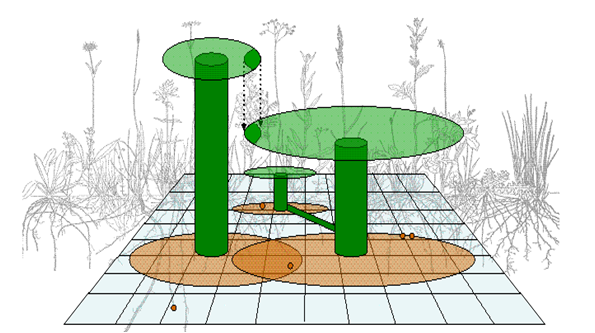
IBC-grass GUI manual

Predicting the impact of herbicide drift on non-target terrestrial plant communities



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# General information

The IBC-grass GUI was developed to facilitate the use of the plant community model IBC-grass for herbicide risk assessments of non-target terrestrial plant communities in Central Europe. Users are able to run simulations for various plant communities, which may differ in their species composition, environmental parameter settings and herbicide settings. Several different outputs can be generated on population as well as on community level.

Detailed information on the model can be found in the ODD-protocol and GMP document.

For support, please contact Jette Reeg ([jreeg@uni-potsdam.de](mailto:jreeg@uni-potsdam.de)).

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# Requirements

The IBC-grass source codes are compiled using a g++ compiler, e.g. MinGW (<http://www.mingw.org/>). To test, if you have a g++ compiler installed, open the command prompt (click on the start button, search for ‘cmd’, click on ‘Command Prompt’) and type in ‘g++ --version’.

To start the GUI, R (<https://www.r-project.org/>) needs to be installed on the local machine and set as an environmental variable. To test whether R is set as environmental variable, open the command prompt (click on the start button, search for ‘cmd’, click on ‘Command Prompt’) and type in ‘R --version’. It should return the current version of R. If R is not set as environmental variable, right click ‘My Computer’ -> ‘Properties’ -> ‘Advanced’ -> ‘Environment variables’. Under ‘system variables’ select Path, click on edit and add (button ‘new’) the path of R, e.g. “C:\Program Files\R\R-3.5.2\bin”.

The IBC-grass GUI was tested under Windows 7 and higher and Ubuntu 16.04.

Under MAC, GTK (<https://www.gtk.org/>) needs to be installed; otherwise the R package RGtk2 cannot be installed and thus the GUI cannot be started. However, the source codes of IBC-grass can still be compiled under MAC using the clang compiler and thus, IBC-grass simulations can be generated (according to SimulationSpecifics.R 🡪 StartSimulations()) and the output files can be analyzed (according to SimulationSpecifics.R 🡪 StartSimulations() and AnalysesDialog.R 🡪 BasisAnalyses()) by hand.

# Simulation output and analyses

The IBC-grass model calculates various endpoints on population and community level. On community level the number of PFTs, the overall number of plant individuals, the overall aboveground biomass and 4 different diversity indices (Shannon index, Simpson index, inverse Simpson index and evenness) are calculated. On population level, the number of plant individuals, aboveground biomass and cover are calculated. The raw data include the values for each time step (week) and each simulation run (Monte Carlo run).

The GUI automatically analyses the raw data:

1. The mean for the control simulations is calculated per time step.
2. For all simulation runs (control and treatments), the value per time step is divided by the mean of the control to calculate effects relative to the control mean. (i.e. 0.7 represents 30% reduction compared to the mean of the control).
3. Population level endpoints are saved in the file ‘*resultsPFT.txt*’; community level endpoints are saved in the file ‘*resultsGRD.txt*’.
4. In the next step, the effects are averaged (mean (mean effect), 2.5th percentile (maximal effect) and 97.5th percentile (minimal effect)) over all simulations. On the one hand per time step, but also per year. Results are saved as ‘*effect.timestep.PFT.txt*’ and ‘*effect.year.PFT.txt*’ for population level endpoints and ‘*effect.timestep.GRD.txt*’ and ‘*effect.year.GRD.txt*’ for community level endpoints.
5. Based on the weekly analyses (‘*effect.timestep.\**’), the number of weeks in which the (mean, minimum, maximum) effect is within a certain interval are summed up. For this, we used effect intervals of <10%, 10-20%, 20-30%, 30-40% and >50%. The results are saved for each endpoint separately as *‘\*\_PFT.txt*’ for population level endpoints and *‘\*\_GRD.txt’* for community level endpoints.

If a project is saved, the GUI can show the graphical output (point 4) and tables (point 5). Please be aware, that under point 5, positive effects will be included in the interval <10%.

# Data structure and organization

## In general

The IBC-grass GUI package includes several folders:

* *Manual, GMP, ODD, Literature*

Here you can find the manual, good modeling practice document, a model description following the ODD-protocol, a DoxyGen documentation of the model and additional literature on IBC-grass.

* *Model-files*

This folder includes the source files of IBC-grass.

* *R-files*

This folder includes R-files on which the GUI is based on. If you change something in these files, the GUI might not be working.

* *Input-files*

Here you can find all input files necessary for the GUI and the IBC-grass executing file, but also exemplary dose-response data (Example\_dose\_response\_values.txt) or community files, which might interest you. However, never delete or change any file. If you do some changes, please save the file under a new name.

* *ExampleAnalyses*

Here you can find two examplary IBC-grass projects (one for dose-response based simulations and one for a txt-file based simulation.) See chapter *Examples* for further details

## Project structure

If you save a project, not only the model output files (see *Simulation output and analyses*), but also other settings will be saved:

In the base directory you can find all output files of the project (see chapter *Simulation output and analyses*). You may also want to save all figures or tables in this folder.

In the *HerbicideSettings* folder you can find all specific settings of the project. The settings are saved in ‘*SimulationSettings.Rdata’*. You will need this file if you want to rerun the simulations. This file will also be opened when you open the project with the IBC-grass GUI (see chapter *Open existing project*). In addition, for each simulation run, a community file with the PFT specific sensitivities is stored in this folder. If the herbicide effects were based on txt-file, you can find the PFT specific sensitivity trait in the column ‘sens’, or if the effect were based on dose-responses each PFT has specific EC50/slope values for each of the affected attributes. In addition, you can find the herbicide effects - if based on a txt-file - in the file ‘HerbFact.txt’ or in the specific ‘EC50\*’-files.

# Getting started

Before you can start the GUI, make sure, g++ and R are installed on your local machine and set as an environmental variable (see Requirements). After downloading the IBC-grass GUI:

1. Open the folder.
2. Start the GUI:
   1. Windows: Double click on ‘*RunIBCgrassGUI\_Windows.bat*’
   2. Linux: Start the bash prompt and open the file *‘./RunIBCgrassGUI\_Linux.sh’*

You might need to run the script as an administrator.

C++ source code will be compiled on your local machine and the GUI will open.

1. You can now choose between starting a new project (see chapter *Start a new project*) or open an existing project (see chapter *Open existing project*), which you have saved in earlier sessions (Figure 1).



Figure 1: Welcome screen of the IBC-grass GUI

# Open existing project

Click on ‘*Open existing project*’ and select the folder of the project you want to open. A new window will open (Figure 2)

Two exemplary projects are included in the IBC-grass GUI package (./ExampleAnalyses/DoseResponse and ./ExampleAnalyses/TXTfile, see chapter *Examples*). To get an idea of potential outputs, you can open one of these projects.

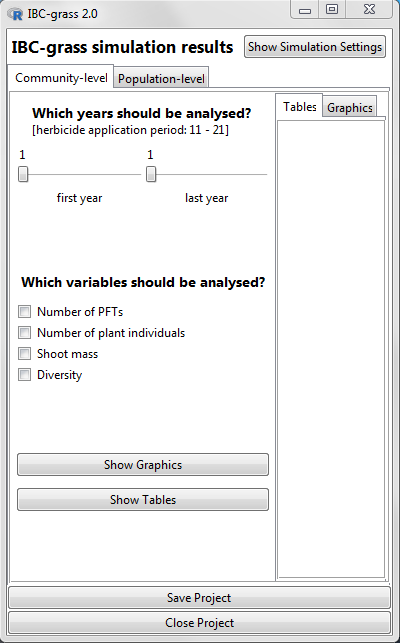


Figure 2: Showing the results of an IBC-grass project

## Show settings of the project

If you click on the button ‘*Show Simulation Settings*’, a new window will pop up, which gives you an overview of the environmental and herbicide settings (Table 1).

Table 1: List of IBC-grass parameter settings

|  |  |  |
| --- | --- | --- |
| IBC-grass parameter | Type of value | Explanation |
| IBCommunity | string | Name of the PFT community used. If ‘Community.txt’, then an individual community was used. |
| IBCgridsize | integer | Number of grid cells |
| IBCabampl | double | Amplitude for aboveground resource seasonality |
| IBCabres | integer | Aboveground resource units |
| IBCbelres | integer | Belowground resource units |
| IBCSeedInput | integer | Number of seeds per PFT added at the beginning of each year |
| IBCcut | integer | Number of cutting events per year |
| IBCgraz | double | Amount of area grazed during one year |
| IBCtramp | double | Amount of area trampled during one year |
| IBCInit | integer | Number of initial years |
| IBCDuration | integer | Number of year with simulated herbicide application |
| IBCRecovery | integer | Number of years following the herbicide application period |
| IBCherbeffect | string | If ‘txt-file’: herbicide effects are based on a txt-file (HerbFact.txt)  If ‘dose-response’: herbicide effects are based on dose-response data |
| IBCApprates | integer | Only if based on dose-response data: Which application rates were tested? |
| BiomassEff | boolean | Was plant biomass affected? |
| EstablishmentEff | boolean | Was seed establishment affected? |
| SeedlingBiomassEff | boolean | Was seedling biomass affected? |
| SeedNumberEff | boolean | Was seed number affected? |
| SeedSterilityEff | boolean | Was seed sterility affected? |
| SurvivalEff | boolean | Was plant survival affected? |
| IBCrepetition | integer | Number of repetitions |

If you click on the button ‘*Show PFT sensitivity settings*’, a new window will pop-up showing a table with the PFT species and the corresponding sensitivity used for the current scenario.

If the herbicide effect is based on a txt-file, there will be an additional button showing the selected effect intensities for each attribute. (button ‘*Show effect intensities*’)

Below the ‘*Show Simulation Settings*’-button you can find two tabular windows: The first shows the results on community-level, the second the results on population level. For each of these tabs, you can define what should be presented.

## Community-level Tab

In the upper part on the left side, you can select which years should be analyzed. In brackets you can see during which years herbicide application was simulated. If you select more than 5 years, the effects are averaged over a year (i.e. the figures are based on the ‘*effect.year.GRD.txt*’ file). Otherwise the results are averaged over each week per year (i.e. the figures are based on the ‘*effect.timestep.GRD.txt*’ file).

Below you can find all community level endpoints that can be plotted or summarized in tables.

If you click on ‘*Show Graphics*’ figures will be generated and shown in the ‘Graphics’ tab. The figures will show the temporal dynamics of the effects.

If you click on ‘*Show Tables*’, tables showing the number of weeks per year, in which the effect is within a certain interval, will be shown in the ‘Tables’ tab. Please be aware that the tables summarize only negative impacts. Positive impacts can be shown in the figures.

## Population-level tab

Also on this level, you can first select which years should be analyzed. In brackets you can see during which years herbicide application was simulated. If you select more than 5 years, the effects are averaged over a year (i.e. the figures are based on the ‘*effect.year.PFT.txt*’ file). Otherwise the results are averaged over each week per year (i.e. the figures are based on the ‘*effect.timestep.PFT.txt*’ file).

Below you can decide which PFTs should be analyzed. Only PFTs which occurred in more than 50% of the simulations will be shown. Thus, infrequent PFTs are ignored. The lower the frequency of a PFT in the simulation runs, the fuzzier are the temporal dynamics.

Below the list of PFTs, you can find the potential endpoints on population level.

If you click on ‘*Show Graphics*’ figures will be generated and shown in the ‘Graphics’ tab. The figures will show the temporal dynamics of the effects.

If you click on ‘*Show Tables*’, tables showing the number of weeks per year, in which the effect is within a certain interval, will be shown in the ‘Tables’ tab. Please be aware that the tables summarize only negative impacts. Positive impacts can be shown in the figures.

## Saving of outputs

You are able to save the generated output files and tables by clicking on the ‘*Save*’ button below a table or figure. Tables must be saved as txt-files. Figures can be saved as jpeg, png or svg files.

# Start a new project

## Plant community and environmental settings

In order to start a new simulation, click on the ‘*Start new project*’ button after starting the GUI. A new window will open (see Figure 3), in which you can choose between

* *Running scenarios with pre-set IBC-grass communities*

The IBC-grass GUI includes three pre-defined plant communities, which were used in an earlier study and which are based on typical grassland communities occurring in the neighborhood of agricultural fields in Europe. For each of the community you can use a preset of environmental settings, which were used also in the publication by Reeg et al. (2017).

* *Creating a new IBC-grass community based on your specific species pool*

You can also decide to create a new IBC-grass community, either by selecting species from the pool of already classified species, or by classifying new plant species.

* *Load a previously saved community file*

If you have already created and saved your own community file, you can also again load this file for further simulations.

* *Load previous simulation settings*

If you want to re-run previous simulations or modify only specific parameters, you can also load previous settings. Therefore, the *SimulationSettings.Rdata* file will be required.

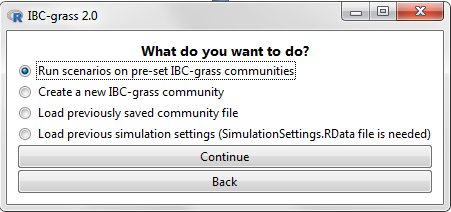


Figure 3: Selection of the community file

Please select one of the 4 options and click on *Continue*.

### Run scenarios on pre-set IBC-grass communities

#### PFT community

You can choose between 3 different plant communities with different PFT compositions (see Figure 4). These three plant communities are based on a literature review of grasslands occurring in the neighborhood of agricultural fields in Europe. They differ not only in their PFT composition, but also represent different environmental settings.

The field boundary community represents a typical strip of field margin, with high resource input, some trampling events and one mowing per year.

The *Calthion* community represents nutrient poor grassland with low disturbances by grazing or trampling. It is mowed once a year.

The *Arrhenatherethalia* community represents nutrient rich grassland with high disturbances by grazing or trampling and 3 mowing events per year.

Please select a community and click on *presettings* in order to select the settings used in the publication by Reeg et al. (2017). If needed or desired, you can adjust the settings.

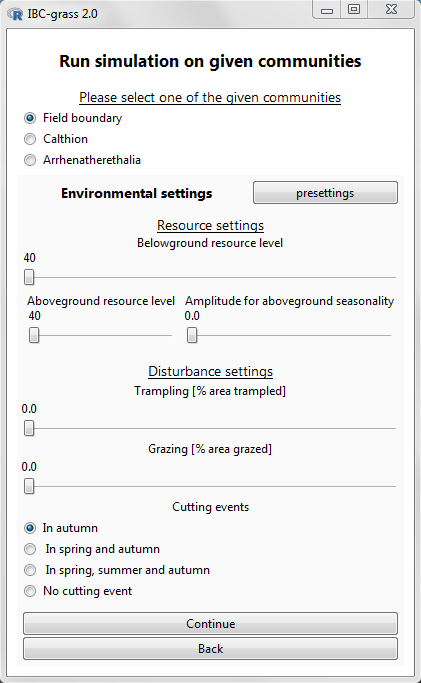


Figure 4: Environmental settings for preset communities.

#### Resource settings

Resources are given in resource units per cm², not defining a specific resource. 40 ru/cm² represent low resource levels, 100 ru/cm² represent high resource levels. You can choose different resource levels for the above- and belowground compartment. For the aboveground resources, you can add a seasonality effect: The aboveground resources can follow a sine curve. The selected amplitude determines the height of the sine curve. You can base this seasonality of light intensity data.

#### Disturbance settings

Three different disturbances are distinguished: grazing, trampling and cutting.

Trampling removes in x% cells of the grid over the year the whole aboveground shoot mass.

Grazing only removes a certain percentage of the aboveground shoot mass of plant individuals depending on the palatability of the PFT.

Cutting events can occur 1, 2, 3 times a year or never. In one cutting event, the aboveground biomass in the whole grid is removed to a certain cutting height.

After you selected the environmental settings, please click on *Continue*.

### Create a new IBC-grass community

A new window will open (see Figure 5), which shows a table of all plant species already classified in IBC-grass. Please select all species you would like to include in the new community. If a species is missing, you can add it in the lower part of the window. You will need to type in the species name and for each specific trait you can choose the suitable trait characteristic. You can find an explanation of each trait and the characteristic in Table 2. After choosing the trait settings, click on the *Add to list*-button, to append the species to the list above. Now you can select the new species for your community.

Table 2: Trait characteristics

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Trait | Values | Based on datebase trait | Corresponding model parameters | | | | |
| Plant size |  | *seed releasing height1* | *maximal plant mass* | *seed mass* | | *seed dispersal* | |
|  | small | <=0.42 | 1000 mg | 0.1 mg | | 0.6 m | |
|  | medium | 0.42-0.87 | 2000 mg | 0.3 mg | | 0.3 m | |
|  | tall | >0.87 | 5000 mg | 1 mg | | 0.1 m | |
| Growth form |  | *rosette attribute2* | *leaf mass ratio* | | | | |
| erect | erect | 0.5 | | | | |
| semi-rosette | semi-rosette | 0.75 | | | | |
| rosette | rosette | 1.0 | | | |  |
| Resource response |  | *ecological strategy2* | *maximal resource units* | | *maximal survival under resource stress* | | |
| stress-tolerator | sr, cs, s | 20 | | 6 | | |
| intermediate | csr, r | 40 | | 4 | | |
| competitor | c, cr | 60 | | 2 | | |
| Grazing response |  | *grazing tolerance2* | *palatability* | | *specific leaf area* | | |
|  | tolerator | 4-6 (resprouter) | 1.0 | | 1.0 | | |
|  | intermediate | 1-3 (no adaption) | 0.5 | | 0.75 | | |
|  | avoider | 7-9 (defence strategies) | 0.25 | | 0.5 | | |
| Clonal type |  | *clonality 3* | *spacer length* | | *resource sharing* | | |
|  | long spacer | lateral spread 0.01-0.25 m/y | 17.5 cm | | 1 | | |
| with resource sharing | with persistence of connection |
|  | long spacer | lateral spread 0.01-0.25 m/y | 17.5 cm | | 0 | | |
| without resource sharing | with persistence of connection |
|  | short spacer | lateral spread < 0.01m/y | 2.5 cm | | 1 | | |
| with resource sharing | with persistence of connection |
|  | short spacer | lateral spread < 0.01m/y | 2.5 cm | | 0 | | |
| without resource sharing | with persistence of connection |
| Flowering type |  | *symphenological groups2* | *start of seed production* | | *end of seed production* | |  |
| early | 1-6 | week 1 | | week 5 | | |
| late | 7-10 | week 16 | | week 20 | | |
| Germination periods |  |  | establishment period | | | |  |
| spring |  | weeks 1-4 | | | | |
| summer |  | weeks 21-25 | | | | |
| spring and summer |  | week 1-4 and 21-25 | | | | |

1 Kleyer et al. 2008. The LEDA Traitbase: A database of life-history traits of Northwest European flora. J. Ecol. 96, 1266–1274.

2 Klimešová and de Bello. 2009. CLO-PLA: the database of clonal and bud bank traits of Central European flora. J. Veg. Sci. 20, 511–516.

3 Klotz et al. 2002. BIOLFLOR - Eine Datenbank zu biologisch-ökologischen Merkmalen der Gefäßpflanzen in Deutschland, in: Klotz, W., Kühn, S., Durka, I. (Eds.), Schriftenreihe Für Vegetationskunde 38. Bundesamt für Naturschutz, Bonn.

It is useful to always *save the updated list of all classified species*. In this case, the newly classified species will already be included in the table the next time you open the dialog window (provided you have not deleted the GUI folder from your computer).

If you plan on using the community also in the future, you should also *save the selected species as new community*, which can be loaded in future projects (e.g. in the ‘*Input-files*’ folder).

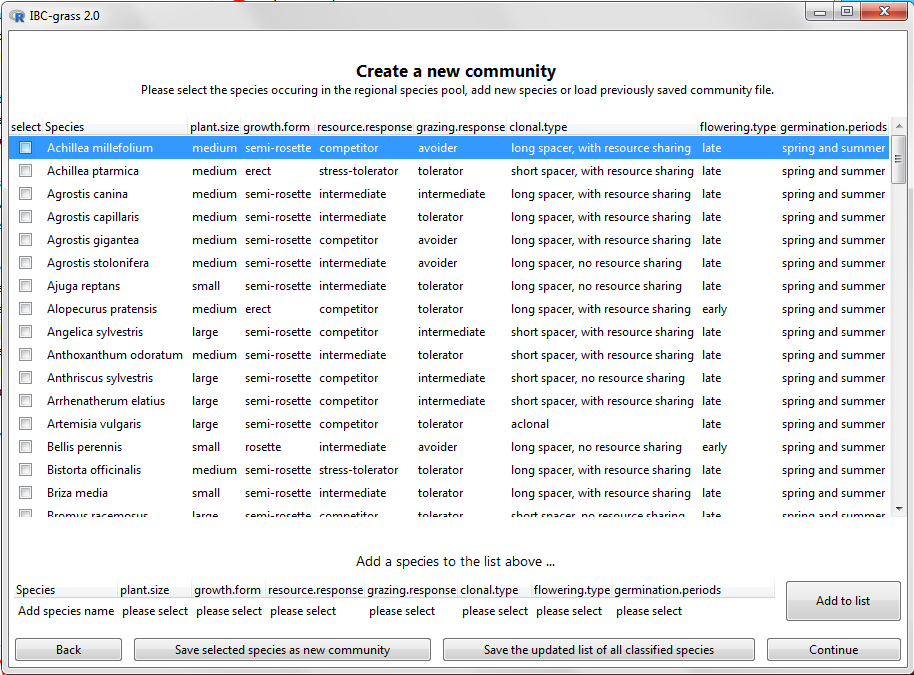


Figure 5: Window for creating a new community

After selecting all species of your new species pool click on *Continue*. A new window opens to set the environmental parameters (Figure 6)

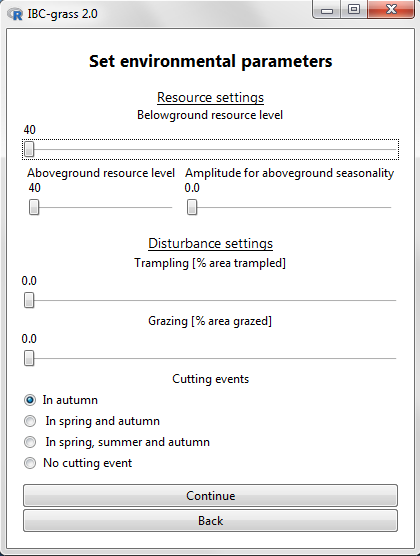


Figure 6: Window for setting the environmental parameters of a new community

#### Resource settings

Resources are given in resource units per cm², not defining a specific resource. 40 ru/cm² represent low resource levels, 100 ru/cm² represent high resource levels. You can choose different resource levels for the above- and belowground compartment. For the aboveground resources, you can add a seasonality effect: The aboveground resources can follow a sine curve. The selected amplitude determines the height of the sine curve. You can base this seasonality of light intensity data.

#### Disturbance settings

Three different disturbances are distinguished: grazing, trampling and cutting.

Trampling removes in x% cells of the grid over the year the whole aboveground shoot mass.

Grazing only removes a certain percentage of the aboveground shoot mass of plant individuals depending on the palatability of the PFT.

Cutting events can occur 1, 2, 3 times a year or never. In one cutting event, the aboveground biomass in the whole grid is removed to a certain cutting height.

After you selected the environmental settings, please click on *Continue*.

### Load previously saved community file

If you have already once saved a new community file, you can load this file for new IBC-grass simulations. After loading the file, you will be able to set the environmental parameters (see Figure 6).

### Load previous simulation settings

You can load also previous simulation settings. To do so, you will need to open the *SimulationSettings.Rdata* file, which was saved in the folder ‘*Herbicide settings*’ of the specific project.

Afterwards you are able to change all other parameters and settings, if necessary.

## Herbicide settings

First, determine over which period the simulations should be running (Figure 7).

#### Initial years

A plant community will take a few years to develop a more or less stable population dynamic. If you want to run realistic, trustful simulations, you should select at least 25 years. However, the run time will increase with increasing number of simulated years. If you only want to test the GUI, you may select a smaller amount of initial years.

#### Herbicide duration

Please select how many years you would like to simulation herbicide application.

#### Recovery duration

You can also look at the recovery potential by simulating subsequent years without herbicide impacts.

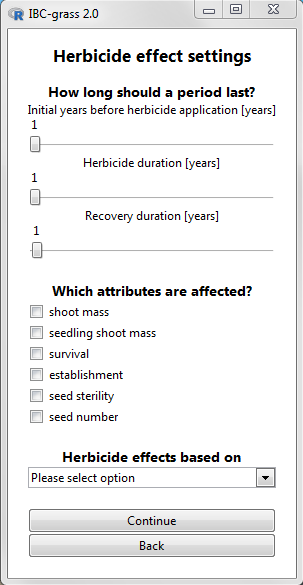


Figure 7: Herbicide effect settings window

#### Affected plant attributes

Then, you can decide on which plant attributes the herbicide should have an effect on. If you have dose response data, you should only select those attributes also measured in the experiments.

* Shoot mass:

If you select this attribute, the biomass gain of plant individuals will be affected in one week.

* Seedling shoot mass:

If you select this attribute, the biomass of plant seedlings (just established plant individuals) will be affected in one week.

* Survival:

If you select this attribute, the mortality of plant individuals will be affected in one week.

* Establishment:

If you select this attribute, the establishment of seeds will be affected in one week.

* Seed sterility:

If you select this attribute, the seed sterility (the ability of a seed to germinate) will be affected in one week.

* Seed number:

If you select this attribute, the number of produced seeds of a plant individual will be affected in one week.

For each attribute, the effect will occur in the first week of the specific process in the model (e.g. the effect on shoot mass will occur at the beginning of the growing season as the model continuously simulates growth; the effect on seed number on the other hand will be simulated in the first week of the seed production period (during simulated spring or autumn).

#### Herbicide effect data

After you selected the duration and the affected attributes, you can now choose on which data the herbicide impact should be based on.

* Txt-file:

If you select ‘txt-file’, a table will pop-up (Figure 8), where you can type in specific effect values for each attributed and each year of simulated herbicide application. These effect values should vary between 0 and 1, 0 meaning no effect at all, 1 meaning 100% effect on the specific attribute (e.g. 100% mortality). Later you will be able to assign different sensitivities of PFTs.

* Dose-response function per attribute:

If you select ‘dose-response function per attribute’, you will be asked to type in the results of your dose response experiments (specifically the number of test species and for each attribute the test rate and measured effects per test species, Figure 9). You can also use copy+paste, but be aware of the data structure.

##### Effects based on txt-file

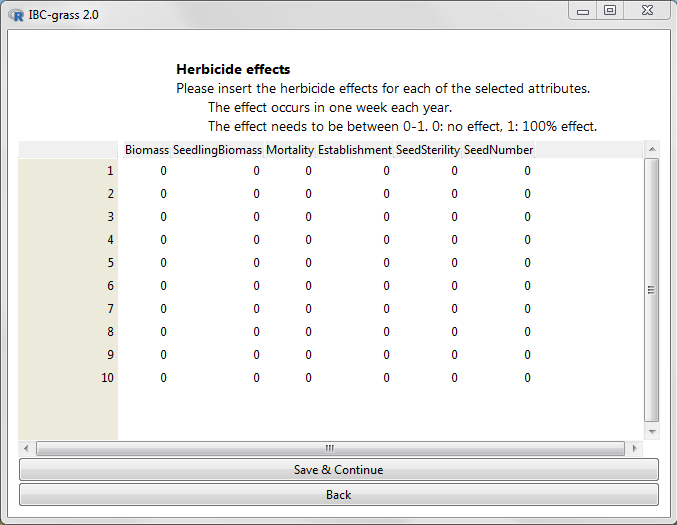


Figure 8: Herbicide effects based on a txt-file

If you chose that the herbicide effects should be based on a txt-file, a new window opens showing a data frame (Figure 8). It shows the selected attributes as columns and the years of simulated herbicide application in the rows. Please type in the specific effect values for each attribute in each year. 0 means that there is no effect, 1 means that the attribute is affected by 100% (e.g. 100% mortality). You can also use copy and paste if you have prepared such a table in advance.

In the next step you can assign PFT specific sensitivities.

##### Effects based on dose-response data

To facilitate the transfer of data, it is recommended to prepare a data file of the structure

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Application Rate Species 1 | Measured value Species 1 | Application Rate Species 2 | Measured value Species 2 | … |
|  |  |  |  |  |

for all of the affected attributes.

First, you will be asked to type in the number of tested species. You should have dose response data for each affected plant attribute and each species. After determining the number of test species, windows for each selected plant attribute will be opened one after the other. If you have prepared a data table as shown above, you can simply copy and paste your data. If not, you will need to type in the tested application rates and the resulting effect for each species (see Figure 9 as an example). You can add rows by clicking right on the row names.

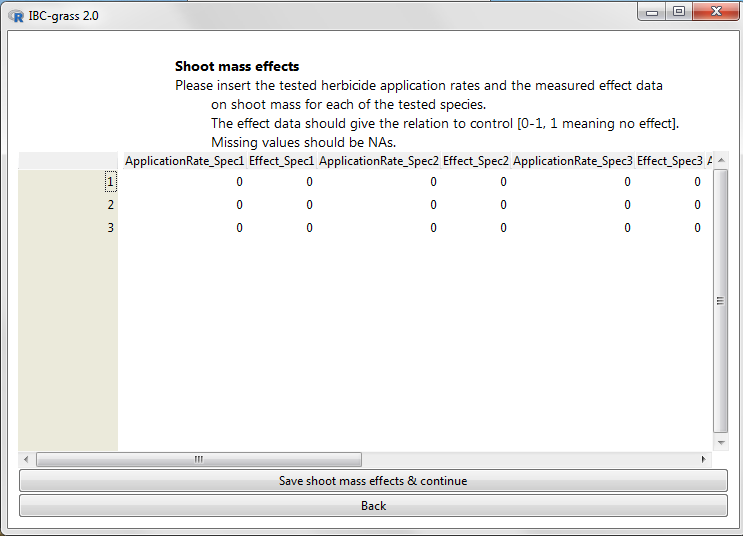


Figure 9: Herbicide effects based on dose responses. Example of the data structure

After you inserted all data, parameters ER50 and slope b of the dose response function (Eq. 1) will be fitted using the optimization routine by Nelder and Mead (1965).

Eq. 1

If the parameters could be optimized, you will be asked to assign PFT specific sensitivities in the next step.

## Sensitivity

### Effects based on txt-file

If the herbicide effects are based on a txt-file, you can assign PFT specific sensitivies (Figure 10). A PFT can either have random (0-1), low (0.1-0.35), medium (0.35-0.65), high (0.65-1) or full (1) sensitivity values or can not be impacted at all (0).

The PFT specific effect value is calculated by multiplying the effect value (of the specific attribute in a specific year, as defined in the txt-file) with the PFT specific sensitivity value.

In the upper part of the window you can set all sensitivities to the selected value, or you can do it PFT by PFT. If you don’t select any sensitivity, a random sensitivity value will be assumed.

By holding the cursor on the PFT label, an example plant species will popup next to the cursor.

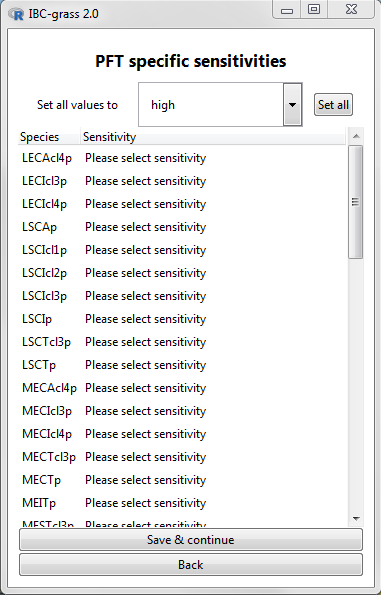


Figure 10: PFT specific sensitivities

### Effects based on dose-response data

If your herbicide effects are based on dose-response functions, you will now be asked to select a dose response function for each PFT. It can either be one of the previously optimized, but you can also select ‘random’. Random means that the parameters ER50 and slope b will be randomly selected within the range of the standard deviation of the calculated dose response functions (mean\_ER50 +- sd\_ER50 and mean\_b +- sd\_b). In this way, a random dose response function will be in the range of the previously calculated ones (see Figure 11). You can also select ‘not affected’ if a PFT should not be affected by an herbicide. When holding the cursor over the PFT code ID, an exemplary plant species will pop up.

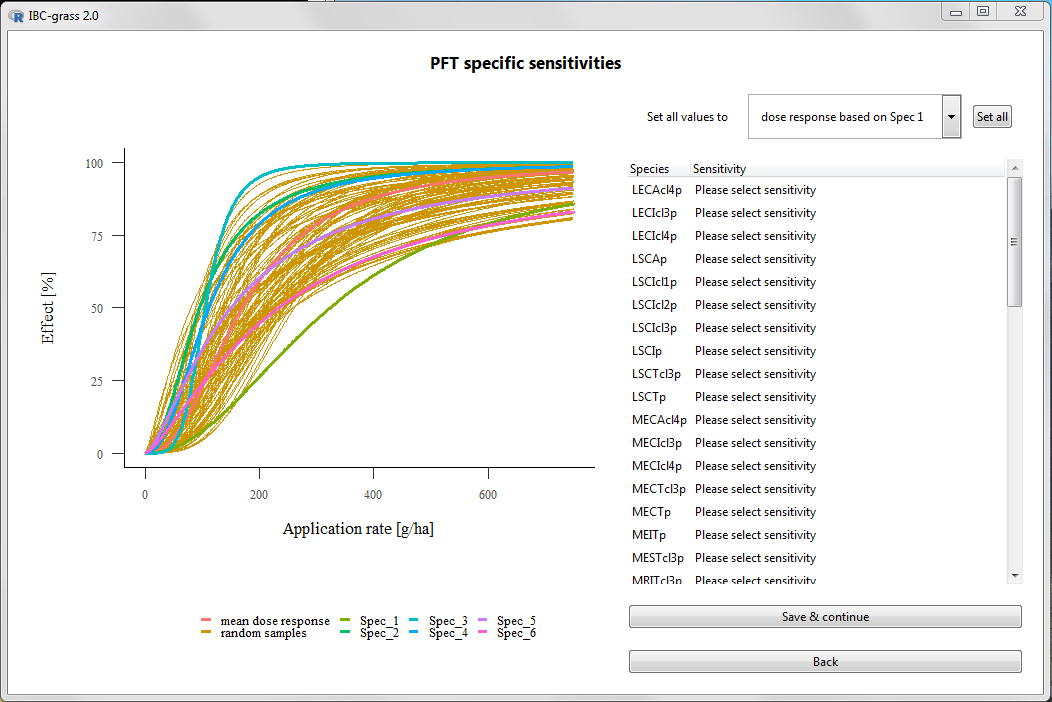


Figure 11: PFT specific dose response functions. The graphic on the right side shows examplary dose response functions based on 6 test species and random samples.

## Start of simulations

After assigning the PFT specific sensitivities, you are now asked to define a few more general simulation specific settings (Figure 12).

### Number of repetitions:

A high number of repetitions is better (due to stochasticity in the model) but will also increase the runtime of the model. If you just want to test the GUI, you may keep the number of repetitions between 3 and 10. Otherwise we recommend using at least 30 repetitions.

### Plot size

If you simulate small plot sizes, the runtime will be faster. However, you will have a lower number of PFTs in your system and /or higher variability in your simulations. When testing the GUI, you may set the plot size to 1 m², but if you run serious simulations, you should set it to 3 m².

### External seed input

External seed input determines the degree of patch isolation. Without seed input, you will have only a few PFTs in your system. If seed input is too high, it might dominate the dynamics. We recommend using 10 for medium seed input.

### Application rates (only if effects are based on dose responses)

Please insert the application rates, which should be tested (e.g. according to realistic drift rate or a worst-case scenario like overspray).

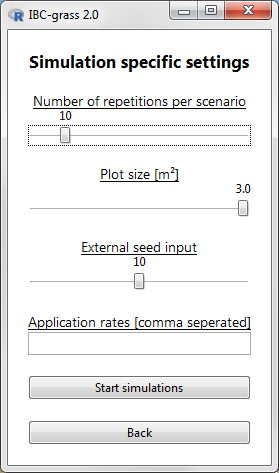


Figure 12: simulation specific settings and start of simulations

After setting the number or repetitions, plot size, seed input and application rates, you can start the simulations. A progress bar will show you the percentage of runs finished.

When all simulation runs finished, the model output is pre-analyzed (see chapter *Simulation output and analyses*).

## Simulation output and analyses

After the simulations have finished and the output was pre-analyzed, a new window will open (Figure 2).

### Show settings of the project

If you click on the button ‘Show Simulation Settings’, a new window will pop up, which gives you an overview of the environmental and herbicide settings (Table 1).

Below you can find two tabular windows: The first shows the results on community-level, the second the results on population level. For each of these tabs, you can define what should be presented.

### Community-level Tab

You can select which years should be analysed. In brackets you can see during which years, herbicide application was simulated. If you select more than 5 years, the effects are averaged over a year (i.e. the figures are based on the ‘*effect.year.GRD.txt*’ file). Otherwise the results are averaged over each week per year (i.e. the figures are based on the ‘*effect.timestep.GRD.txt*’ file).

Below you can find all community level endpoints that can be plotted or summarized in tables.

If you click on ‘*Show Graphics*’ figures will be generated and shown in the ‘Graphics’ tab. The figures will show the temporal dynamics of the effects.

If you click on ‘*Show Tables*’, tables showing the number of weeks per year, in which the effect is within a certain interval, will be shown in the ‘Tables’ tab. Please be aware, that an increase in the endpoint will be included in the interval <10%.

### Population-level tab

Also on this level, you can first select which years should be analyzed. In brackets you can see during which years, herbicide application was simulated. If you select more than 5 years, the effects are averaged over a year (i.e. the figures are based on the ‘*effect.year.PFT.txt*’ file). Otherwise the results are averaged over each week per year (i.e. the figures are based on the ‘*effect.timestep.PFT.txt*’ file).

Below you can decide which PFTs should be analyzed. Only PFTs which occurred in more than 50% of the simulations will be shown. Thus, infrequent PFTs are ignored. The lower the frequency of a PFT in the simulation runs, the fuzzier are the temporal dynamics.

Below the list of PFTs, you can find the potential endpoints on population level.

If you click on ‘*Show Graphics*’ figures will be generated and shown in the ‘Graphics’ tab. The figures will show the temporal dynamics of the effects.

If you click on ‘*Show Tables*’, tables showing the number of weeks per year, in which the effect is within a certain interval, will be shown in the ‘Tables’ tab. Please be aware, that an increase in the endpoint will be included in the interval <10%.

### Saving of outputs

You are able to save the generated output files and tables by clicking on the ‘*save*’ button below a table or figure. Tables must be saved as txt-files. Figures can be saved as jpeg, png or svg files.

### Saving the project

You should save the project, if you want to save the simulation settings, the results and/or want to generate additional graphics or tables at a later point in time. Latest when closing the project, you will be asked whether to save the project for later use. Please follow the directions and create a new folder in which the project should be saved. See chapters *Simulation output and analyses* and *Data structure and organization* to see all files that will be saved. You can choose if you want to keep the raw data files. (Can make up several GB of data)

# Examples

The IBCgrassGUI folder includes two examples: one for a txt-file based herbicide effect and one for a dose-response based herbicide effect. Here we will present only few examples of potential model output parameter.

## Example for Herbicide effects based on a txt-file

This example simulated the impact of 90% individual-level effects on biomass, plant mortality and establishment on PFT individuals of a field edge community. The herbicide effect was simulated for 10 years after an initialization phase of 25 years. PFTs had random sensitivities (0-1). Thus, the PFT specific effect varied between 0 – 100%. Table 3 summarizes the simulation settings for this example.

Table 3: Summary of simulation settings for the example of herbicide effects mased on a txt-file

|  |  |  |
| --- | --- | --- |
| IBC-grass parameter | Type of value | Explanation |
| IBCommunity | Fieldedge.txt | Name of the PFT community used. If ‘Community.txt’, then an individual community was used. |
| IBCgridsize | 173 | Number of grid cells |
| IBCabampl | 0.0 | Amplitude for aboveground resource seasonality |
| IBCabres | 100 | Aboveground resource units |
| IBCbelres | 90 | Belowground resource units |
| IBCSeedInput | 10 | Number of seeds per PFT added at the beginning of each year |
| IBCcut | 1 | Number of cutting events per year |
| IBCgraz | 0.001 | Amount of area grazed during one year |
| IBCtramp | 0.1 | Amount of area trampled during one year |
| IBCInit | 25 | Number of initial years |
| IBCDuration | 10 | Number of year with simulated herbicide application |
| IBCRecovery | 5 | Number of years following the herbicide application period |
| IBCherbeffect | Txt-file | If ‘txt-file’: herbicide effects are based on a txt-file (HerbFact.txt)  If ‘dose-response’: herbicide effects are based on dose-response data |
| BiomassEff | TRUE | Was plant biomass affected? |
| EstablishmentEff | TRUE | Was seed establishment affected? |
| SeedlingBiomassEff | FALSE | Was seedling biomass affected? |
| SeedNumberEff | FALSE | Was seed number affected? |
| SeedSterilityEff | FALSE | Was seed sterility affected? |
| SurvivalEff | TRUE | Was plant survival affected? |
| IBCrepetition | 20 | Number of repetitions |

### Results on community level

During the first year of herbicide application, the number of individuals is decreasing and exceeding the normal range of fluctuations (Fig. 13). In addition, the diversity indices are showing a similar pattern (Fig. 14). However, especially the diversity index Inverse Simpson Index is very sensitive. However, over the long-term, only the diversity indices showed effects exceeding the standard control fluctuations (Fig. 15).

During the first year of simulated herbicide impact (year 25) the effect on the mean number of plant individuals is in 3 out of 30 weeks between 40-50% (Table 4), in 2 weeks between 30-40% and in 1 week between 20-30% and 10-20%, respectively. The impact on inverse Simpson index is lower with only 9 week in which the mean effect is within 10-20% (Table 5).

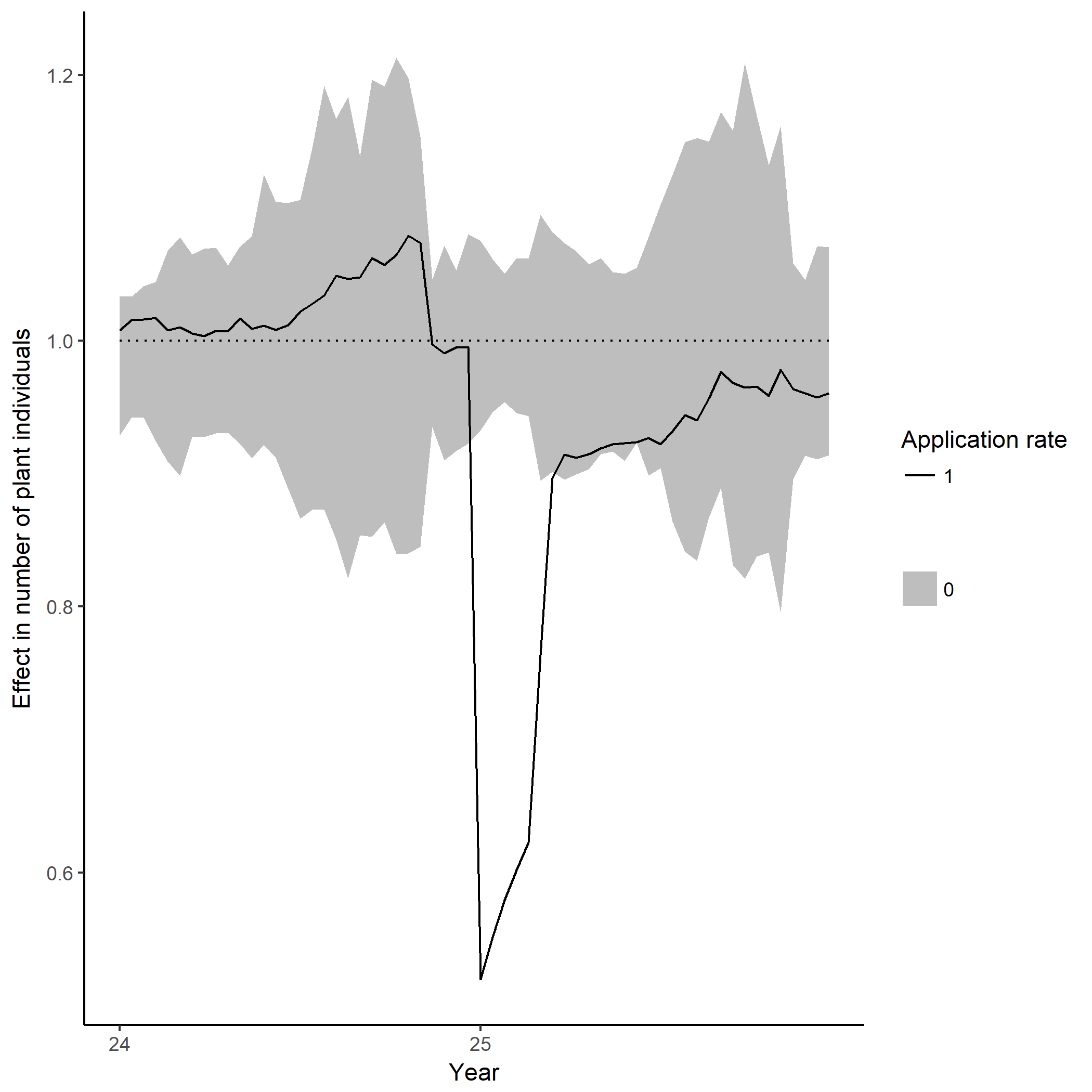


Figure 13: Effect in number of plant individuals during the first year of simulated herbicide impact. The theoretical herbicde had an impact on biomass, mortality and establishment (0.9, respectively). PFTs had random sensitivities. Grey ribbons show the fluctuations within control simulations, the black line shows the mean of the treatment.

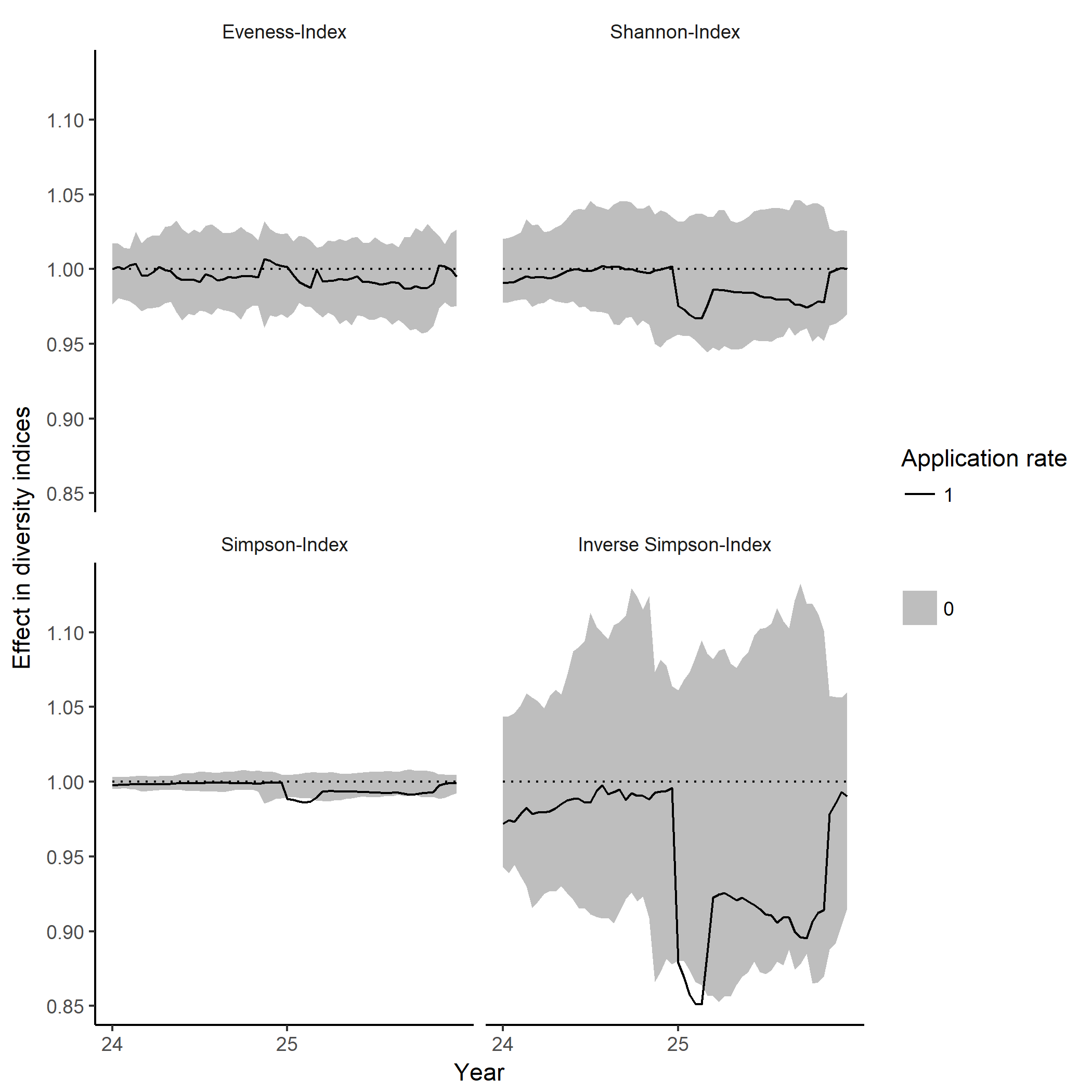


Figure 14: Effect on different diversity indices during the first year of simulated herbicide impact. The theoretical herbicde had an impact on biomass, mortality and establishment (0.9, respectively). PFTs had random sensitivities. Grey ribbons show the fluctuations within control simulations, the black lines show the mean of the treatment.

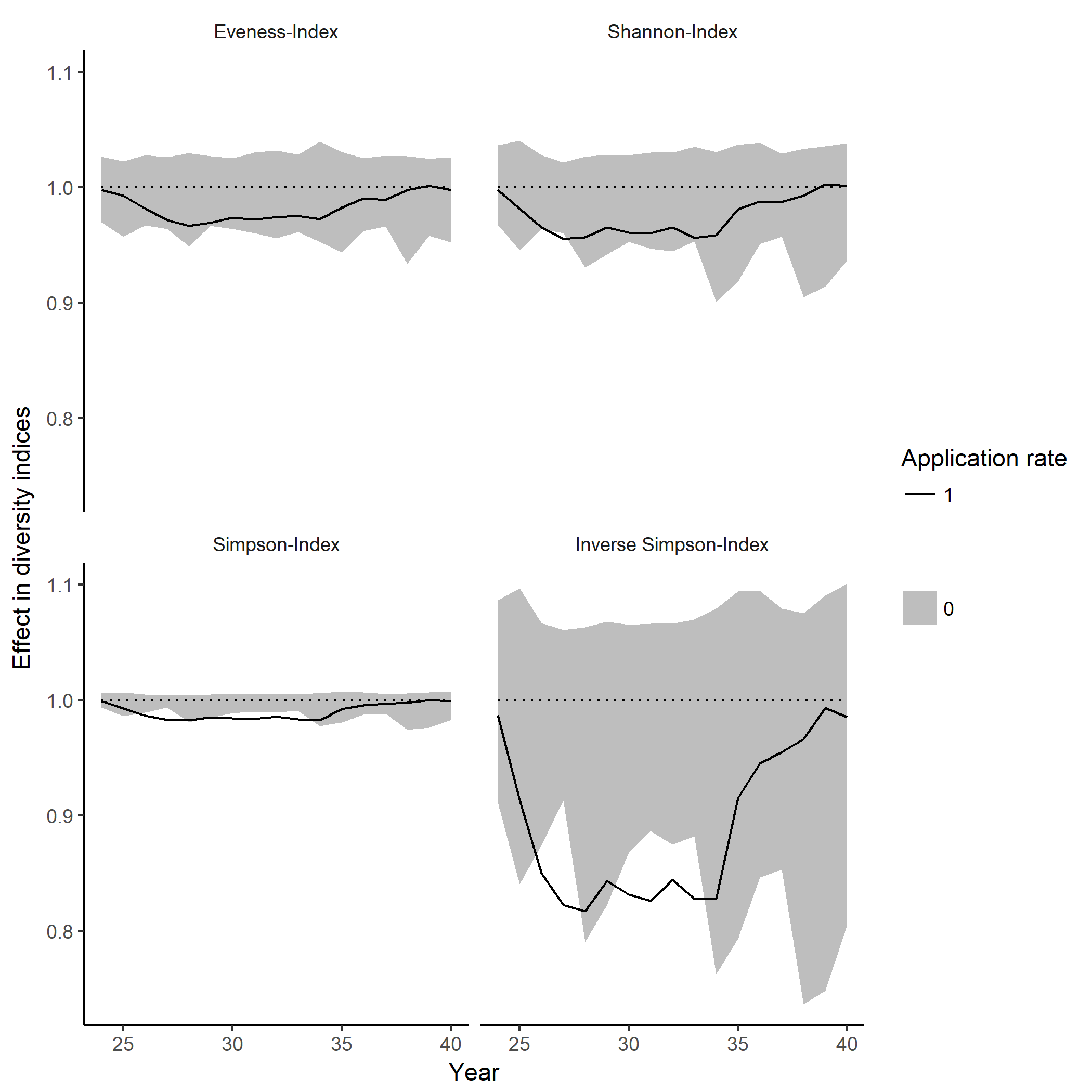


Figure 15: Long-term impacts on the diversity indices over the simulated period. Herbicide application starts in year 25 and ended in year 35. . The theoretical herbicde had an impact on biomass, mortality and establishment (0.9, respectively). PFTs had random sensitivities. Grey ribbons show the fluctuations within control simulations, the black lines show the mean of the treatment.

Table 4: Number of weeks in which the mean (mininmal and maximal) negative effect on the number of plant individuals is within a certain effect class. As IBC-grass simulates only 30 weeks of growing period, the maximal number of weeks is 30. Simulated herbicide application starts in year 25.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Application rate | <10% | 10-20% | 20-30% | 30-40% | 40-50% | >50% |
| 24 | 0 | 30 (30 7) | 0 (0 13) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
| 1 | 30 (30 0) | 0 (0 26) | 0 (0 4) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
| 25 | 0 | 30 (30 15) | 0 (0 14) | 0 (0 1) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
| 1 | 23 (24 0) | 1 (1 9) | 1 (3 12) | 2 (2 4) | 3 (0 0) | 0 (0 5) |

Table 5: Number of weeks in which the mean (mininmal and maximal) negative effect on the inverse simpson index is within a certain effect class. As IBC-grass simulates only 30 weeks of growing period, the maximal number of weeks is 30. Simulated herbicide application starts in year 25.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Application rate | <10% | 10-20% | 20-30% | 30-40% | 40-50% | >50% |
| 24 | 0 | 30 (30 26) | 0 (0 4) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
| 1 | 30 (30 0) | 0 (0 29) | 0 (0 1) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
| 25 | 0 | 30 (30 2) | 0 (0 28) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
| 1 | 21 (30 0) | 9 (0 4) | 0 (0 24) | 0 (0 2) | 0 (0 0) | 0 (0 0) |

### Results on population level

The impact on population size and shoot mass is similar. Therefore we only show the impact on population size for selected PFTs (Figure 16). Several PFTs showed decreases in population sizes. Especially the PFT MEITp showed long-term decrease, which exceeded the control range in some years. In contrast, the PFT MSCTcl2p increased in population size over the long-term. Table 6 summarizes the negative effect extends for these two PFTs. Positive effects are not included in this table, but can be observed in the PFT specific figures (like Figure 16).

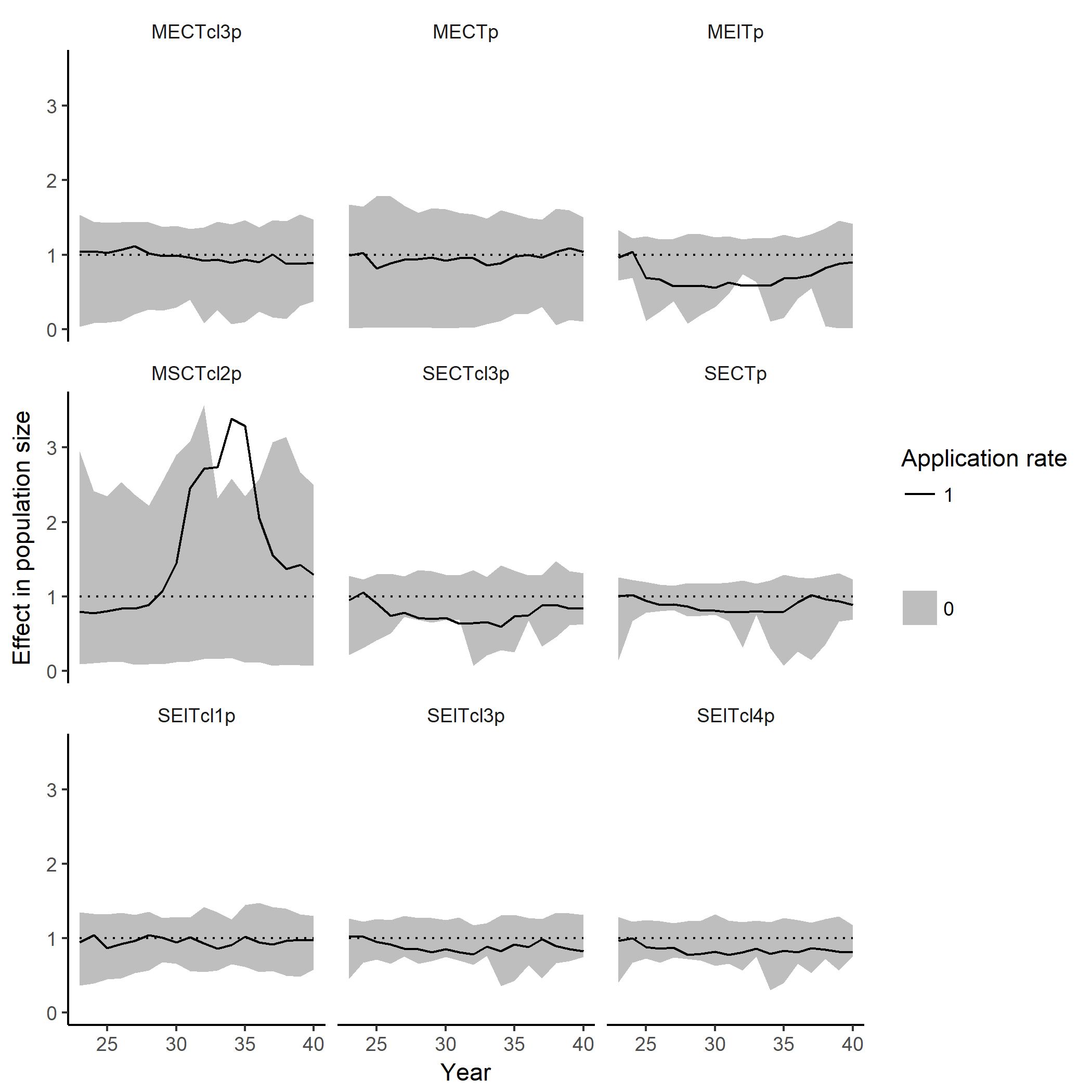


Figure 16: Long-term impacts on the population sizes of selected PFTs over the simulated period. Herbicide application starts in year 25 and ended in year 35. The theoretical herbicde had an impact on biomass, mortality and establishment (0.9, respectively). PFTs had random sensitivities. Grey ribbons show the fluctuations within control simulations, the black lines show the mean of the treatment. PFT MEITp showed long-term impacts that exceed the control range in some years. MSCTcl2p showed an increase in population size, which actually exceeded the control range in some years.

Table 6: Number of weeks in which the mean (mininmal and maximal) negative effect on population size is within a certain effect class for two different PFTs. As IBC-grass simulates only 30 weeks of growing period, the maximal number of weeks is 30. Simulated herbicide application starts in year 25.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PFT | Year | Application rate | <10% | 10-20% | 20-30% | 30-40% | 40-50% | >50% |
| MEITp | 24 | 0 | 30 (30 0) | 0 (0 10) | 0 (0 11) | 0 (0 3) | 0 (0 2) | 0 (0 4) |
| 1 | 30 (30 0) | 0 (0 5) | 0 (0 21) | 0 (0 0) | 0 (0 0) | 0 (0 4) |
| 25 | 0 | 30 (30 0) | 0 (0 28) | 0 (0 0) | 0 (0 0) | 0 (0 4) | 0 (0 26) |
| 1 | 0 (28 0) | 0 (1 0) | 23 (1 0) | 1 (0 0) | 4 (0 0) | 2 (0 30) |
| MSCTcl2p | 24 | 0 | 30 (30 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 30) |
| 1 | 2 (30 0) | 8 (0 0) | 15 (0 0) | 5 (0 0) | 0 (0 0) | 0 (0 30) |
| 25 | 0 | 30 (30 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 28) |
| 1 | 6 (30 0) | 11 (0 0) | 8 (0 0) | 0 (0 0) | 5 (0 2) | 0 (0 20) |

## Example for herbicide effects based on dose-responses

This example simulated the impact of a potential herbicide for PFT populations of a field edge community. The herbicide effect was simulated for 10 years after an initialization phase of 10 years. The herbicide effects were based on dose-responses of 6 test species and assumed to effect biomass and mortality of the plant individuals. Dose responses were randomly sampled for each PFT. The simulation settings are summarized in Table 7 for this example.

Table 7: Summary of simulation settings for the example of herbicide effects mased on dose-responses

|  |  |  |
| --- | --- | --- |
| IBC-grass parameter | Type of value | Explanation |
| IBCommunity | Fieldedge.txt | Name of the PFT community used. If ‘Community.txt’, then an individual community was used. |
| IBCgridsize | 173 | Number of grid cells |
| IBCabampl | 0.0 | Amplitude for aboveground resource seasonality |
| IBCabres | 100 | Aboveground resource units |
| IBCbelres | 90 | Belowground resource units |
| IBCSeedInput | 10 | Number of seeds per PFT added at the beginning of each year |
| IBCcut | 1 | Number of cutting events per year |
| IBCgraz | 0.001 | Amount of area grazed during one year |
| IBCtramp | 0.1 | Amount of area trampled during one year |
| IBCInit | 10 | Number of initial years |
| IBCDuration | 10 | Number of year with simulated herbicide application |
| IBCRecovery | 5 | Number of years following the herbicide application period |
| IBCherbeffect | Dose-response | If ‘txt-file’: herbicide effects are based on a txt-file (HerbFact.txt)  If ‘dose-response’: herbicide effects are based on dose-response data |
| IBCApprates | 90, 260 | Only if based on dose-response data: Which application rates were tested? |
| BiomassEff | TRUE | Was plant biomass affected? |
| EstablishmentEff | FALSE | Was seed establishment affected? |
| SeedlingBiomassEff | FALSE | Was seedling biomass affected? |
| SeedNumberEff | FALSE | Was seed number affected? |
| SeedSterilityEff | FALSE | Was seed sterility affected? |
| SurvivalEff | TRUE | Was plant survival affected? |
| IBCrepetition | 10 | Number of repetitions |

### Results on community level

During the first year of herbicide application, the number of individuals is decreasing and exceeding the normal range of fluctuations (Fig. 17). The effects are increasing with higher application rate. In addition, the diversity indices show no significant effect (i.e. the mean effect is not exceeding the range of the control simulations) for the lower application rate of 90 mL/ha (Fig. 18). For an application rate of 260 mL/ha, all diversity indices except for the evenness show a decrease below the control range.

However, over the long-term, no diversity index showed effects exceeding the standard control fluctuations (Fig. 19).

During the first year of simulated herbicide application rate of 90 mL/ha (year 10) the effect on the mean number of plant individuals is in 2 out of 30 weeks between 20-30% (Table 8) and in 3 weeks between 10-20%. For an application rate of 260 mL/ha, the effect on the mean number of plant individuals is in 5 out of 30 weeks greater than 50% (Table 8) and in 1 week between 10-20%

Only for the simulated application rate of 260 mL/ha, the inverse Simpson index had a negative mean effect of 10-20% in 5 weeks (Table 9) in the first year of herbicide application.

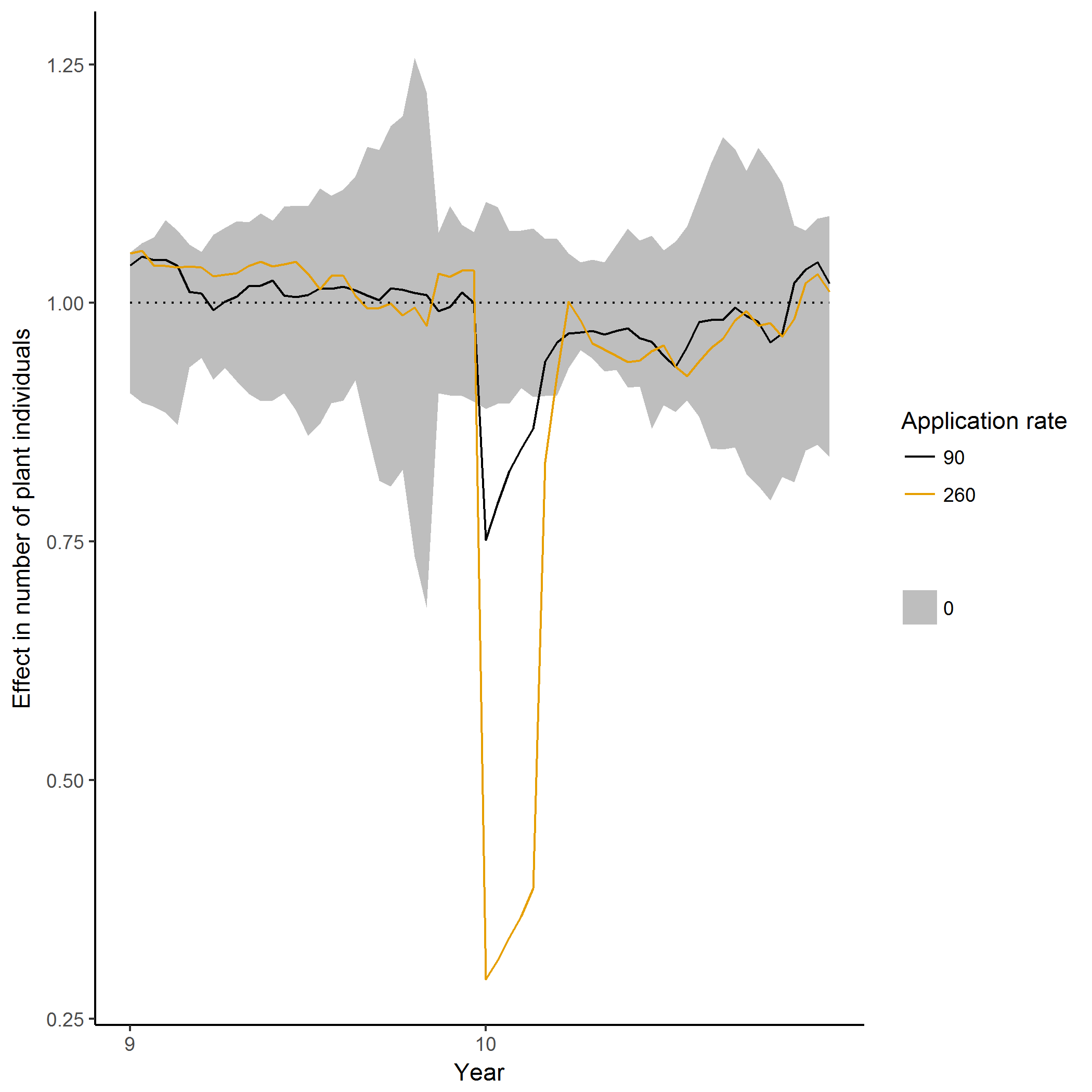


Figure 17: Effect in number of plant individuals during the first year of simulated herbicide impact. The theoretical herbicde had an impact on biomass and mortality. PFTs had random dose response-curves. Grey ribbons show the fluctuations within control simulations, the black line shows the mean for 90 mL/ha application rate and the orange line the mean for 260mL/ha application rate.

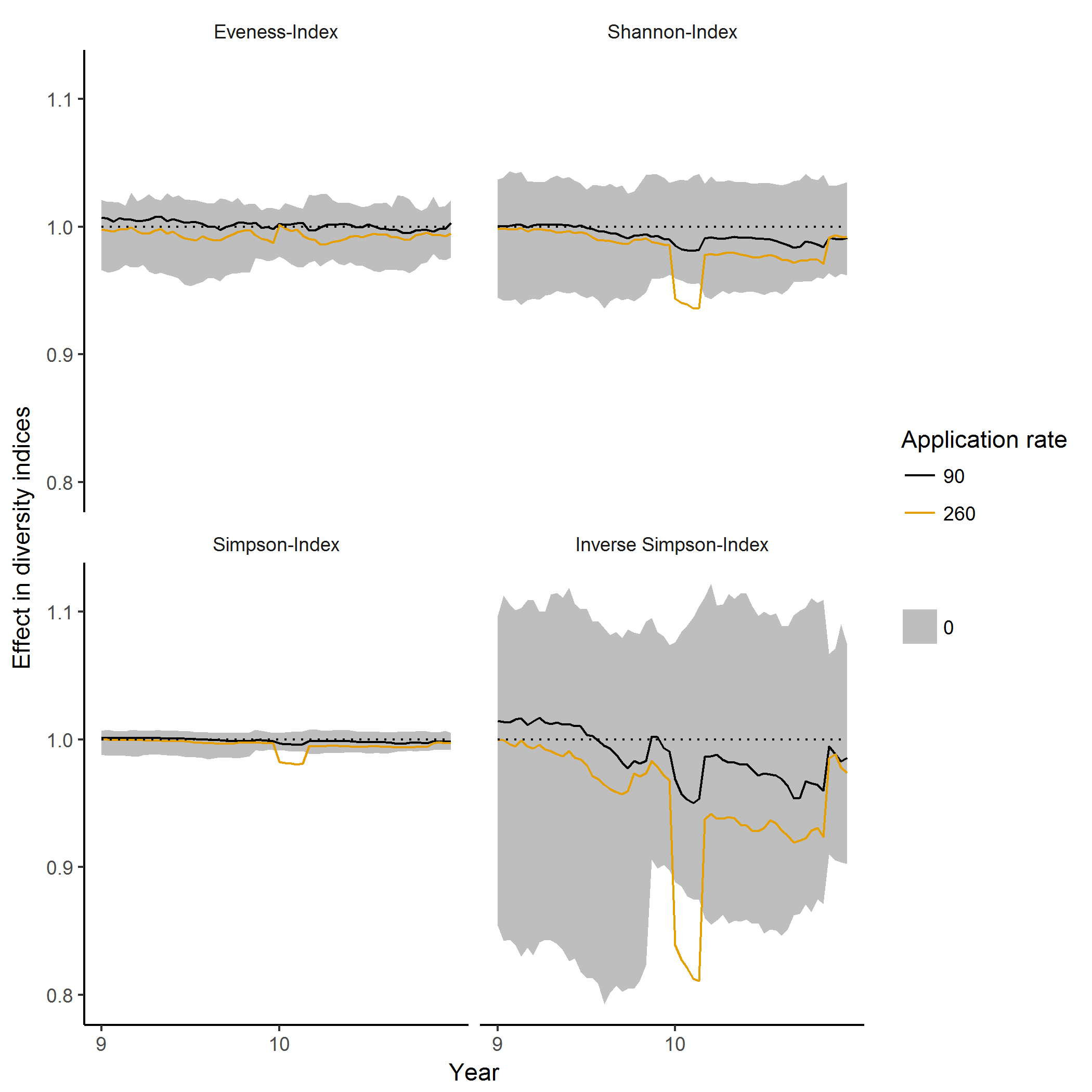


Figure 18: Effect on different diversity indices during the first year of simulated herbicide impact. The theoretical herbicde had an impact on biomass and mortality. PFTs had random dose response curves. Grey ribbons show the fluctuations within control simulations, the black lines show the mean for an application rate of 90mL/ha and the orange line the mean for an application rate of 260 mL/ha.

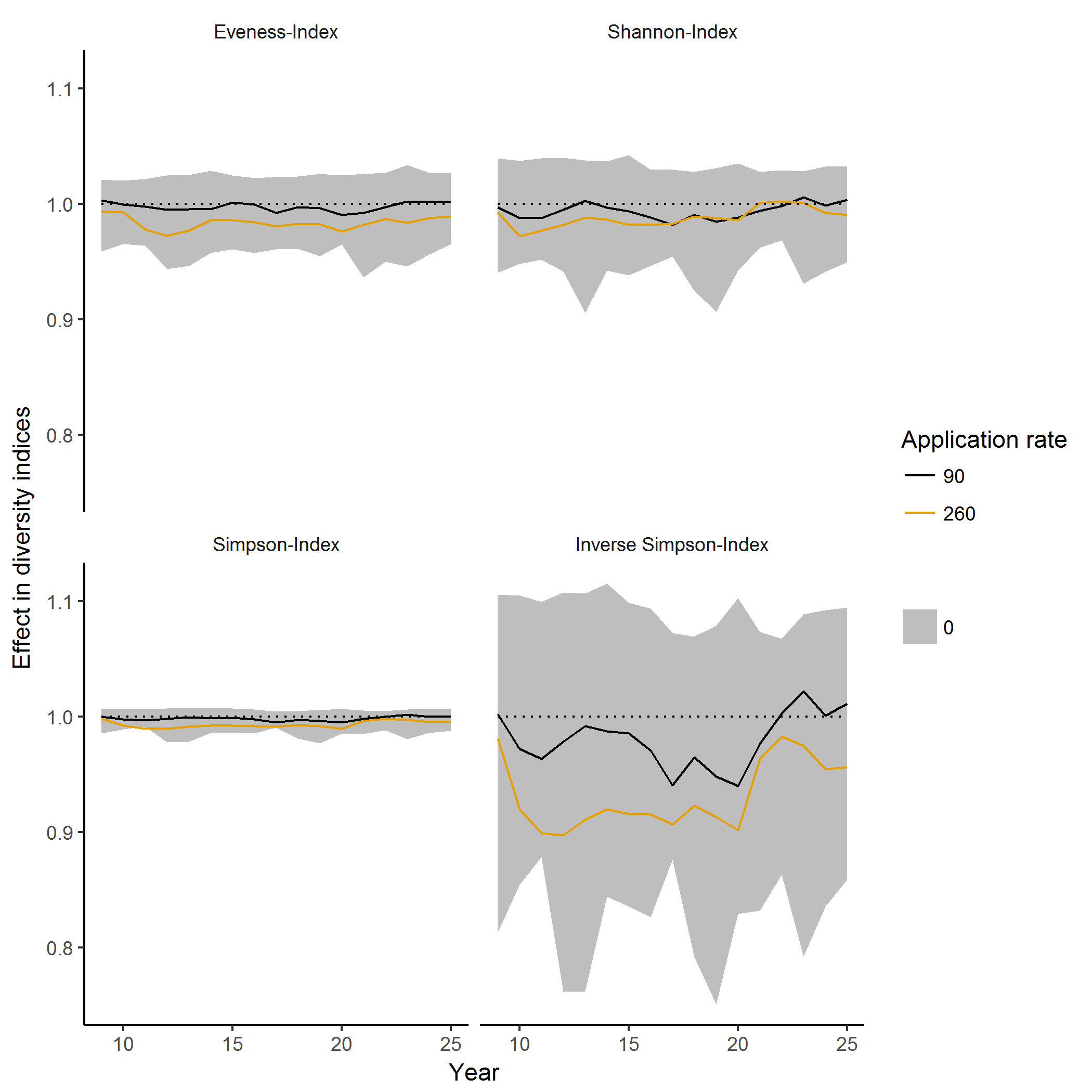


Figure 19: Long-term impacts on the diversity indices over the simulated period. Herbicide application starts in year 10 and ended in year 20. The theoretical herbicde had an impact on biomass and mortality. PFTs had random dose response curves. Grey ribbons show the fluctuations within control simulations, the black lines show the mean of the 90 ml/ha application rate, the orange line the mean of the 260 mL/ha application rate.

Table 8: Number of weeks in which the mean (mininmal and maximal) negative effect on the number of plant individuals is within a certain effect class. As IBC-grass simulates only 30 weeks of growing period, the maximal number of weeks is 30. Simulated herbicide application starts in year 10.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Application rate | <10% | 10-20% | 20-30% | 30-40% | 40-50% | >50% |
| 9 | 0 | 30 (30 12) | 0 (0 16) | 0 (0 1) | 0 (0 1) | 0 (0 0) | 0 (0 0) |
| 90 | 30 (30 12) | 0 (0 12) | 0 (0 6) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
|  | 260 | 30 (30 19) | 0 (0 6) | 0 (0 5) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
| 10 | 0 | 30 (30 11) | 0 (0 18) | 0 (0 1) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
| 90 | 25 (28 1) | 3 (2 18) | 2 (0 8) | 0 (0 3) | 0 (0 0) | 0 (0 0) |
|  | 260 | 24 (24 3) | 1 (1 11) | 0 (0 11) | 0 (0 0) | 0 (0 0) | 5 (5 5) |

Table 9: Number of weeks in which the mean (mininmal and maximal) negative effect on the inverse simpson index is within a certain effect class. As IBC-grass simulates only 30 weeks of growing period, the maximal number of weeks is 30. Simulated herbicide application starts in year 10.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Application rate | <10% | 10-20% | 20-30% | 30-40% | 40-50% | >50% |
| 9 | 0 | 30 (30 2) | 0 (0 27) | 0 (0 1) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
| 90 | 30 (30 0) | 0 (0 26) | 0 (0 4) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
|  | 260 | 30 (30 0) | 0 (0 7) | 0 (0 23) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
| 10 | 0 | 30 (30 4) | 0 (0 26) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
| 90 | 30 (30 0) | 0 (0 0) | 0 (0 30) | 0 (0 0) | 0 (0 0) | 0 (0 0) |
|  | 260 | 25 (30 0) | 5 (0 3) | 0 (0 19) | 0 (0 3) | 0 (0 5) | 0 (0 0) |

### Results on population level

The impact on population size and shoot mass is similar. Therefore we only show the impact on population size for selected PFTs (Figure 20). Only for an simulated herbicide application rate of 260 mL/ha, some PFTs showed long-term decreases in population sizes (SECTp and SEITcl4p). For these PFTs and the 260 mL/ha application rate, the mean effect is falling below the control range in some years. In contrast, the PFTs MSITcl3p and SSCTp increased in population size over several years. However, during the recovery period, starting in year 20, the population sizes are decreasing again.

Table 10 summarizes the negative effect extends for these PFTs during the first year of herbicide application. Although there is a long-term positive trend for MSITcl3p and SSCTp, these PFTs show strong short-term impacts.

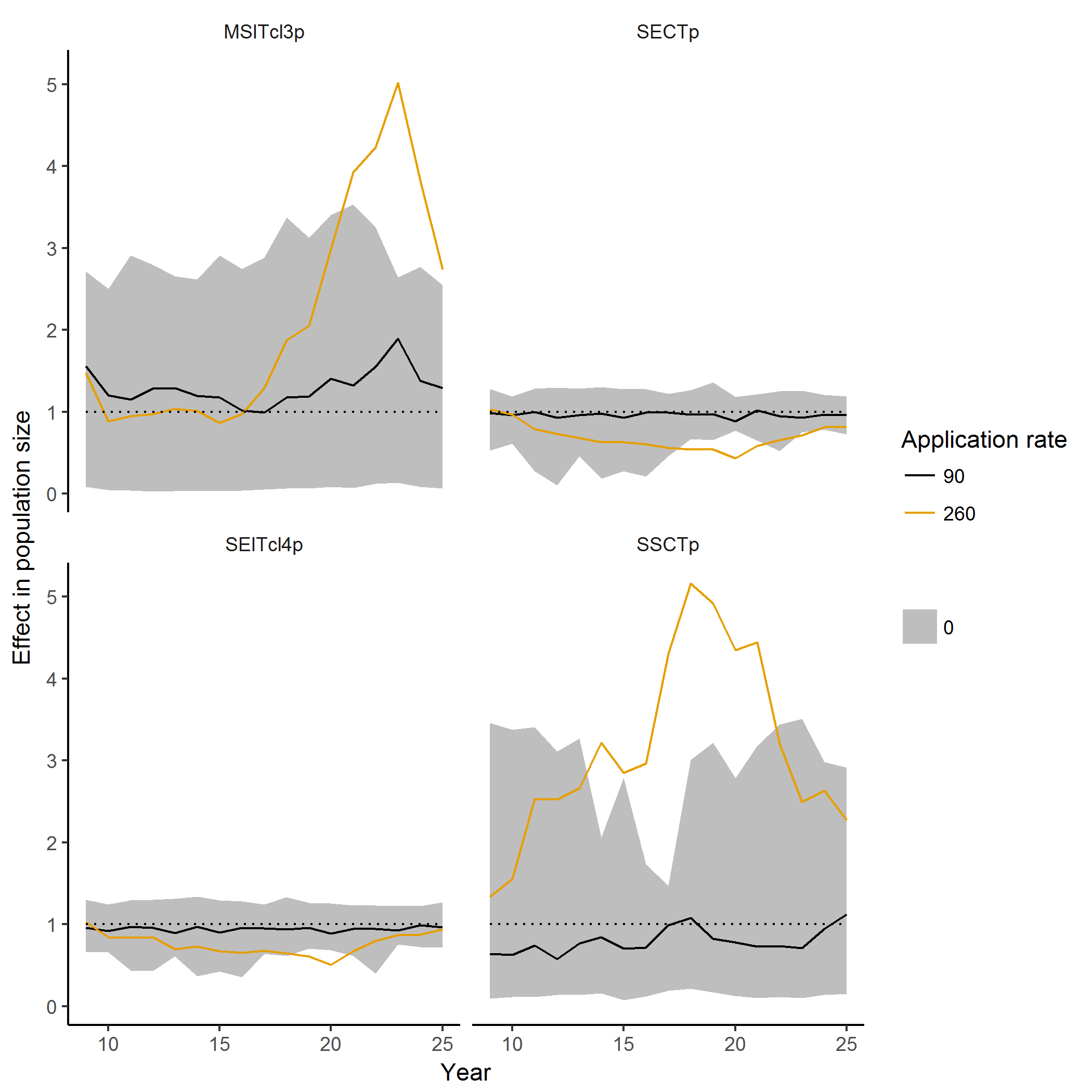


Figure 20: Long-term impacts on the population sizes of selected PFTs over the simulated period. Herbicide application starts in year 25 and ended in year 35. The theoretical herbicde had an impact on biomass, mortality and establishment (0.9, respectively). PFTs had random sensitivities. Grey ribbons show the fluctuations within control simulations, the black lines show the mean of the treatment. PFT MEITp showed long-term impacts that exceed the control range in some years. MSCTcl2p showed an increase in population size, which actually exceeded the control range in some years.

Table 10: Number of weeks in which the mean (mininmal and maximal) negative effect on population size is within a certain effect class for two different PFTs. As IBC-grass simulates only 30 weeks of growing period, the maximal number of weeks is 30. Simulated herbicide application starts in year 10.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PFT | Year | Application rate | <10% | 10-20% | 20-30% | 30-40% | 40-50% | >50% |
| MSITcl3p | 9 | 0 | 30 (30 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 30) |
| 90 | 30 (30 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 30) |
|  | 260 | 30 (30 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 30) |
| 10 | 0 | 30 (30 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 30) |
| 90 | 28 (30 0) | 2 (0 0) | 0 (0 0) | 0(0 0) | 0 (0 0) | 0 (0 30) |
|  |  | 260 | 20 (30 0) | 5 (0 0) | 0 (0 0) | 0 (0 0) | 1 (0 0) | 4 (0 30) |
| SECTp | 9 | 0 | 30 (30 0) | 0 (0 0) | 0 (0 4) | 0 (0 22) | 0 (0 4) | 0 (0 0) |
| 90 | 30 (30 0) | 0 (0 0) | 0 (0 13) | 0 (0 10) | 0 (0 0) | 0 (0 0) |
|  | 260 | 30 (30 0) | 0 (0 7) | 0 (0 16) | 0 (0 7) | 0 (0 0) | 0 (0 0) |
| 10 | 0 | 30 (30 0) | 0 (0 0) | 0 (0 16) | 0 (0 14) | 0 (0 0) | 0 (0 0) |
| 90 | 25 (30 0) | 4 (0 3) | 1 (0 1) | 0 (0 13) | 0 (0 13) | 0 (0 0) |
|  |  | 260 | 25 (25 4) | 0 (0 11) | 0 (0 6) | 0 (0 0) | 0 (0 0) | 5 (5 9) |
| SEITcl4p | 9 | 0 | 30 (30 0) | 0 (0 3) | 0 (0 15) | 0 (0 8) | 0 (0 4) | 0 (0 0) |
| 90 | 30 (30 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 30) |
|  | 260 | 30 (30 0) | 0 (0 11) | 0 (0 9) | 0 (0 7) | 0 (0 3) | 0 (0 0) |
| 10 | 0 | 30 (30 0) | 0 (0 5) | 0 (0 14) | 0 (0 7) | 0 (0 4) | 0 (0 0) |
| 90 | 22 (30 0) | 6 (0 0) | 2 (0 0) | 0 (0 0) | 0 (0 2) | 0 (0 28) |
|  |  | 260 | 21 (25 0) | 4 (0 1) | 0 (1 2) | 0 (1 10) | 0(3 7) | 5 (0 10) |
| SSCTp | 9 | 0 | 30 (30 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 2) | 0 (0 28) |
| 90 | 0 (30 0) | 0 (0 0) | 7 (0 0) | 15 (0 0) | 5 (0 2) | 3 (0 28) |
|  | 260 | 30 (30 0) | 0 (0 0) | 0 (0 0) | 0 (0 0) | 0 (0 2) | 0 (0 28) |
| 10 | 0 | 30 (30 0) | 0 (0 0) | 0 (0 0) | 0 (0 1) | 0 (0 5) | 0 (0 24) |
| 90 | 0 (30 0) | 5 (0 0) | 6 (0 0) | 5 (0 1) | 5 (0 5) | 9 (0 24) |
|  |  | 260 | 25 (30 0) | 0 (0 0) | 0 (0 0) | 0 (0 1) | 2 (0 5) | 3 (0 24) |