in the user guide.
>>  Select 1 of the following:
>>  1. Complete
>>  2. CompleteStandSpread
>>  3. PartialStandSpread
>>  4. PatchCutting

>>                  Percentage  Patch Size
>>                  ----------  ----------
    SiteSelection   Patchcutting   15%         3

>>  COHORT REMOVAL METHOD:
>>  The different Cohort Removal methods are listed below.
>>  Select 1 of the following:
>>  1. ClearCut
>>  2. SpeciesList      - requires SPECIES information

    CohortsRemoved  ClearCut

>>  MORE PRESCRIPTION EXAMPLES:
>>  The following section is a set of example prescriptions
>>  These examples show how the 'stand ranking' methods,
>>  'site selection' methods and the 'cohort removal' methods can be
>>  recombined to make new prescriptions.


>>--------------------------------------------------------------------
>>  This example aims to show how species information can be used to
>>  refine a harvest prescription.

Prescription    RedMapleHarvest

    Minimum Age     20 << years
    StandRanking    Economic

>>  The 'Economic' ranking requires species information.
>>  Below is a table listing a species name, its 'Economic Rank', and
>> 'Minimum Age' requirement.

>>  Species     Economic Rank   Minimum Age
>>  -------     -------------   -----------
    acerrubr    20              60

    SiteSelection   Complete
    CohortsRemoved  SpeciesList
```

```
>>  The 'SpeciesList' cohort-removal method requires species information.
>>  The table below lists species' cohorts to be removed.
>>  The 'Selection' methods shown below provide three example.

    >>  Species     Selection
    >>  -------     ---------
        abiebals    All
        acerrubr    AllExceptYoungest
        pinubank    50

>>--------------------------------------------------------------------
>>  This example shows a simple and short harvest prescription.

Prescription    MaxAgeClearcuts

    StandRanking    MaxCohortAge
    SiteSelection   Complete
    CohortsRemoved  ClearCut

>>--------------------------------------------------------------------
>>  HARVEST IMPLEMENTATION TABLE
>>  The following table defines which management units (defined in the
>>  ManagementArea file) are treated by which prescription(s).
>>  In the example below, both management units 1 and 2 are treated
>>  by the same prescription, while management unit 3 is treated by two
>>  different prescriptions.

>>  Also demonstrated is beginning and end times for each prescription
>>  implementation.

    HarvestImplementations

>>  Mgmt Area   Prescription    Harvest Area    Begin Time  End Time
>>  ---------   ------------    ------------    ----------  --------
    1           RandomClearCut  10% 0     50
    2           RandomClearCut  20%
    3           RedMapleHarvest 8%  50    100
    3           MaxAgeClearcuts 15%

>>--------------------------------------------------------------------------
>> OUTPUT FILES

PrescriptionMaps    harvest/prescripts-{timestep}.gis
EventLog            harvest/event-log.csv
SummaryLog          harvest/summary-log.csv
>>--------------------------------------------------------------------------
```