4C user manual WPM and SEA

1 WOOD PROCESSING MODEL

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.

1.1 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

1.2 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

1.3 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

1.4 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

stored in	description
sum_input	sums of input carbon per year
use_cat	final use categories values, used for the output

1.5 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

1.6 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

1.7 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

2 SOCIO ECONOMIC ANALYSIS

The Socio Economic Analysis (SEA) allows analysing a wood stock due to the aspects of costs, revenues and subsidies in a given time frame.

SEA uses the 4C information about the harvested wood, standing stock and silvicultural operations of a simulated area, sorts the input analog to WPM into different timber grades and computes the costs, assets and subsidies per year. Unlike the WPM it analyses also the standing stock in respect to its financial value. As further input SEA needs a “sea_prices.wpm” input file with the current prices. This file contains timber prices, silvicultural costs and possible subsidies.

2.1 Getting Started

To get started following is required:

- Set the “flag_wpm” to the desired value
- Make sure forest management took action
- A “sea_prices.wpm” file must exist in the input directory (can not 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

2.2 The Output

Four output files are generated. The output includes the different sorted timber grades of standing stock and harvested wood, estimated costs, assets and resumed values as liquidation value, net present value (NPV) and NPV+.

Output Files Description

extension	description
"_sea"	costs and revenues for standing stock, harvested timber, silvicultural costs, fixed costs and subsidies
"_sea_ms"	timber grading of harvested wood
"_sea_st"	timber grading of standing stock
"_sea_npv"	liquidation value, NPV, NPV+ (NPV with four different interest rates a-d, the first rate a is 0)

The liquidation value indicates the value of the standing stock over the years. NPV contains the revenues of harvested timber in regard to the given interest rates.

2.3 The Implementation

The Implementation of SEA contains following components

- data module
- SEA functions
- implemented interfaces in the 4C simulation
- initial, allocate and deallocate functions

2.4 Data Module data_wpm

This table lists variables stored in the *data_wpm* module used for SEA.

data_wpm Description

stored in	description
mansort, standsort, manrec	data from the 4C simulation mansort: harvested timber standsort: standing stock manrec: management information
nr_years	simulation years number
mansort_tg, standsort_tg	sorted timber grades of harvested wood and standing stock

stored in	description
chainsaw_prices, harvester_prices, planting_price, planting_subs, fence, fix, brushing, tending_prices, ext_for	prices from the SEA prices file
int_rate	interest rates for NPV
sum_costs	cumulative costs: entire sum of all costs and partial sums (subsidies, silvicultural costs, harvested timber costs, standing stock costs) per year
subsidy	stores subsidies calculation values
npv	the estimated NPV values
net_prices	timber prices per species
hsystem	percentage of chainsaw to harvester methods of harvesting (usually set to 0.2 to 0.8)
plant_year	year of planting
flag_plant	planting flag for estimation of the planting
ms_costs, ms_assets	the costs and revenues for harvested timber
st_costs, st_assets	the costs and assets for the standing stock

2.5 The SEA Functions

The SEA consists of following steps:

- sorting of standing stock and harvested timber into timber grades
- calculation of costs, silvicultural costs, subsidies and revenues for sorted timber grades per year
- calculation of summation values: liquidation value, NPV, NPV+

2.5.1 The Sorting of Timber Grades

The assortments from *mansort* and *standsort* inputs are sorted in the way similar to the first step in WPM. The single timber grades results from sorting the wood according to the type, specification and the diameter of the trunk. The *mansort* input (harvested timber) must be summed up due to the years of management listed in *manrec* input (s. WPM). The standing stock grading is done for each year.

Timber Grading of Harvested Wood and Standing Stock

type	spec	diam in cm²	timber grade index	number of timber grades
fue	1, 2, 3, 4		1	4x
in1 + in2	1, 2, 3, 4		2	4x
sg1 + sg2	1, 2, 3, 4	<15	3	20x
		15-20	4	
		20-25	5	
		25-30	6	
		> 30	7	
ste1 + ste 2	1, 2, 3, 4	25-30	8	12x
		25-30	9	
		> 35	10	

The volume per year *v* specified in the timber grades is calculated by the following equation:

*v = volume * number*,

where volume and number are estimated in the *timsort.f* subroutines.

A fix part (0.4) of timber grades values are shifted to the timber grades of the lower quality.

(sg1, sg2, ste1, ste2) => (in1, in2)

(in1, in2) => (fue)

The results of timber grading are stored in “sea_ms” and “sea_st” output files.

2.5.2 The Economical Analysis

The sorted timber amounts can now be evaluated due to the timber prices, silvicultural costs and subsidies.

The harvest costs, also the virtual harvest of the standing stock, are calculated. For the amount of harvested timber the actual harvests are taken into account. For the standing stock potential harvest costs are calculated yearly. Analog the revenues due to the given prices are computed.

The silvicultural costs and corresponding subsidies are estimated due to the management in certain years. Management operations are:

- tending
- brushing
- felling
- shelterwood system 1 and 2
- felling after shelterwood system
- thinning,
- planting

Planting costs are down to the amount of the planted trees per ha and the tree species. The planting method is estimated by the stored *flag_plant*. Some management activities combine several costs and subsidies categories.

Costs and revenues can now be aggregated over the years to the NPV and NPV+ due to the interest rates.

The costs and revenues for every tree species are aggregated per year in the output file "_sea". NPV and NPV+ values can be found in the "_sea_npv" output file.

The overview of the SEA subroutines are shown in the following table.

Subroutines and their Description

subroutines	**description**
read_sea_prices	read the SEA prices file
sort_standsort, sort_standsort	timber grading of harvested timber and standing stock
sort_industrial	fix part (0.4) of timber grades is shifted to the grades of lower quality
calculate_harvest_costs	calculate harvest cost
calculate_assets	calculate revenues for the standing stock and actually harvested wood due to the net prices
calculate_costs	calculate costs and corresponding subsidies due to the management method: tending, brushing, felling, shelterwood system 1 and 2, felling after shelterwood system, thinning, planting
calculate_npv	calculate NPV, NPV+ due to the interest rates

2.5.3 The Coupling to the 4C implementation

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

- the input interface and
- the output interface

As mentioned above, SEA uses *mansort, standsort* and the *manrec* data modules. Also the information about planting, such as planting year, amount of planted trees and the stock mixture is a matter of concern. Some general information such as number of simulation years are needed, too.

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 the one simulation run is over in *finisim.f*

Input Interface

data	**where**
mansort	sorting of timber in *timsort.f,* harvested timber
standsort	sorting of timber in *timsort.f,* standing stock
manrec	management subroutines in *management.f*
year etc.	import of the data_simul module
plant_year	planting subroutines in *planting.f*
num_plant	planting subroutines in *planting.f*
flag_plant	planting subroutines in *planting.f*

SEA Subroutine Calls in 4C

content	**Fotran files**
SEA subroutine calls	simul.f finisim.f
SEA data, subroutines etc.	wpm.f wpm_wood_proc.f amod_wpm.f

content	Fotran files
output interface	amod_out.f old_out.f output.f
input interface	timsort.f management.f planting.f simul.f amod_simul.f

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.