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Application of multiple competition indices to trace competition sensitivity in a complex mixed species forest

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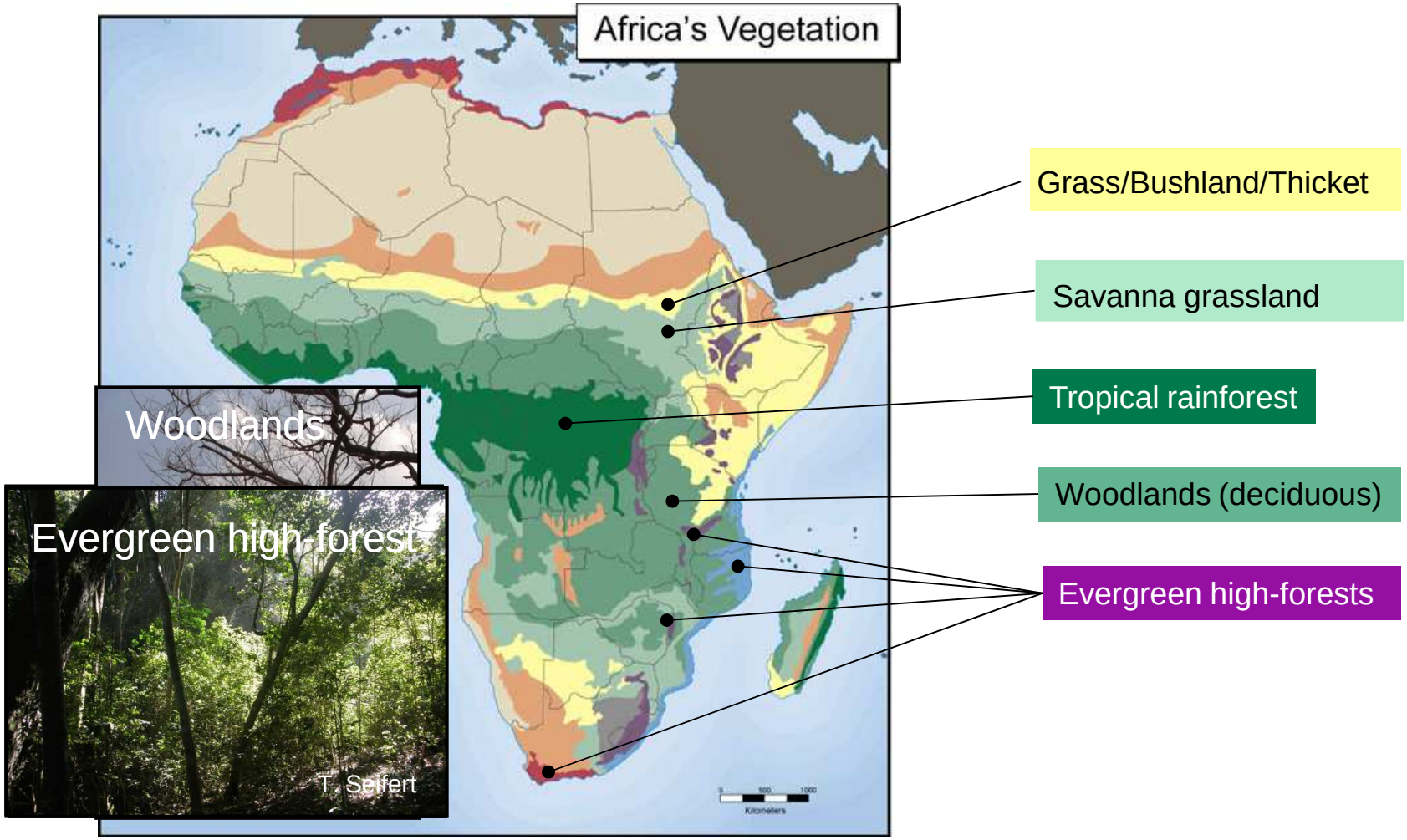
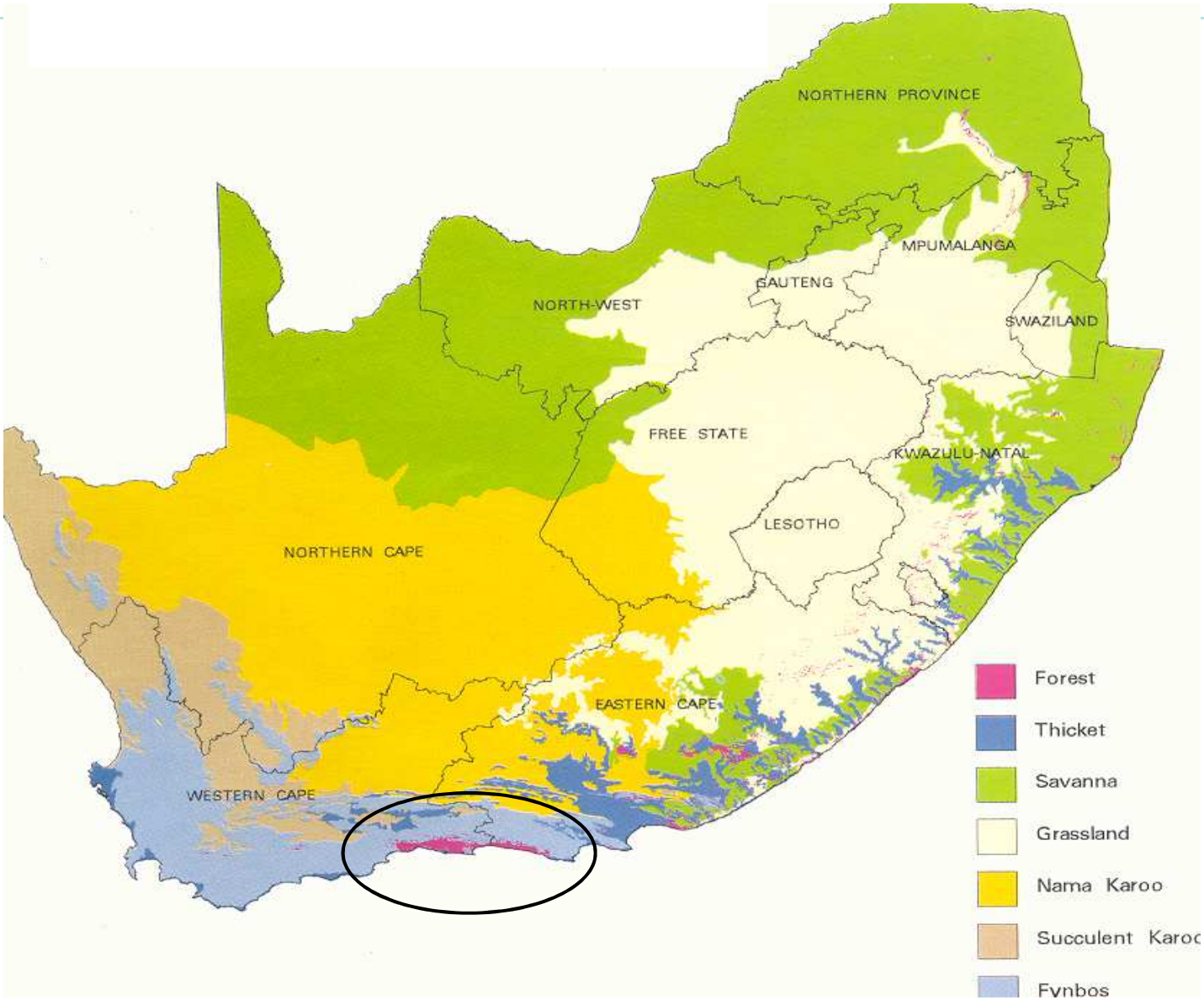
Journeés CAQSIS, 7th-9th April 2015

Vegetation zones in Africa



http://exploringafrica.matrix.msu.edu/teachers/curriculum/m6/map3.php

Afrotemperate Forests in South Africa



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Afrotemperate Forests

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Disturbance regime

(coarse grain disturbance regime very rare)

Disturbance regime

(fine grain disturbance regime prevailing)

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Forest Structure

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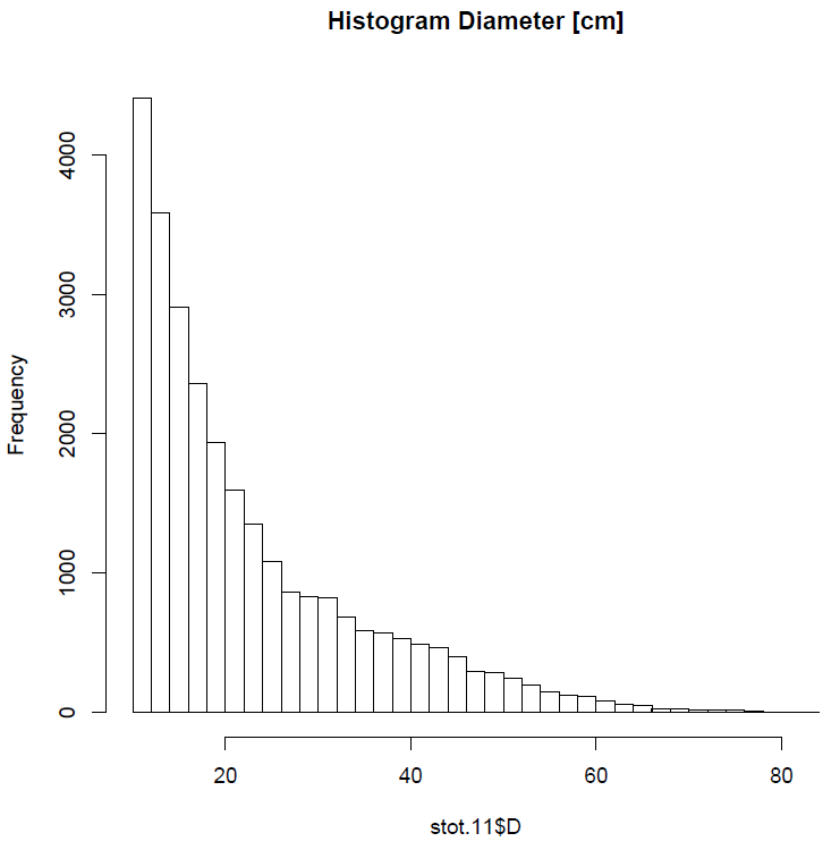
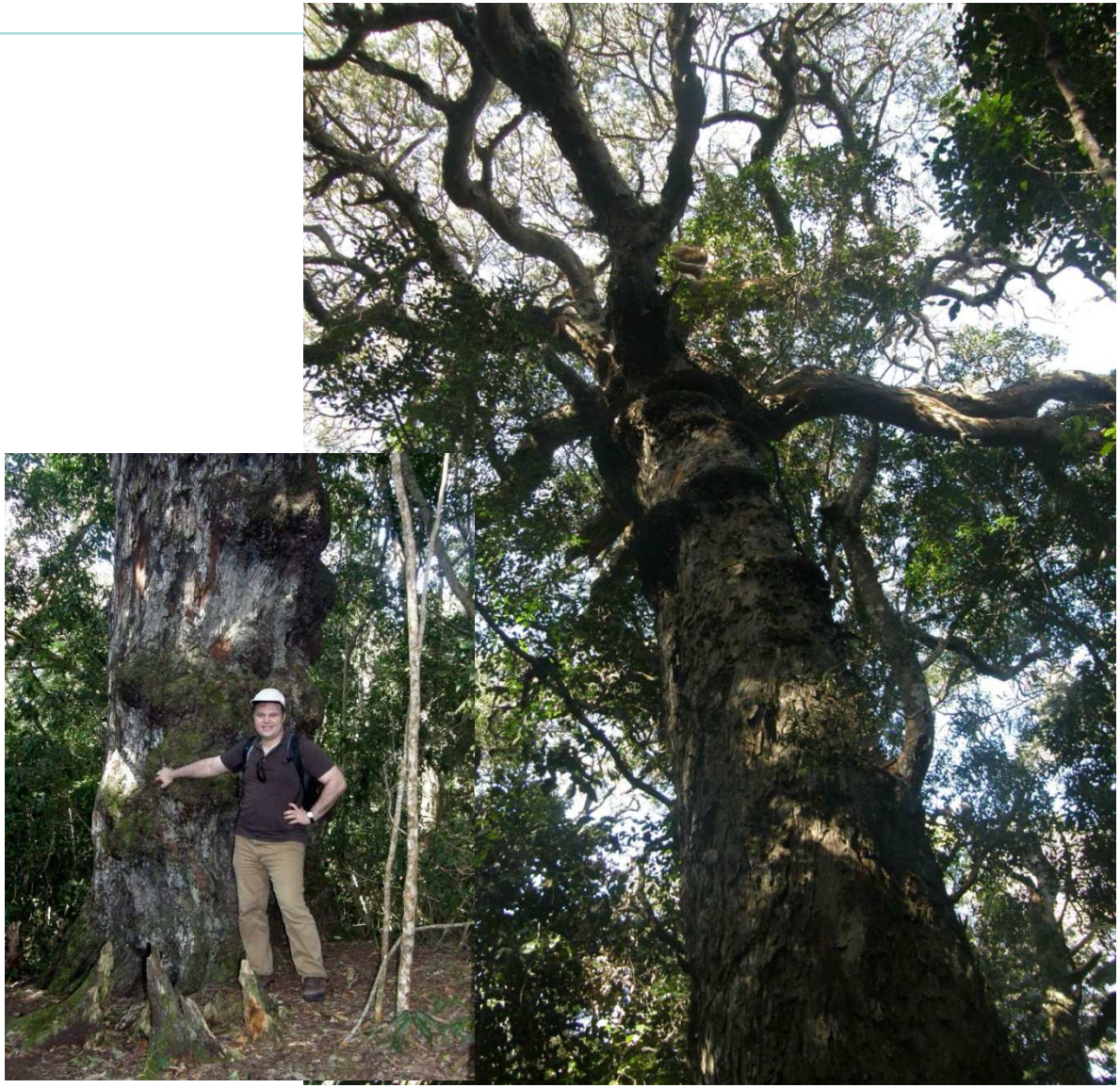


Forest Structure



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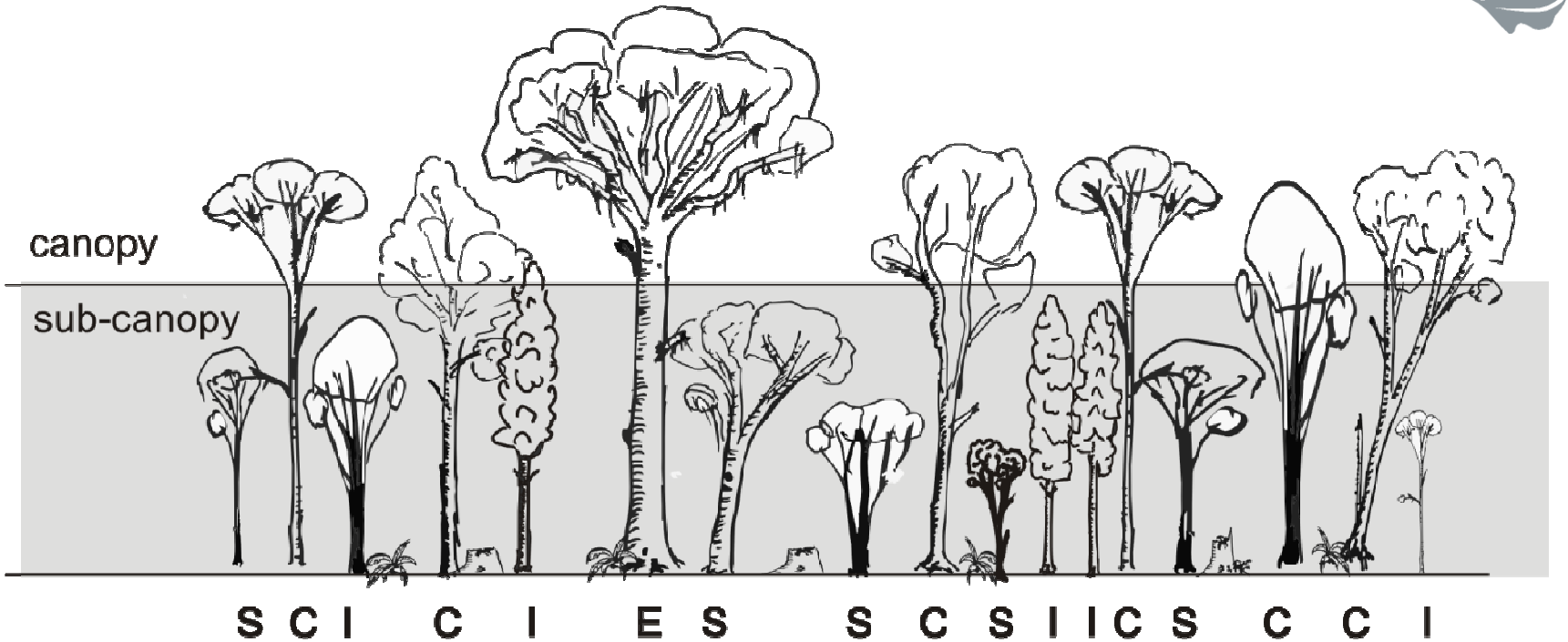
Forest structure of afrotemperate forests



E: Emergent
C: Canopy
S: Sub-canopy
I: Juvenile

Objectives

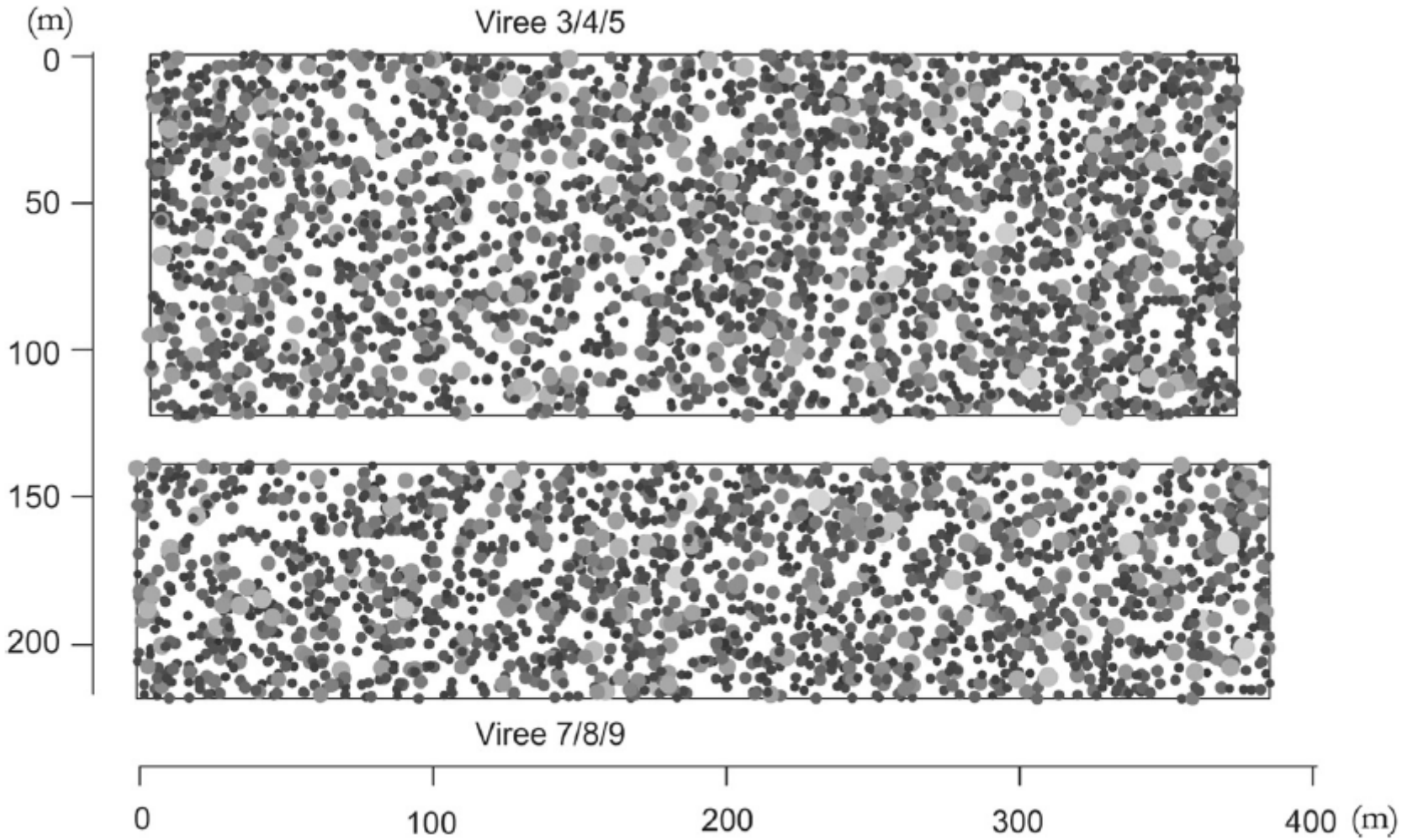
1. Are there species-specific differences in the correlation of diameter increment with distance dependent competition indices?

2. Do tree species respond differently to crowding or overtopping in different ontogenetic stages?

3. Can we use this knowledge to adapt distance dependent Euroepean individual tree models to water limited environments?

Seifert T, Seifert S, Seydack A, Durrheim G, von Gadow, K (2014) Competition effects in an afrotemperate forest. Forest Ecosystems,1:13.

Simultaneous application of CI's



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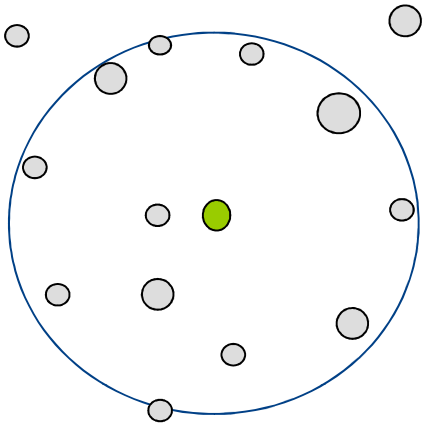
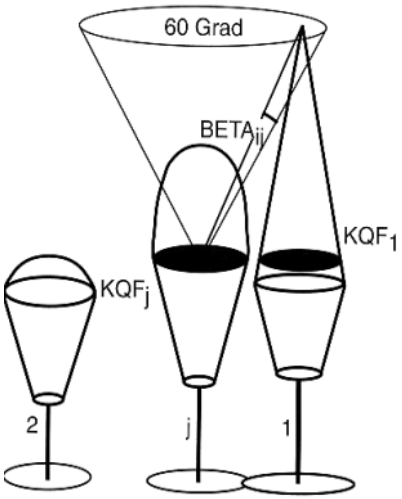
Competition indices as a way to quantify different aspects of competition



Local basal area



Pretzsch (1992)

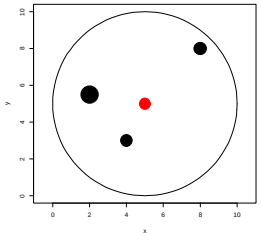
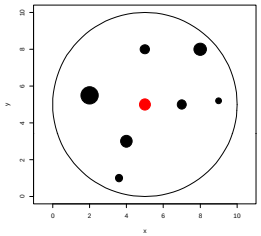
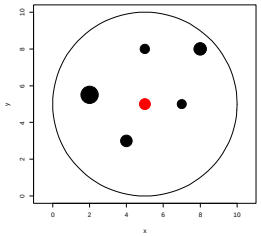
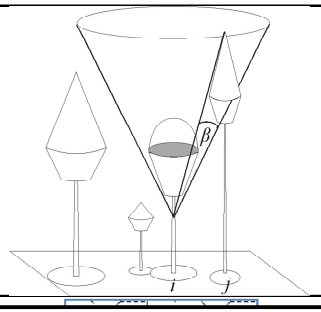
local density

overtoppping

edaphic

light

Analyse sensitivivty to different CIs

Name	Formula	Graph	Reference
Basal area of larger trees	$BAL_{ij} = \sum_{j=1}^{n} BA_j$, where $BA_i > BA_j$		Wykoff et al. (1982)
Local basal area	$lBA = \sum_{j=1}^{n} BA_j$		Steneker and Jarvis (1963)
Hegyi	$ITH = \sum_{j=1}^{n} \left(\frac{D_j}{D_i} \cdot \frac{1}{DIST_{ij}} \right)$		Hegyi (1974)
Crown Competition Index KKL	$KKL = \sum_{j=1}^{n} b_j \cdot \left(\frac{CCA_i}{CCA_j} \right) \cdot TM_j$, where $j \neq i$		Pretzsch et al. (2002)

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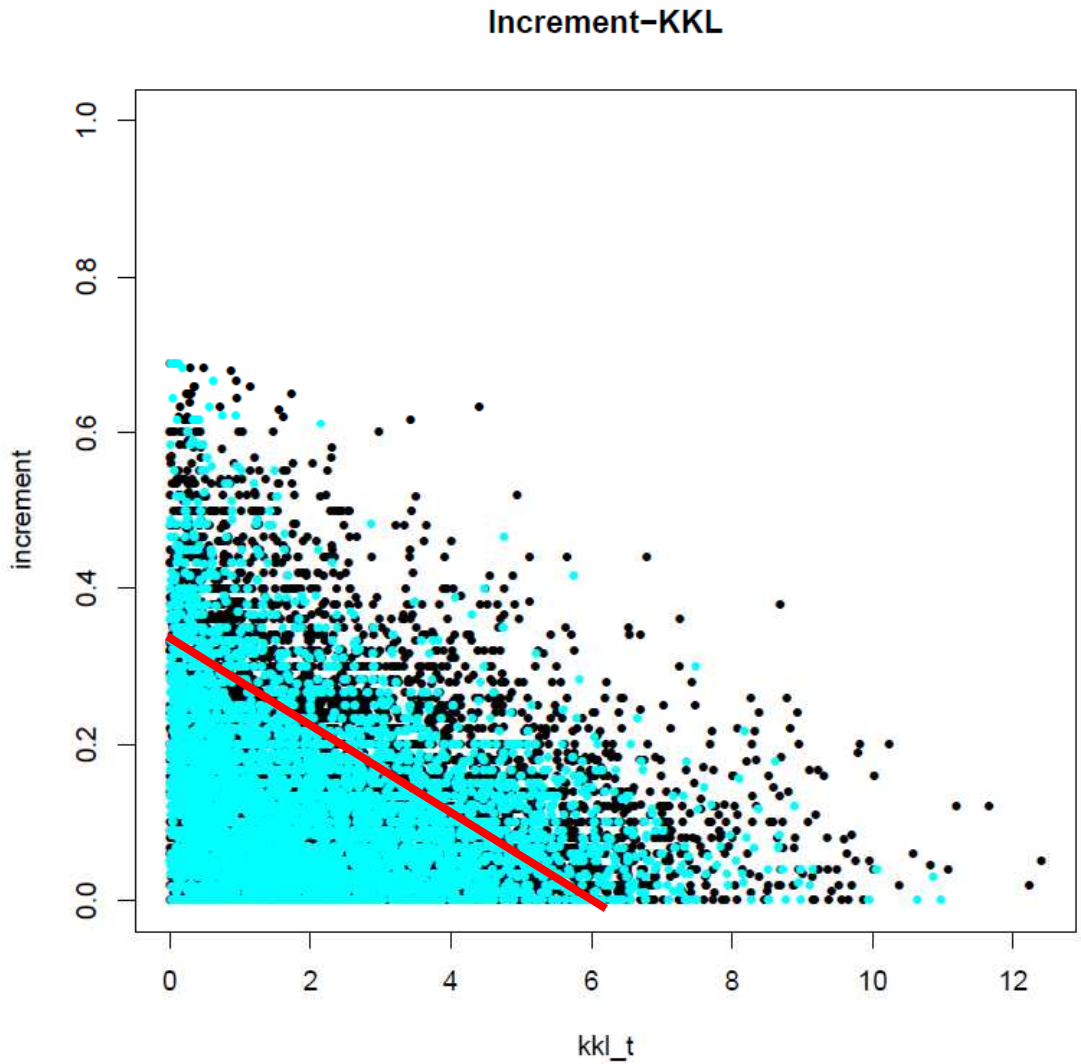
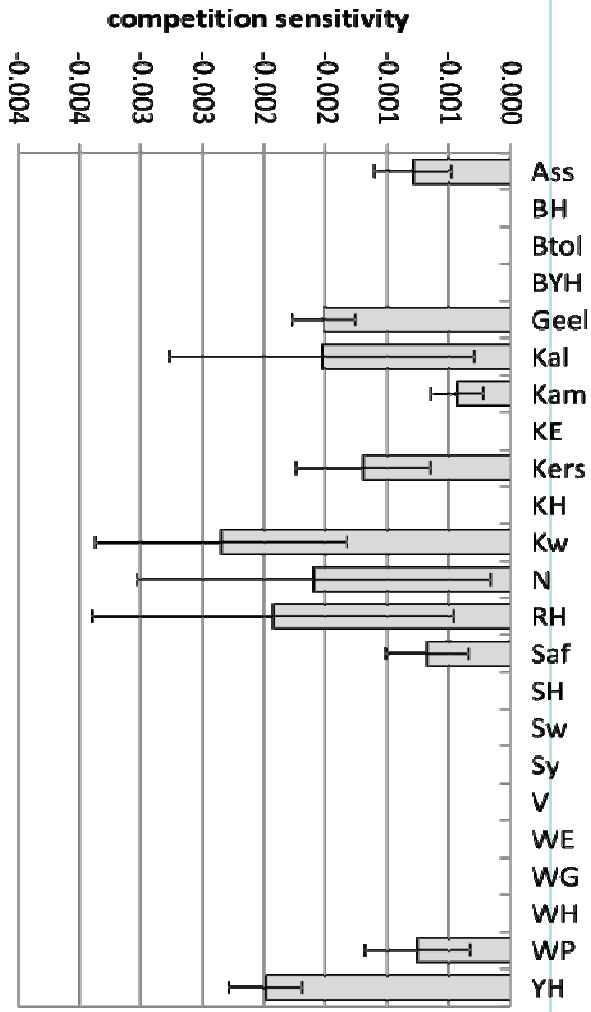
Calculating the sensitivity to a CI

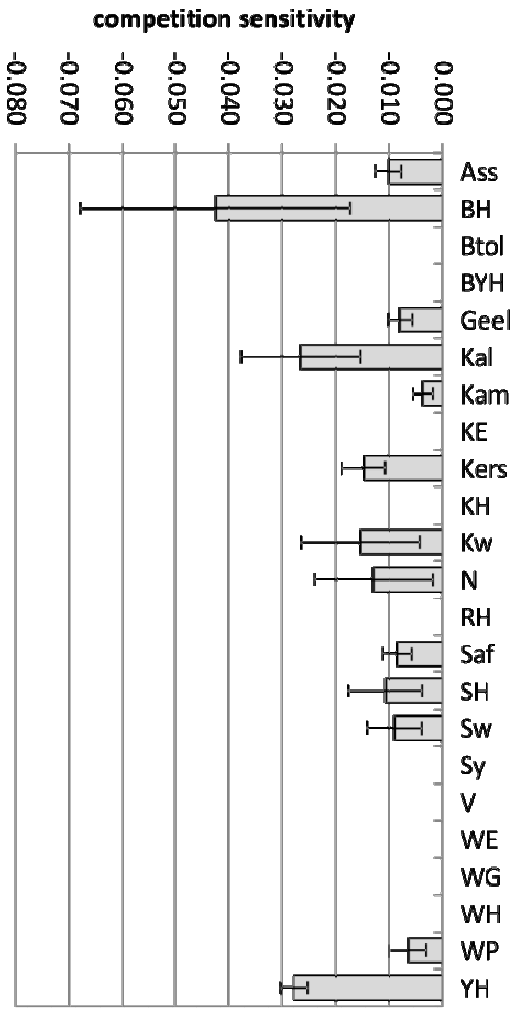


$$zd = \mathrm{a} + \mathrm{b} \cdot CI$$

slope b
Interpreted as
sensitivivty
to CI

Sensitivity to different CI's





Sensitivity to different CI's

Spezies	IBA		CR13		HgCI		KKL-t		N von 4 CIs
Ass	-0.00079	***			-0,00863	***	-0,01016	***	3
BH					-0,04100	**	-0,04251	**	2
Geel	-0,00152	***	-3,8568E-06	***			-0,00799	***	3
Kal	-0,00153	*			-0,01984	***	-0,02660	***	3
Kam	-0,00044	***	-2,5260E-06	***	-0,00281	***	-0,00372	***	4
Kers	-0,00120	***	-2,4227E-06	*	-0,00779	***	-0,01482	***	4
Kw	-0,00235	***	-4,6099E-06	*	-0,01375	*	-0,01537	**	4
N	-0,00160	*			-0,01048	*	-0,01292	*	3
RH	-0,00193	*							1
Saf	-0,00068	***	-2,1381E-06	**	-0,00428	***	-0,00852	***	4
SH					-0,00616	*	-0,01067	**	2
Sw					-0,00661	***	-0,00894	***	2
Sy					-0,01130	*			1
V					0,00822	**			1
WH			3,6453E-05	*					1
WP	-0,00075	***			-0,00523	***	-0,00649	***	3
YH	-0,00199	***	-2,6044E-06	***	-0,01442	***	-0,02781	***	4
N von 18 Spezies	11		7		14		13		Σ45

Competition

Ontogenetic difference in competition sensitivity

Ass	le	l	e
Geel	le	l	e
Kal	l		l
Kers	l	l	l
Kw	e		le
SH	l	n	n
Sw	le	l	e

Conclusions for Afrotemperate Forests

1. Different species showed a different sensitivity to various indices

2. Sensitivity to certain CIs hanged with tree size (age) and social canopy status. A multiple CI approach was suitable to explain the ontogenetically different competition sensitivity.

What can we learn for climate change adaptation of statistical growth simulators?

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Adapating SILVA for *Pinus elliottii* in South Africa

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Adapating SILVA for *Pinus elliottii* in South Africa

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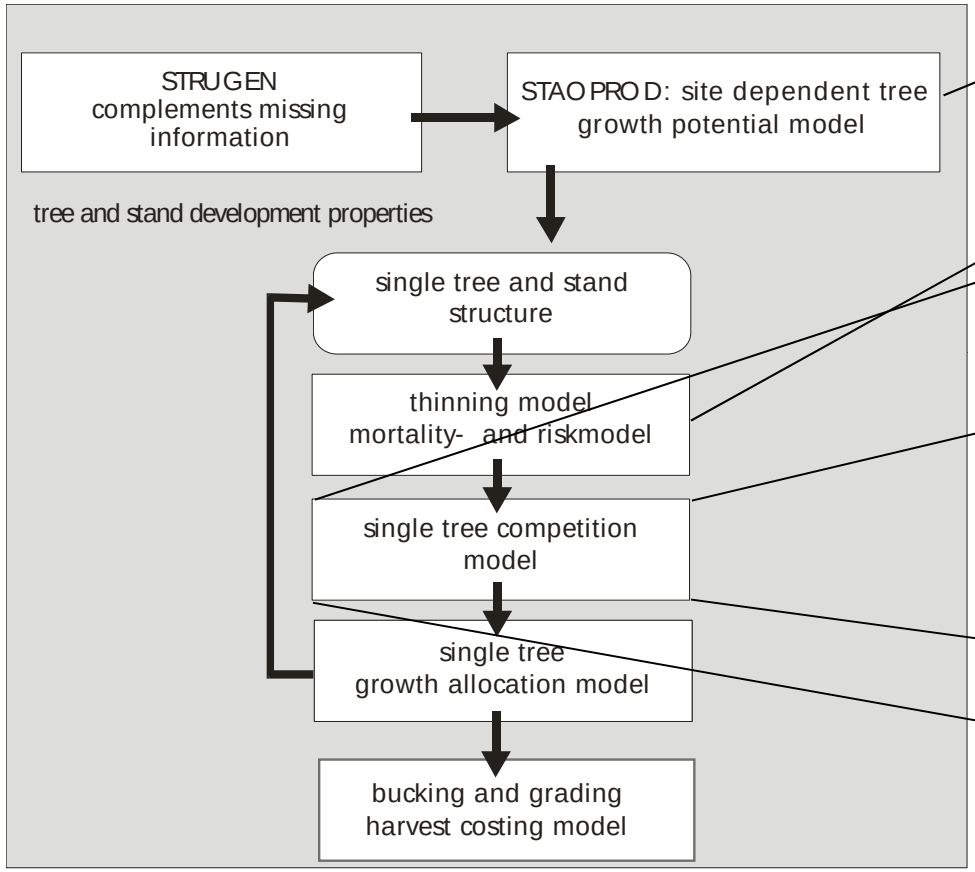
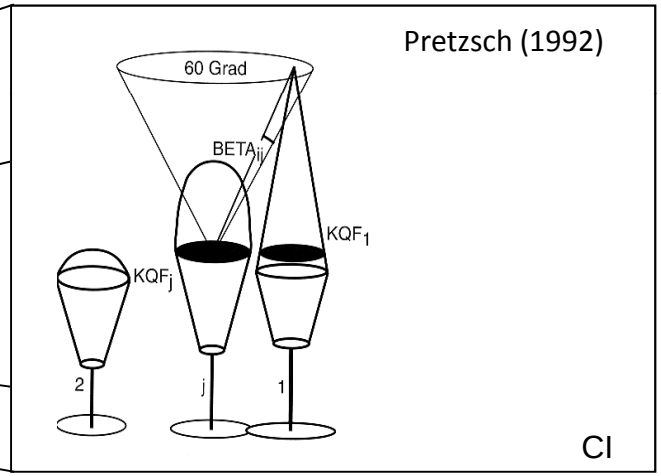
Calculations



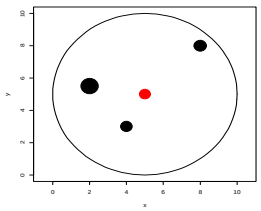
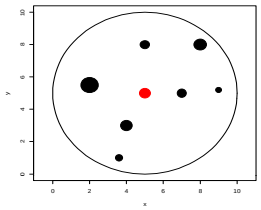
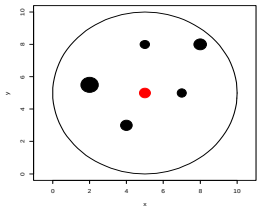
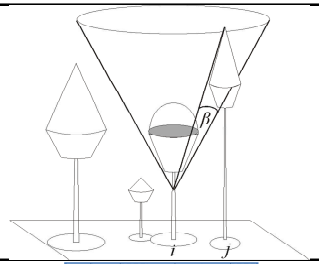
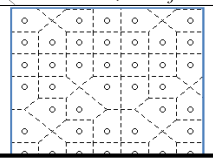
Site Index modellling

Mortality and risk modeling



Explicit spatial approach

Competition Indices (CIs)

Name	Formula	Graph	Reference
Basal area of larger trees	$BAL_{ij} = \sum_{j=1}^{n} BA_j$, where $BA_i > BA_j$		Wykoff et al. (1982)
Local basal area	$IBA = \sum_{j=1}^{n} BA_j$		Steneker and Jarvis (1963)
Hegyi	$ITH = \sum_{j=1}^{n} \left(\frac{D_j}{D_i} \cdot \frac{1}{DIST_{ij}} \right)$		Hegyi (1974)
Crown Competition Index KKL	$KKL = \sum_{j=1}^{n} b_j \cdot \left(\frac{CCA_i}{CCA_j} \right) \cdot TM_j$, where $j \neq i$		Pretzsch et al. (2002)
Voronoi	Division of growing space based on connection of bisecting line distances		(Brown 1965)

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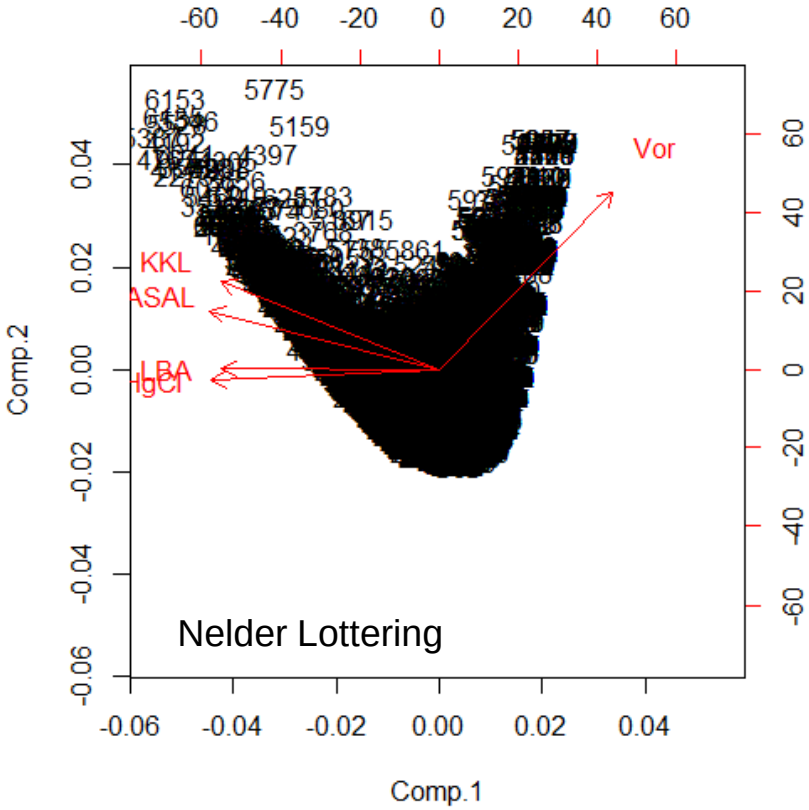
Analyse and if necessary combine CIs to improve growth prediction

Principal component analysis (PCA)



Results

- Voronoi area was different from all other indices
- KKL and BAL were similar as were lBA and HgCI
- KKL and lBA were chosen as candidates to be combined

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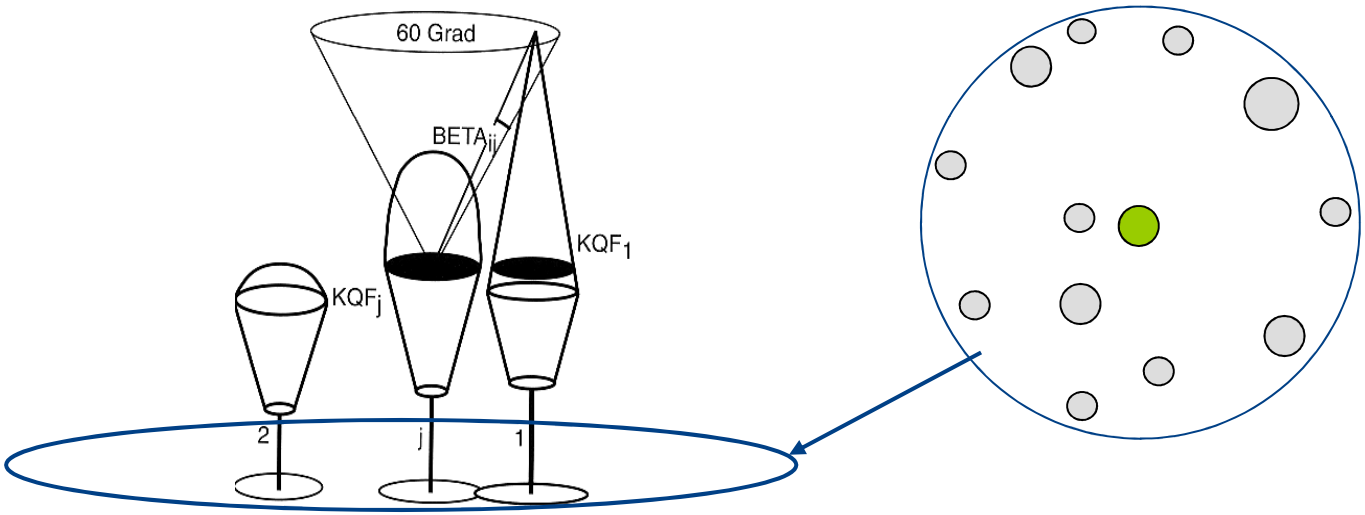
Using a combined CI approach

$$id_{pot} * e^{(a+b*W*KKL+c*W*LBA)}$$

$$W(Aridity\ Index) = \frac{Precipitation}{PET}$$



Pretzsch (1992)

light dominated KKL

water dominated IBA

Modelling diameter increment including LBA

$$id_{pot} * e^{(a+b*W*KKL+c*W*LBA)}$$

Analysis of Variance Table

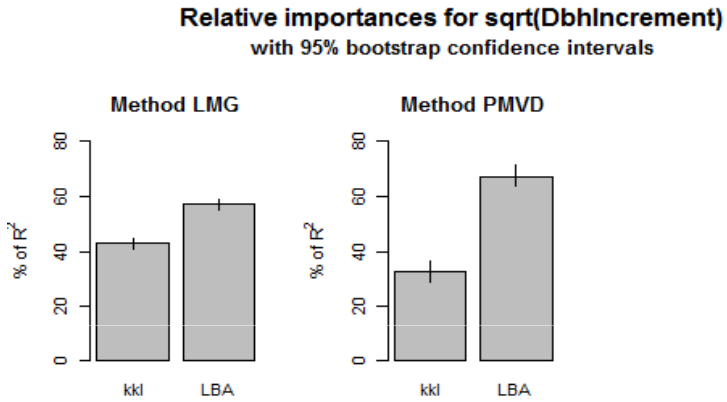
Model	Res.Df	Res.Sum Sq	Df	Sum Sq	AIC	RMSE	F value	Pr(>F)	
KKL	7494	3385.5			15320.34	0.67204			
LBA	7494	4139.9	0	0	16828.38	0.743157			
KKL + LBA	7493	3366.5	1	773.37	15280.29	0.670158	1721.3	<2.20E-16	***

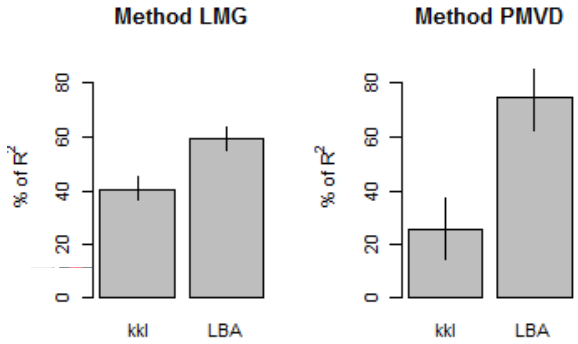
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Relative information value of KKL and lBA

Wetter site (Nelder Lottering)

Dryer site (CCT Tweefontein)



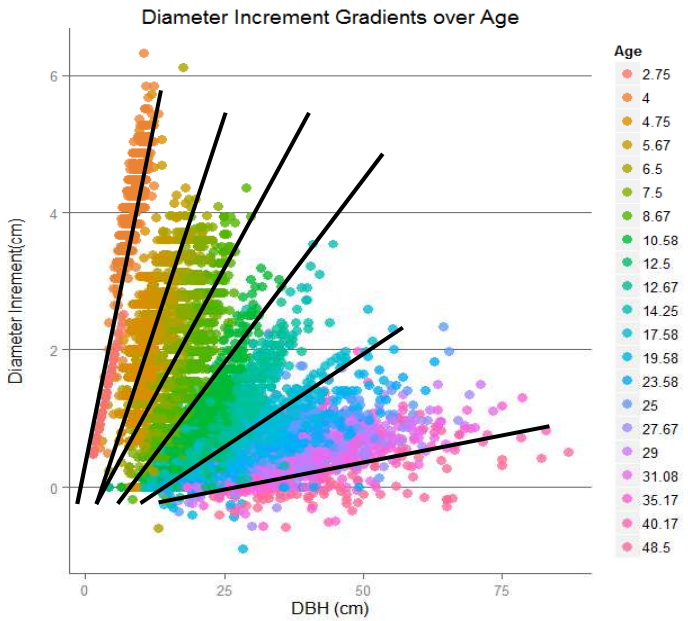


	Nelder		Tweefontein	
Method	KKL	LBA	KKL	LBA
lmg	0.431	0.569	0.407 ↓	0.593
pmvd	0.329	0.671	0.255 ↓	0.745

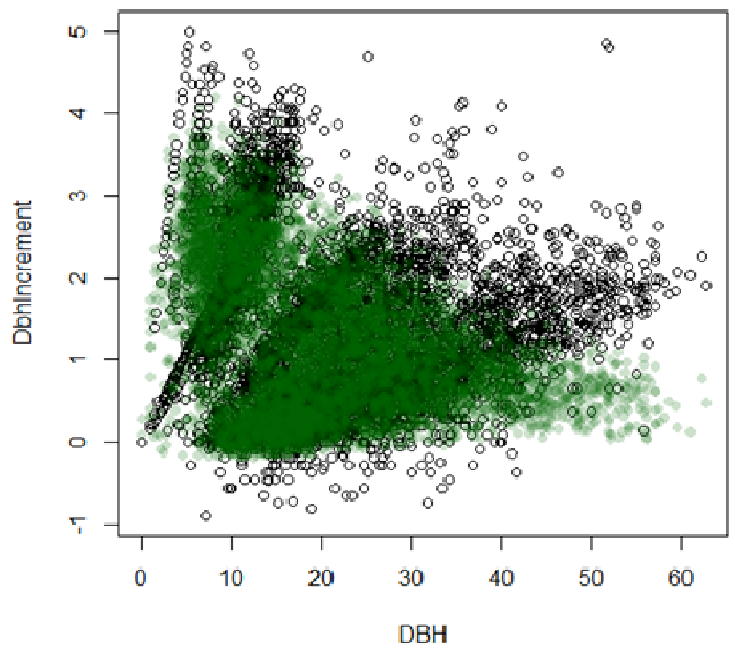
KKL increased in relative information value on site with better water supply

Diameter increment model in response to resource limitations and site classification

Pinus elliotii



Empirical data



Model (green) against empirical (black)

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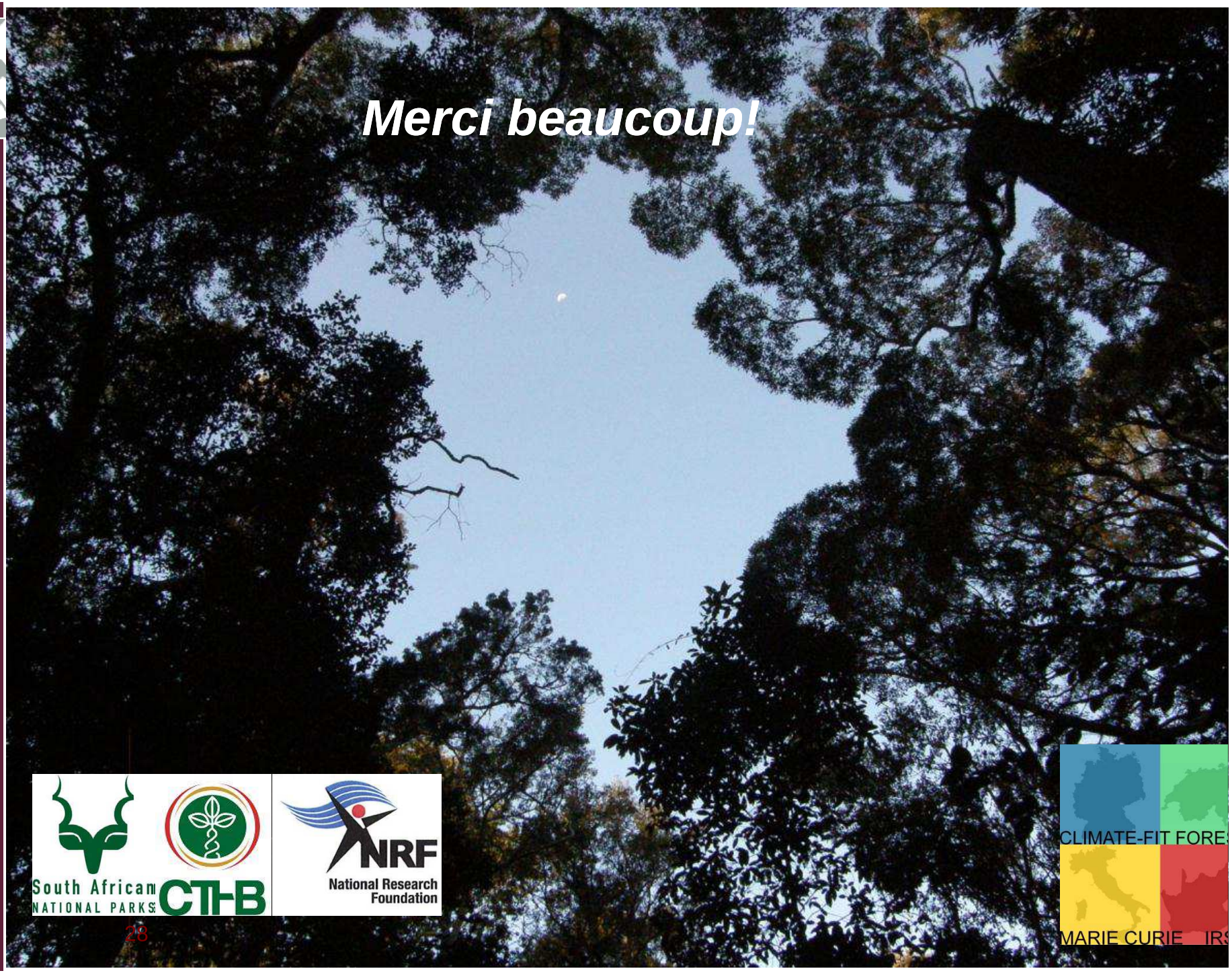

Merci beaucoup!

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