Final Report

BEEHAVEecotox landscape extension – a manual

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TABLE OF CONTENT

Introduction

This manual is an add-on to the existing manuals of previous BEEHAVE versions (Becher et al. 2014) and only addresses new features of the landscape extension of BEEHAVE$_{ecotox}$. (Preuss et al. 2022). The model was implemented in http://ccl.northwestern.edu/netlogo/ (Wilensky, 1999), version 5.3.1.

Manual

Preparing input files

A new *SUBSTANCE_FILE* has been created and a new format for the already existing *INPUT_FILE* has been defined. To use BEEHAVE$_{ecotox}$, prepare these files according to the format specified in the ODD protocol:

The *Substance_File*

The *SUBSTANCE_FILE* is a text file (e.g. "SubstanceFile.txt") that provides the parameter values for various pesticides. It consists of a header defining the 13 columns and a number of lines, each line defining one substance:

Header[1]	Example line 1	Unit
substanceName	„Substance1"	
etox_DT50_Substance	100	[d]
etox_Forager_Oral_LD50_Substance	1000	[µg/bee]
etox_Forager_Oral_slope_Substance	100	
etox_Forager_contact_LD50_Substance	0.6	[µg/bee]
etox_Forager_contact_slope_Substance	1.08	
etox_Larvae_Oral_LD50_Substance	0.0014	[µg/bee]
etox_Larvae_Oral_slope_Substance	1.6	
etox_Forager_ImmediateMortality_Substance	FALSE	
etox_degradation_honey_Substance	FALSE	
etox_DT50_honey_Substance	60	[d]
etox_FF_Nursebees_Nectar_Substance	0.25	
etox_FF_Nursebees_Pollen_Substance	1	

The *INPUT_FILE*

The *Input_File* has been in use for the original BEEHAVE version (Becher et al. 2014) already and the updated BEEHAVE$_{ecotox}$ module is still compatible with the original file format (if no pesticides are applied). However, a new file format has been defined in order to describe pesticide applications at food sources. Compared to the original file format, the new file format was changed in two aspects:
1.   The new file format provides on additional information regarding applications of toxicants
2.   The definition of resource availability has been simplified. In the original format, resource availability is described explicitly for each patch and day. In the new format, for each patch a single flowering period is given, during which a constant amount of daily nectar and

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[1] Parameter names are similar to the names defined in BEEHAVE$_{ecotox}$. The extension "_Substance" is appended to the original names.

pollen is provided. Outside the flowering period, the patch does not provide resources. This change shortens the file to a single data line per *flowerPatch*.

Advantage of this change is a significant reduction of file complexity for most cases of BEEHAVE application and a considerable reduction in startup time, when reading landscapes from file. It can also be used, when the BEEHAVE₍ecotox₎ module is switched off.
The new format is a text file with a header, defining the 24 colum names (see table below) and one line per each *flowerPatch*. Most of the landscape defining information is identical to the original file format, except for the two new variables *startDay* and *stopDay*, defining the beginning and the end of the annual flowering period. These are followed by eight columns, describing the pesticide application in a food source:

Header[2]	Example flowerPatch	Unit
ID	0	
oldPatchID	0	
patchType	„RedPatch"	
distance_m	500	[m]
xcor	500	
ycor	0	
size_sqm	500000	[m²]
quantityPollen_g	1000	[g]
concentration	1.5	[mol/l]
quantityNectar_l	20	[l]
calc_DetectProb	0.2	
model_DetectProb	-999	
NectarGathering_s	1200	[s]
PollenGathering_s	600	[s]
startDay	1	[day of year]
stopDay	365	[day of year]
ETOX_ApplicationList_patch	[50 100]	[days of year]
ETOX_ExposurePeriodsList_patch	[10]	[day(s) of year]
ETOX_PPPConcNectar_patch	990	[µg/kg]
ETOX_PPPConcPollen_patch	26631	[µg/kg]
ETOX_PPPContact_patch	0.3	[kg/ha]
ETOX_WaterVolume_patch	10000	[ml]
ETOX_WaterConc_patch	0	[µg/l]
ETOX_RUD_patch	21	[(ha*mg)/(kg*kg)]

ETOX_ApplicationList_patch is a list (i.e. in brackets), with each number defining the start day of an annual pesticide application. If the list is empty (i.e. []), no application takes place.
ETOX_ExposurePeriodsList_patch describes the duration of each application. If only one number is present, this value applies to all applications. If more than one number is provided, the number of durations have to match the number of applications in *ETOX_ApplicationList_patch*. Other variables are as defined in the original BEEHAVE₍ecotox₎ module.
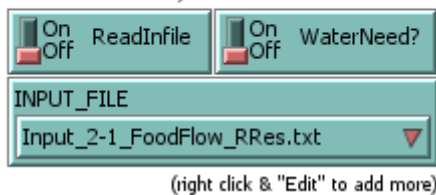
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[2] The new ecotoxicological parameter names are similar to the names defined in BEEHAVE₍ecotox₎. The extension "_patch" is appended to the original names.
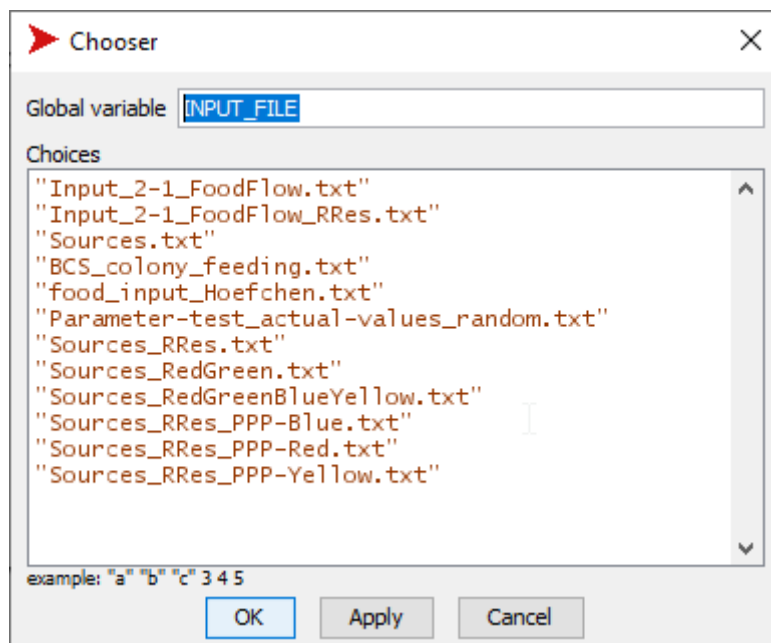
Selecting input files

The **INPUT_FILE** was already in place in the original BEEHAVE version and it is selected in the same way:

FILES - in

Food sources (e.g. from BeeMapp or BEESCOUT):

| On/Off ReadInfile | On/Off WaterNeed? |

INPUT_FILE
Input_2-1_FoodFlow_RRes.txt ▽

(right click & "Edit" to add more)

Set *ReadInfile* TRUE and choose an input file option from the Netlogo *INPUT_FILE* chooser. If a new file has been created, add it as on option to the chooser: right mouse click on the chooser, select "Edit..." and add the file name plus extension (.txt) in double quotes. Then press "OK". The file must be located in the same folder as the ".nlogo" file of BEEHAVE.

Chooser ✕

Global variable INPUT_FILE

Choices

```
"Input_2-1_FoodFlow.txt"
"Input_2-1_FoodFlow_RRes.txt"
"Sources.txt"
"BCS_colony_feeding.txt"
"food_input_Hoefchen.txt"
"Parameter-test_actual-values_random.txt"
"Sources_RRes.txt"
"Sources_RedGreen.txt"
"Sources_RedGreenBlueYellow.txt"
"Sources_RRes_PPP-Blue.txt"
"Sources_RRes_PPP-Red.txt"
"Sources_RRes_PPP-Yellow.txt"
```

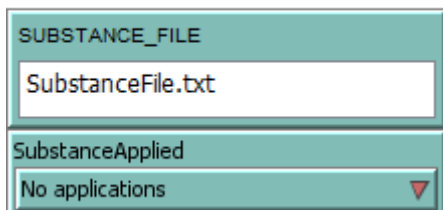example: "a" "b" "c" 3 4 5

| OK | Apply | Cancel |

The next "Setup" will then use the landscape information from the *INPUT_FILE* instead of the information from the interface.

Specify in the Netlogo input field *SUBSTANCE_FILE* which file is used. The default *SUBSTANCE_FILE* is "SubstanceFile.txt" and new substances can be added to this file. The file must be located in the folder with the ".nlogo"-file of BEEHAVE. The options in chooser *SubstanceApplied* must be adapted to the substance names in the substance file. To do so: right mouse click on the chooser, select "Edit...", delete unused substances and add (within

double quotes) the new ones. The upper two entries "No applications" and "Defined via GUI" should not be deleted or changed. "Substance1", "Substance2" and "GUIcopy" are hypothetical pesticides, the latter represents the original BEEHAVE$_{ecotox}$ substance specifications. Finally, press "OK" and select the pesticide from *SubstanceApplied*.

ETOX Landscape update:

SUBSTANCE_FILE

SubstanceFile.txt

SubstanceApplied

No applications

If the substance is not defined via an input file but from the interface, choose "Defined via GUI". If no application should take place at all, select "No applications".

ETOX Default and Version Test buttons

Two new buttons have been added to the interface:

ETOX Default

ETOX Version Test
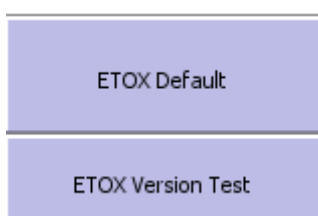
"ETOX Default" sets the parameters on the interface to their default value. These are mostly identical to the default values of the original BEEHAVE (2014) version, but the BEEHAVE$_{ecotox}$ module is switched on and ecotoxicological variables are set values as in the BEEHAVE$_{ecotox}$ (2022) version. "ETOX Version Test" runs the model under defined conditions and compares a resulting test number with an expected value. If the numbers do not match, a user message pops up, warning the user that the code or input files have been modified.

References

Becher, M.A., Grimm, V., Thorbek, P., Horn, J., Kennedy, P.J., & Osborne, J. L. (2014). BEEHAVE: A systems model of honeybee colony dynamics and foraging to explore multifactorial causes of colony failure. Journal of Applied Ecology, 51(2), 470-482. https://doi.org/10.1111/1365-2664.12222.

Preuss, T.G., Agatz, A., Goussen, B., Roeben, V., Rumkee, J., Zakharova, L., & Thorbek, P. (2022). The BEEHAVEecotox Model—Integrating a Mechanistic Effect Module into the Honeybee Colony Model. Environmental Toxicology and Chemistry, 41(11), 2870-2882. https://doi.org/10.1002/etc.5467.

Wilensky, U. (1999). NetLogo. Center for Connected Learning and Computer-Based Modeling, Northwestern University. https://ccl.northwestern.edu/netlogo/.