User's Manual for CIPSR

Version 4.0.0

Center for Intensive Planted-forest Silviculture (CIPS)

College of Forestry, Oregon State University
Corvallis, OR 97331

Sukhyun Joo (sukhyun.joo@oregonstate.edu)
Douglas B. Mainwaring (doug.mainwaring@oregonstate.edu)
David W. Hann (david.hann@oregonstate.edu)
Nathaniel L. Osborne (nathaniel.osborne@rayonier.com)
Douglas A. Maguire (doug.maguire@oregonstate.edu)

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Executive Summary

CIPSR is an R package for running the growth and yield models CIPSANON and ORGANON. CIPSANON is a spinoff from ORGANON, an individual-tree, distance-independent growth model that was developed and refined at Oregon State University over the last 40 years by David Hann and associated staff. ORGANON simulates the growth, yield and stand dynamics of mixed coniferous and hardwood forests in southwestern Oregon (SWO variant), Douglas-fir dominated forests of northwestern Oregon (NWO variant), intensively managed Douglas-fir and western hemlock plantations in western Oregon, Washington and southwestern British Columbia (SMC variant), and red alder plantations in western Oregon and Washington (RAP variant). CIPSANON was developed by building on the basic structure of ORGANON after formation of the Center for Intensive Planted-forest Silviculture (CIPS) in 2009, but applies annual time steps and can start simulations from plantation age 0 based on measured or generated tree lists. CIPSANON focuses on intensively managed stands of Douglas-fir and western hemlock, but has been most fully developed for intensive management of Douglas-fir plantations by incorporating the effects of competing vegetation control, thinning, fertilization, genetic tree improvement and Swiss needle cast severity. CIPSANON has been a the result of a collaborative effort between CIPS staff and many other research cooperatives in the Douglas-fir region (VMRC-Vegetation Management Research Cooperative, NWTIC-Northwest Tree Improvement Cooperative, SMC-Stand Management Cooperative, USDA-FS Northwest Research Station, PNWTIRC-Pacific Northwest Tree Improvement Research Cooperative, and SNCC-Swiss Needle Cast Cooperative).

This user's manual describes the basic architecture of CIPSANON v. 4.0.0 and instructions for running the CIPSR package.

Table of Contents

1. Introduction

This user's manual describes how to operate the CIPSR an R package, an interface to ORGANON and CIPSANON growth and yield models, by calling a series of dynamic link library (DLL) files. All DLL files are written in FORTRAN source code and compiled as 32- and 64-bit for the Windows operating system. ORGANON is an individual-tree distance-independent growth and yield model incorporating four variants: Southwest Oregon (SWO), Northwest Oregon (NWO), Stand Management Cooperative (SMC), and red alder plantations (RAP). The first version of ORGANON was developed in southwest Oregon as part of the Forestry Intensified Research (FIR) program in the early 1980s by David Hann (Hann, 2011). CIPSANON is an individual-tree, distance-independent growth and yield model built on the ORGANON architecture and code but can simulate annual time steps and start at plantation age 0 years. The first version of CIPSANON was developed by Doug Mainwaring and staff at CIPS (Center for Intensive Planted-forest Silviculture) for Douglas-fir and western hemlock plantations growing in western Oregon, Washington, and southwestern British Columbia (Mainwaring, 2020). CIPSANON has two variants: Southwest Oregon (SWO) and Pacific Northwest (PNW). The CIPSR package **version 4.0.0** supports SWO, NWO, and SMC variants from ORGANON and the PNW [and the variant from CIPSANON.

2. Overview of the CIPSR system

The following flow chart (Fig. 1) depicts CIPSR system, showing major DLL files from CIPSANON and ORGANON and their relationship.

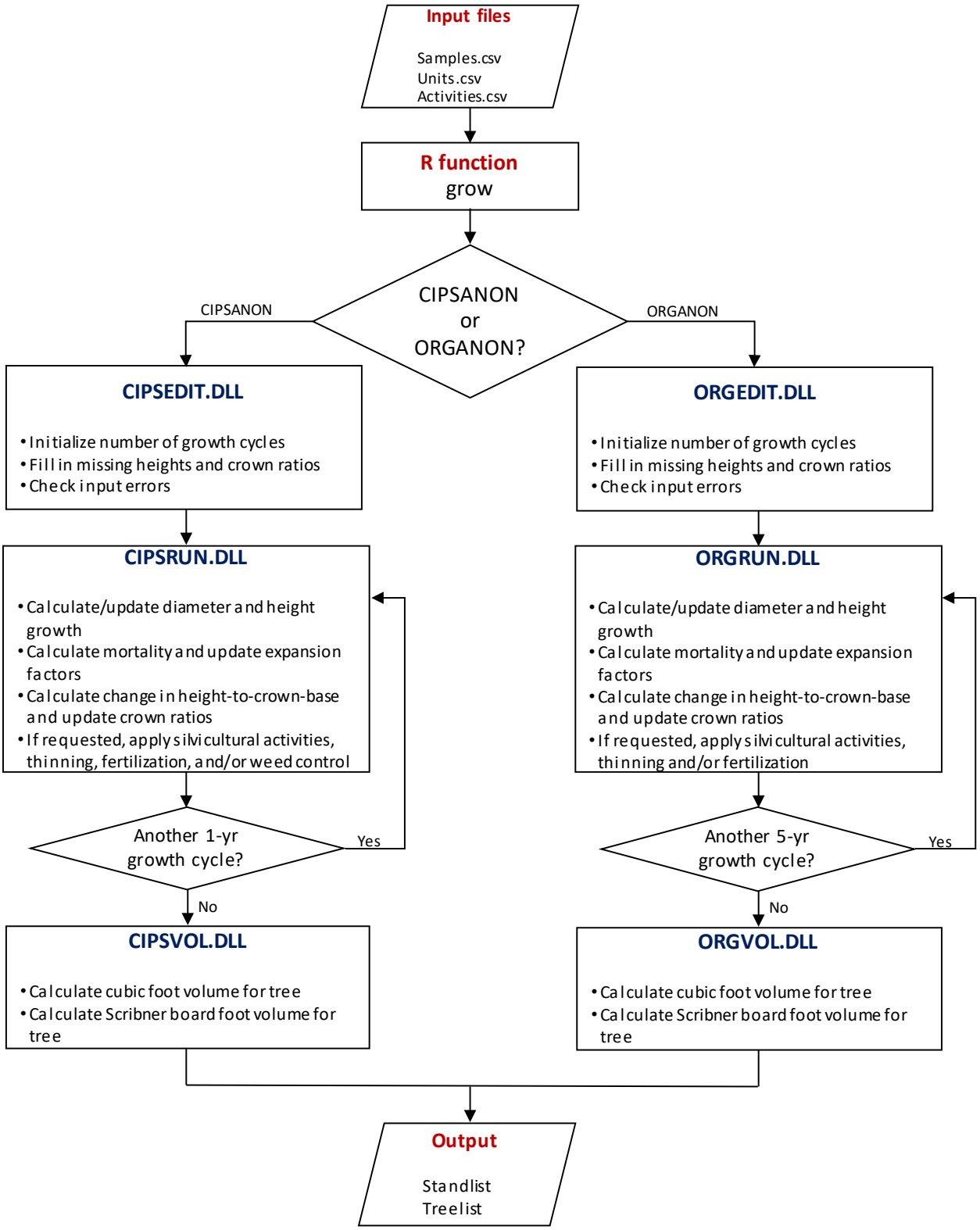

Figure 1. Flow chart of CIPSR system.

3. Installation and loading

The CIPSR package is only available for members of CIPS, can be downloaded and installed from the CIPS website (http://cips.forestry.oregonstate.edu/). The CIPSR package can be installed and run only in Windows computer, and the copy of R must be greater or equal to version 3.0.0. The CIPSR package is compiled as .zip file and has to keep it as .zip file. Extracted CIPSR files will not be installed. All the CIPSR files should be in the same folder. Following steps explain how to download, install, and load the 'cipsr':

a. Download and copy the following files into your working directory:

- "cipsr_4.0.0.zip" ('cipsr' package)
- "Install_run_cipsr.R" (R code to run 'cipsr')
- "Samples_example_cipsr.csv" (Input file)
- "Units_example_cipsr.csv" (Input file)
- "Activities_example_cipsr.csv" (Input file)

b. Run "Install_run_cipsr.R"

c. Check your working directory matches to the folder contains all CIPSR files:

```
getwd()
```

d. Install 'cipsr' package:

```
install.packages("cipsr_4.0.0.zip", repos = NULL, type = "win.binary")
```

e. Load 'cipsr' package:

```
library(cipsr)
```

4. Input files in CIPSR

The CIPSR has three input files. "Samples_example_cipsr.csv" contains initial individual tree information. "Units_example.cipsr.csv" contains initial conditions and specifications of each unit for the simulation "Activities_example_cipsr.csv" prescribes silvicultural activities to each unit during the simulation, such as weed control, thinning, and fertilization. All input files must be saved as comma-delimited .csv format. These three example input files could be referenced when creating new input files with your own data. The following tables explain the description of variables and how to insert values in input files:

4.1. Samples

- "Samples_example_cipsr.csv"

Table 1. Variable description for samples input file.

Variable	Description	Unit
unit	Identifies the sampled stand (unit) of trees. These names must be matched with unit variable in *units* and *activities*.	-
sample	Identifies the sample nested within a unit.	-
tree	Identifies an individual tree within a sample and unit.	-
expan	Expansion factor.	trees/acre
user	Stand age (years) to remove a given tree. This value is associated with the user thinning approach which may be specified in *activities*. A value of 0 indicates that the user thinning approach will not be used	-
species	Tree species identification code. The table below lists species names and their corresponding codes.	-
dbh	Diameter at breast height.	inches
tht	Total tree height. The total height of each tree is not required. If left equal zero, this value will be estimated.	feet
cr	Crown ratio. This is the crown length of a tree (feet) divided by the total tree height (feet). If left equal zero, this value will be estimated. The crown ratio of each tree is not required. If left equal zero, this value will be estimated.	-
radgro	Five-year radial growth. The radial growth of each tree is not required. If left equal zero, this value will be estimated.	inches

4.2. Units

- "Units_example_cipsr.csv"

Table 2. Variable description for units input file.

Variable	Description	Unit
unit	Identifier for the sampled stand (unit) of trees. These names must be matched with unit variable in *samples* and *activities*.	-
latitude	Latitude (decimal degrees) of the unit. This value is only necessary when using the CIPSANON SWO variant and you want to condition growth on whc (water holding capacity) and pptdd (precipitation for degree days), but do not supply estimates of those variables.	-
longitude	Longitude (decimal degrees) of the unit. This value is only necessary when using the CIPSANON SWO variant and you want to condition growth on whc (water holding capacity) and pptdd (precipitation for degree days), but do not supply estimates of those variables.	-
pptdd	Precipitation for degree days greater than or equal to 41 degrees F. A value of zero indicates that this value will be estimated by CIPSR. A	-

	value for pptdd is only necessary when the CIPSANON SWO variant is in use and you want to condition growth using whc (water holding capacity) and pptdd (precipitation for degree days), instead of site-index.	
whc	Water holding capacity of the top 20 inches of soil. A value of zero indicates that this value will be estimated by CIPSR. A value for whc is only necessary when the CIPSANON SWO variant is in use and you want to condition growth using whc and pptdd, instead of site-index.	-
wantplot	Indicates where to produce a series of descriptive graphs. (0: No graphs should be made; 1: Make graphs in R session; 2: Print graphs to a folder in the working directory)	-
wanttable	Indicates whether or not to produce a table of results outside of R. A limit of Microsoft Excel .csv output is enforced. If row limit is exceeded, you will be informed and referred to the big data. (0: No table should be printed to the working directory; 1: Print an Excel .csv file to a folder the working directory)	-
woodqual	Indicates whether or not to estimate wood quality attributes of individual trees. A value for woodqul is only necessary when the ORGANON is in use. (0: Do not estimate wood quality attributes; 1: Estimate wood quality attributes)	-
model	Model to be used in the simulation. (1: ORGANON; 2: CIPSANON)	-
variant	Model variant to be used. (For ORGANON model - 1: SWO - Southwest Oregon; 2: NWO - Northwest Oregon; 3: SMC - Stand Management Cooperative). For CIPSANON model - 1: SWO - Southwest Oregon; 2: PNW - Pacific Northwest)	-
driver	If CIPSANON is in use, this defines how to drive site productivity. (0: Use a traditional site index estimate; 1: Do not use site index: condition growth on whc and pptdd. Only the SWO variant of CIPSANON allows this option)	-
groyrs	Number of years to grow the unit. If ORGANON is used, this number should only be in 5-year increments. If CIPSANON is used, this number can be in 1-year increments.	-
iseven	Indicates whether or not the unit is even-aged. (0: The unit is uneven aged; 1: The unit is even aged)	-
partcut	Indicates whether or not the unit has been partially harvested in the past. (0: The unit has not been partially harvested; 1: The unit has been partially harvested)	-
pastfert	Indicates whether or not the unit has been fertilized in the past. (0: The unit has not been fertilized; 1: The unit has been fertilized)	-
stage	Total age of the unit (years). If the unit is uneven-aged, this value must be zero.	-
bhage	Breast height age of the unit (years).	-

dfsi	Douglas-fir 50-year site index, depending on model variant. (SWO - Hann and Scrivani (1987), NWO - King (1966), SMC - Bruce (1981) for ORGANON, and PNW - Bruce (1981) for CIPSANON.	feet
otsi	Other species 50-year site-index, depending on model variant. (SWO - Hann and Scrivani (1987) for ponderosa pine, NWO - Flewelling et al. (2001) for western hemlock, SMC - Flewelling et al. (2001) for western hemlock in ORGANON, and PNW - Wiley (1978) for western hemlock in CIPSANON	feet
dhcal	Indicates whether or not diameter and height should be calibrated. (0: Do not calibrate diameter and height; 1: Calibrate diameter and height)	-
ccal	Indicates whether or not crown ratio should be calibrated. (0: Do not calibrate crown ratio; 1: Calibrate crown ratio)	-
dgrocal	Indicates whether or not diameter growth should be calibrated. (0: Do not calibrate diameter growth; 1: Calibrate diameter growth)	-
triple	Indicates whether or not to use tripling in the simulation. (0: Do not triple the tree list; 1: Triple the tree list)	-
maxsdi	Indicates whether or not to enforce a maximum size-density limit. (0: Do not enforce limit; 1: Enforce a maximum size-density limit)	-
dfsdi	Douglas-fir maximum size-density index. If left equal zero, a default maximum size-density of 520 is used.	-
wgsdi	White/Grand fir maximum size-density index. If left equal zero, a variant specific default maximum size-density is used.	-
phsdi	Ponderosa pine/Western hemlock maximum size density index. If left equal zero, a variant specific default maximum size-density is used.	-
weedcov	Weed cover in percent at the start of the growth period. Only available for CIPSANON model. Set to 0 for SWO variant. Must be entered for PNW variant ($0 \leq$ weedcov ≤ 250)	percent
yswc	Number of years since competing vegetation has been treated (used in the PNW variant only). Set to 0 for the SWO variant. Set to initial stand age if no treatment of competing vegetation has been done in the PNW variant. Must be less than or equal to 80 if treatment of competing vegetation has been done in the PNW variant.	-
gdval	Douglas-fir genetic worth value for diameter growth. If you are not conditioning growth on genetic worth, leave this value equal zero.	%
ghval	Douglas-fir genetic worth value for height growth. If you are not conditioning growth on genetic worth, leave this value equal zero.	%
dfret	Needle retention of Douglas-fir infected by Swiss-needle cast. If the unit is not infected with Swiss needle cast, leave this value equal zero.	-
genes	Use genetic worth values for diameter and height growth. (0: Do not use genetic worth values; 1: Use genetic worth values for diameter and height growth)	-

snc	Indicates whether a unit is infected with Swiss needle cast. (0: Unit is not infected with Swiss needle cast; 1: Unit is infected with Swiss needle cast)	-
core	Description of the juvenile wood code when estimating wood quality attributes. (0: Assume age description; 1: Assume crown description)	-
cftd	Top diameter inside bark for cubic foot volume estimation.	inches
cfsh	Stump height for cubic foot volume estimation.	feet
logll	Log length for Scribner volume estimation. If set to zero, a default log length of 32 feet is used.	feet
logml	Minimum log length for Scribner volume estimation. If set to zero, a default minimum log length of 8 feet is used.	feet
logtd	Top diameter inside bark for Scribner volume estimation. If set to zero, a default top diameter of 6 inches is used.	inches
logsh	Stump height for Scribner volume estimation. If set to zero, a default stump height of 0.5 feet is used.	feet
logta	Trim allowance for Scribner volume estimation. If set to zero, a default trim allowance of 8 inches is used.	inches

4.3. Activities

- "Activities_example_cipsr.csv"

Table 3. Variable description for activities input file.

Variable	Description	Unit
unit	Identifier for the sampled stand (unit) of trees. These names must be matched with unit variable that defined in *samples* and *units*.	-
trigger	Type of unit condition used to trigger a silvicultural activity: **year:** Stand age (years); **tpa:** Number of trees per acre (trees/acre); **bap:** Basal area per acre (sq. feet/acre); **sdi:** Stand density index	-
when	Level that a given trigger must reach in order to initiate a silvicultural activity (what)	-
what	Silvicultural activity to be carried out if/when a trigger is met: **thin:** Thin the unit to some target; **fert:** Fertilize the unit to some target; **weed:** Weed control the unit to some target	-
how	Instructions for how a silvicultural activity should be carried out: **below:** Remove trees with smaller diameter before trees with larger diameter; **above:** Remove trees with larger diameter before trees with smaller diameter; **prop:** Proportion of the stand to remove; **user:** Remove trees at an age specified with a user code in the sample sheet; **N:** Nitrogen fertilization; **herb:** Herbicide weed control	-
metric	Type of unit condition used to define the residual target of a silvicultural activity: **tpa:** Trees per acre (trees/ac); **bap:** Basal area per acre (sq. ft/ac); **sdi:** Stand density index (index); **pounds:** Pounds of fertilizer to apply per acre; **percent:** Percent of weed to be left. For "user" in how, input user code.	-
target	Intensity of silvicultural treatment in units defined by the metric.	-
species	Defines what species will be targeted in the thinning: 1 = all species, 3 = all hardwoods, 4 = all conifers. For one specific species, input species code.	-

Table 4. Tree species code for CIPSR.

Tree species code				
Code	**Species**	**SWO**	**NWO**	**SMC**
015	White fir	Y	N	N
017	Grand fir	Y	Y	Y
081	Incense cedar	Y	N	N
117	Sugar pine	Y	N	N
122	Ponderosa pine	Y	N	N
202	Douglas-fir	Y	Y	Y

231	Pacific yew	Y	Y	Y
242	Western red cedar	Y	Y	Y
263	Western hemlock	Y	N	Y
312	Bigleaf maple	Y	Y	Y
351	Red alder	Y	Y	Y
361	Pacific madrone	Y	Y	Y
431	Golden chinkapin	Y	N	N
492	Pacific dogwood	Y	Y	Y
631	Tanoak	Y	N	N
805	Canyon live oak	Y	N	N
815	Oregon white oak	Y	Y	Y
818	California black oak	Y	N	N
920	Willow	Y	Y	Y

5. Run CIPSR

Once 'cipsr' is installed and loaded in R, you need to import three input files into R. Here is the code using example input files:

```
Samples_1 <- read.csv("Samples_example_cipsr.csv", header = T)
Units_1 <- read.csv("Units_example_cipsr.csv", header = T)
Activities_1 <- read.csv("Activities_example_cipsr.csv", header = T)
```

Three input files should be combined into one input list in R:

```
InputList <- list(samples = Samples_1,
                  units = Units_1,
                  activities = Activities_1)
```

The "grow" function in 'cipsr' simulates stands based on the information from three input files, now combined to one input list:

```
grown_exercise_1 <- grow(InputList)
```

6. Export output files

Generally, 'cipsr' has two output files: 1) standlist and 2) treelist. If you checked *wanttable* variable as 1 in units input file, output files ("cipsr_output_standlist.csv" and "cipsr_output_treelist.csv") would be generated in "My output" folder at your working directory. If you checked *wanttable* variable as 0 in units input file, you could view your standlist and treelist output files in R by the following code:

For standlist:

```
View(grown_exercise_1$samplelist)
```

For treelist:

```
View(grown_exercise_1$treelist)
```

Also, you can download output files into your working directory. The output files would be generated in .csv:

For standlist:

```
write.csv(grown_exercise_1$samplelist,
          " cipsr_output_standlist.csv",
          row.names = FALSE,
          na = "")
```

For treelist:

```
write.csv(grown_exercise_1$treelist,
          " cipsr_output_treelist.csv",
          row.names = FALSE,
          na = "")
```

If the output files exceed the limit of Microsoft Excel .csv format, you can download output files as .txt into your working directory:

For standlist:

```
write.table(grown_exercise_1$samplelist,
            file = " cipsr_output_standlist.txt",
            sep = "\t",
            row.names = FALSE)
```

For treelist:

```
write.table(grown_exercise_1$treelist,
            file = " cipsr_output_treelist.txt",
            sep = "\t",
            row.names = FALSE)
```

6.1. Standlist output

- "cipsr_output_standlist.csv"

Table 5. Variable description for standlist output file.

Variable	Description	Unit
model	Indicate which model was used. (1: ORGANON, 2: CIPSANON)	-
unit	Unit identifier corresponding with the input dataset.	-
period	Growth period in the simulation.	-
subperiod	Growth subperiod in the simulation. (0: Non-harvested subperiod; 1: Harvest subperiod)	-
stage	Stand age (years).	-
bap	Basal area per acre.	square feet/acre
tpa	Number of trees per acre.	tree/acre
qmd	Quadratic mean diameter.	inches
sdi	Stand density index.	index
rel	Relative stand density.	percent
bfv	Board foot volume per acre.	board feet/acre
cfv	Cubic foot volume per acre.	cubic feet/acre
weedcov	Percentage of weed cover.	%
yswc	Year since weed control.	year

6.2. Treelist output

- "cipsr_output_treelist.csv"

Table 6. Variable description for treelist output file.

Variable	Description	Unit
model	Indicate which model was used. (1: ORGANON, 2: CIPSANON)	-
unit	Unit identifier corresponding with the input dataset	-
period	Growth period in the simulation	-
subperiod	Growth subperiod in the simulation. (0: Non-harvested subperiod; 1: Harvest subperiod)	-
stage	Stand age (years)	-
user	Code used to mark trees for harvest at a given stand age	-
tree	Tree identification number	-
species	Species identification code	-
dbh	Diameter at breast height	inches
tht	Total tree height	feet
cr	Crown ratio	-
expan	Expansion factor	trees/acre
mgexp	Cut tree expansion factor	trees/acre
weedcov	Percentage of weed cover.	%

yswc	Year since weed control.	year
cfv	Cubic foot volume	cubic feet/tree
bfv	Scribner board foot volume	board feet/tree

7. Version history

Table 7. Version history of CIPSR.

Version	Description of the updates to CIPSR	Releasing date	Senior developer
4.0.0	• Updated CIPSANON equations. • Fixed an issue that projected top height at age 50 years was less than the estimated site index.	7/23/2018	S. Joo
3.0.0	• Incorporated THINNING.DLL files. • Added vegetation control responses. • Allowed to project young trees (total height below breast height with DBH=0). • Changed a format of input files from one .xls to three comma-delimited .csv files (samples.csv, units.csv, activities.csv). • The 'cipsr' dependencies, rJava, XLConnect, and XLConnectJars are no longer needed. • Unable to compile CIPSANON SWO variant due to raster files. • From now, CIPSR will not be updated to the public domain. The new version of CIPSR will only be released through the CIPS website (http://cips.forestry.oregonstate.edu/).	6/10/2018	S. Joo
2.2.4	• Added warning message to the 'process' function. • Updated 'cipsr' dependencies to support R version 3.2	8/18/2015	N. Osborne
2.2.3	• Fixed typos in the 'process' function • Error check in the 'grow' function	6/2/2015	N. Osborne
2.2.2	• Added a database with pole specifications for merchandising values. • Included equations for taper of many species and exclude analysis of hardwood trees.	1/17/2015	N. Osborne
2.2.1	• Minor edit to the plotting color scheme. • General debugging.	1/6/2015	N. Osborne
2.2	• Fixed unexpected stop by user inputs and outputs. • Fixed for big output data. • Renamed vignette to "introduction" (user's instructions).	1/2/2015	N. Osborne

2.1	• Compiled DLL files for both 32- and 64 bit. • Updated 'cipsr' dependencies, raster, rgdal, rJava, sp, and XLConnect. • Notification to users to install Java for importing input data as a format of .xls into R.	11/29/2014	N. Osborne
2.0	• Ready to use 'cipsr' as a package in R. • Linked DLL files and spatial files with the R source code.	10/11/2014	N. Osborne
1.0	• Completed R source code.	10/10/2014	N. Osborne

8. Literature cited

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