Simulation of Ground Vegetation Diversity in Boreal Forests

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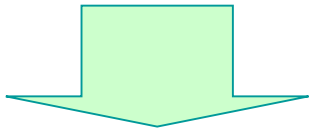
Dynamics of ecosystem and plant species diversity

- **abiotic parameters** (climatic, soil, water, etc.)
- **temporal parameters** of plant populations in different forest zones
- **spatial parameters** of the area and plant populations
- availability of **seed sources**



Forest Ecosystem Modelling

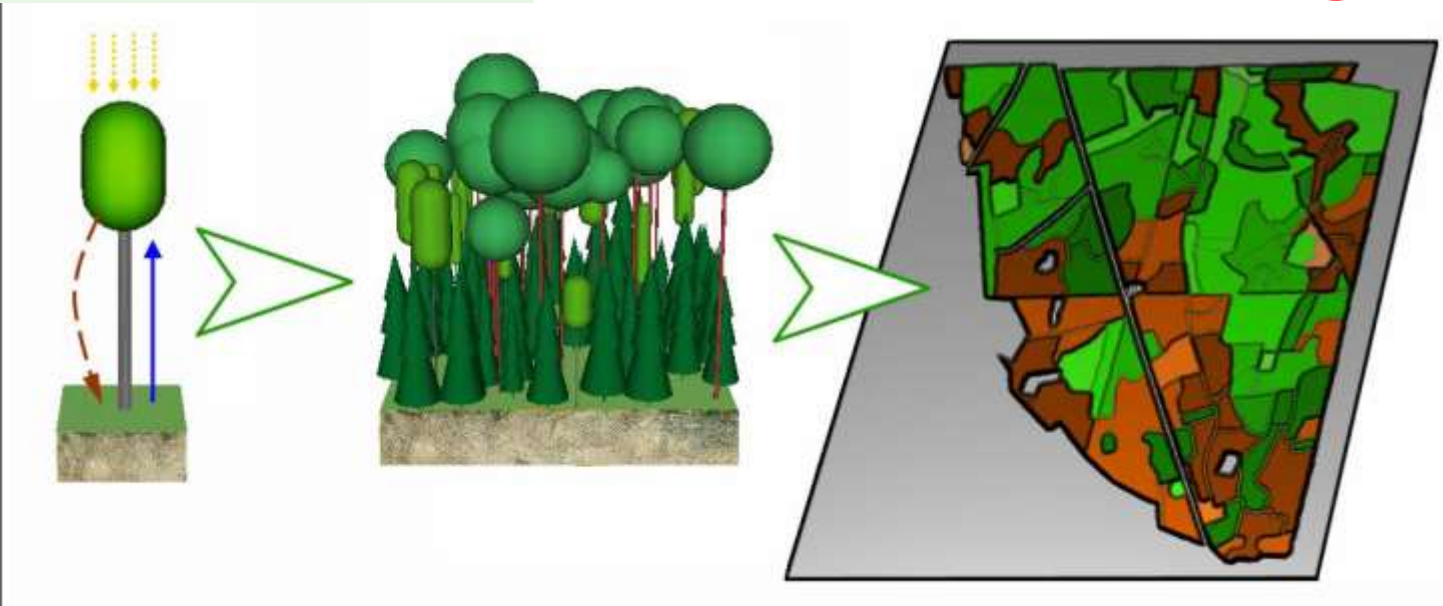
Forest ecosystem modelling

EFIMOD forest-soil model (Chertov et al., 1999, Komarov, et al., 2003)

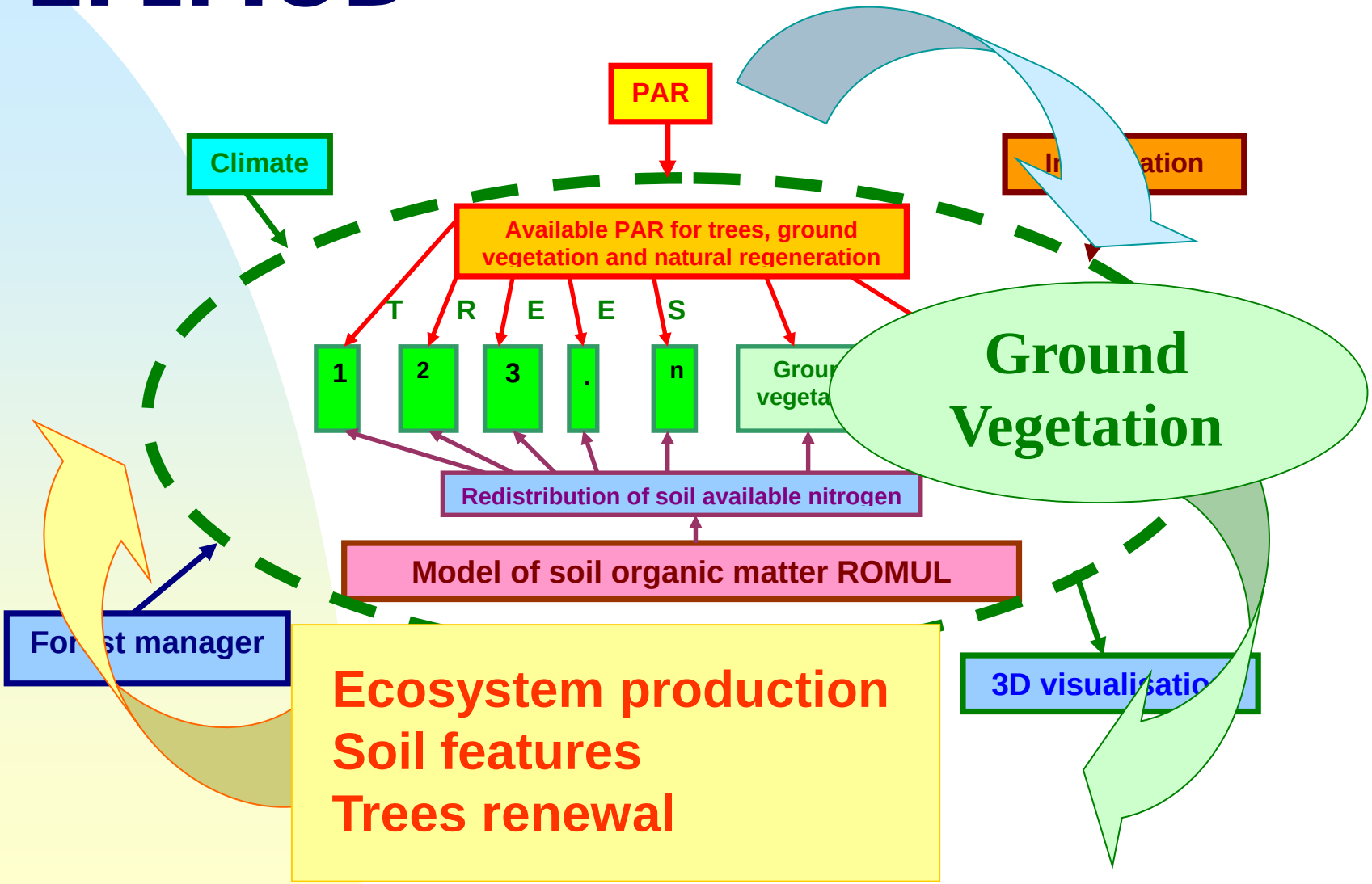
FORRUS forest model (Chumachenko et al., 2003)

Individual-based models

Different levels of forest modelling



EFIMOD


PAR
Climate
Available PAR for trees, ground vegetation and natural regeneration
T R E E S
1
2
3
.
n
Ground Vegetation
Redistribution of soil available nitrogen
Model of soil organic matter ROMUL
Forest manager
3D visualisation
Ecosystem production
Soil features
Trees renewal

The first step

to calculate dynamics of ground vegetation diversity at a level of forest stand on a base of

- State Forest Inventory Data
- Forest simulated results

Our approach

plant species functional groups in ground vegetation modelling

ecological-coenotic species groups

introduced in Nitsenko (1969)

derived from **multivariate analysis**

- species traits matrix
- community matrix
- matrix of environmental factors

Ecological-coenotic groups

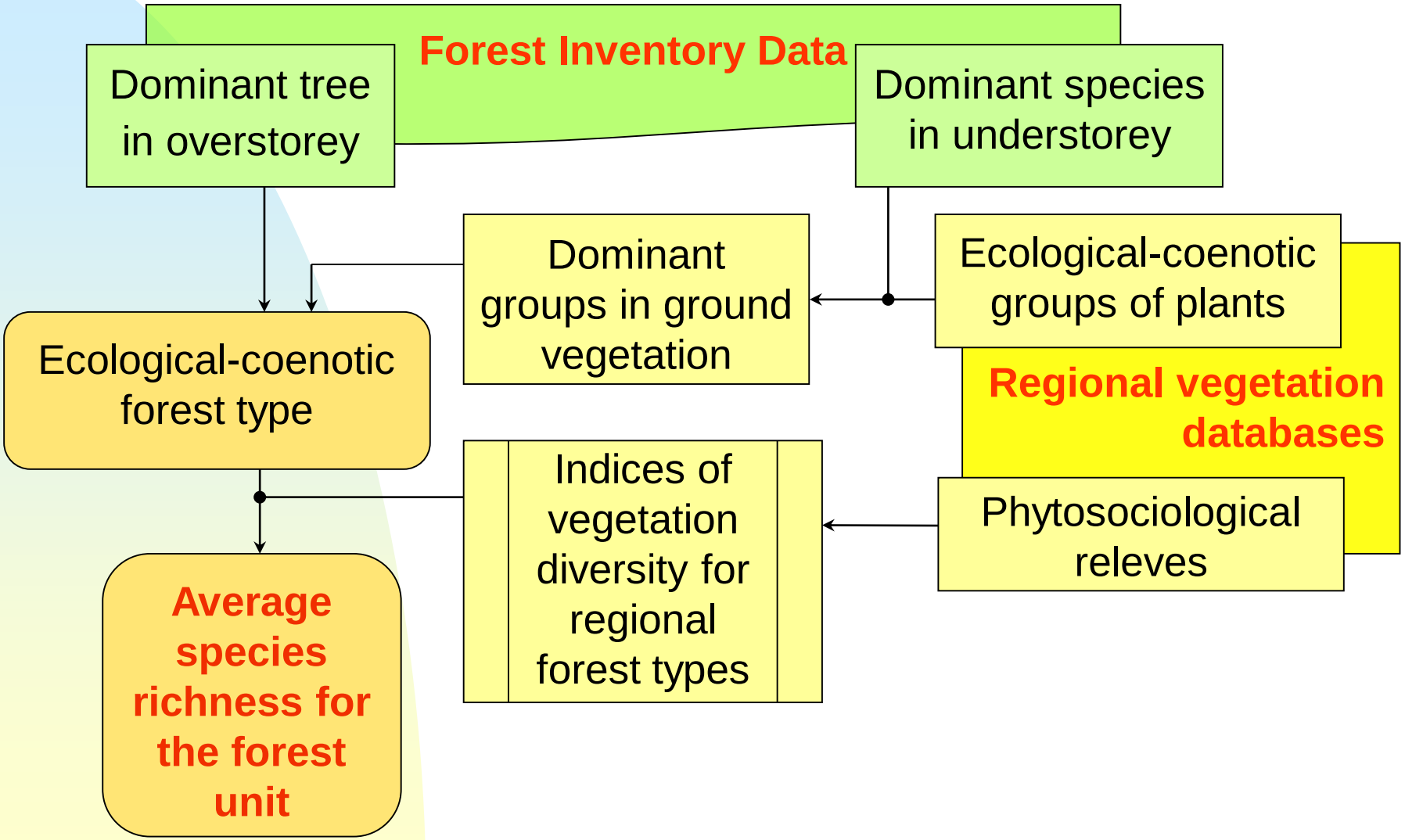
Nemoral Nm	species of broad-leaved and oak forests
Boreal Br	species of boreal spruce and spruce-fir forests
Piny Pn	species of pure pine forests
Nitrophilous Nt	species of flooded black alder forests
Meadow Md	species of meadows, steppes and forest edge
Water-marsh Wt	species of coastal and intrawater habitats, low bogs
Oligotrophic Olg	plants of oligotrophic bogs

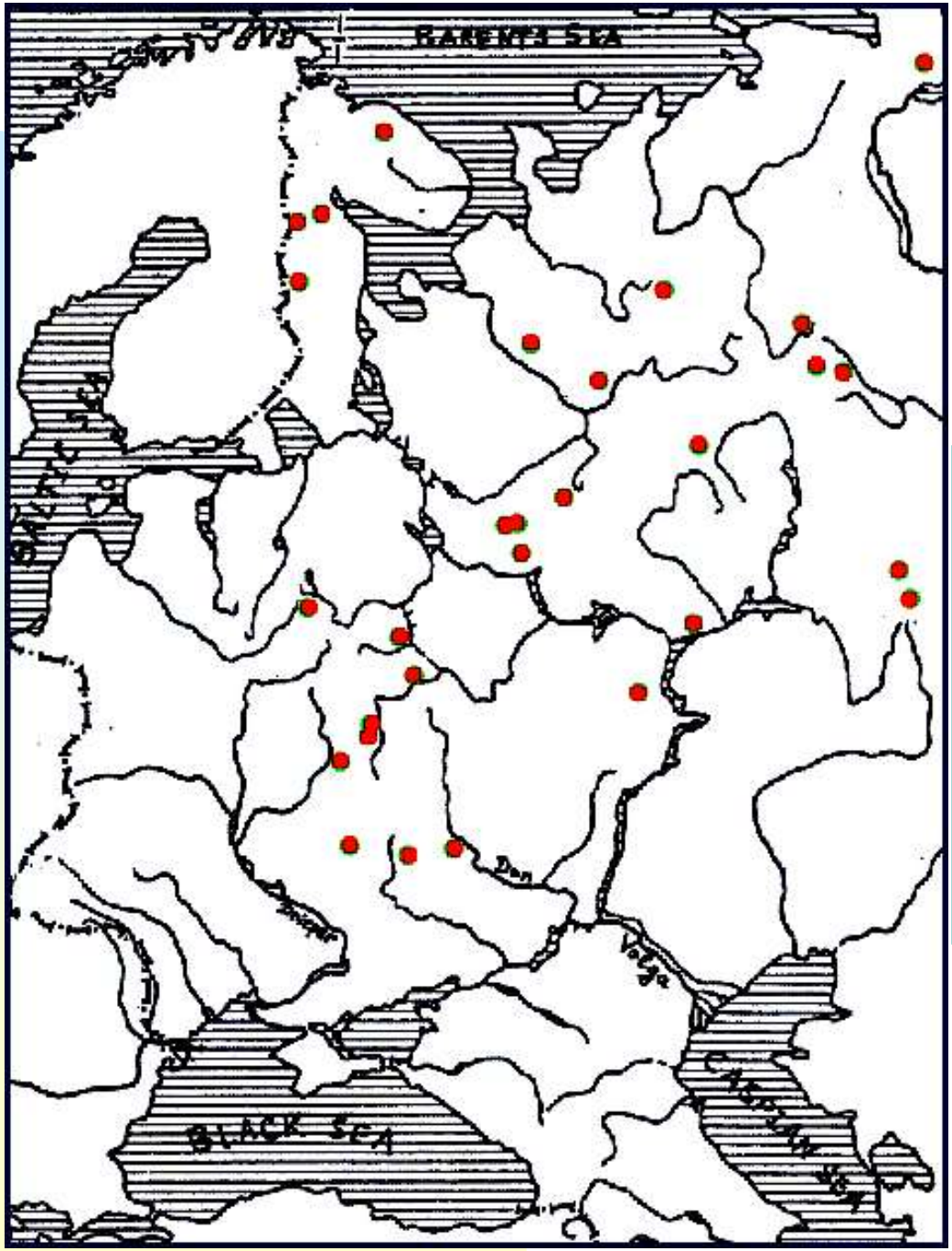
To use the groups for modelling dynamics of ground vegetation

- to define the dominant group at the initial step of simulation
- to define rules of the group switching according to dynamics of the simulated parameters

tree species composition,
light supply, deadwood, litter,
soil C and N pools etc.

At the initial step of simulation



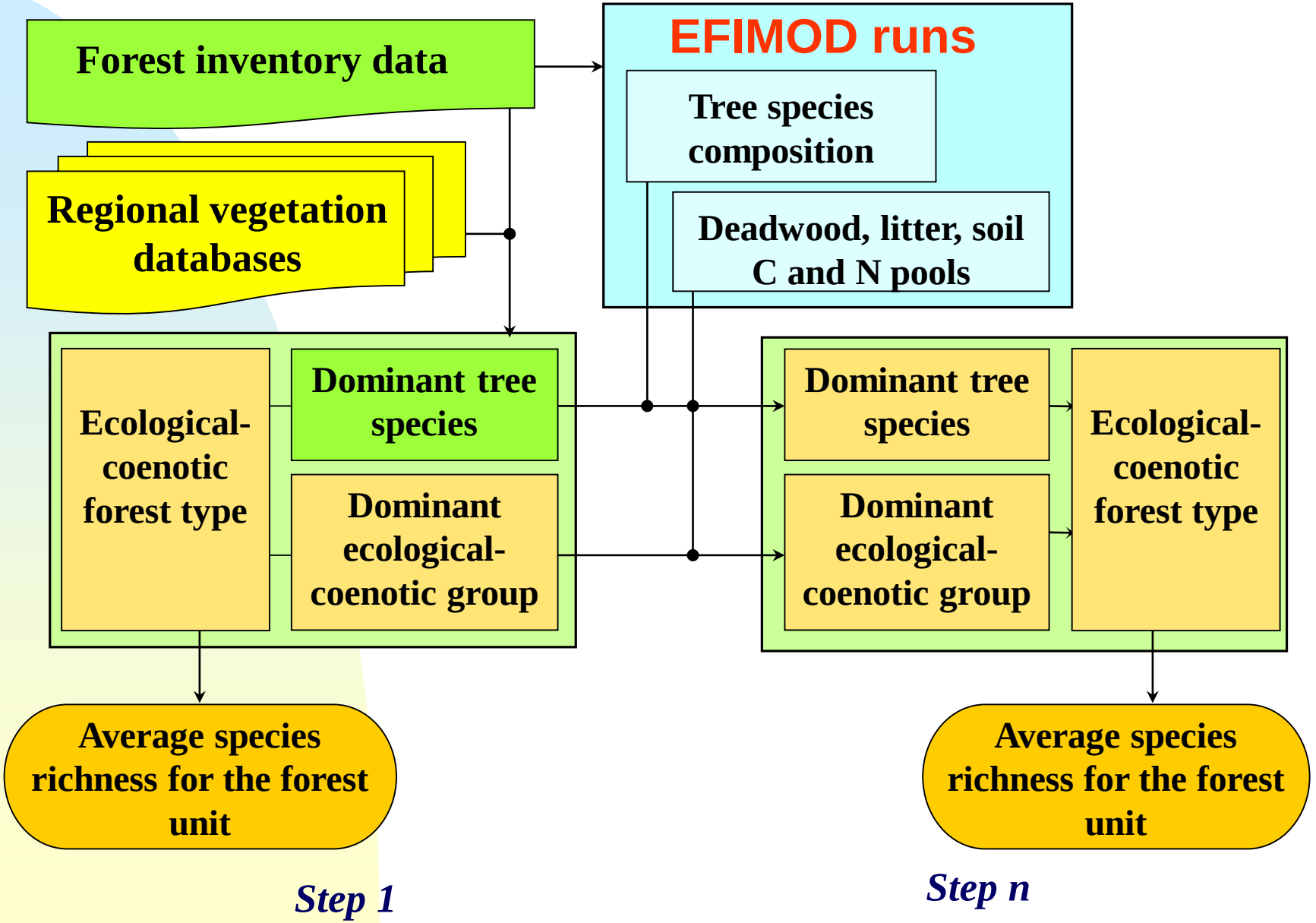


Datab**ase on**
11000 vegetation
sample plots
in ma**pped p**oints of
Euro**pean Russian**
fores**t**

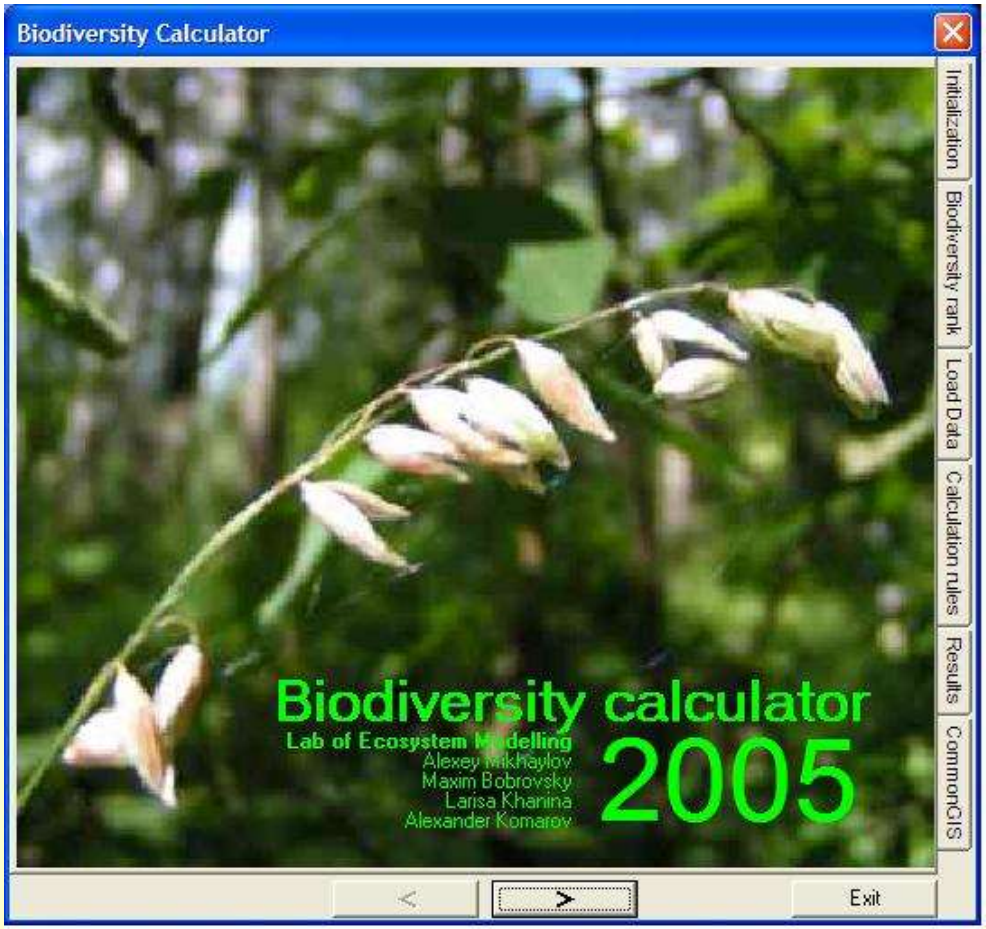
Regional vegetation databases

Phytosociological releves

Dynamics of ground vegetation diversity



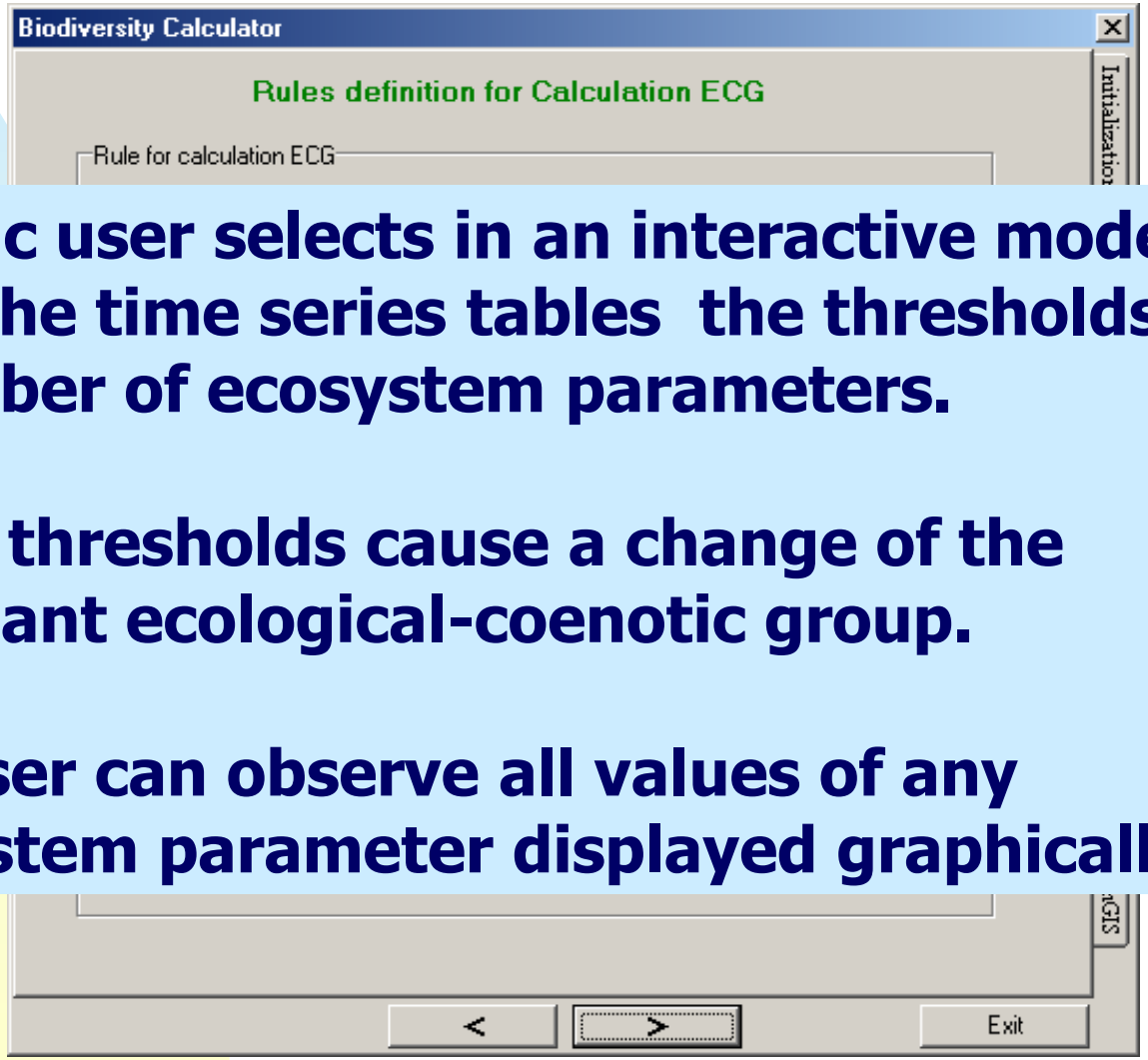
BioCalc - a software for dynamic analysis of forest ground vegetation diversity



BioCalc input data

- tables of probabilistic distribution of the groups in ground vegetation according to the tree dominant and the forest site class
- a correspondence tables between the forest types and ranks of plant species richness
- a time series table of forest stand ecosystem parameters (results of the EFIMOD runs)

Creation of rules for the switching the ecological-coenotic groups

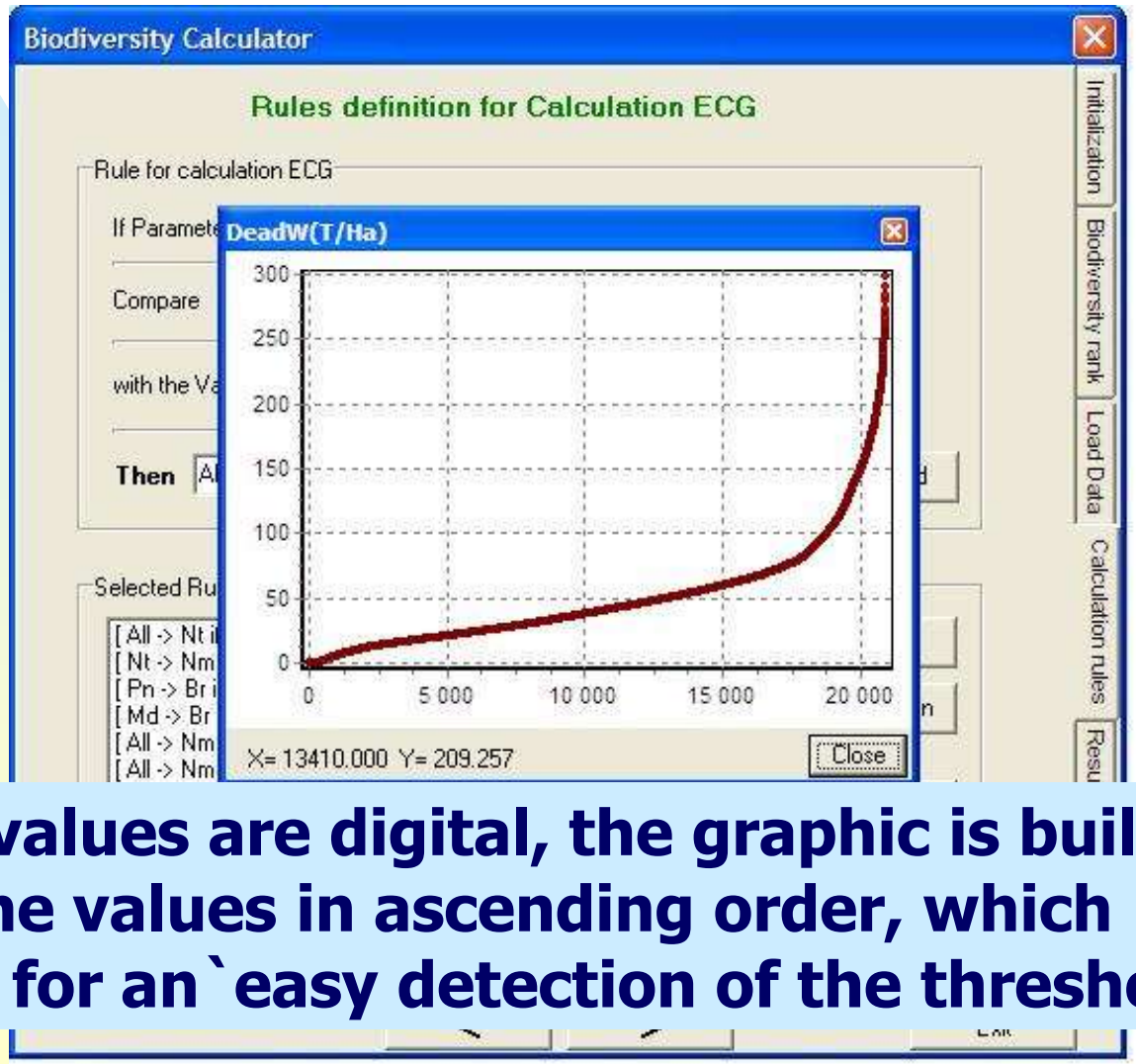


BioCalc user selects in an interactive mode from the time series tables the thresholds for a number of ecosystem parameters.

These thresholds cause a change of the dominant ecological-coenotic group.

The user can observe all values of any ecosystem parameter displayed graphically

Creation of rules for the switching the ecological-coenotic groups



If the values are digital, the graphic is built with the values in ascending order, which allows for an`easy detection of the thresholds

BioCalck outputs

Dynamics of

- ground vegetation functional groups,
- forest types, and
- ranks of species diversity

Transfer of the output results to the Common-GIS (Andrienko, Andrienko, 1999) for visual exploration of ground vegetation dynamics at the landscape level

A case study experimental forestry "Russkii Les" (Moscow region)

273 ha
104 units

Strategies of silvicultural regimes for 200 years time span

- natural development
- legal clear cutting
- selective cutting
- illegal clear cutting

Case study rules of functional group switching

(i) meadow group switched to boreal group when spruce began to dominate in overstorey

(ii) any group switched to nemoral when oak and lime began to dominate in overstorey

(iii) piny group switched to boreal group when deadwood overpassed the 1st threshold value

(iv) any group switched to nitrophilous group when deadwood overpassed the second threshold value, and

(v) nitrophilous group switched to nemoral group when deadwood fell below the 2nd threshold value

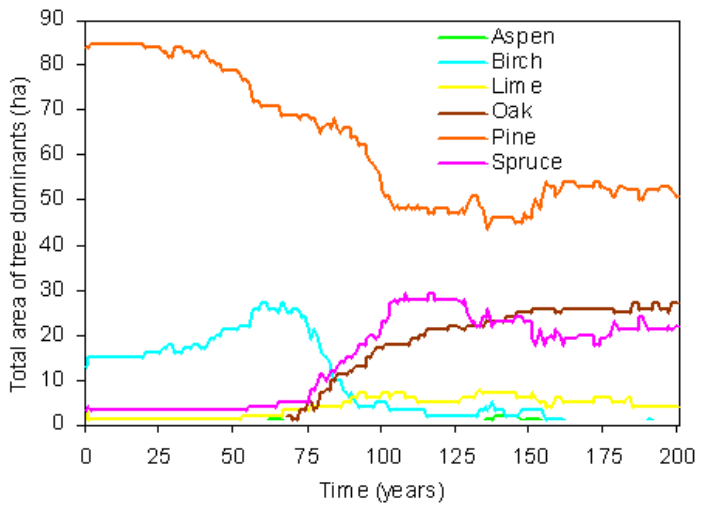
Case study rules of functional group switching

In the scenarios with clear cuttings:

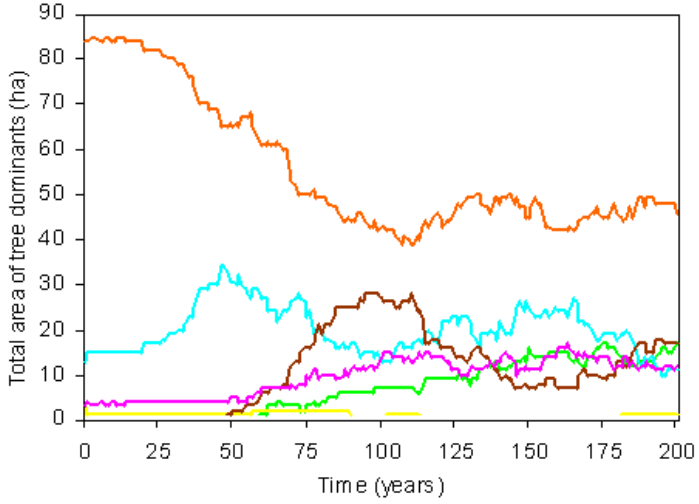
after the clear cutting, a dominant group was taken from a specially designed probabilistic table of the group distribution in ground vegetation designed for the after-clear-cutting conditions

Tree dominant dynamics

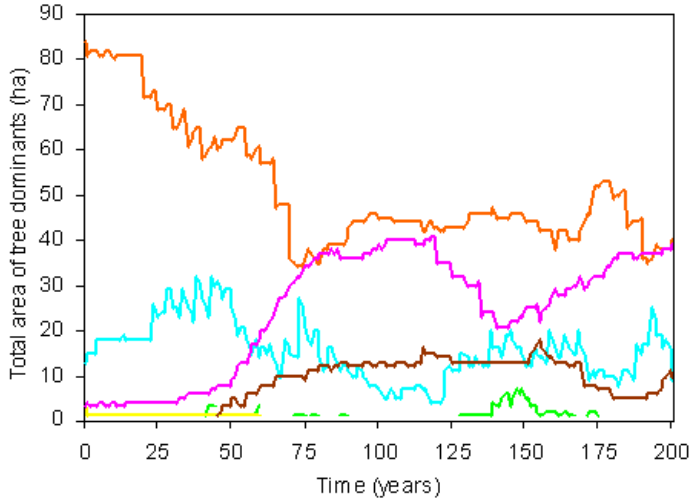
Natural development



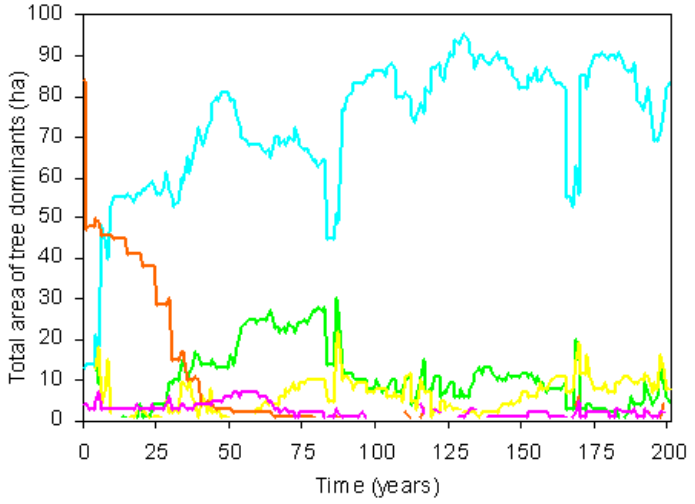
Selective cuttings



Legal clear cuttings

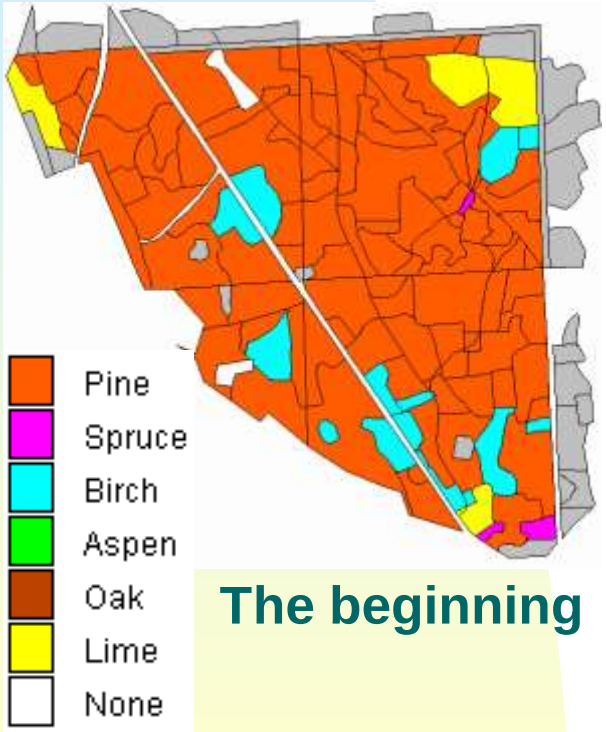


Illegal clear cuttings

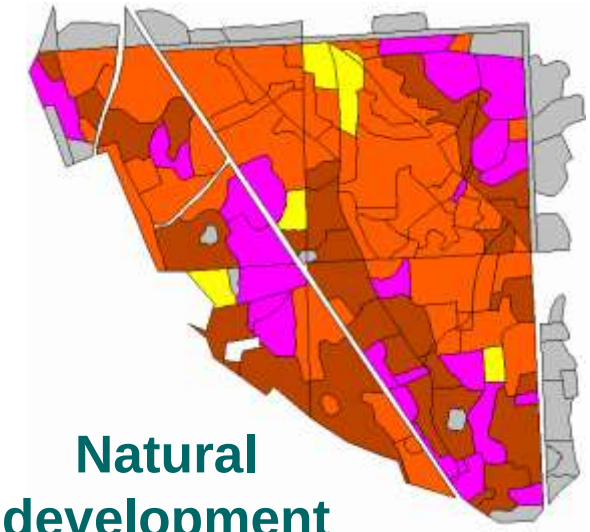


Tree dominant dynamics

200-year dynamics

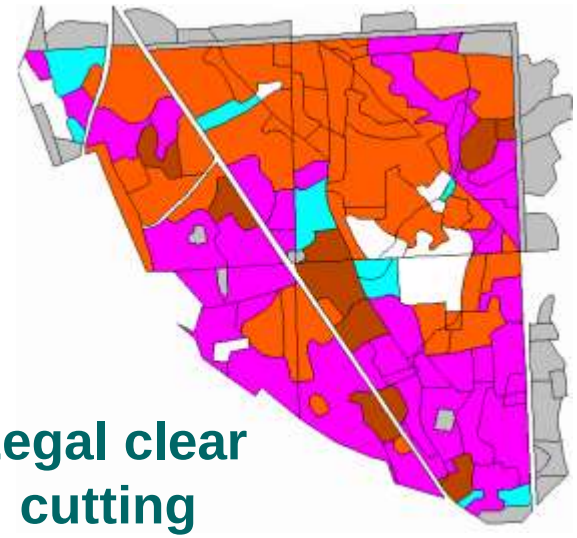


The beginning



Natural development

Legal selective cutting



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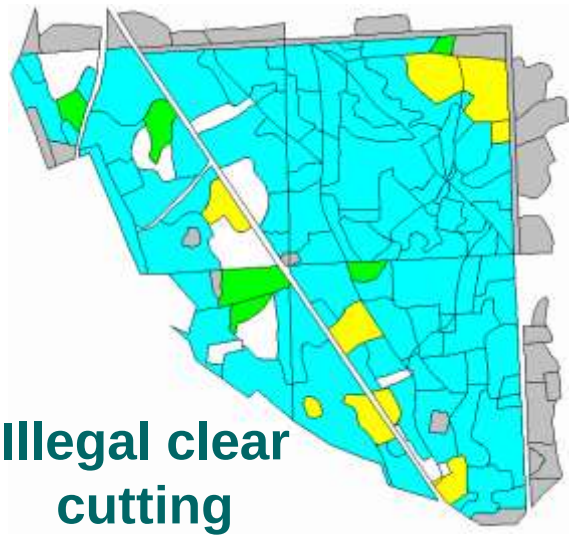
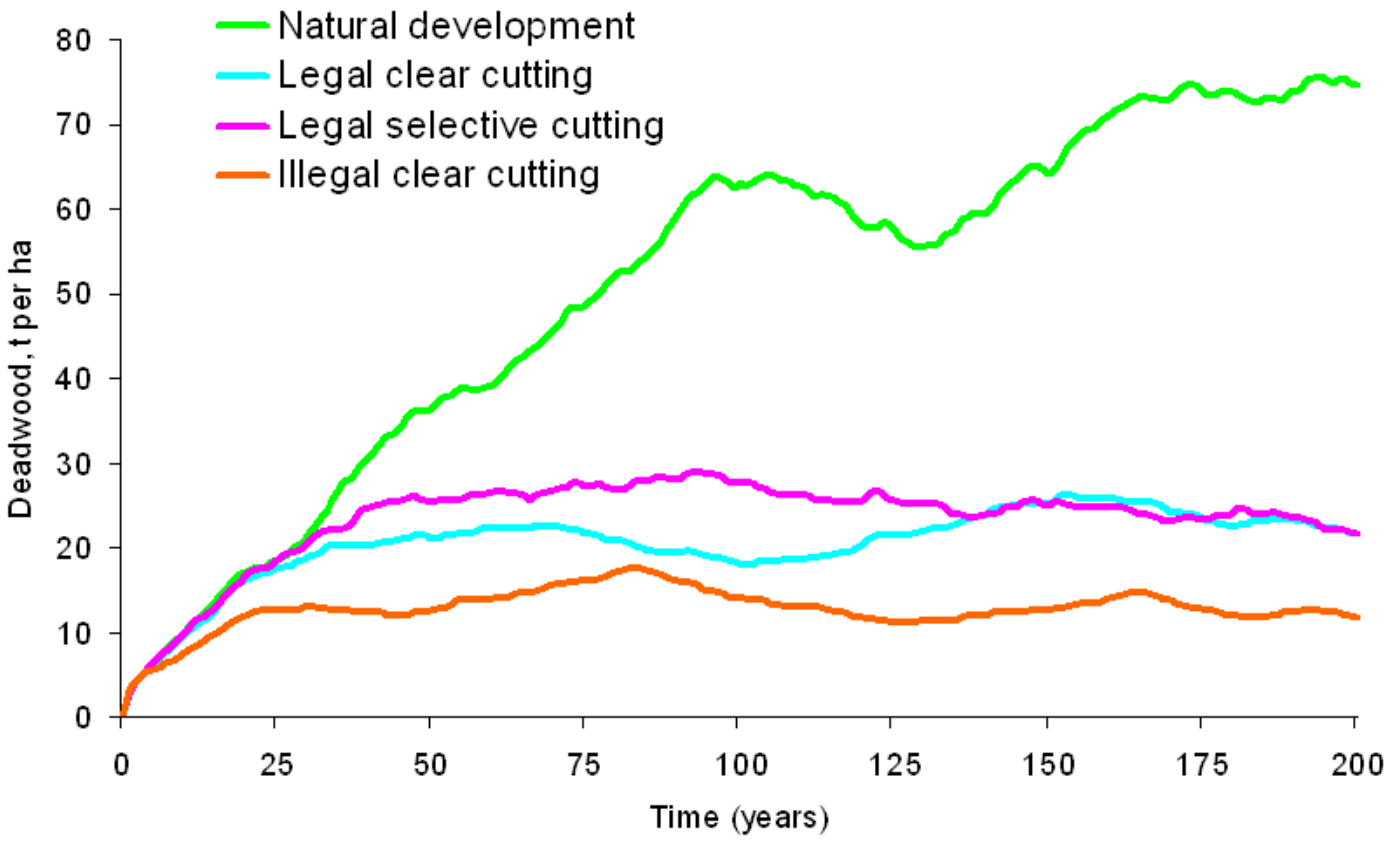


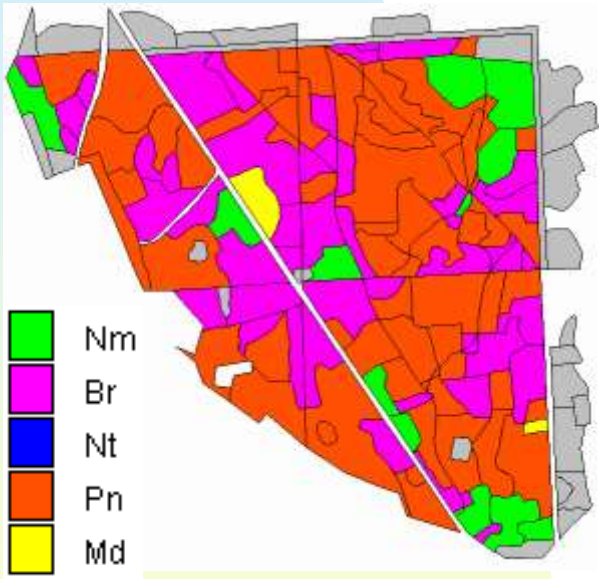
Illegal clear cutting

Deadwood dynamics



Functional group dynamics

200-year dynamics



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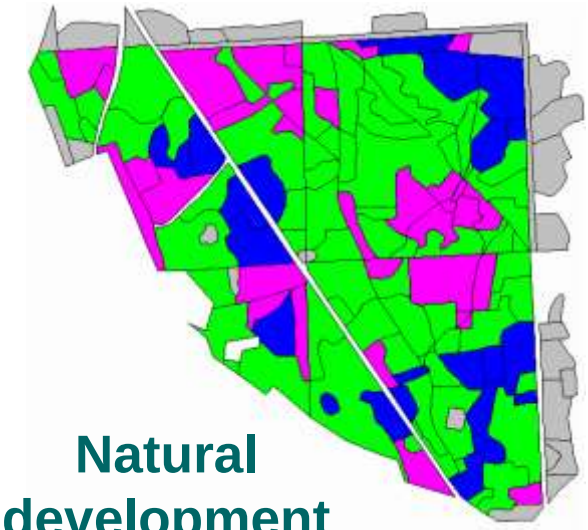
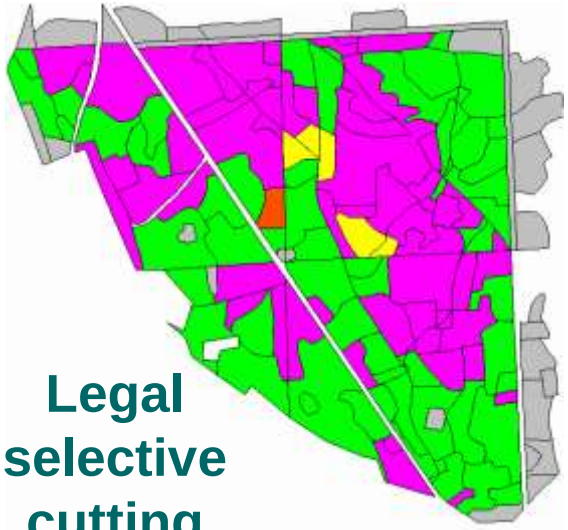
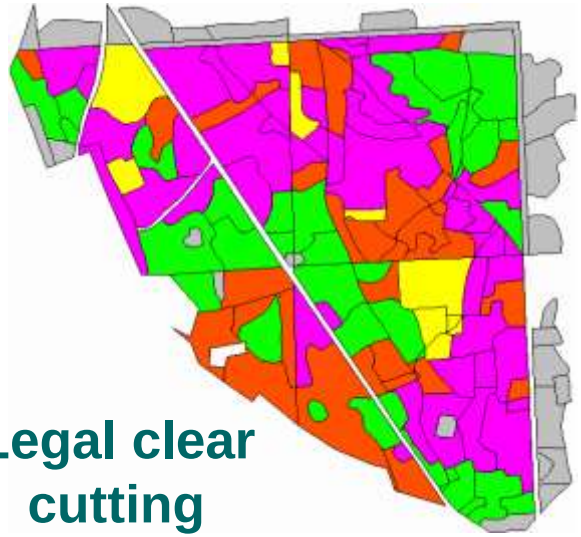


Natural development



Legal selective cutting



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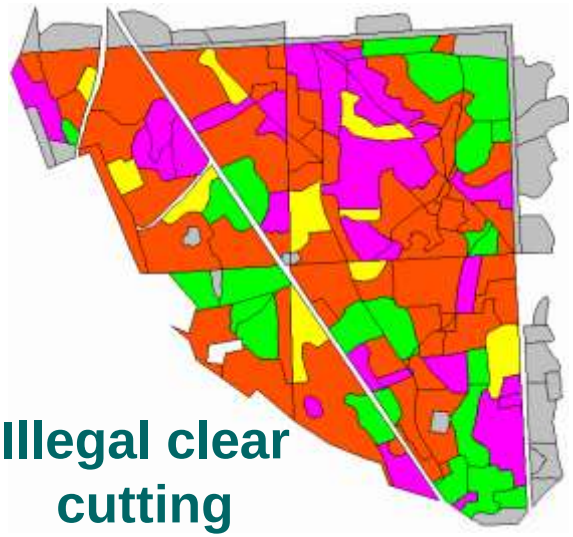
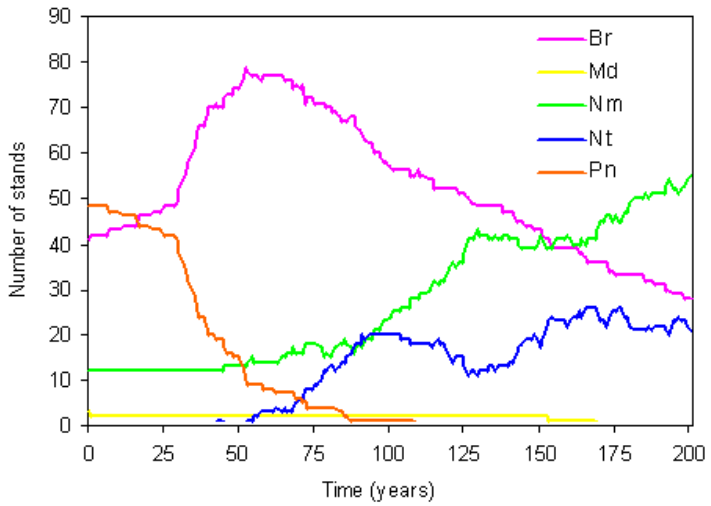


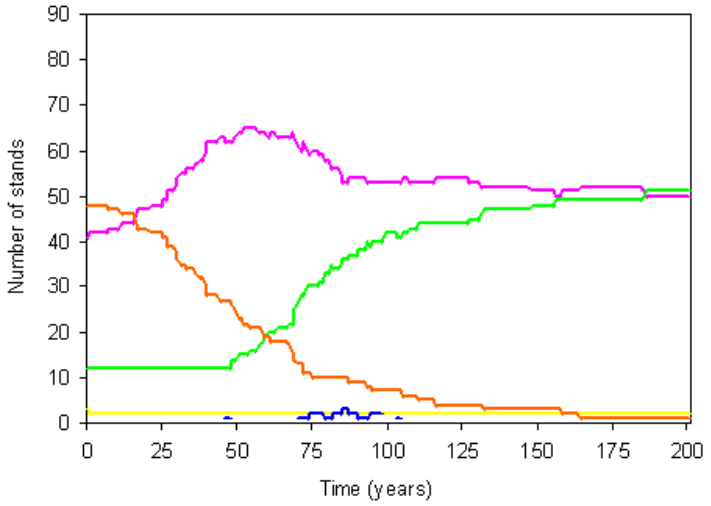
Illegal clear cutting

Functional group dynamics

Natural development



Legal selective cuttings



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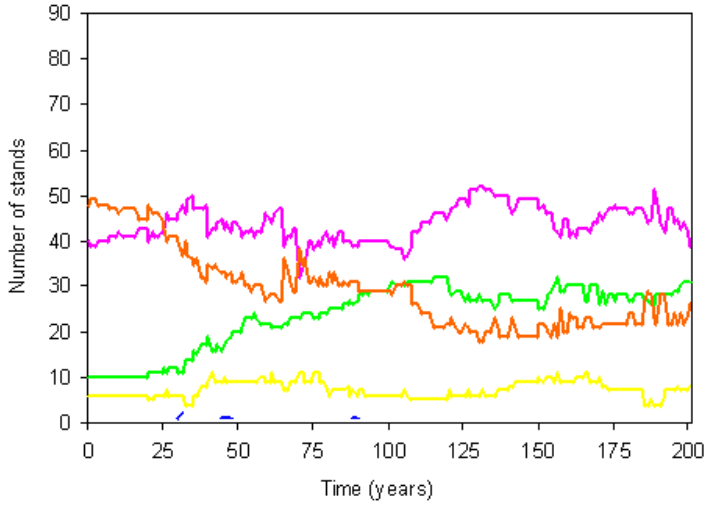

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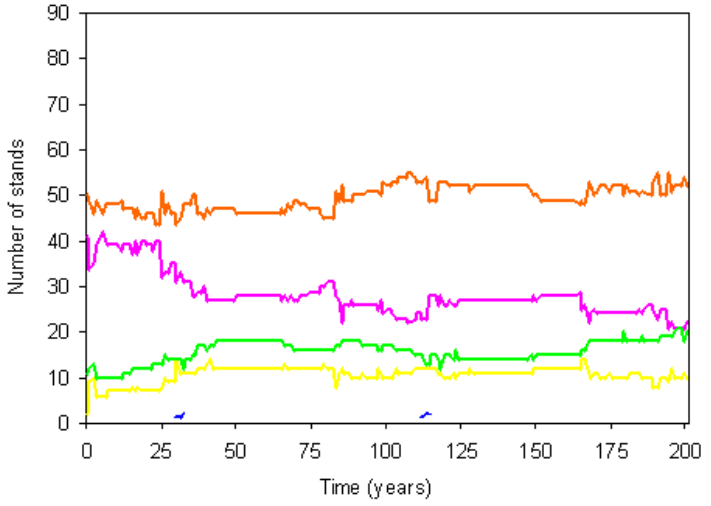
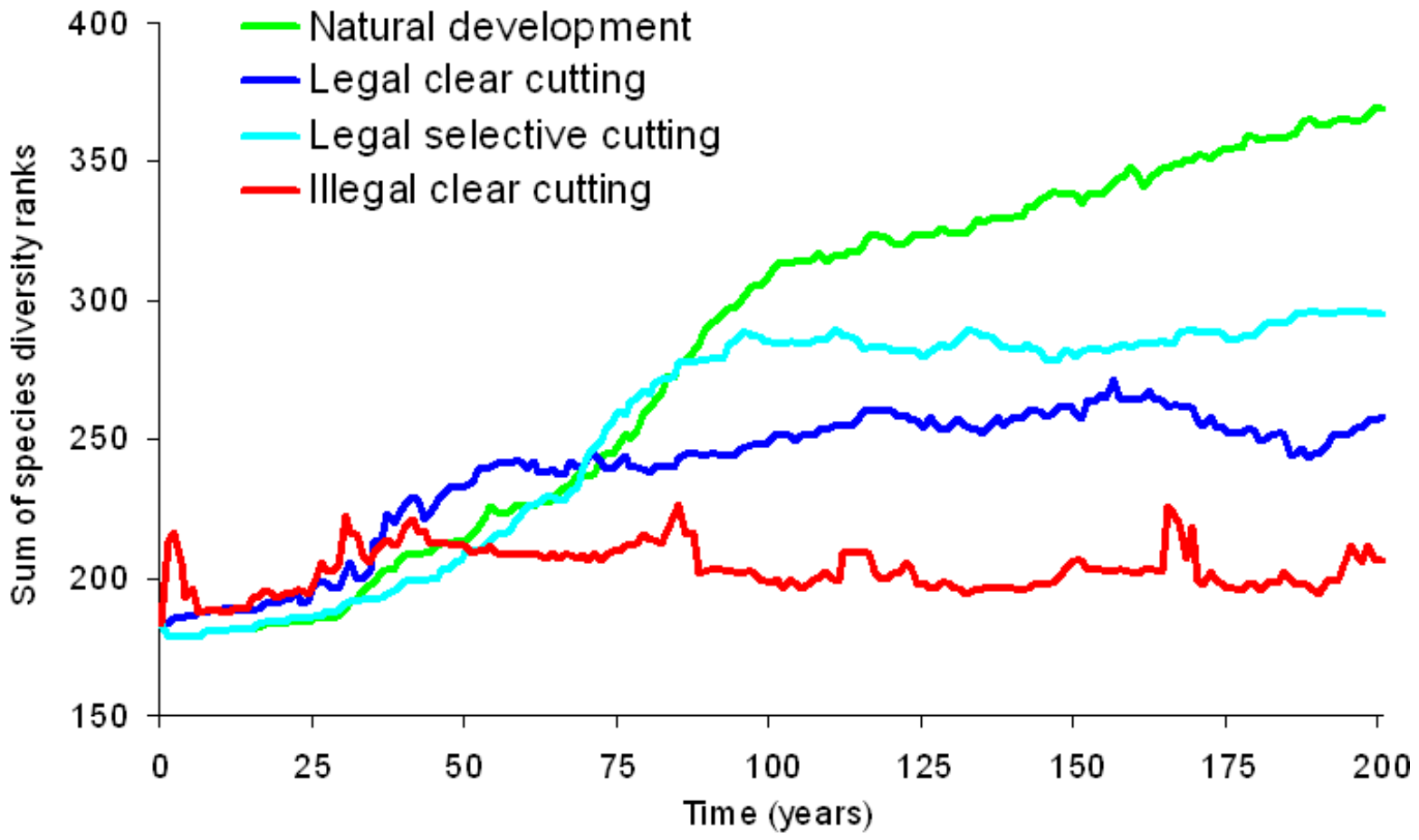
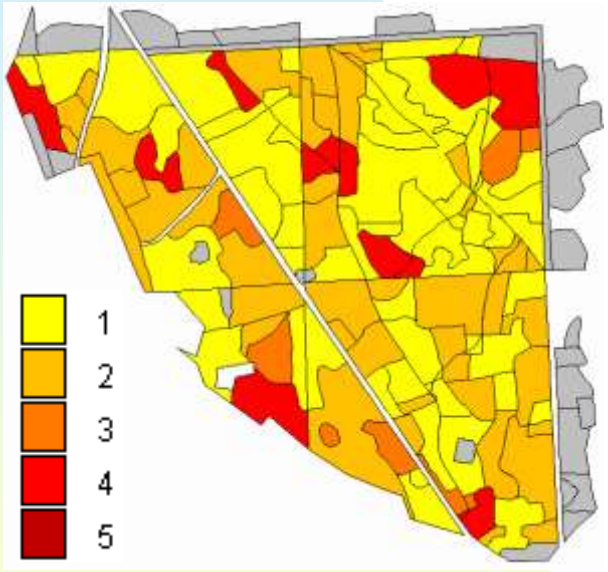


Species diversity dynamics



Species diversity dynamics

200-year dynamics



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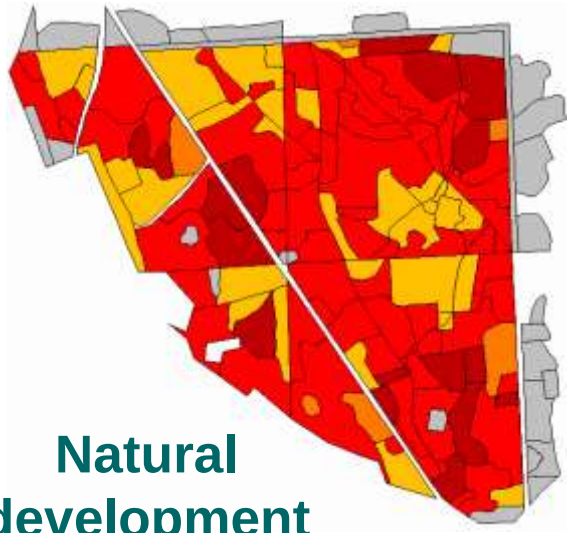
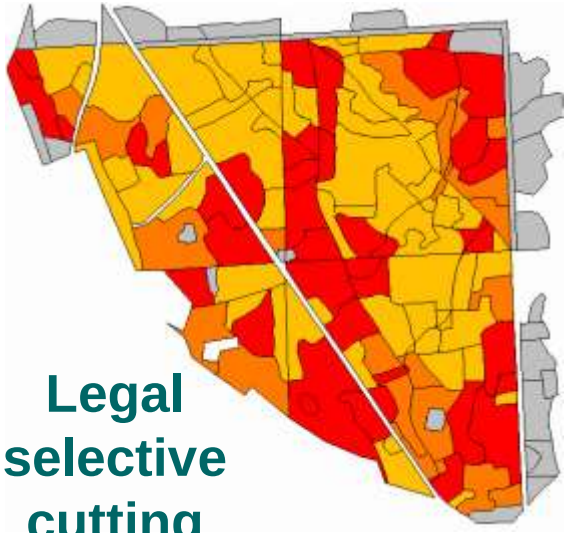
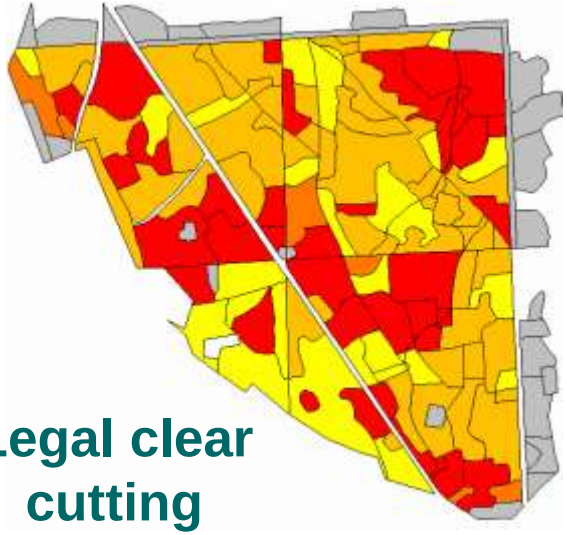


Natural development



Legal selective cutting



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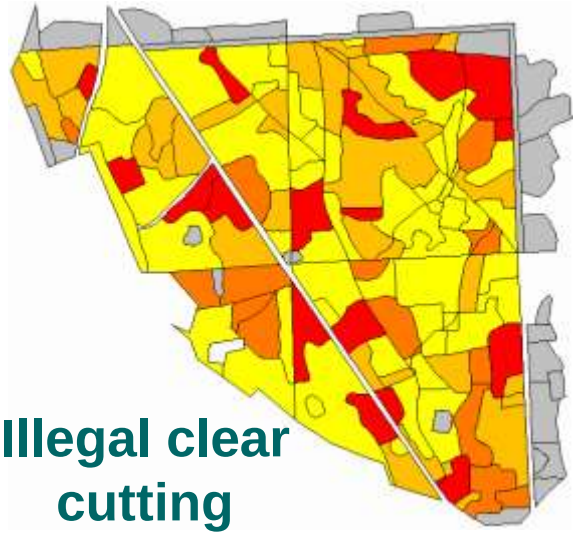
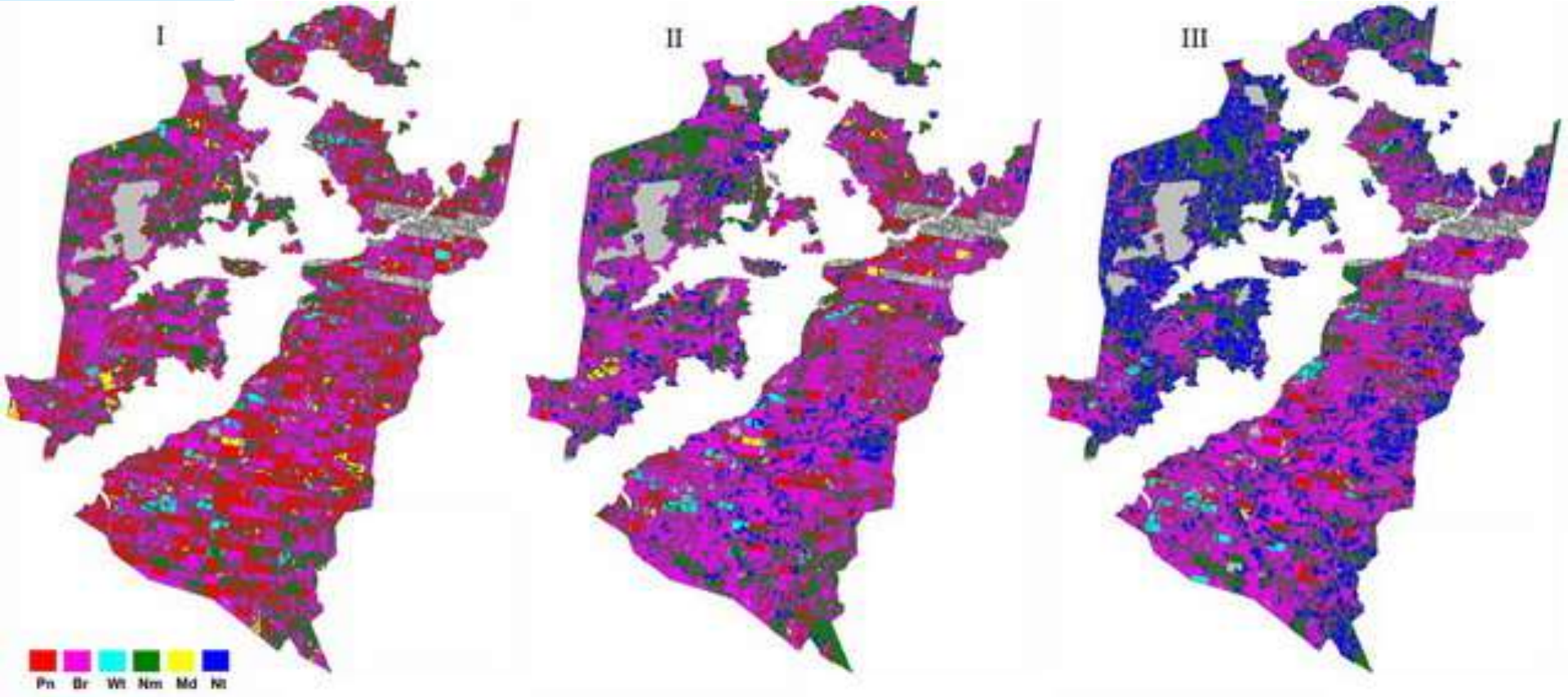


Illegal clear cutting

Regional level: Manturovsky forestry (Kostroma region), 120 000 ha, 3430 units



50-year dynamics

I initial state, II legal clear-cutting, III natural development

Conclusion

The functional group approach was elaborated and tested for modelling the dynamics of forest ground vegetation diversity.

The modelling results showed that cuttings support a higher ecosystem diversity of the area in comparison to the free forest development.

However, the protective strategy leads to the higher species diversity in ground vegetation, if a free forest development has taken place for rather long time, e.g. more than 100 years in our study area.

EFIMOD parameters for ground vegetation dynamics

used	tree composition deadwood
in progress	C and N soil pools
in plan	light soil moisture

Thank you for your attention!