Individual tree based models

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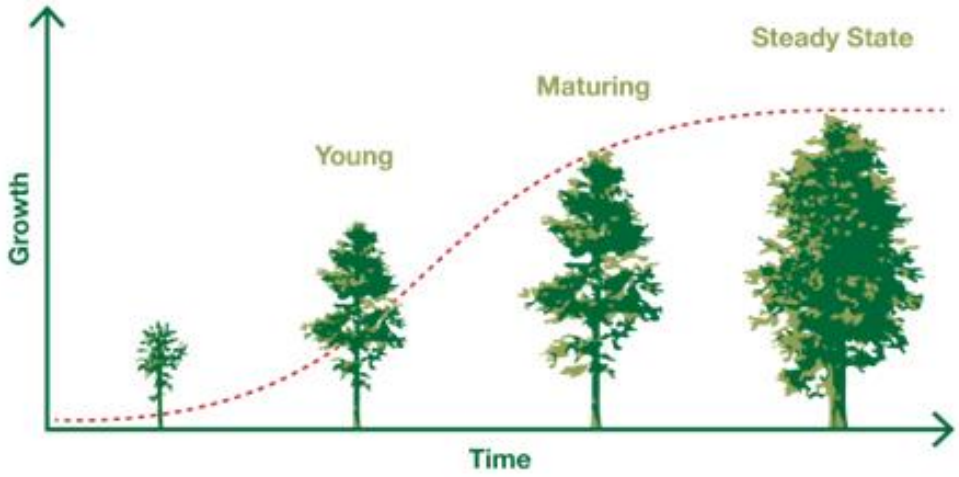
Individual tree based models

= ***each tree*** is considered as a separate unit



- Growth of each tree is simulated separately

- account for the ***competition*** between trees

- individual tree data are aggregated *after* the model grows each tree

- *Distance-independent models*
- *Distance-dependent models*

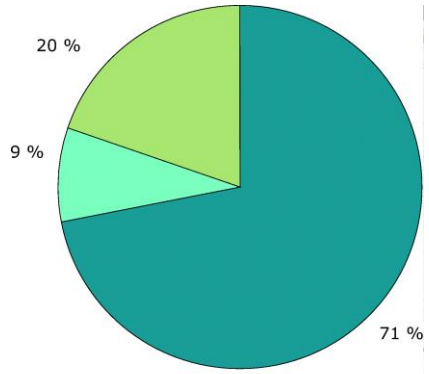
Distance–independent models

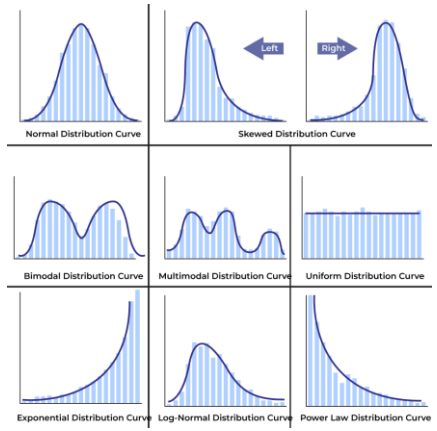
Distance–independent models

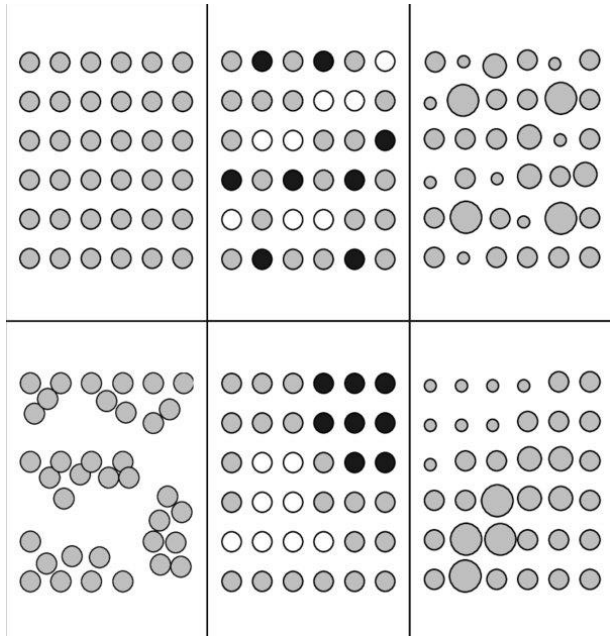
– account for **dimensions** of individual trees

- do not account for the **spatial distribution** of trees within the stand

- define the competitive neighborhood for a subject tree by its own diameter, height, and stand characteristics (basal area, number of trees per area, and mean diameter)







Distance – dependent models

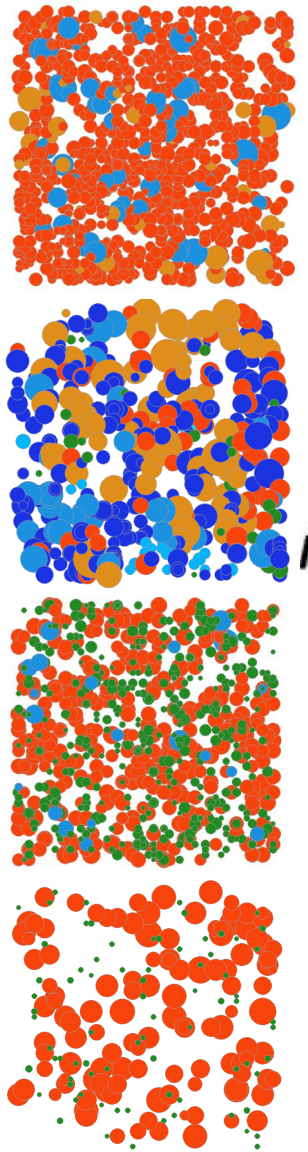
Distance – dependent models

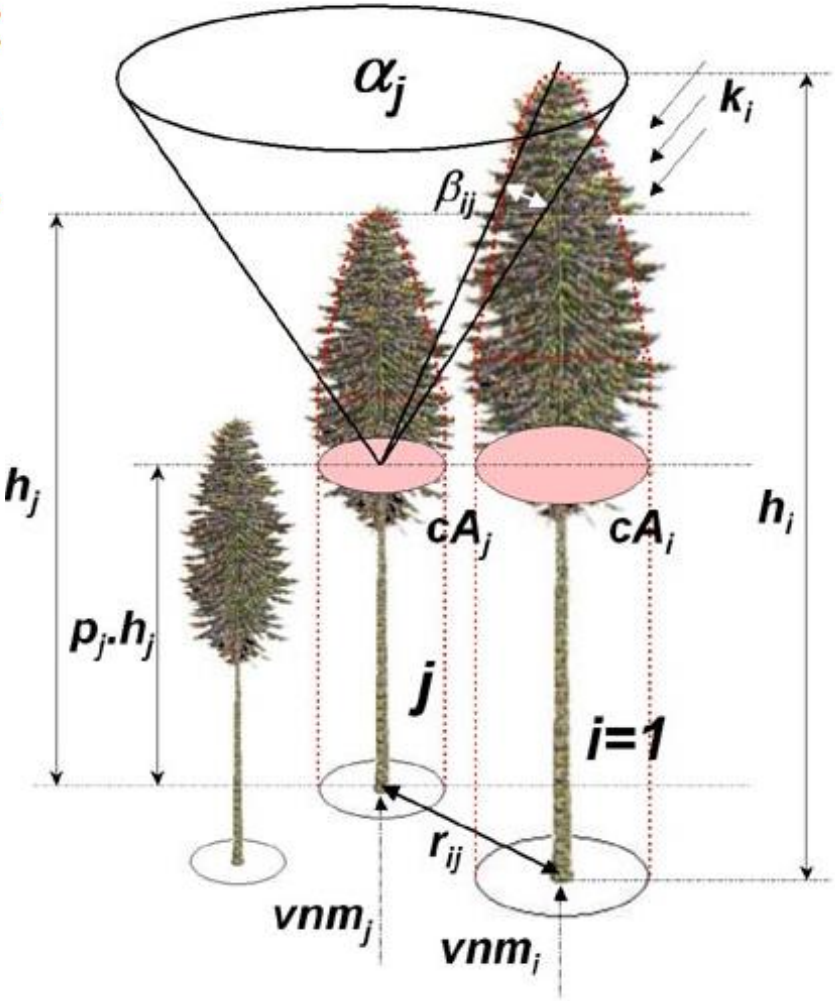
– account for the **dimensions** and

spatial distribution of trees within the stand

- the **competitive neighborhood** for each subject tree is precisely and uniquely defined (distances and bearings to all neighbours, and their dimensions)

- These models enable to explore how individual trees compete with one another for space, sunlight, nutrients, and other resources





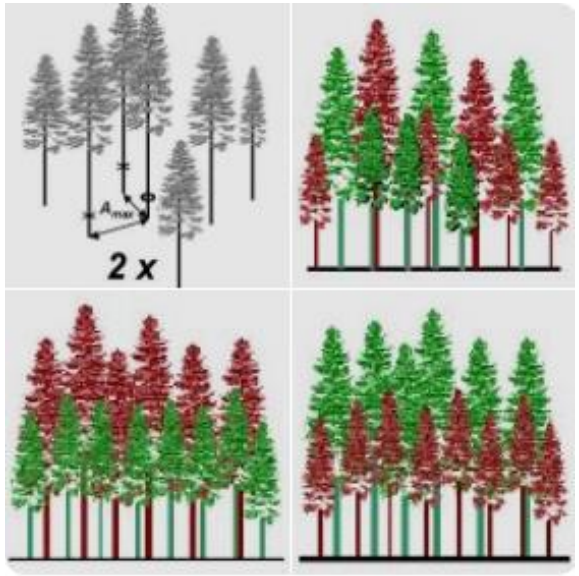
https://etools.tuzvo.sk/sibyla

Advantages of individual tree based models

They account for **characteristics of individual trees** and **inter-tree competition** and their impact on:

- growth
- vitality
- susceptibility to disturbance agents
- mortality

- They can simulate different management scenarios including non-schematic ones driven by characteristics of individual trees and stand spatial structure



Disadvantages of individual tree based models

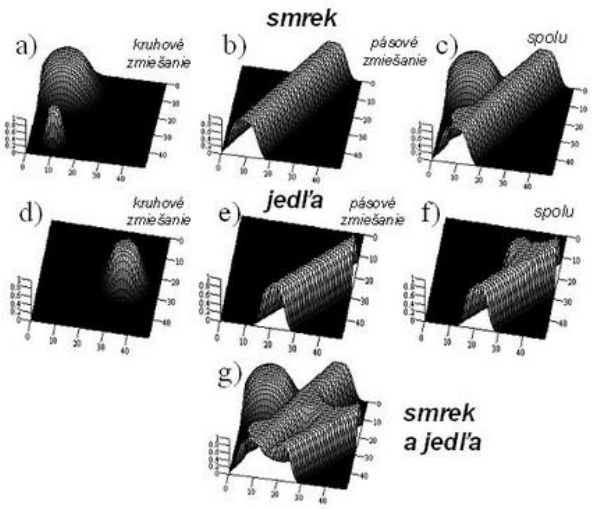
– they need information about individual trees:

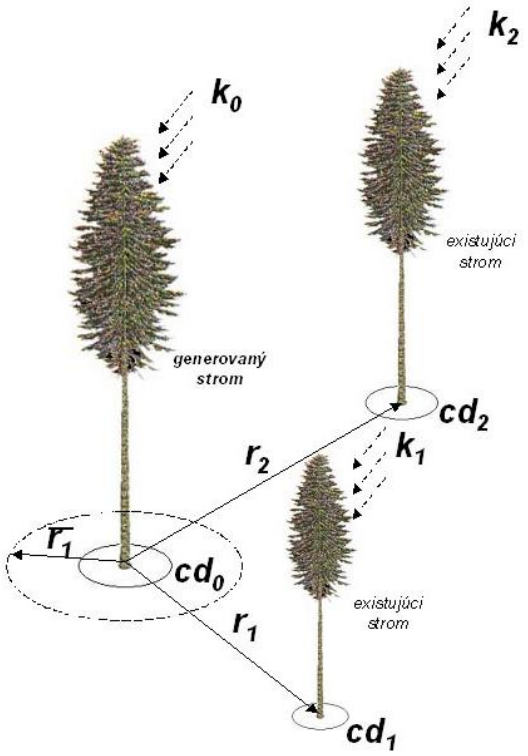
- dimensions
- spatial position

To overcome the data needs:

- Generators of tree characteristics
- Generators of spatial distribution

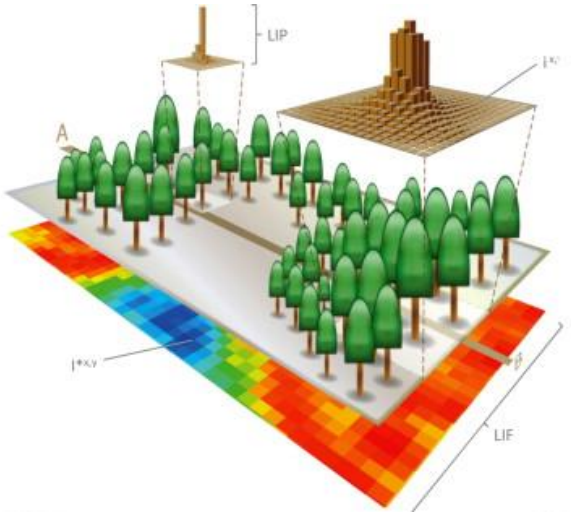
of trees in a stand





iLand

= individual-based distance-dependent forest landscape and disturbance model



https://iland-model.org, developed by Rupert Seidl and Werner Rammer at BOKU Vienna, now at TU Münich

Process-based model of the primary demographic processes in forest ecosystems, i.e. growth, mortality, and regeneration of trees.

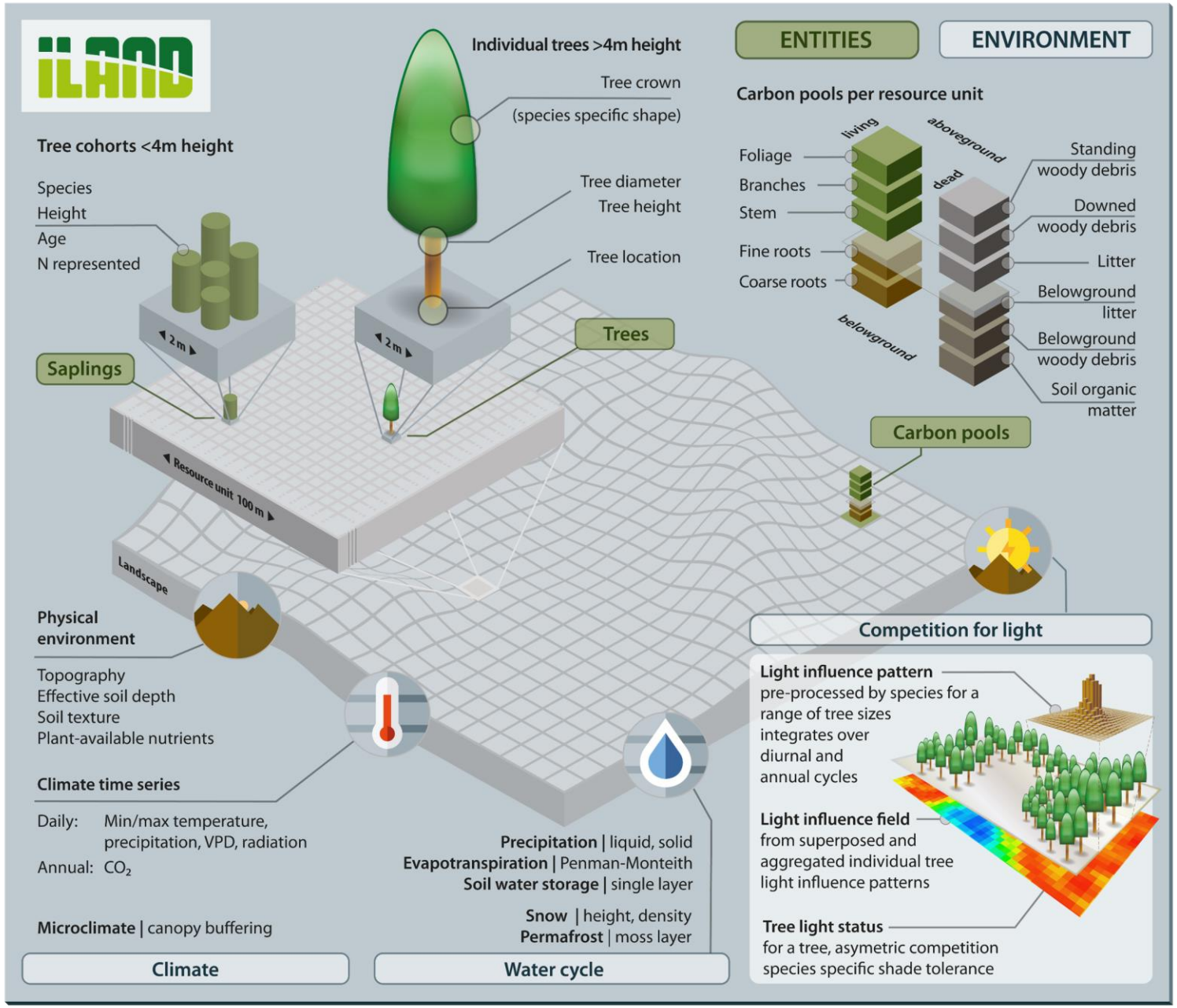
Seed dispersal: spatially explicit, determines tree regeneration and species distribution.

Productivity: is derived at stand-level light-use efficiency approach, and downscaled to individuals via local light availability

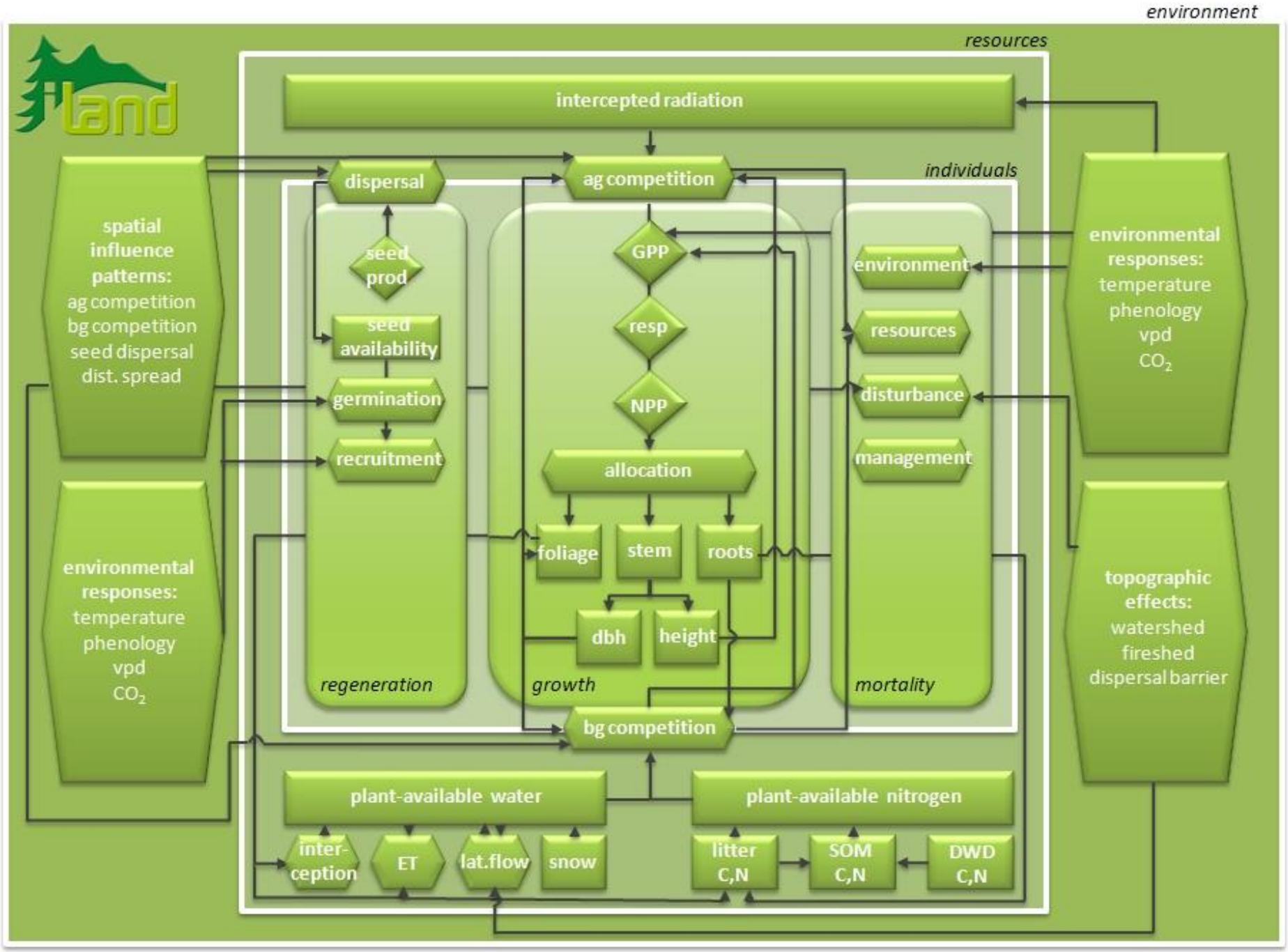
Individual tree mortality: based on carbon starvation, while spatially explicit modules of disturbance agents (wind, bark beetles, wildfire) can be used to simulate large-scale mortality events

Agent-based model of forest management: dynamically address the interactions between forests and managers as coupled human and natural systems.

iLand

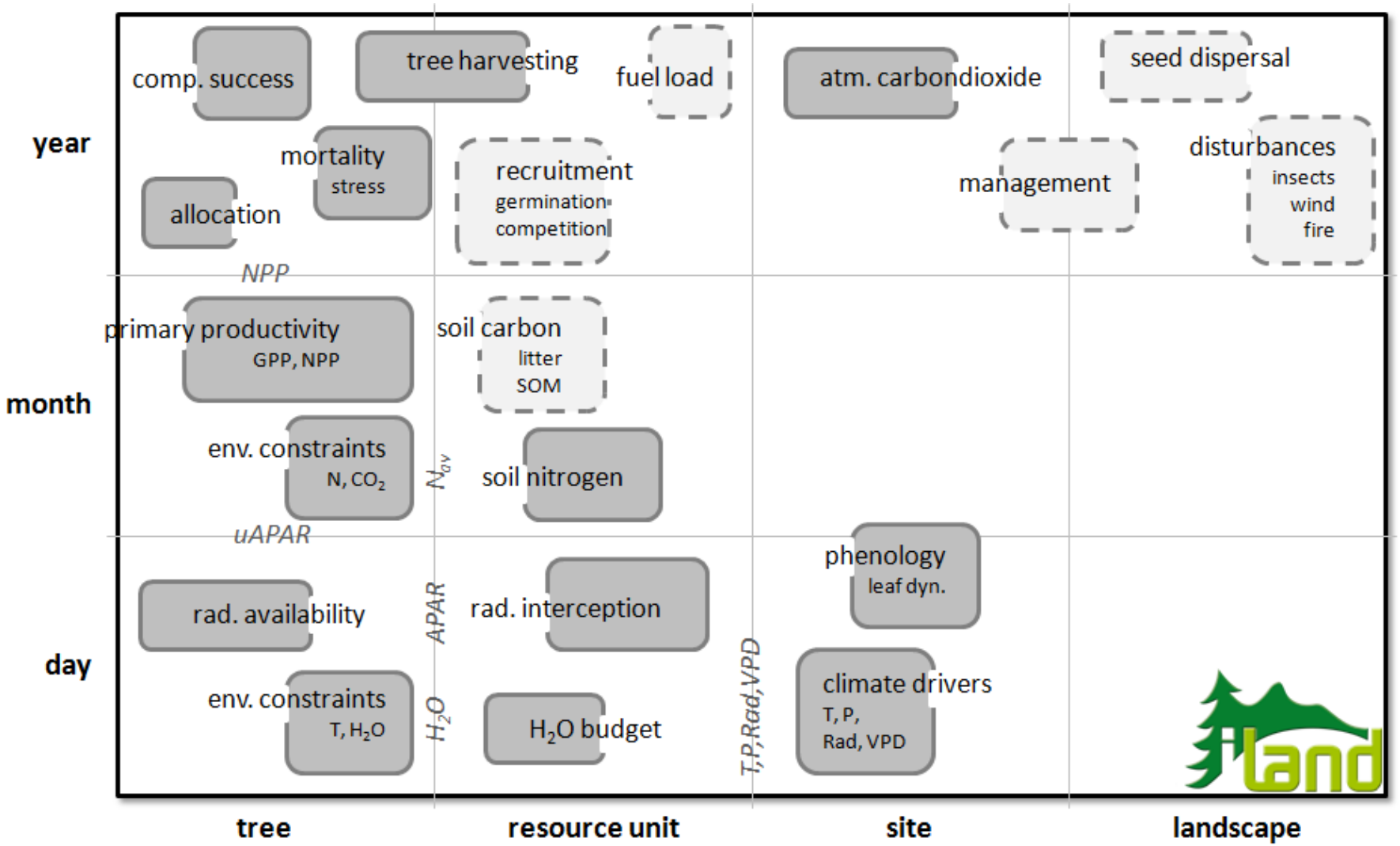


https://iland-model.org/iland-book/intro.html


environment
resources
intercepted radiation
individuals
dispersal
ag competition
spatial influence patterns: ag competition bg competition seed dispersal dist. spread
seed prod
seed availability
germination
recruitment
GPP
resp
NPP
allocation
foliage
stem
roots
dbh
height
environment
resources
disturbance
management
environmental responses: temperature phenology vpd CO_2
regeneration
growth
mortality
bg competition
plant-available water
plant-available nitrogen
inter-ception
ET
lat.flow
snow
litter C,N
SOM C,N
DWD C,N
topographic effects: watershed fireshed dispersal barrier

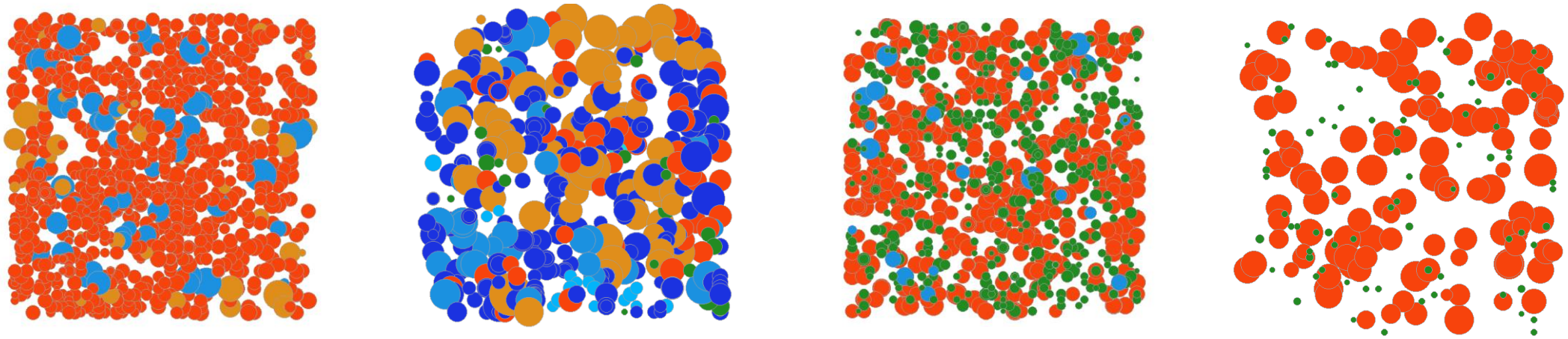
iLand


Ecosystem complexity
STRUCTURAL
SPATIAL
FUNCTIONAL
iland


year
month
day
comp. success
tree harvesting
fuel load
atm. carbondioxide
seed dispersal
mortality
stress
recruitment
germination
competition
management
disturbances
insects
wind
fire
allocation
NPP
primary productivity
GPP, NPP
soil carbon
litter
SOM
env. constraints
N, CO2
soil nitrogen
uAPAR
phenology
leaf dyn.
rad. availability
APAR
rad. interception
env. constraints
T, H2O
H2O
H2O budget
T,P,Rad,VPD
climate drivers
T, P,
Rad, VPD
iland
tree
resource unit
site
landscape

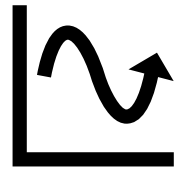
Exercise

We will use iLand in „stand-mode”, and simulate a 1 ha areas that are representative for our plots.



What do we want to find out?

- How will our plots depelop in the future?



- How can different climatic conditions affect the development?

iLand can simulate forest development driven by different environmental conditions.

Our application

- Simulate the development of our research plots at a stand scale driven by **reference climatic conditions** and some **climate change scenarios**

- Input data
  - Daily climate
  - Tree (positions, species, dbh, height)
  - Soil (depth, sand, silt clay %)

- Outputs
  - Tree (e.g. positions, dbh, height)
  - Landscape (e.g. mean dbh per species, carbon, volume, basal area)

- To run the model we need a **project file (xml)** with all the settings

Project_file_plot1.xml - Notepad

File Edit Format View Help

PROJECT FILE

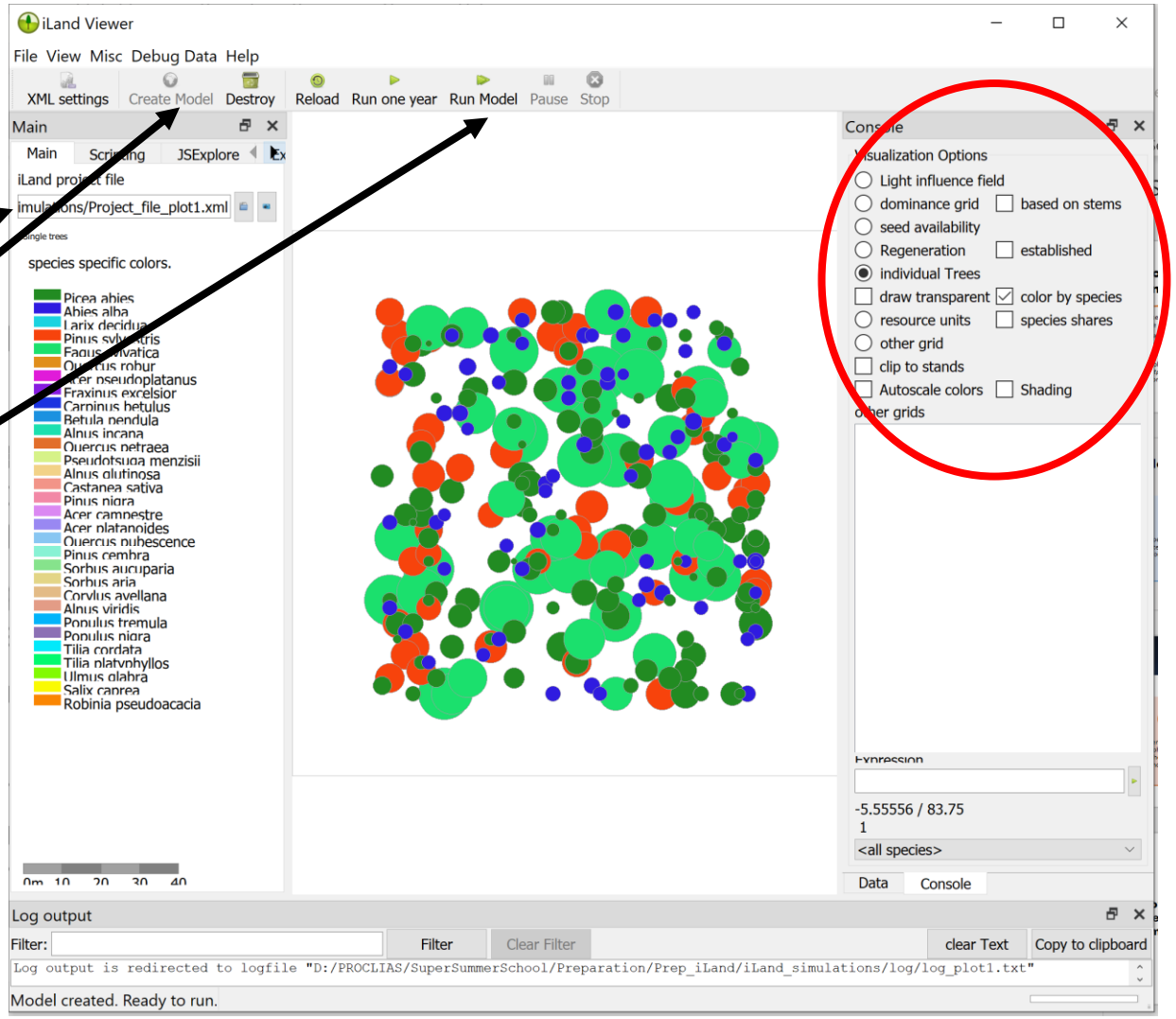
```
<?xml version="1.0" encoding="utf-8"?>
<project>
  <system>
    <path>
      <home></home>
      <database>database</database>
      <lip>lip</lip>
      <temp>temp</temp>
      <script>scripts</script>
          <init>init</init>
          <output>output</output>
    </path>
    <database>
      <in>species_param_europe.sqlite</in> <!-- species parameters-->
      <out>Output_plot1.sqlite</out> <!-- _$date$ --> <!--test.sqlite-->
      <climate>E-OBSv27_Roznik_46.05_14.45_1961-1990.sqlite</climate>
    </database>
        <logging>
                <logTarget>file</logTarget> <!-- console | file -->
                <logFile>log/log_plot1.txt</logFile>
                <flush>false</flush> <!-- setting to true forces debug output to be written immediately (can help for debugging) -->
        </logging>
    <settings>
      <!-- multithreading: either "true" or "false" default: false -->
      <multithreading>false</multithreading>
      <debugOutput>32</debugOutput>  <!-- 1=Tree NPP, 2=Tree partition, 4=tree growth, 8=Standlevel NPP, 16=Water Cycle, 32=Daily responses,
      <debugOutputAutoSave>true</debugOutputAutoSave>
          <randomSeed>0</randomSeed>
          <expressionLinearizationEnabled>true</expressionLinearizationEnabled>
          <logLevel>Warning</logLevel>
          <responsive>false</responsive>
          <threadCount>-1</threadCount>
    </settings>
        <javascript>
                <fileName></fileName> <!-- for instance, extra.js -->
        </javascript>

  </system>
  <model>
    <settings>
          <regenerationEnabled>true</regenerationEnabled> <!-- normally true -->
      <mortalityEnabled>true</mortalityEnabled> <!-- normally true -->
```

Output file name

Climate file name

How to do the simulations?

- Open the graphical interface of the model with *iland.exe*
- *Load a project file* for one simulation (Project_file_Plot1.xml)
- Click *Create Model*
- *Run Model* for xx years
- Look for the ouput file in the *output* folder (Sqlite file with more tables)



Output_plot1.sqlite

DB Browser for SQLite - D:\PROCLIAS\SuperSummerSchool\Preparation\Prep_iLand\iLand_simulations\output\Output_plot1.sqlite

File Edit View Tools Help

New Database | Open Database | Write Changes | Revert Changes | Open Project | Save Project | Attach Database | Close Database

Database Structure | Browse Data | Edit Pragmas | Execute SQL

Table: landscape

Filter in any column

	year	area	area_100m	species	count_ha	dbh_avg_cm	height_avg_m	volume_m3	total_carbon_kg	gwl_m3	basal_area_m2	NPP_kg	NPPabove_kg	LAI	cohort_count_ha
1	0	1.0	1.0	abal	68	12.554560415885	10.0436482569751	4.33641000540516	2264.48979038	4.33641000540516	0....	0.0	0.0	0....	0
2	0	1.0	1.0	fasy	50	49.864955329895	28.3370248603821	136.895786736017	49667.4525077343	136.895786736017	10.2322163021207	0.0	0.0	0....	0
3	0	1.0	1.0	piab	120	32.7314120928446	22.0071268777053	150.34004538132	45424.6412958801	150.34004538132	12.1157843437306	0.0	0.0	1.22598624296188	0
4	0	1.0	1.0	pisy	49	50.4504934038435	28.6669329818414	126.092303953767	42580.5644721985	126.092303953767	9.90102864865446	0.0	0.0	1.13237720794678	0
5	1	1.0	1.0	abal	68	14.1555026699515	11.3983616057564	6.12900960468063	2784.08857256174	6.12900960468063	1.0937619615478	1657.54244250883	1128.88810927563	0....	42
6	1	1.0	1.0	fasy	50	50.9348888778687	28.8361233901978	143.510490268561	53051.925757885	143.510490268561	10.6257775328906	9855.39246924801	6472.19863719711	0....	56
7	1	1.0	1.0	piab	117	33.9730940068889	22.7598254313836	157.496421514961	48100.7181224823	161.756430351725	12.5362718173782	11308.240428309	7809.11432949471	1.27039540681839	94
8	1	1.0	1.0	pisy	47	51.5571628327065	29.17210031063	128.631433914964	44511.3182430267	133.239894554213	9.9215764308334	11370.0349761449	7553.81123629041	1.16703214874268	27
9	2	1.0	1.0	abal	67	15.2975761498978	12.3232297043302	7.6046884487447	3294.54248571396	7.71114617325755	1.25781581822126	1665.68090078571	1102.19070054637	0....	48

DB Browser for SQLite - D:\PROCLIAS\SuperSummerSchool\Preparation\Prep_iLand\iLand_simulations\output\Output_plot1.sqlite

File Edit View Tools Help

New Database | Open Database | Write Changes | Revert Changes | Open Project | Save Project | Attach Database | Close Database

Database Structure | Browse Data | Edit Pragmas | Execute SQL

Table: tree

Filter in any column

	year	ru	rid	species	id	x	y	dbh	height	basalArea	volume_m3	age	leafArea_m2	foliageMass	stemMass	branchMass	fineRootMass	coarseRoo
1	0	0	1	fasy	1	79.0	51.0	69.4511108398438	39.4673538208008	0....	6.47402213252733	493	322.750671386719	29.3409690856934	3099.62084960938	378.690856933594	22.0057258605957	337.26263
2	0	0	1	fasy	2	69.0	91.0	68.9508590698242	39.1830711364746	0....	6.33513119737595	489	318.808563232422	28.9825954437256	3049.60424804687	372.446533203125	21.736946105957	331.653472
3	0	0	1	fasy	3	59.0	83.0	68.4268112182617	38.8852729797363	0....	6.19178023242734	486	314.700347900391	28.6091213226318	2997.69287109375	365.968048095703	21.4568405151367	325.834838
4	0	0	1	piab	4	99.0	19.0	68.3690719604492	45.9682846069336	0....	7.13851564977475	492	295.848175048828	69.6113357543945	2192.06372070312	365.258178710937	52.2085037231445	526.403198
5	0	0	1	fasy	5	63.0	61.0	66.8702163696289	38.0006980895996	0....	5.77876201555075	475	302.627319335937	27.5115756988525	2846.41259765625	347.102661132813	20.6336822509766	308.896118
6	0	0	1	fasy	6	55.0	61.0	65.8000030517578	37.3925170898437	0....	5.50572234528479	467	294.439819335937	26.7672576904297	2744.92138671875	334.458526611328	20.0754432678223	297.547729
7	0	0	1	fasy	7	35.0	23.0	65.1091766357422	36.999942779541	0....	5.33412559057111	462	289.203948974609	26.2912693023682	2680.494140625	326.437286376953	19.7184524536133	290.350402
8	0	0	1	fasy	8	63.0	37.0	62.9601402282715	35.7786979675293	0....	4.82318236535268	447	273.164459228516	24.8331317901611	2485.4912109375	302.185607910156	18.624849319458	268.599304