4C user manual
Wood Processing Model (WPM)

The Wood Processing Model (WPM) estimates the carbon content in different timber products and such carbon reservoirs as landfill and atmosphere over the given number of years.

As input values WPM uses the pre-estimated amount of harvested wood from the 4C simulation, assumed a forest management was accomplished. A spinup file can be used to initialize single product, landfill and atmosphere pools with realistic values.

First, the harvested wood is sorted into different timber grades which then are rearranged into different timber product groups.

Then the product group carbon flow is simulated over the number of simulation years. The product groups have different life spans. The life span functions determine the half-life period of timber and therefore the recycled timber amount yearly. The timber removed from the product groups is partly recycled and returns into the timber cycle labelled as timber of age 0.

The carbon cycle ends on landfill areas, by burning and hence in the atmosphere. A fixed percentage rate from the landfill carbon volatilises to the atmosphere where it accumulates over the years.

The model background of WPM is mainly based on (Eggers, 2002) and is described in detail in the 4C_WPM_SEA_description.pdf.

1 GETTING STARTED

To get started following is required:

Set the “flag_wpm” to the desired value

Make sure forest management took action

A spinup file must exist in the input directory (can be a dummy file).

Flag Options

flag name	value	description
flag_wpm	0	no calculation of sea and wpm
	1	calculation of wpm with the German parameter set
	2	SEA calculation
	3	WPM and SEA calculation
	21, 31	WPM with other parameter sets

2 THE OUTPUT

Two output files are generated. The output includes the different sorted timber grades and the carbon amount in different timber categories per year.

Output Files

extension	description
"_wpm"	carbon content in different pools after calculating use categories burning landfill atmosphere CO_2 emission Energy substitution Material substitution Sum of the last three components
"_wpm_inter"	intermediate steps of WPM carbon content in different products as timber grades industrial lines product lines

3 THE IMPLEMENTATION

The implementation of the WPM (Wood Processing Model) consists of

- data modules

- WPM functions
- implemented interfaces in the 4C simulation
- initial, allocate and deallocate functions

4 DATA MODULE DATA_WPM

This section describes variables stored in the *data_wpm* module used for the WPM.

data_wpm Description

stored in	**description**
mansort, standsort, manrec	data from the 4C simulation mansort: harvested wood standsort: standing stock manrec: management information
product_lines	product lines information: values and sorting parameters
use_categories	use categories: parameters and values
landfill	amount of carbon in landfill per year
burning	amount of burned carbon per year
atmo_year, atmo_cum	amount of carbon in the atmosphere, yearly and accumulated
debug, spinup	processing flags
life_span	parameters for the life span function half-life period parameters
proc_par	sorting parameters for product lines and use categories
nr_years	simulation years number
nr_management_years	management years number
nr_pr_ln	product lines number
pl	intermediate results of sequential sorting of the product lines ("_wpm_inter" output)
sum_use_cat	sums of use categories values per year
sum_input	sums of input carbon per year

stored in	description
use_cat	final use categories values, used for the output

5 THE FUNCTIONS

The implemented functions correspond to the single steps of the WPM and are proceeded sequently. The overview of the single processes can be seen in [WPM-document].

Subroutines Description

subroutines	content description
calculate_product_lines	sorting and aggregation of the removals into the product lines / roundwood for each management year
calculate_wood_processing	the already calculated product lines sortings due to the parameters industrial lines (IL) => product lines (PL) => use categories (UC)
calculate_use_categories	aggregation of the product lines to the initial use categories values for each management year
calculate_output	calculations of the carbon distribution in the pools as result of the timber circle and the recycling process

6 THE COUPLING TO THE 4C IMPLEMENTATION

The coupling of the WPM and the 4C implementation can be distinguished into two parts

- the input interface and
- the output interface

As mentioned above, WPM uses both the *mansort* and the *manrec* data modules and some general information such as number of simulation years as input data.

For the output the changes were made to match the 4C output interface in three files: *amod_out.f, old_out.f, output.f*.

The deallocation of wpm is called after one simulation run is over in *finisim.f*

Input Interface

data	where
mansort	sorting of timber in timsort.f
manrec	management subroutines in management.f
year etc.	import of the data_simul module

WPM Subroutine Calls in 4C

content	Fotran files
WPM subroutine calls	simul.f finisim.f
WPM data, subroutines etc.	wpm.f wpm_wood_proc.f amod_wpm.f
output interface	amod_out.f old_out.f output.f
input interface	timsort.f management.f simul.f amod_simul.f

7 THE SPINUP FILE

The initial values of all the product lines, use categories, landfill, burning and atmosphere pools are filled with 0. This is not a realistic approach because the wood production might have been running for decades before the beginning of the simulation. The spinup file contains estimated initial values for the mentioned pools.

The spinup process is based on an ordinary WPM calculation. A *mansort* file with continually input of harvested wood is used as input. A proper simulation time was selected to make sure the pools volumes become steady over the years. As mentioned above, it needs a hand-made *mansort* and *manrec* files. The output is a spinup file.

Further comments:

Model changes in amod_wpm.f for working with spinup are necessary:

- Generating a spinup-file: output_spinup='TRUE'
- Initilisation with a spinup-file: spinup_on = 'TRUE'

Standard name of the spinup-file: spinup.wpm

Furthermore, it is necessary to link the 4C model with

amod_wpm_sp.f

wpm_sp.f

wpm_input_sp.f

Example of a manrec-file for the spin up

```
#  Management record
# Year          management          measure
1               thinning            1
2               thinning            1
3               thinning            1
4               thinning            1
5               thinning            1
```

Example of a mansort-file for the spin up

```
#Management assortment
#                                   cm      cm      cm          cm      cm      m² ha-1     kg C/ha
#year   count   spec    type    len     diam    diam_wob    top_d   t_d wob Volume      DW      number
1       1       3       in1     0       0       0           0       0       0           7.153   1
1       2       3       sg1     0       0       0           0       0       0           654.05  1
2       1       3       in1     0       0       0           0       0       0           7.153   1
```

2	2	3	sg1	0	0	0	0	0	0	654.05	1
3	1	3	in1	0	0	0	0	0	0	7.153	1
3	2	3	sg1	0	0	0	0	0	0	654.05	1
4	1	3	in1	0	0	0	0	0	0	7.153	1
4	2	3	sg1	0	0	0	0	0	0	654.05	1
5	1	3	in1	0	0	0	0	0	0	7.153	1
5	2	3	sg1	0	0	0	0	0	0	654.05	1
6	1	3	in1	0	0	0	0	0	0	7.153	1
6	2	3	sg1	0	0	0	0	0	0	654.05	1
7	1	3	in1	0	0	0	0	0	0	7.153	1
7	2	3	sg1	0	0	0	0	0	0	654.05	1
8	1	3	in1	0	0	0	0	0	0	7.153	1
8	2	3	sg1	0	0	0	0	0	0	654.05	1
9	1	3	in1	0	0	0	0	0	0	7.153	1
9	2	3	sg1	0	0	0	0	0	0	654.05	1
11	1	3	in1	0	0	0	0	0	0	7.153	1
11	2	3	sg1	0	0	0	0	0	0	654.05	1
12	1	3	in1	0	0	0	0	0	0	7.153	1
12	2	3	sg1	0	0	0	0	0	0	654.05	1
13	1	3	in1	0	0	0	0	0	0	7.153	1
13	2	3	sg1	0	0	0	0	0	0	654.05	1
14	1	3	in1	0	0	0	0	0	0	7.153	1
14	2	3	sg1	0	0	0	0	0	0	654.05	1
15	1	3	in1	0	0	0	0	0	0	7.153	1
15	2	3	sg1	0	0	0	0	0	0	654.05	1
16	1	3	in1	0	0	0	0	0	0	7.153	1
16	2	3	sg1	0	0	0	0	0	0	654.05	1

17	1	3	in1	0	0	0	0	0	0	7.153	1
17	2	3	sg1	0	0	0	0	0	0	654.05	1
18	1	3	in1	0	0	0	0	0	0	7.153	1
18	2	3	sg1	0	0	0	0	0	0	654.05	1
19	1	3	in1	0	0	0	0	0	0	7.153	1
19	2	3	sg1	0	0	0	0	0	0	654.05	1
20	1	3	in1	0	0	0	0	0	0	7.153	1
20	2	3	sg1	0	0	0	0	0	0	654.05	1
21	1	3	in1	0	0	0	0	0	0	7.153	1
21	2	3	sg1	0	0	0	0	0	0	654.05	1
22	1	3	in1	0	0	0	0	0	0	7.153	1
22	2	3	sg1	0	0	0	0	0	0	654.05	1
23	1	3	in1	0	0	0	0	0	0	7.153	1
23	2	3	sg1	0	0	0	0	0	0	654.05	1
24	1	3	in1	0	0	0	0	0	0	7.153	1
24	2	3	sg1	0	0	0	0	0	0	654.05	1
25	1	3	in1	0	0	0	0	0	0	7.153	1
25	2	3	sg1	0	0	0	0	0	0	654.05	1
26	1	3	in1	0	0	0	0	0	0	7.153	1
26	2	3	sg1	0	0	0	0	0	0	654.05	1
27	1	3	in1	0	0	0	0	0	0	7.153	1
27	2	3	sg1	0	0	0	0	0	0	654.05	1
28	1	3	in1	0	0	0	0	0	0	7.153	1
28	2	3	sg1	0	0	0	0	0	0	654.05	1
29	1	3	in1	0	0	0	0	0	0	7.153	1
29	2	3	sg1	0	0	0	0	0	0	654.05	1
30	1	3	in1	0	0	0	0	0	0	7.153	1

30	2	3	sg1	0	0	0	0	0	0	654.05	1
31	1	3	in1	0	0	0	0	0	0	7.153	1
31	2	3	sg1	0	0	0	0	0	0	654.05	1
32	1	3	in1	0	0	0	0	0	0	7.153	1
32	2	3	sg1	0	0	0	0	0	0	654.05	1
33	1	3	in1	0	0	0	0	0	0	7.153	1
33	2	3	sg1	0	0	0	0	0	0	654.05	1
34	1	3	in1	0	0	0	0	0	0	7.153	1
34	2	3	sg1	0	0	0	0	0	0	654.05	1
35	1	3	in1	0	0	0	0	0	0	7.153	1
35	2	3	sg1	0	0	0	0	0	0	654.05	1
36	1	3	in1	0	0	0	0	0	0	7.153	1
36	2	3	sg1	0	0	0	0	0	0	654.05	1
37	1	3	in1	0	0	0	0	0	0	7.153	1
37	2	3	sg1	0	0	0	0	0	0	654.05	1
38	1	3	in1	0	0	0	0	0	0	7.153	1
38	2	3	sg1	0	0	0	0	0	0	654.05	1
39	1	3	in1	0	0	0	0	0	0	7.153	1
39	2	3	sg1	0	0	0	0	0	0	654.05	1
40	1	3	in1	0	0	0	0	0	0	7.153	1
40	2	3	sg1	0	0	0	0	0	0	654.05	1
41	1	3	in1	0	0	0	0	0	0	7.153	1
41	2	3	sg1	0	0	0	0	0	0	654.05	1
42	1	3	in1	0	0	0	0	0	0	7.153	1
42	2	3	sg1	0	0	0	0	0	0	654.05	1
43	1	3	in1	0	0	0	0	0	0	7.153	1
43	2	3	sg1	0	0	0	0	0	0	654.05	1

44	1	3	in1	0	0	0	0	0	0	7.153	1
44	2	3	sg1	0	0	0	0	0	0	654.05	1
45	1	3	in1	0	0	0	0	0	0	7.153	1
45	2	3	sg1	0	0	0	0	0	0	654.05	1
46	1	3	in1	0	0	0	0	0	0	7.153	1
46	2	3	sg1	0	0	0	0	0	0	654.05	1
47	1	3	in1	0	0	0	0	0	0	7.153	1
47	2	3	sg1	0	0	0	0	0	0	654.05	1
48	1	3	in1	0	0	0	0	0	0	7.153	1
48	2	3	sg1	0	0	0	0	0	0	654.05	1
49	1	3	in1	0	0	0	0	0	0	7.153	1
49	2	3	sg1	0	0	0	0	0	0	654.05	1
50	1	3	in1	0	0	0	0	0	0	7.153	1
50	2	3	sg1	0	0	0	0	0	0	654.05	1

Count - counter for stem segments of same type

Spec - tree species

Type -type of graded wood (fue - fuelwood, in1, in2 - industrial wood, sg1, sg2 - partial logs, ste1, ste2 - logs)

Len - length of the log or the graded element

Diam - diameter of the stem segment

Diam_wob - diameter without bark

Top_d - top diameter

T_d wob - top diameter without bark

Volume - volume of the stem segment

DW - carbon content of the stem segment

Number - number of graded elements

REFERENCES

Eggers, T., 2002. The impacts of manufacturing and utilization of wood products on the European carbon budget. Internal report 9, European Forest Institute, Joensuu, 90 pp.