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## Simulation der ökonomischen und ökologischen Entwicklungen bei verschiedenen waldbaulichen Eingriffen

Daniel Kraus, Benoit Courbaud, François de Coligny, Laurent Larrieu,  
Anthony Letord, Andreas Schuck

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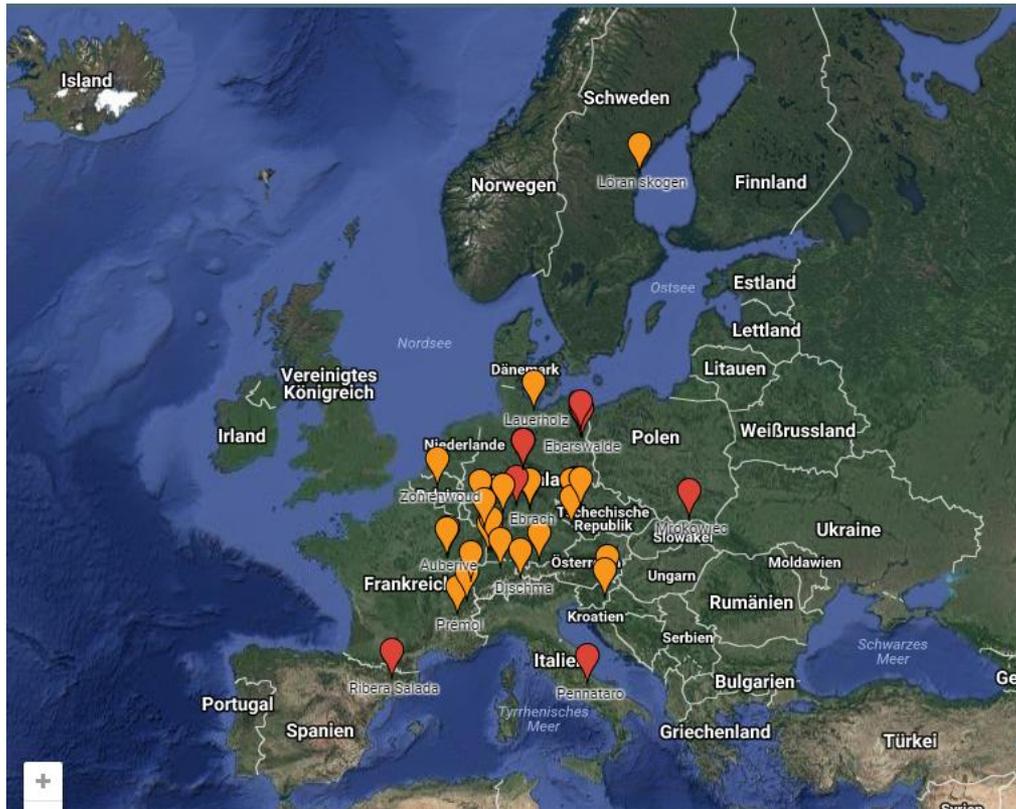
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# Simulation der ökonomischen und ökologischen Entwicklungen bei verschiedenen waldbaulichen Eingriffen

D. Kraus, B. Courbaud, F. de Coligny, L. Larrieu, A. Letort, A Schuck



**“Establishing a European network of demonstration sites for the integration of biodiversity conservation into forest management (Integrate+)”**



**2013-2016, gefördert vom  
BMEL**

**Etablierung eines europäischen  
Netzwerks von Demonstrations-  
und Schulungsflächen**

**Entwicklung einer mobilen  
Software**

**Durchführung von Waldbau-  
Training**

**Kooperation mit Netzwerk-  
partnern aus Wissenschaft und  
Praxis**

**Aufbau und Förderung  
internat. Erfahrungsaustauschs**

# Waldbautraining



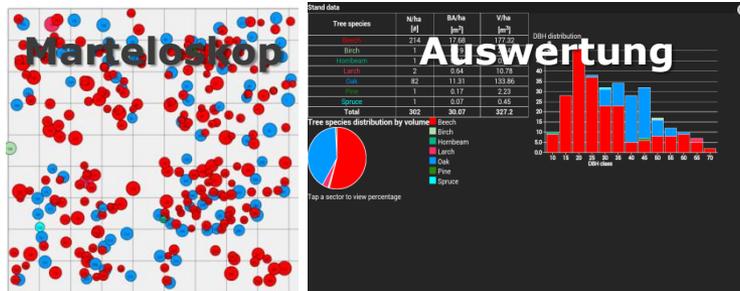
**Marteloskop Steinkreuz**

Name: Lukas Fischer

Ausnahmegrund	Belastungsgrund			
	Stammesschnitt	Zufallsauswahl	Bedürftiger Struktur	Vergleichung
Stammesschnitt	274			
Zufallsauswahl	256			
Bedürftiger Struktur	222			
Vergleichung	212			
Sonstige	168			
	175			

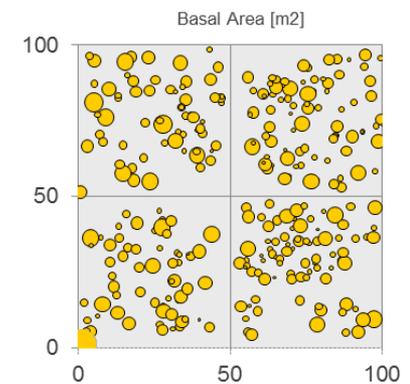
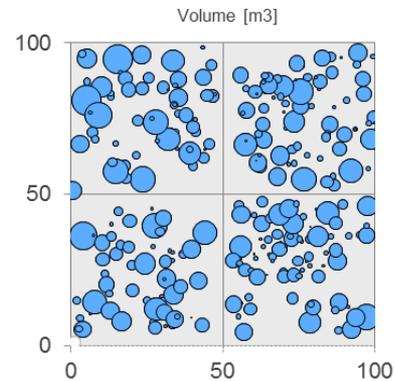
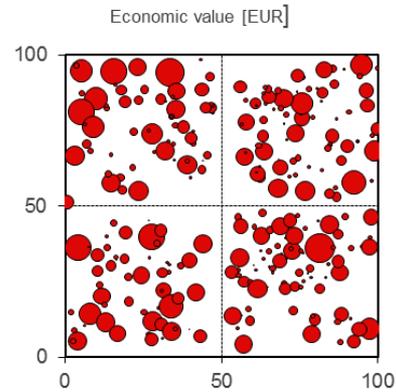
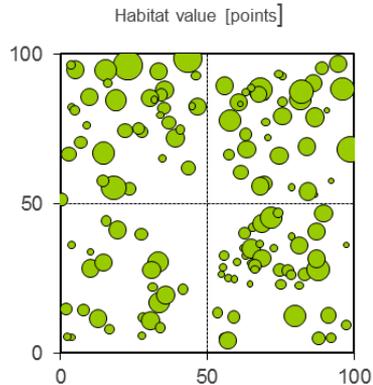
Belastungsgrund	Ausnahmegrund			
	Stammesschnitt	Zufallsauswahl	Bedürftiger Struktur	Vergleichung
Stammesschnitt				
Zufallsauswahl				
Bedürftiger Struktur				
Vergleichung				
Sonstige				

## MARTELOSKOPE: praxisnahe Trainingstools für Waldbauer



# Was kann man damit machen?

- Didatisches Werkzeug für Waldbau-Übungen
- Transparente Auswertung waldbaulicher Entscheidungen, Feedback
- Darstellung ökonomischer und ökologischer Effekte
- Quantitative Vergleiche
- Objektive Diskussion ist möglich



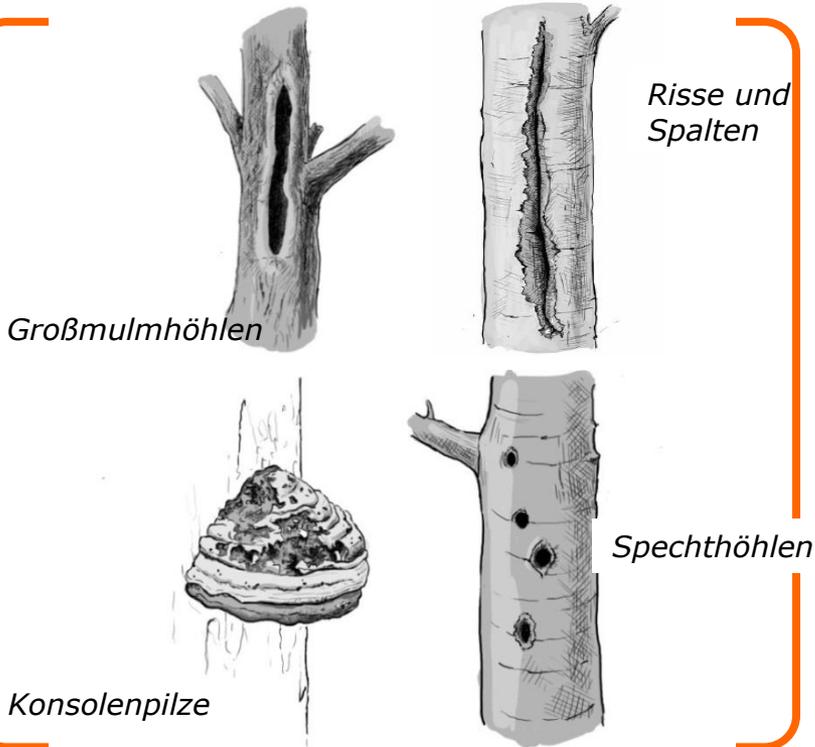
# Was ist ein Habitatbaum?



# Habitatwerte

## Ausschnitt Kriterienliste

### Baummikrohabitate



Saproxyllic Microhabitats	Cavities	CV1	Woodpecker cavities
		CV2	Trunk and mould cavities
		CV3	Branch holes
		CV4	Dendrotelms and water-filled holes
		CV5	Insect galleries and bore holes
	Injuries and Wounds	IN1	Bark loss / Exposed sapwood
		IN2	Exposed heartwood / Stem and crown breakage
		IN3	Cracks and scars
	Bark	BA1	Bark pockets
	Deadwood	DW1	Dead branches and limbs / crown deadwood
Epixylic Microhabitats	Growth orm related microhabitats	GF1	Root buttress cavities
		GF2	Witch broom
		GF3	Cankers and burrs
	Epiphytic krypto- and phanerogams	EP1	Fruiting bodies fungi
		EP2	Myxomycetes
		EP3	Bryophytes
			Foliose lichens
			Lianas
			Ferns
			Misteltoe
Nests and aeries	NE1	Nests / aeries	
Other microhabitats	OT1	Sap and resin run	
	OT2	Microsoil	

# Habitatwerte

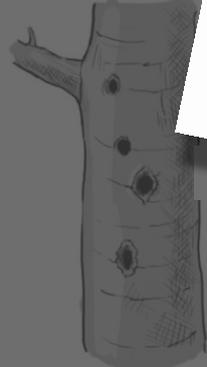
Ausschnitt Kriterienliste

Baummikrohabitate

Großmulmhöhlen



Konsolenpilze



Spechthöhlen

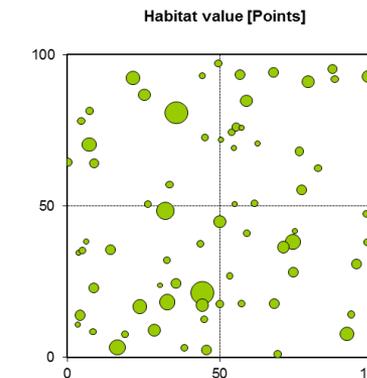
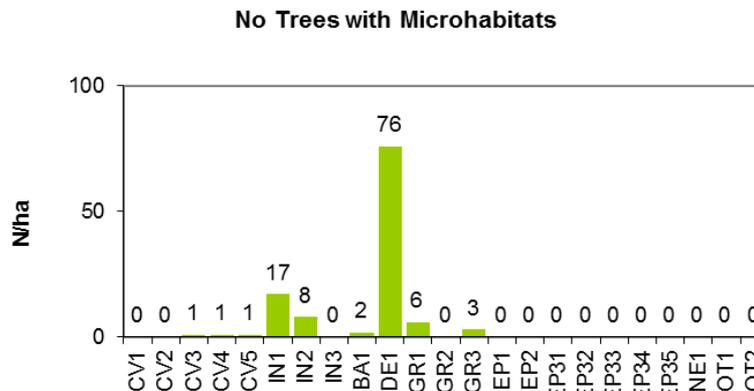
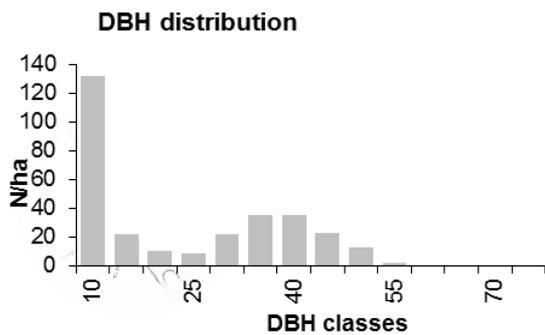
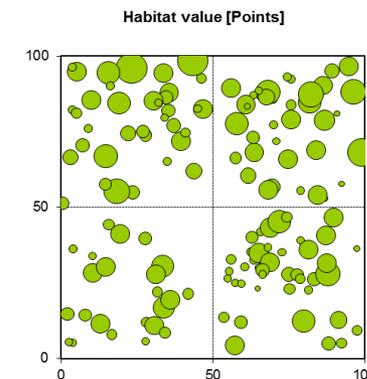
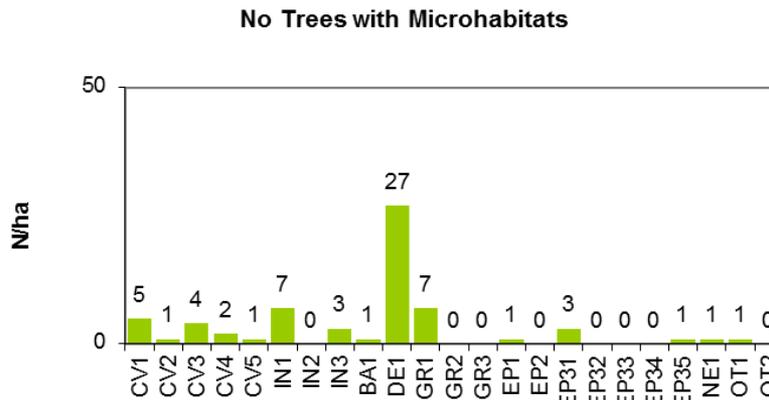
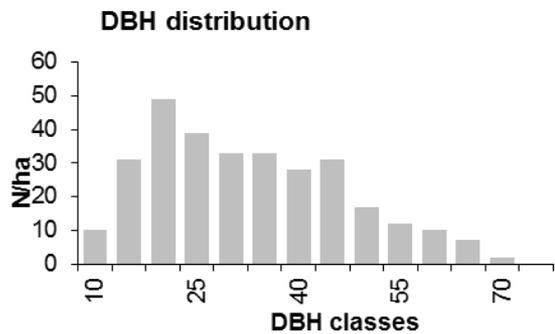
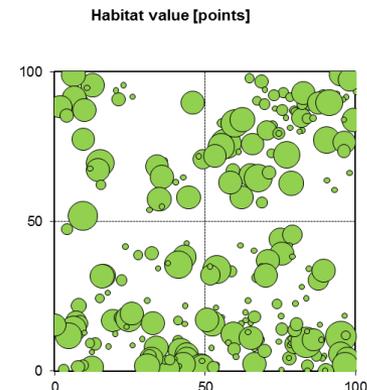
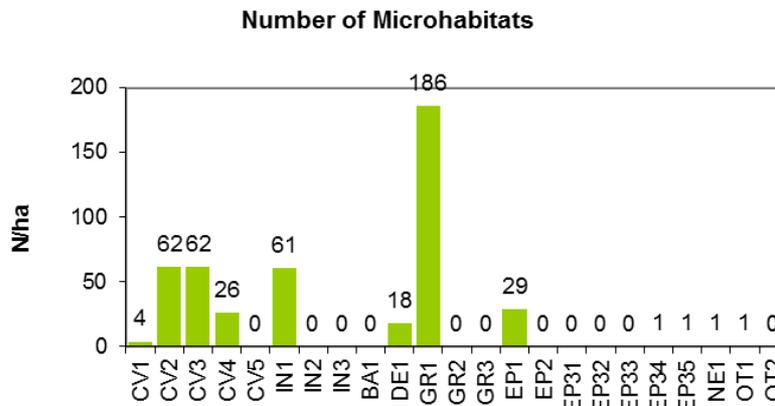
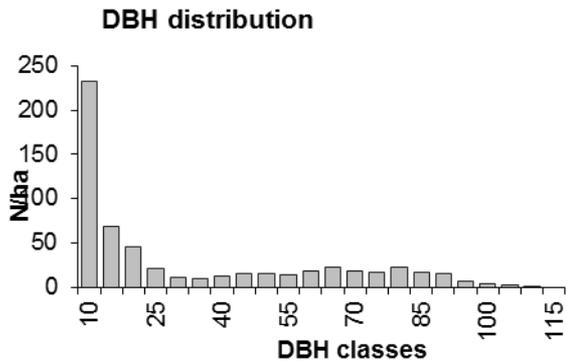


CV1	Woodpecker cavities
	Bank and mould cavities
	Branch holes
	Bendrotelms and water-filled holes
	Insect galleries and bore holes
	Bark loss / Exposed sapwood
	Exposed heartwood / Stem and crown breakage
	Cracks and scars
	Bark pockets
1	Dead branches and limbs / crown deadwood
F1	Root buttress cavities
GF2	Witch broom
GF3	Cankers and burrs
EP1	Fruiting bodies fungi
EP2	Myxomycetes
EP3	Bryophytes
	Foliose lichens
	Lianas
	Ferns
	Misteltoe
NE1	Nests / aeries
OT1	Sap and resin run
OT2	Microsoil

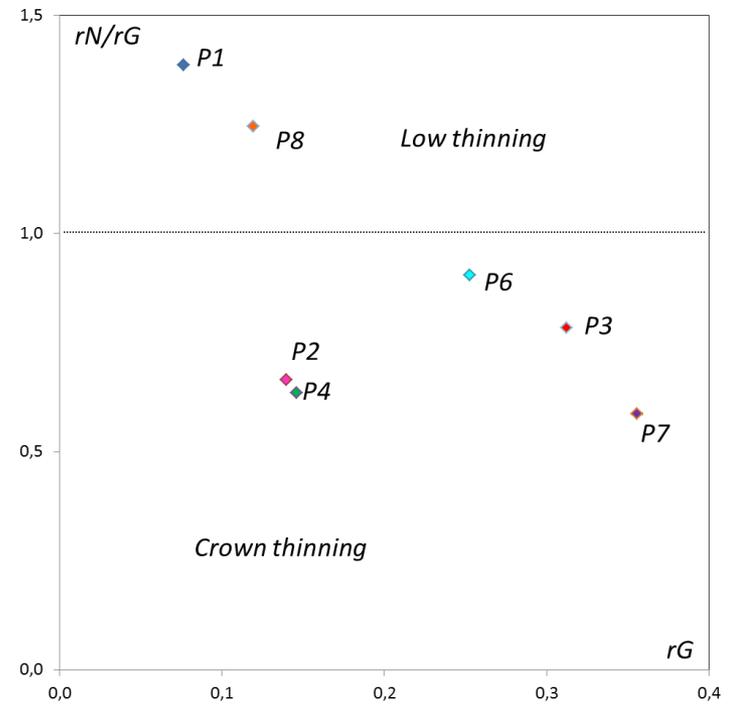
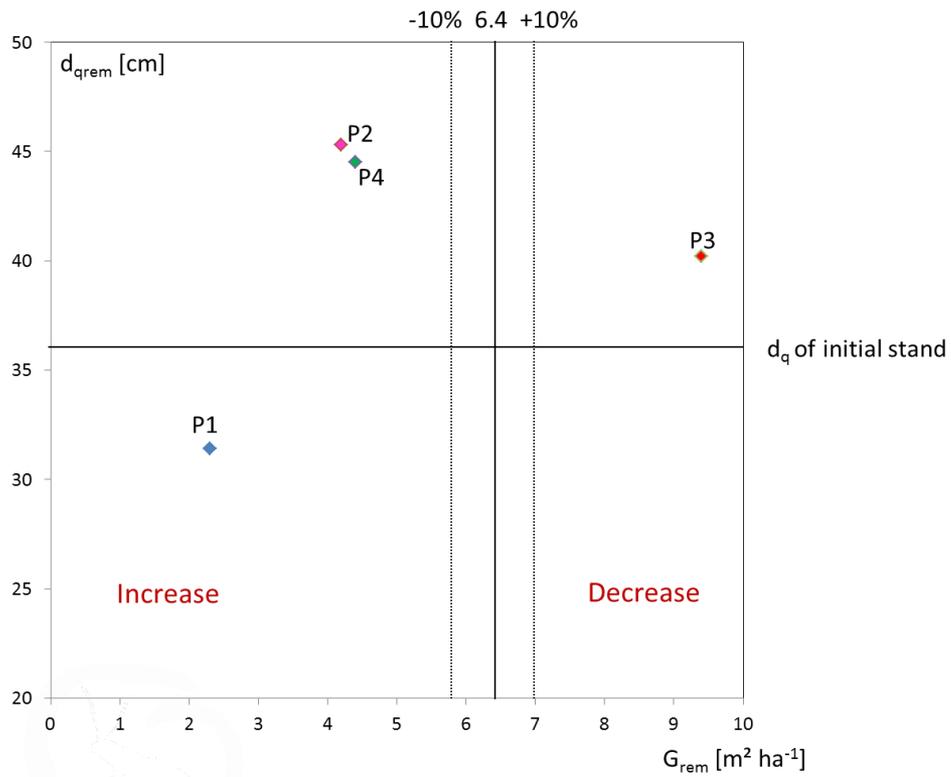
Epiphytic

Nests and aeries

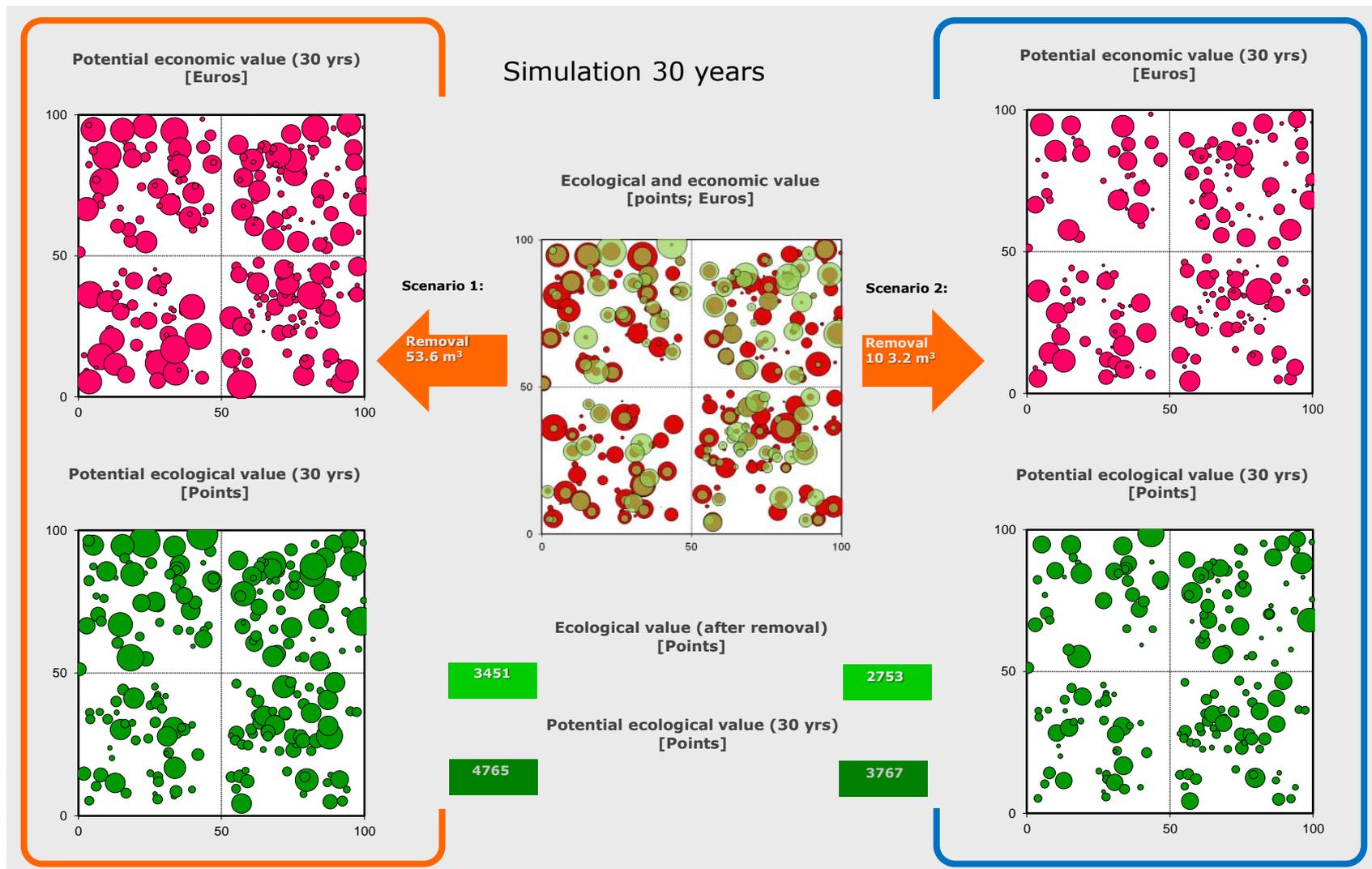
Other microhabitats



# Gruppenergebnisse

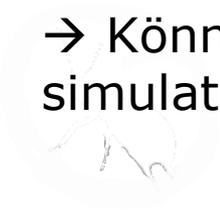


# I+ Simulationen



# Nachlieferung von Mikrohabitaten?

- Innerhalb des integrativen Waldnaturschutzes muss eine konstante Nachlieferung von Mikrohabitaten gewährleistet sein
- Gleichgewicht zwischen der Neubildung und dem Verschwinden von Mikrohabitaten
- Beobachtung von Mikrohabitaten auf verschiedenen Bäume zu einem bestimmten Zeitpunkt
- Die Neubildungsrate von Mikrohabitaten kann nicht direkt gemessen werden.
- Können wir die Wahrscheinlichkeit der Neubildung eines Mikrohabitats vorhersagen?
- Können wir ein Mikrohabitat-Modul in einen Waldwachstums-simulator integrieren?



**Ereigniszeit-Analyse** (Survival analysis): indirekte Schätzmethode, bei der die Zeit bis zu einem bestimmten Ereignis genutzt wird, um die Wirkung zB eines schädlichen Ereignisses zu bewerten

**Anwendung auf Mikrohabitatbildung:**

D: Zufallsvariable abhängig vom BHD, ab dem sich das erste Mikrohabitat bildet

F(d): **Cumulated Distribution Function** (CDF) der Zufallsvariable D. Entspricht der Wahrscheinlichkeit, dass mindestens ein Mikrohabitat an einem Baum vorkommt

$$F(d) = P(D \leq d)$$

h(d): **Hazardfunktion** der Zufallsvariable D. Wahrscheinlichkeit der Bildung des ersten Mikrohabitats an einem Baum, der bisher keines ausgebildet hat

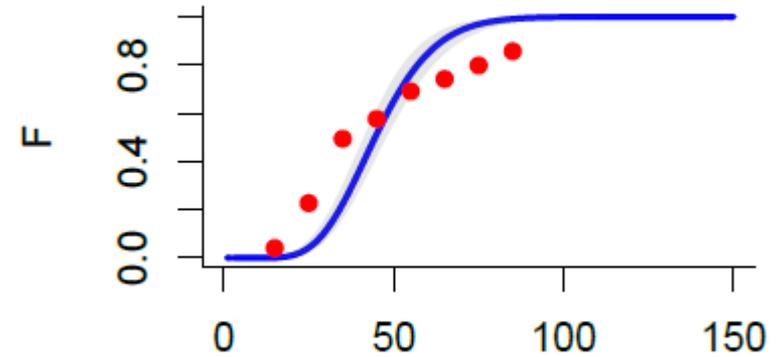


$$h(d) = \frac{dF(d)}{1 - F(d)}$$

# Wahrscheinlichkeit der Entstehung von Mikrohabitaten

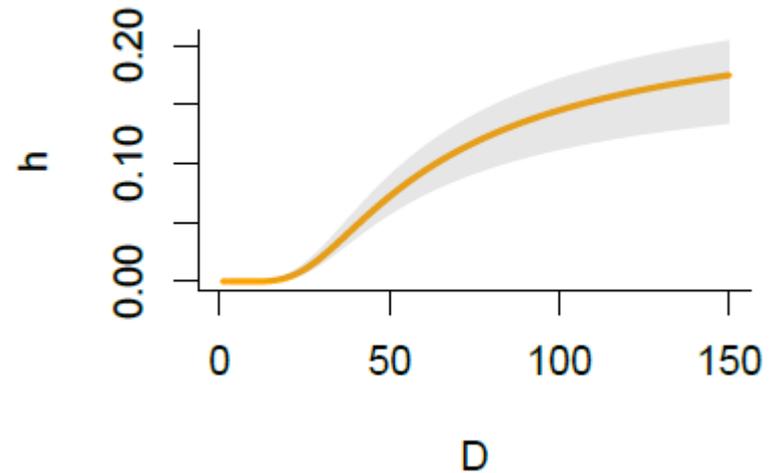
Kalibrierung der F-Funktion aus Beobachtungsdaten

Uholka haP – *Fagus sylvatica* (UH-haP)



Ableitung der h-Funktion zur Beschreibung des Entstehungsprozesses

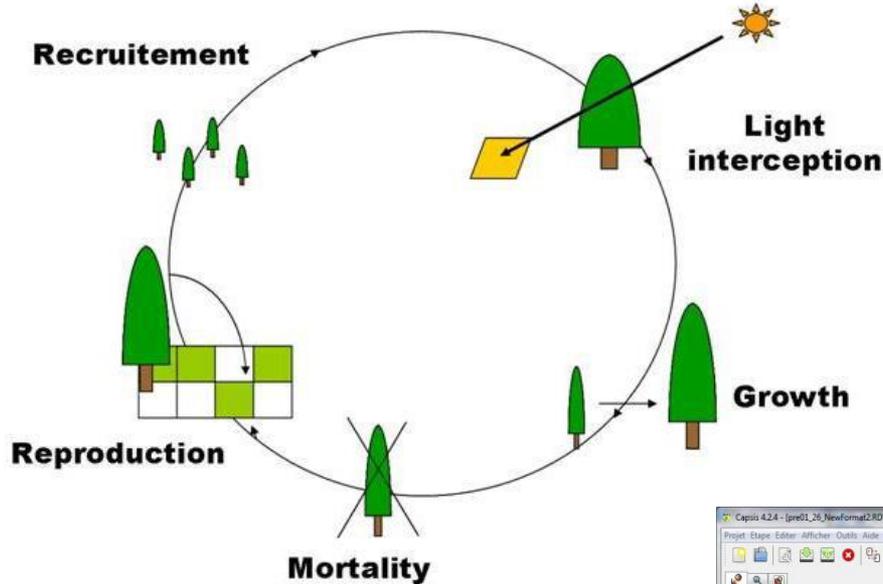
Uholka haP – *Fagus sylvatica* (UH-haP)



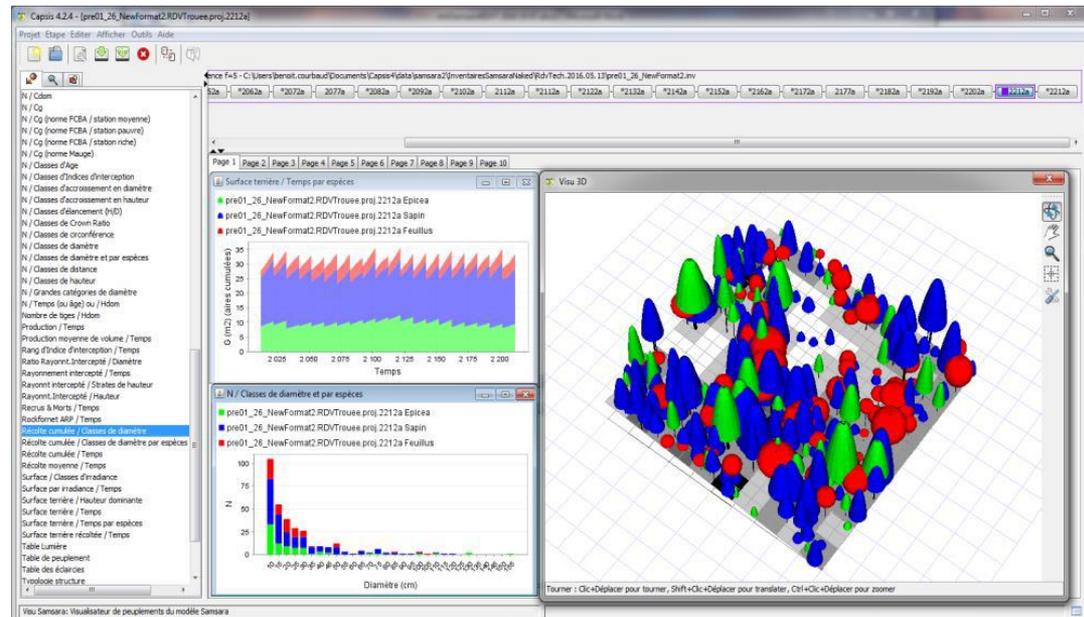
# Integration in den Waldwachstumssimulator Samsara

Samsara: an individual-based, spatially explicit simulation model

Courbaud et al., 2003  
Courbaud et al. 2015

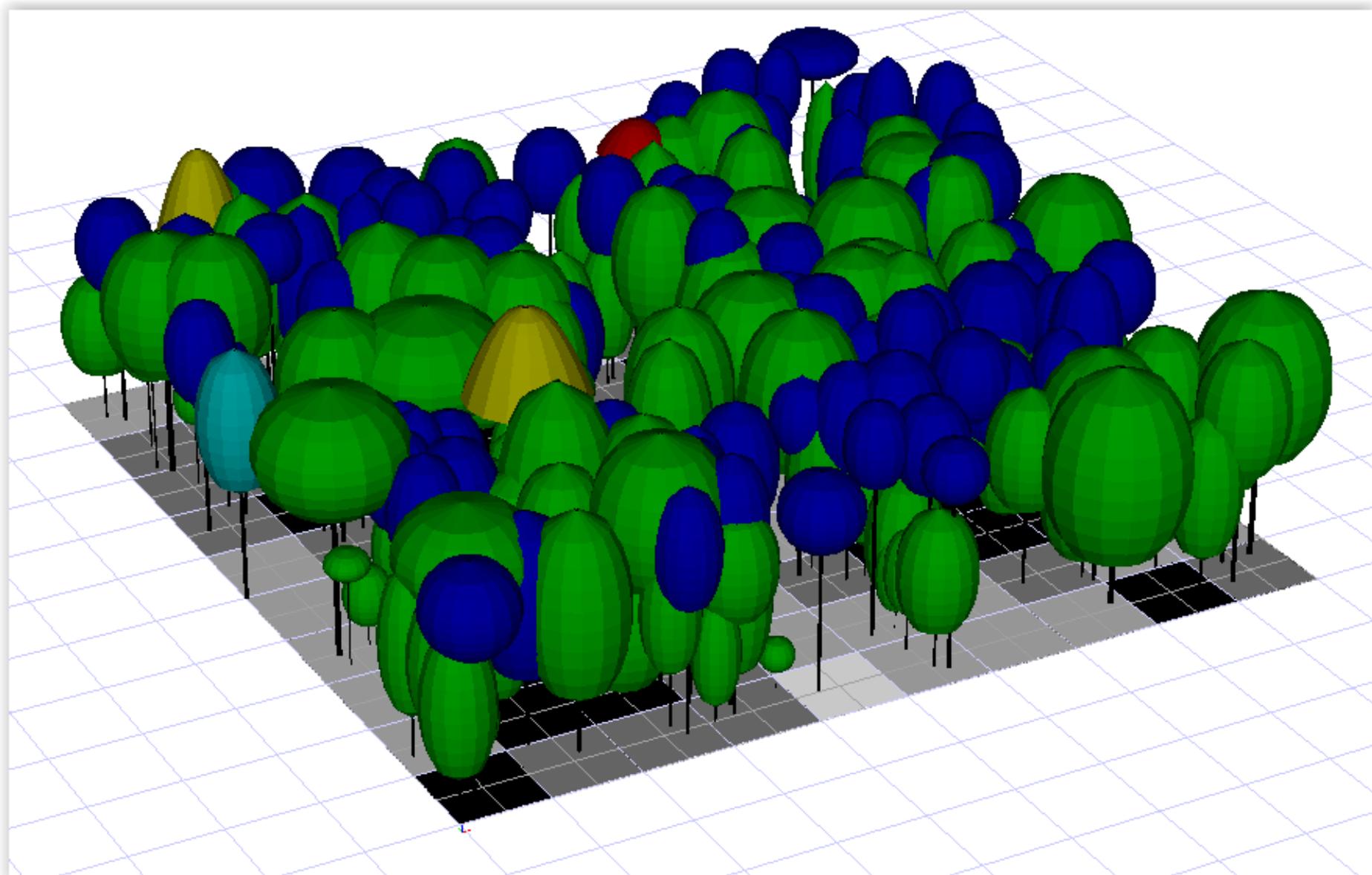


Entwicklungsplattform CAPSIS

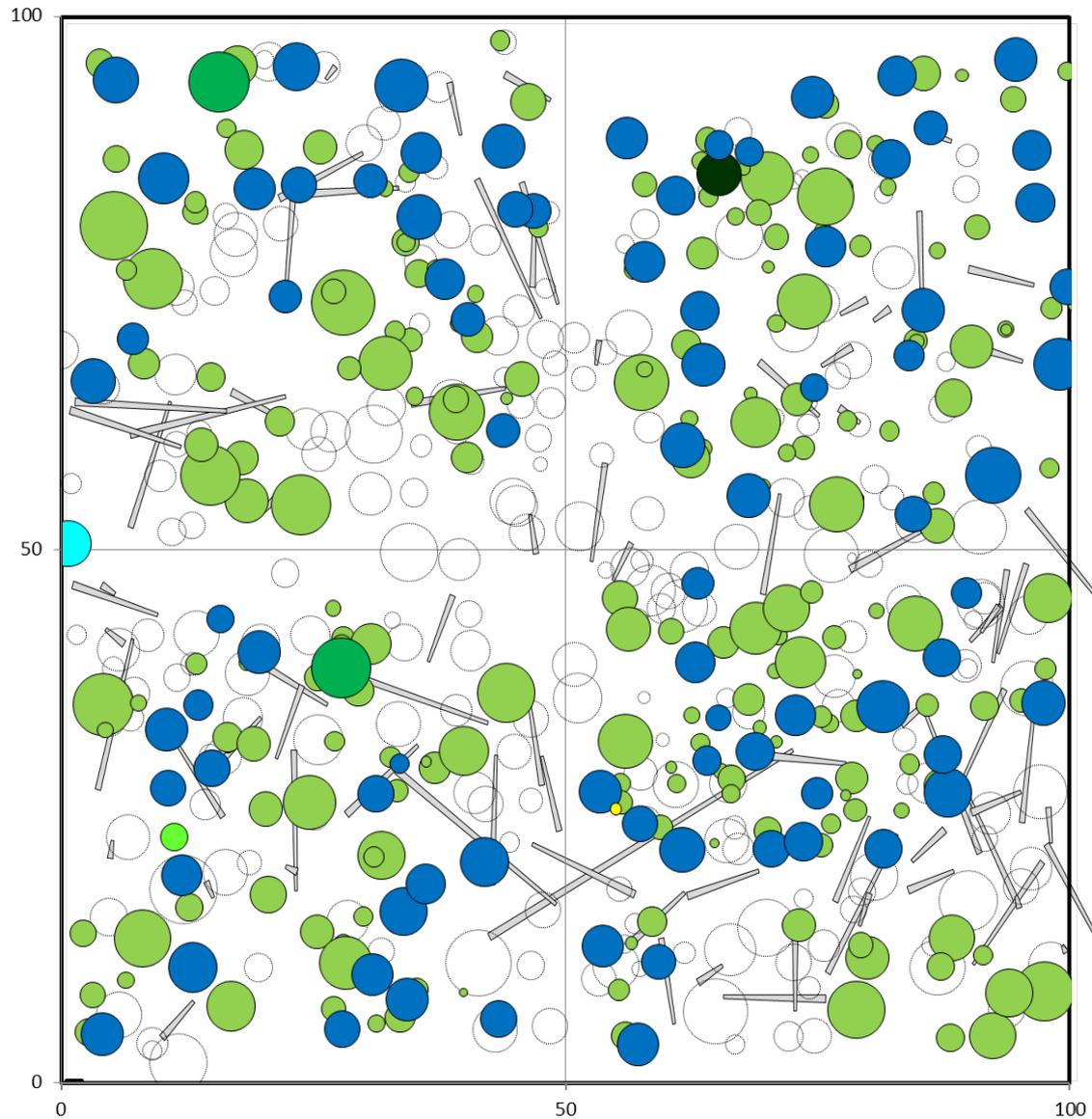


Coligny et al., 2003  
Dufour-Kowalski et al. 2012

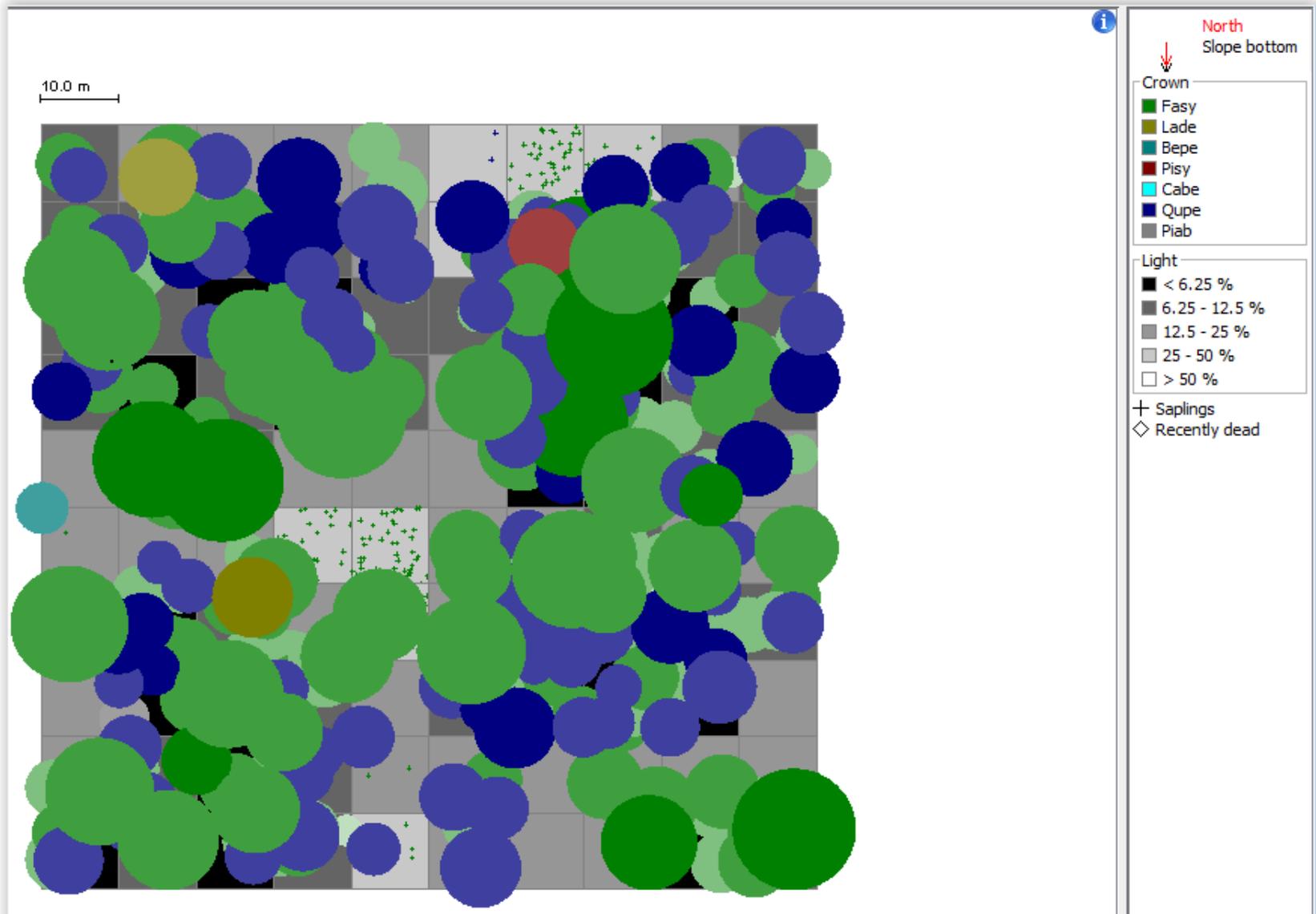
# Das Marteloskop am Steinkreuz - der Bestand



# Totholzinventur am Steinkreuz

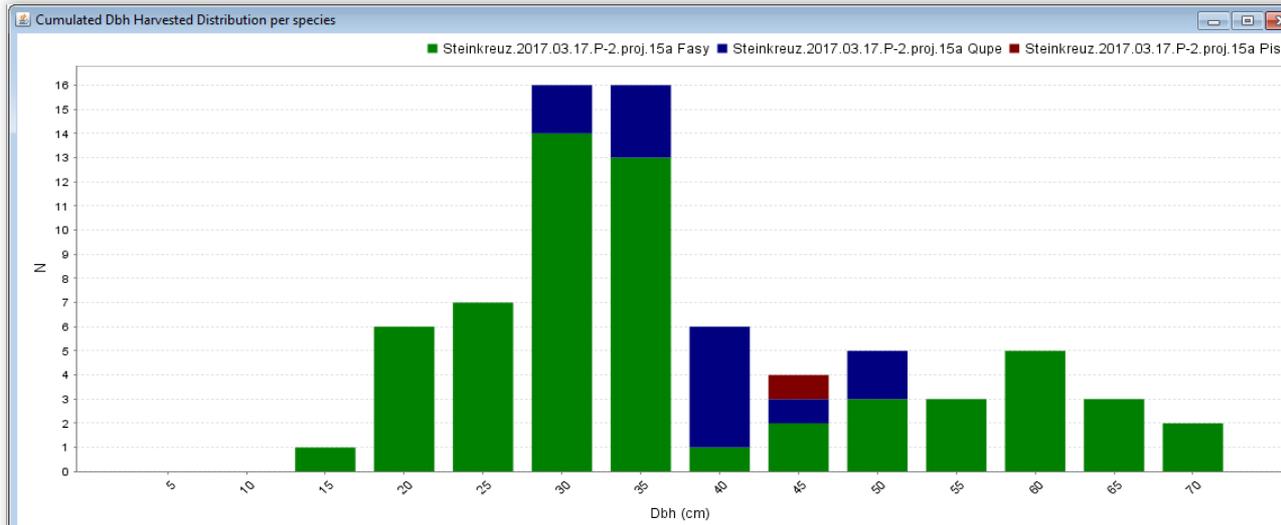


# Ausgangsbestand mit Verjüngung

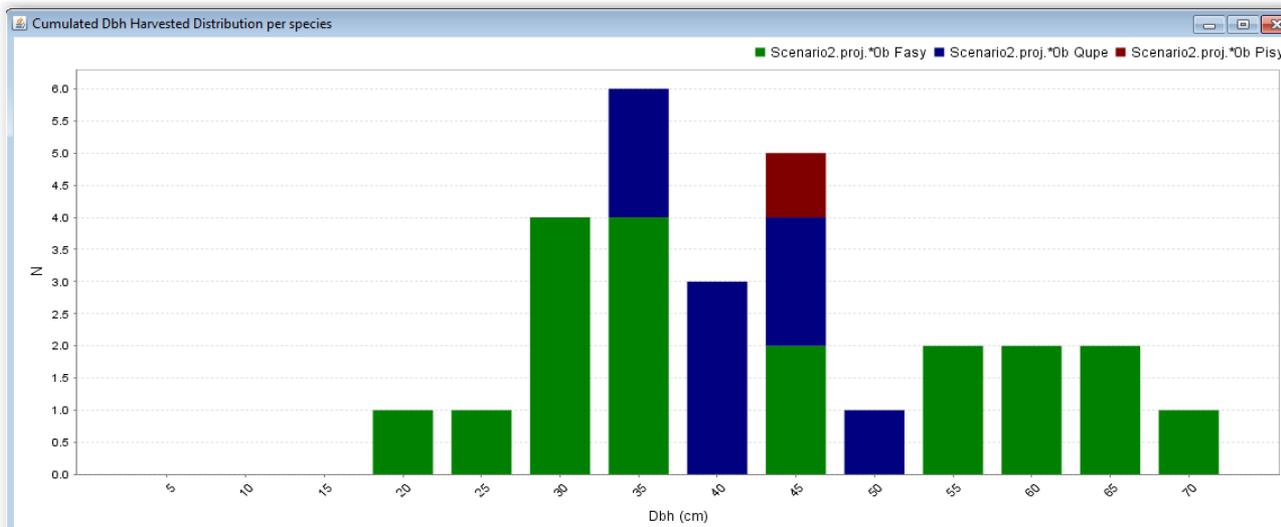


# Simulation der Szenarien

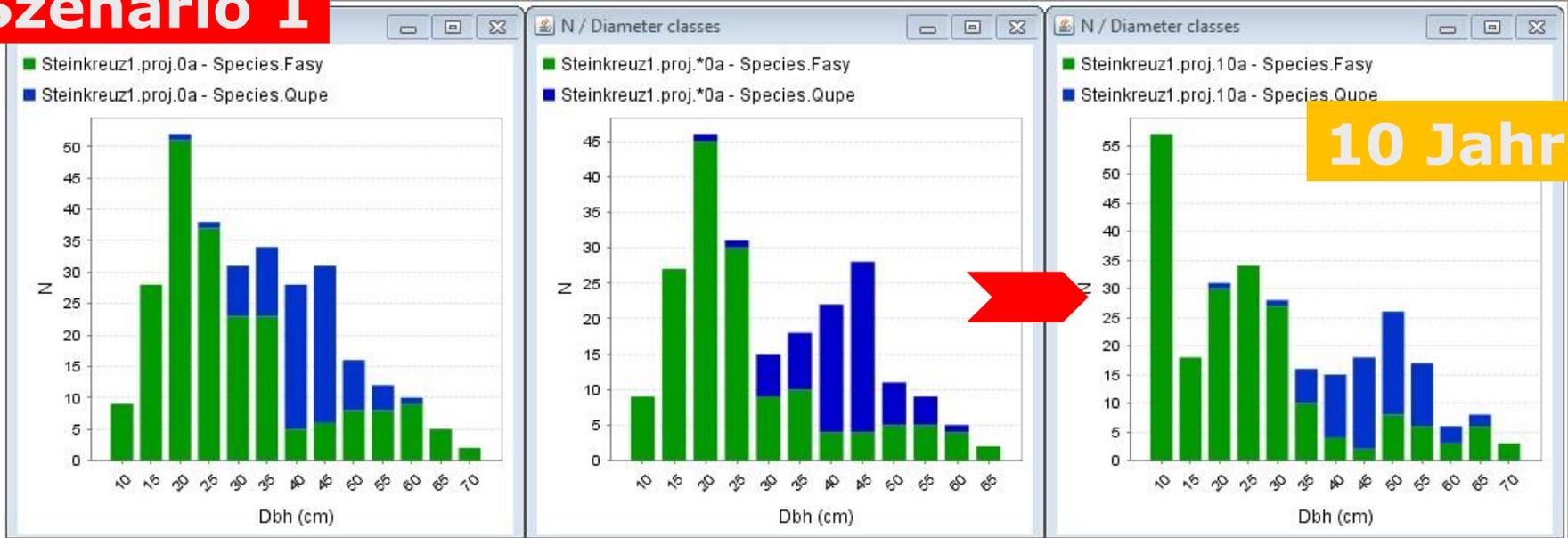
## Szenario 1:



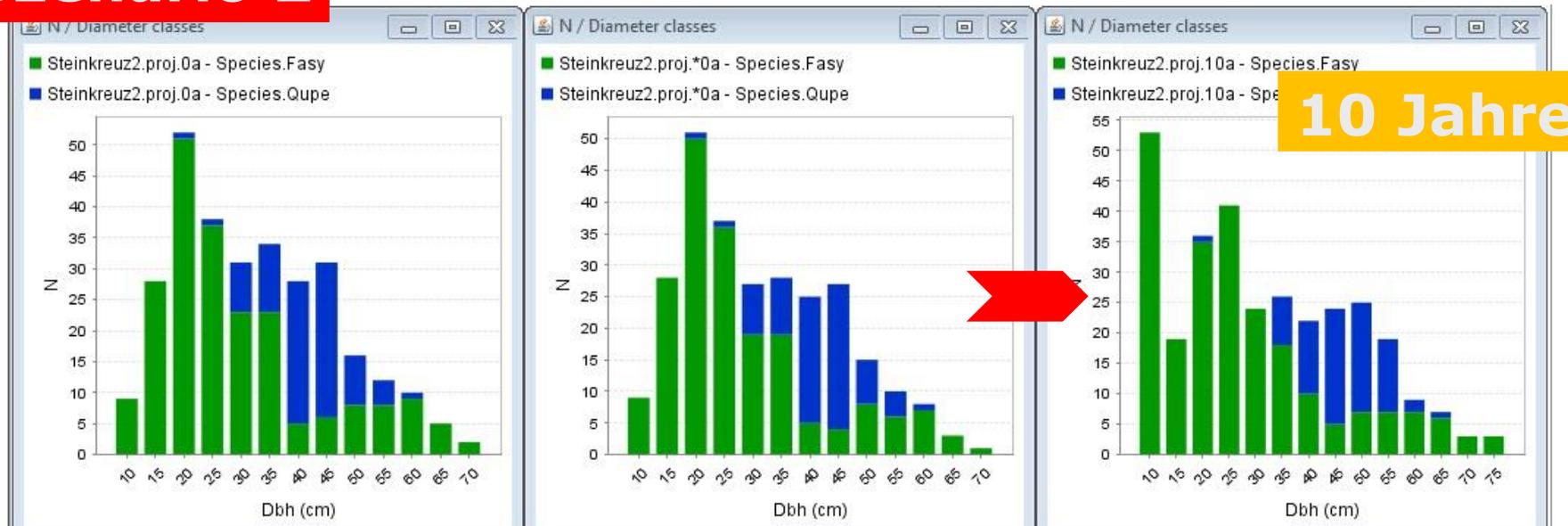
## Szenario 2:



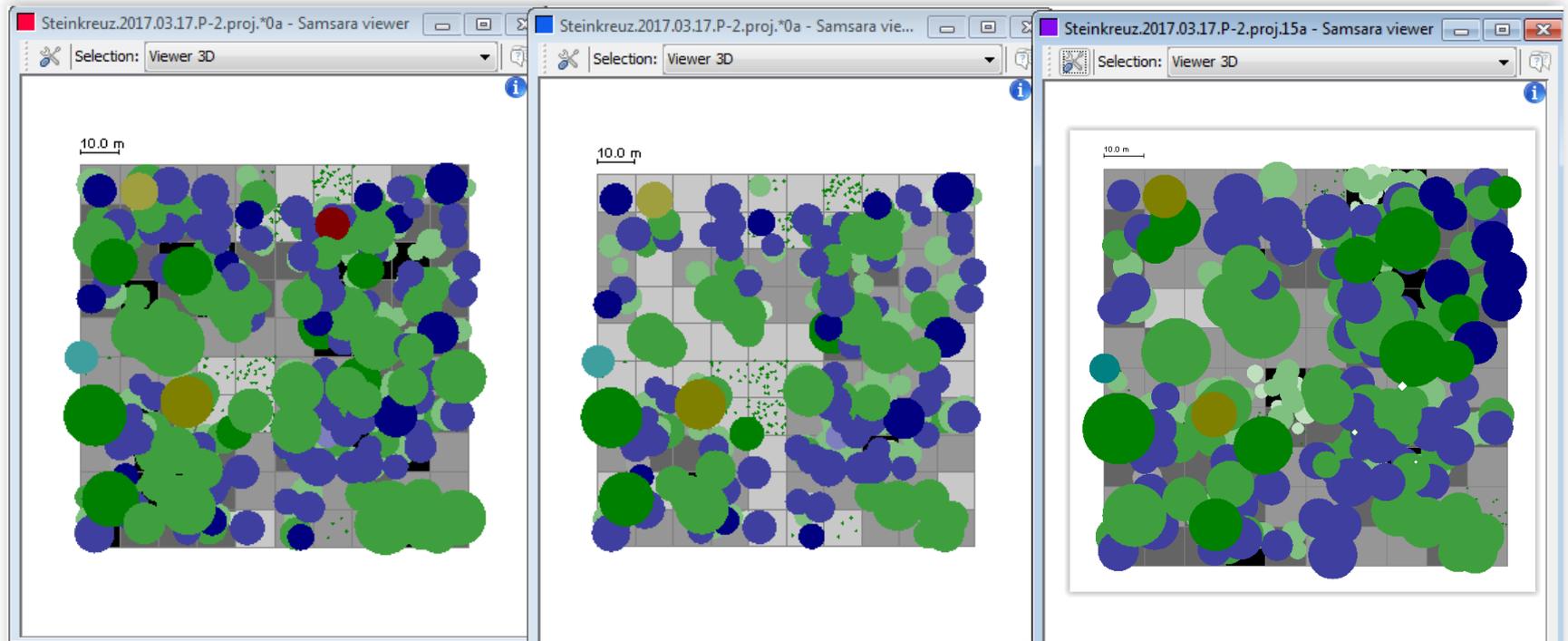
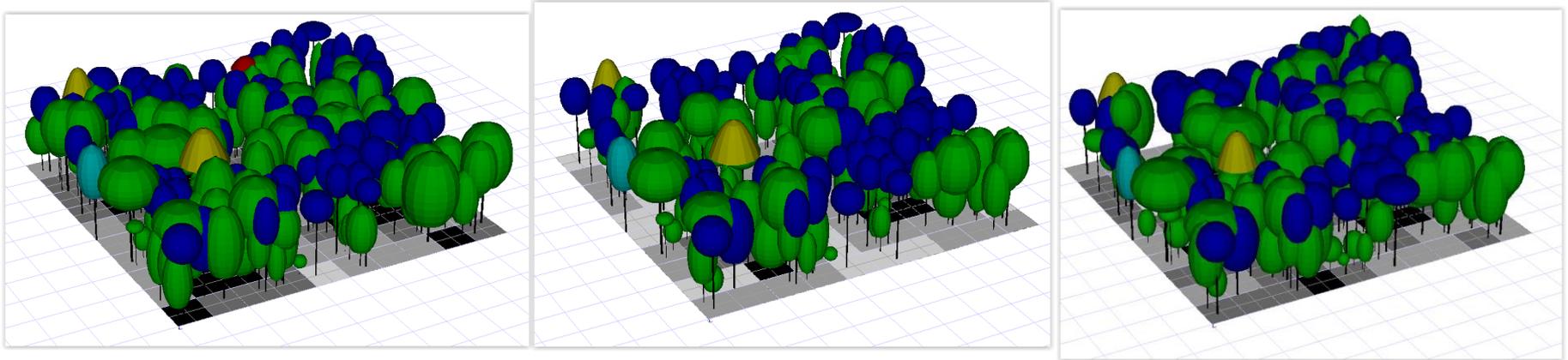
# Szenario 1



# Szenario 2



# Szenario 1

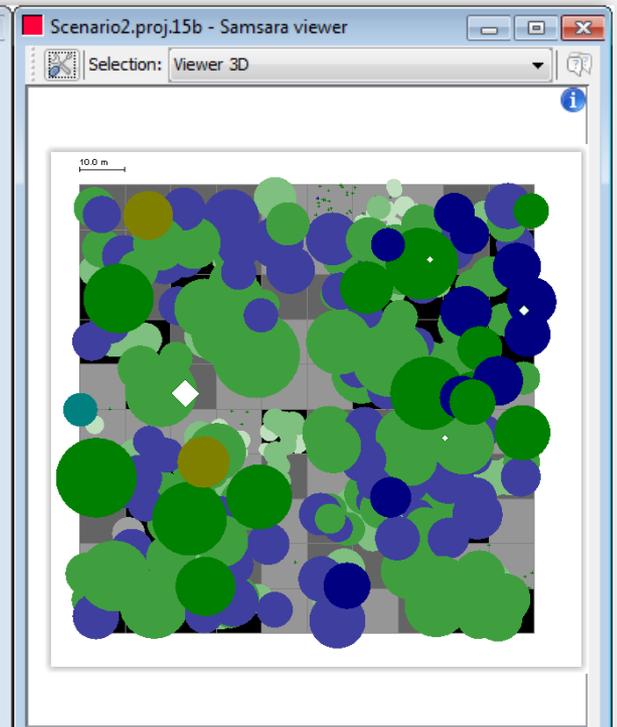
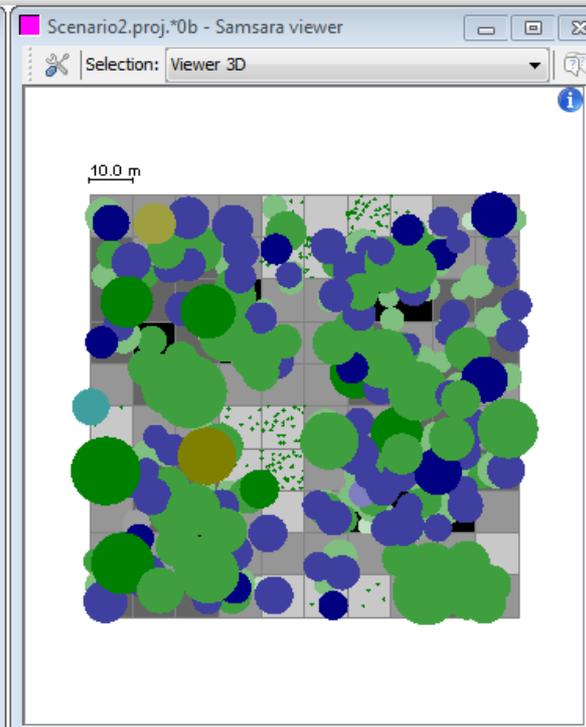
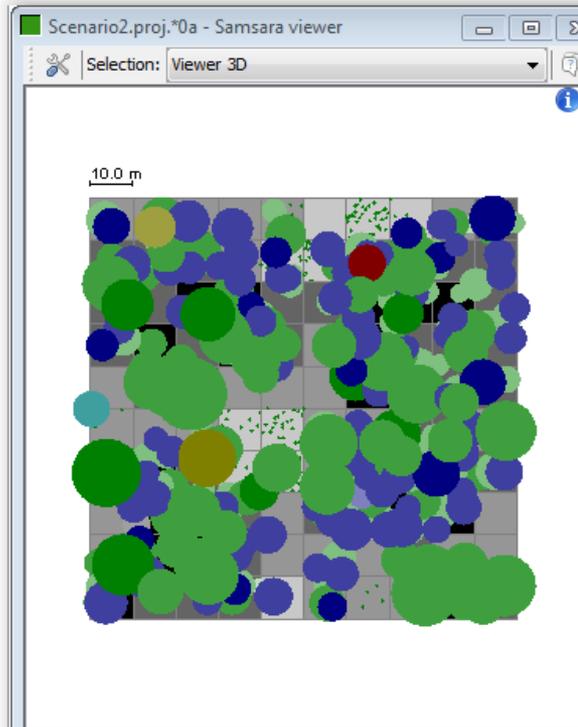
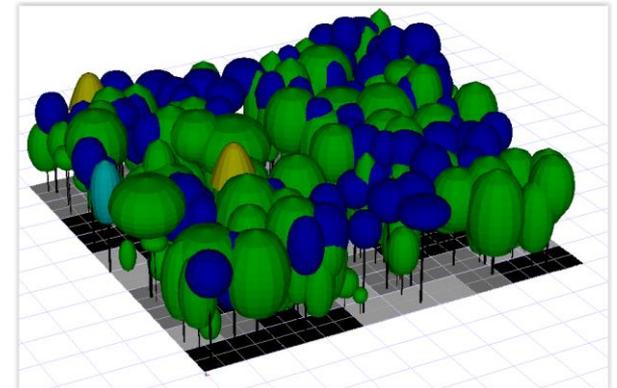
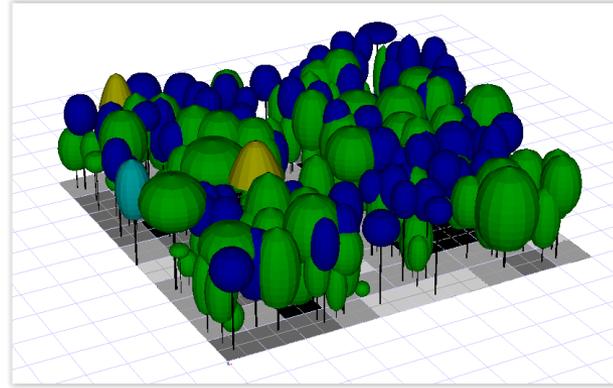
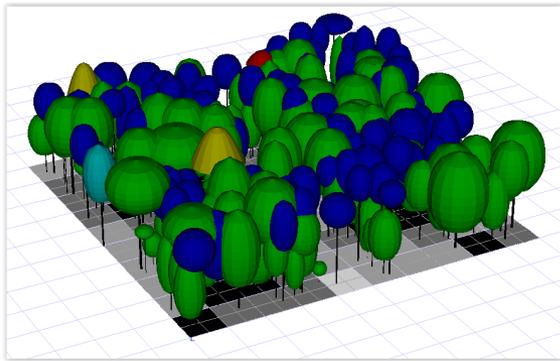


Ausgangsbestand

Nach dem Eingriff

Nach 20 Jahren

# Szenario 2



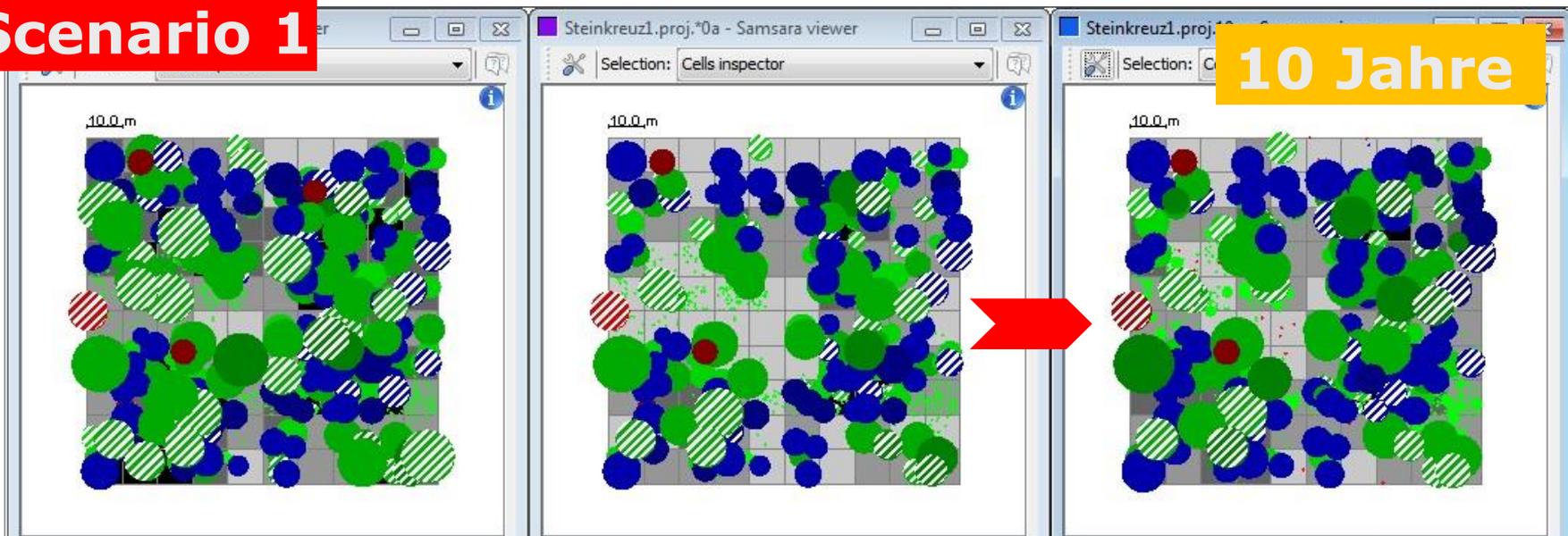
Ausgangsbestand

Nach dem Eingriff

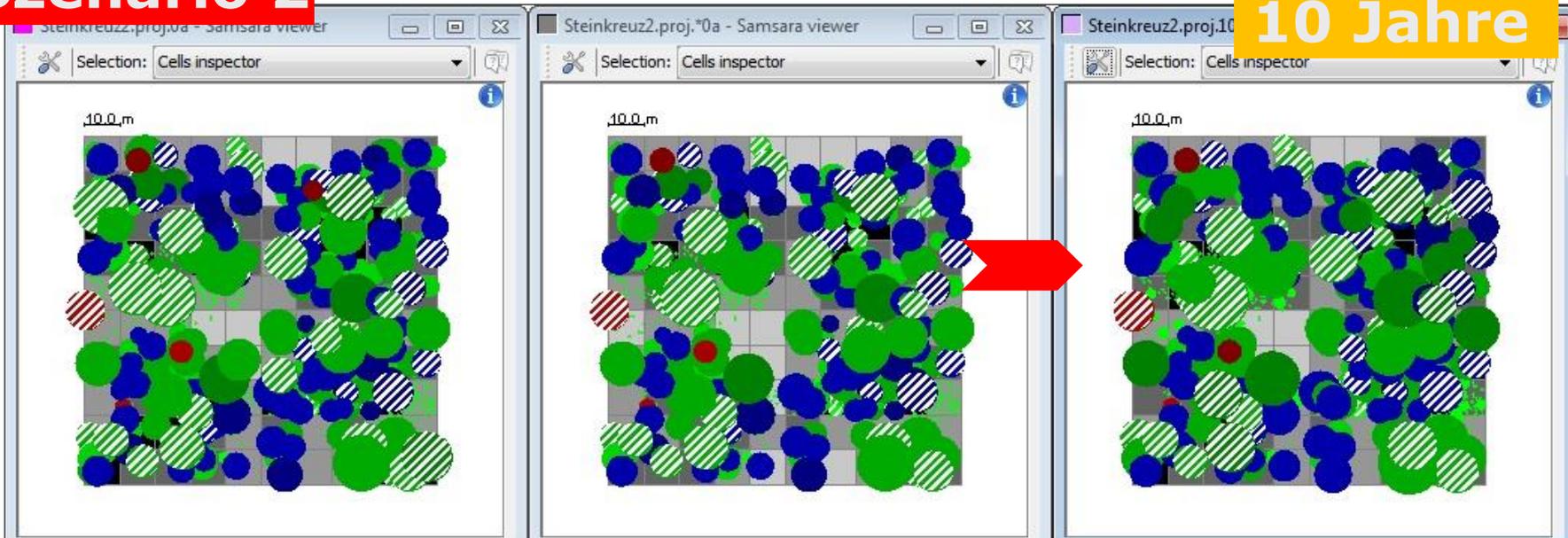
Nach 20 Jahren

# Habitatbaumnchlieferung

## Scenario 1



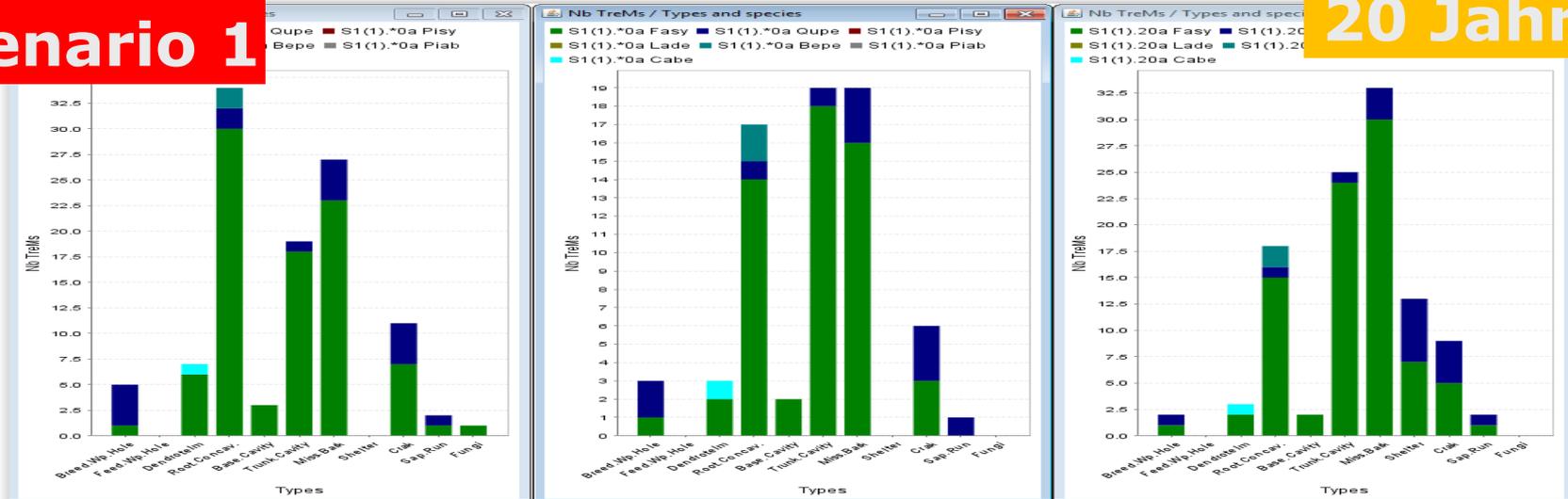
## Szenario 2



# Mikrohabitatneubildung

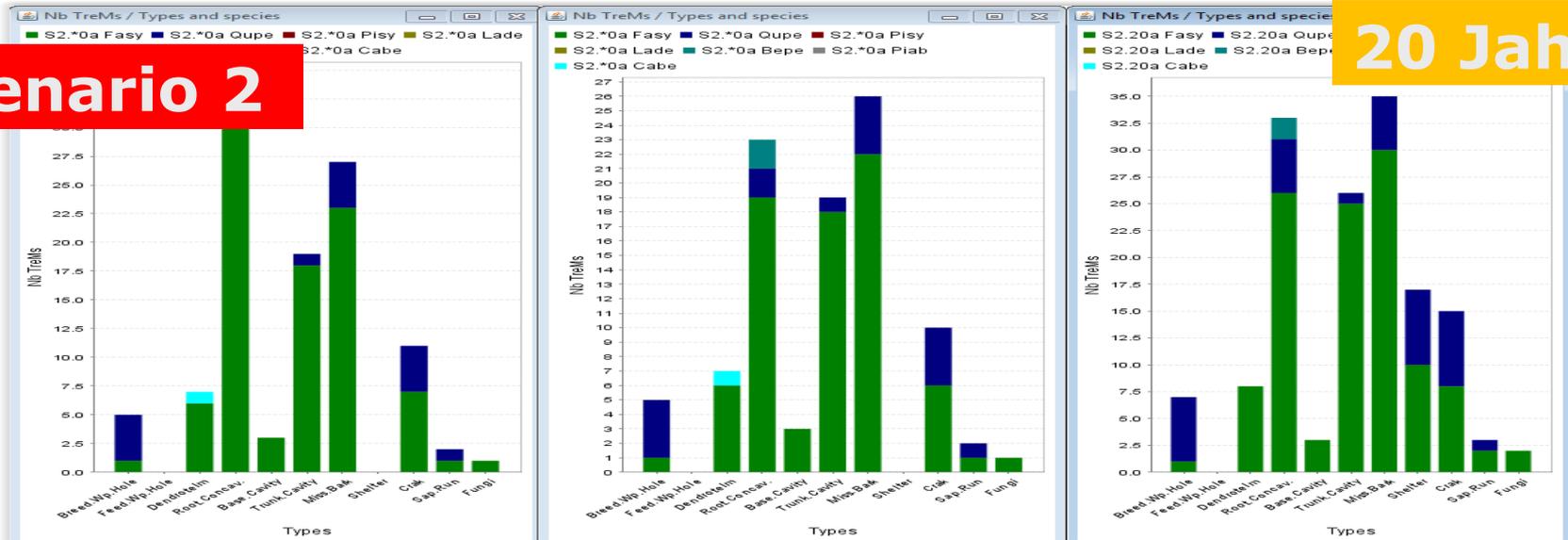
## Szenario 1

20 Jahre

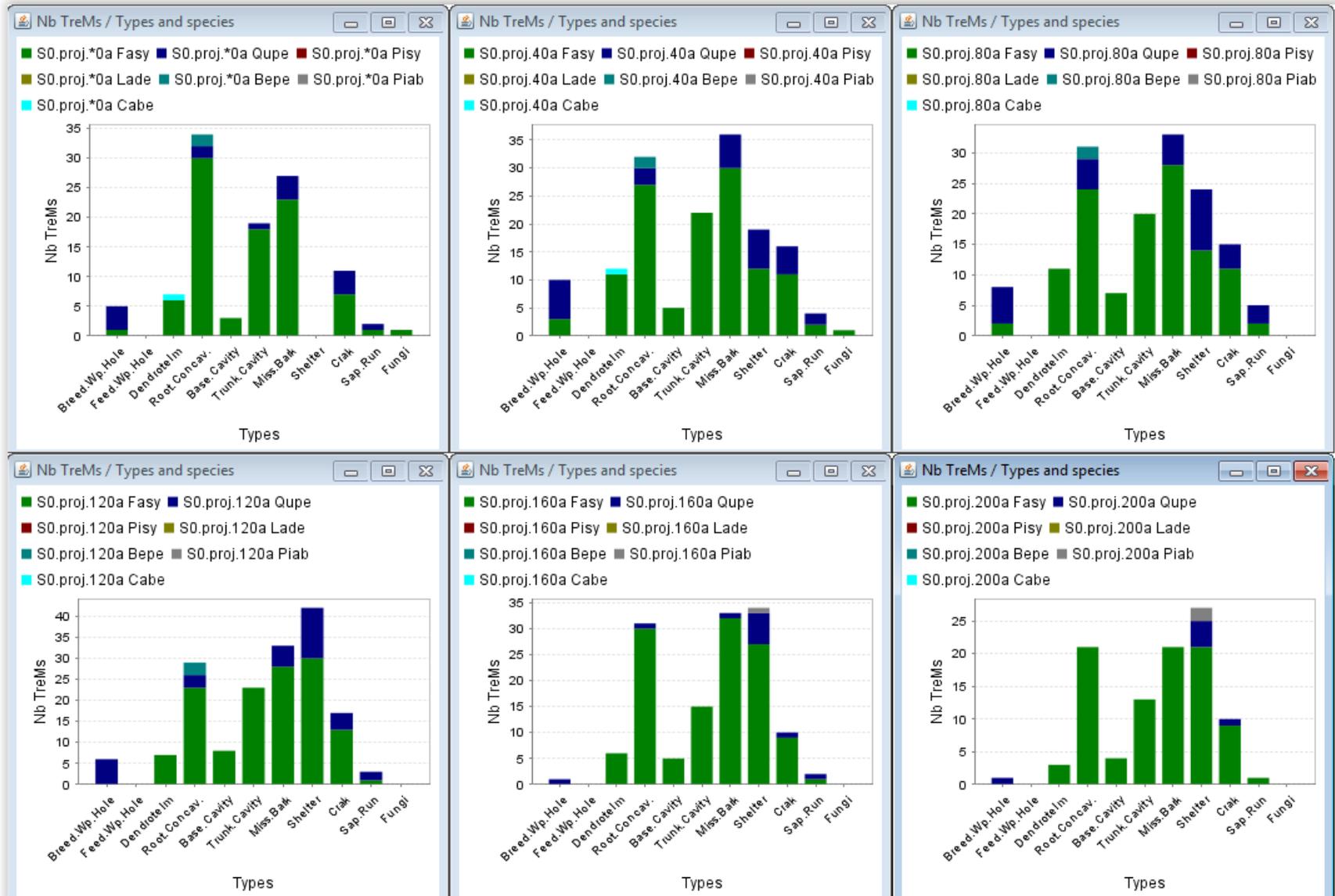


## Szenario 2

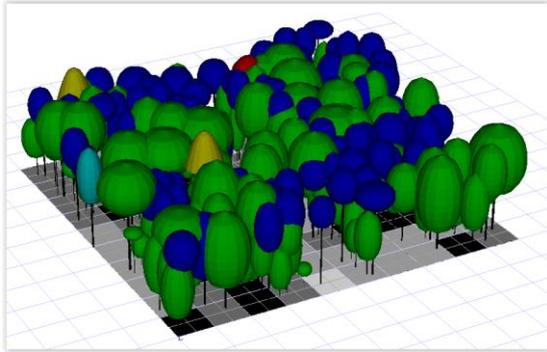
20 Jahre



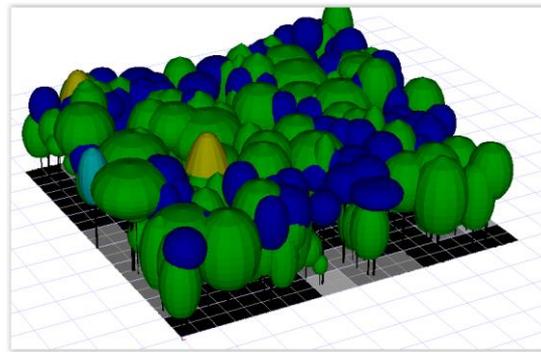
# Szenario 0: Mikrohabitatbildung 200 Jahre



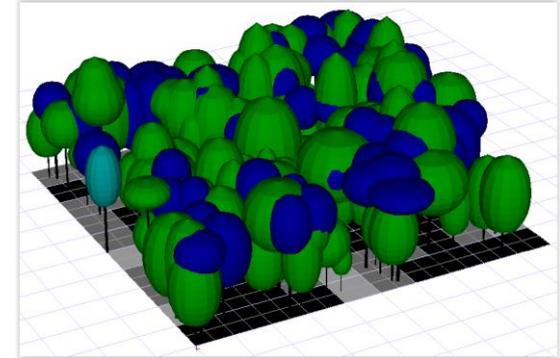
# Szenario 0: Bestandesentwicklung 200 Jahre



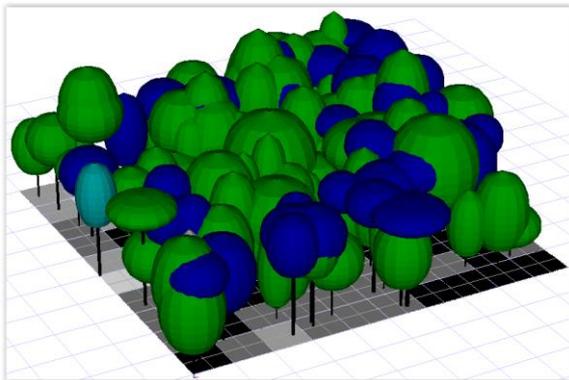
t=0



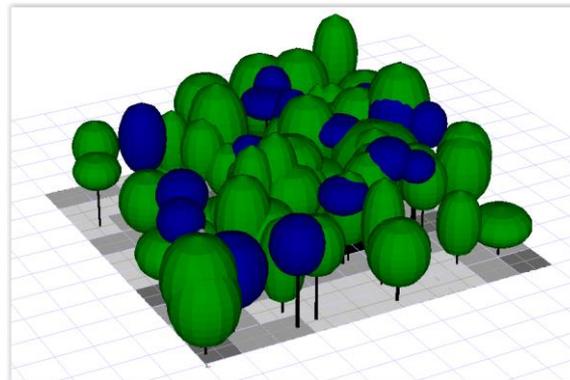
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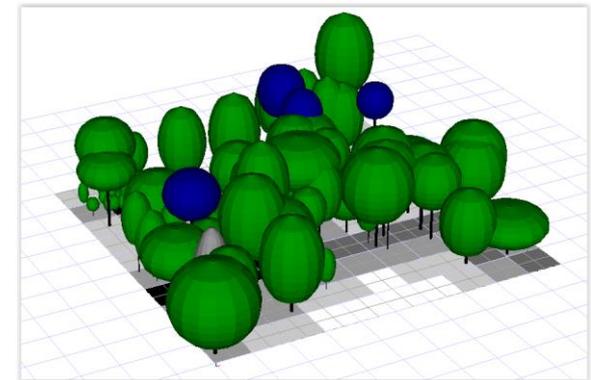
t=80



t=120



t=160



t=200

Wir bedanken uns bei

B. Courbaud (Irstea) , F. de Coligny (INRA), L.  
Larrieu (INRA/CNPF) und A.Letort (Irstea)

für die geleistete Unterstützung!!!





# Vielen Dank für die Aufmerksamkeit!



Integrate+

## What are Martellosopes?

A main task in forest management is to decide, where, when and what kind of forest interventions are applied. Key factors influencing silvicultural decisions that practitioners make are their understanding of forest dynamics and their level of experience. Further, the presence of a wide range of theoretical strategies and concepts in forestry results in differences when implementing certain silvicultural practices. This may apply even when clear forest management guidelines are in place. Therefore it is important to ask how substantial are the consequences of different silvicultural approaches and to what extent do they affect forest biodiversity?

Experimental silviculture ('trial and error') will not provide answers to the above question. Nonetheless simulating interventions applied by practitioners on the same stand can provide such answers.

So-called 'Martellosopes' do the term originates from French and describes a detailed examination of tree growth and their consequences for the stand.

They are silvicultural training tools. In one hectare in which all trees are numbered, mapped and measured an evaluation and selection of trees for virtual tree selection can be performed. The results can be displayed to show the consequences of interventions and future stand dynamics.

Different management approaches and their economic consequences for the stand can be discussed by the

The diagram shows a 20x20 grid representing a forest stand. Each cell contains a colored circle representing a tree. The colors correspond to tree species: red for Beech, blue for Oak, green for Hornbeam, yellow for Birch, purple for Pine, and grey for Spruce. The size of the circles represents the Diameter at Breast Height (DBH) in centimeters. A legend at the bottom right explains the color and size coding.

Tree species	DBH (cm)
Beech	8.0 - 10.0
Oak	10.1 - 25.0
Hornbeam	25.1 - 35.0
Birch	35.1 - 45.0
Pine	45.1 - 65.0
Spruce	65.1 - 75.0

