

Scale-dependent stand heterogeneity in a near-natural, mature, mixed deciduous forest

Collins B. Kukunda

Chair of Forest Inventory & Remote Sensing
University of Göttingen

September 11, 2015



Key message

Would the size of the plate influence the amount of food you would eat?

Key message

Would the size of the plate influence the amount of food you would eat?

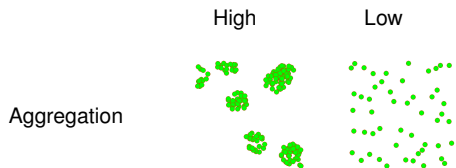


Key message

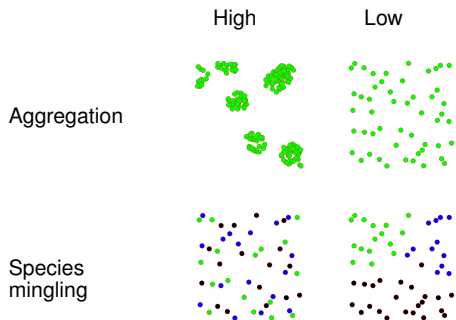
Would the size of the plate influence the amount of food you would eat?



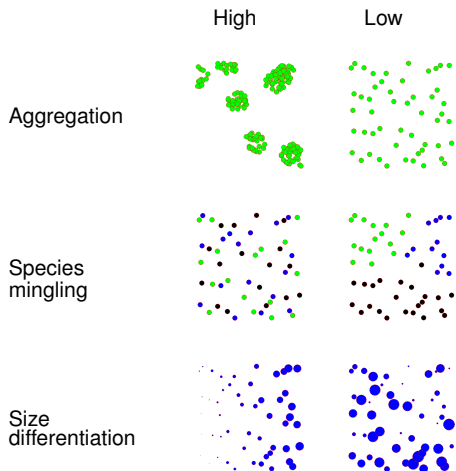
A diverse definition of forest structure



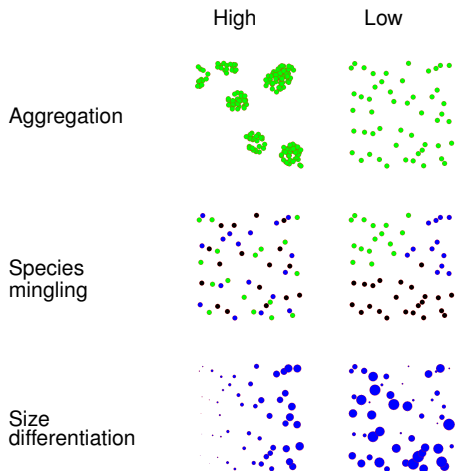
A diverse definition of forest structure



A diverse definition of forest structure

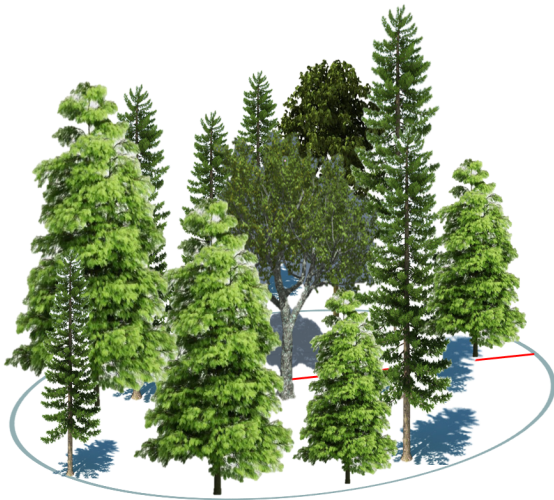


A diverse definition of forest structure



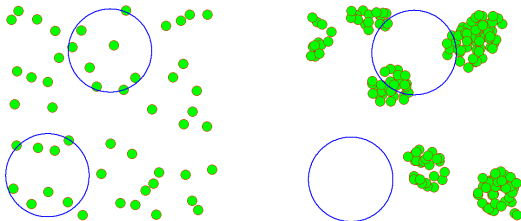
Including also; density, biomass, leaf area, canopy closure and layering, stand development stages, forest area etc...

2-3D Descriptions of forest structure



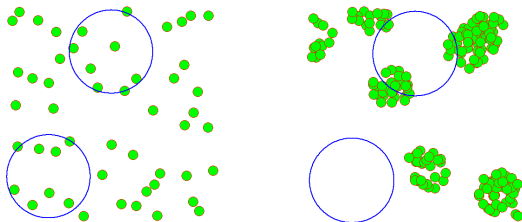
The problem of a bounded observation unit

Density

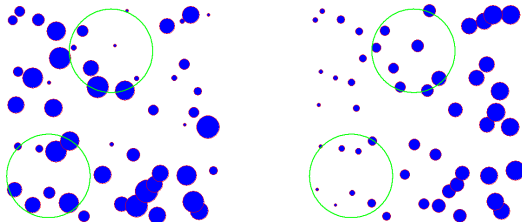


The problem of a bounded observation unit

Density



Basal area/
Volume



Technical Objectives

- 1 To investigate the robustness of three structural indices at characterizing structure of a mature mixed deciduous forest from differing scales of observation.
- 2 To quantify the dependence of forest structural indices on plot size across differing levels of stand complexity and tree aggregation.

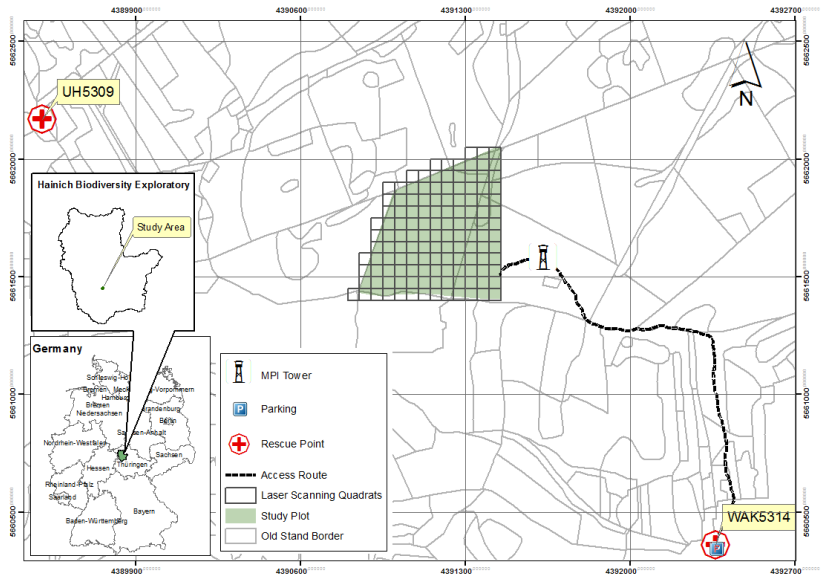
Technical Objectives

- 1 To investigate the robustness of three structural indices at characterizing structure of a mature mixed deciduous forest from differing scales of observation.
- 2 To quantify the dependence of forest structural indices on plot size across differing levels of stand complexity and tree aggregation.

Structural indices

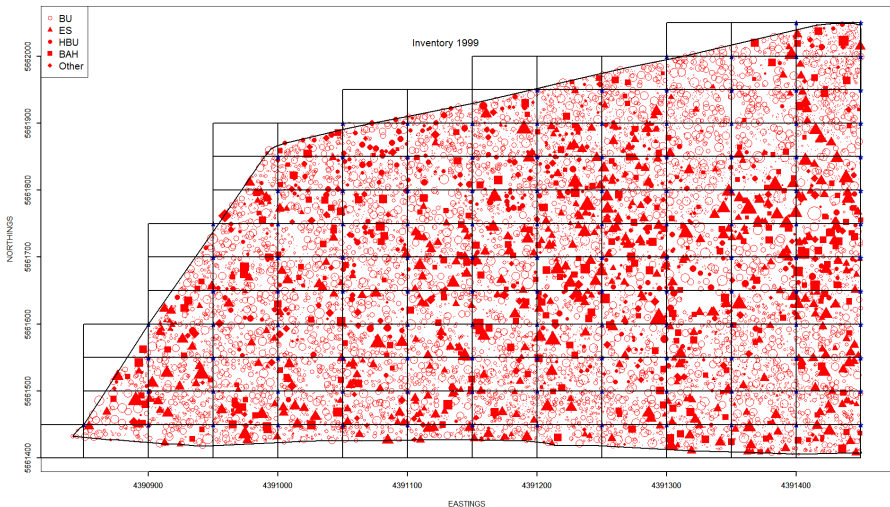
Index	Description	Authors
SCI	$\frac{A_s}{A_p}$	(E.Zenner and D.Hibbs, 2000)
CI	$R = \frac{\bar{R}A}{\bar{R}E}$	(P.J.Clark and F.C.Evans, 1954)
ESCI	$ESCI' = SCI * VRM$ $ESCI = ESCI' * (1 + N^{-10m^2})$	(P.Beckschäfer et al., 2013)

Study Area

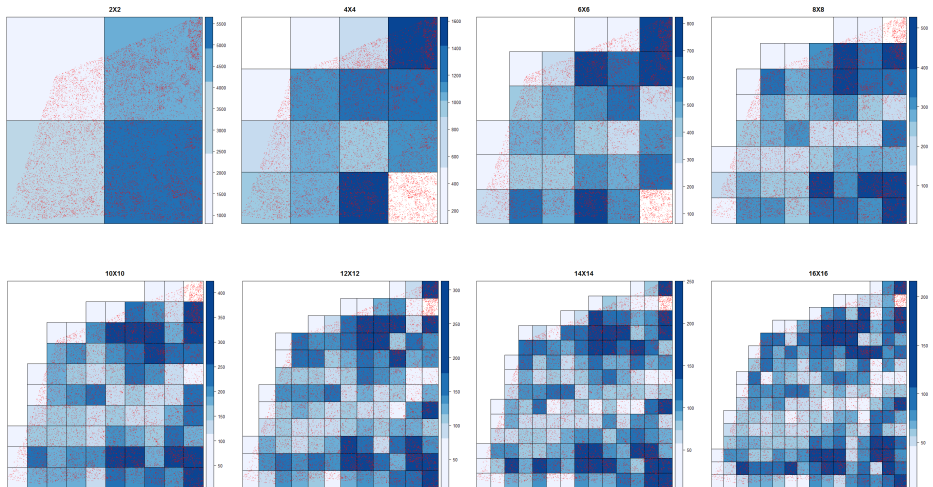


Data

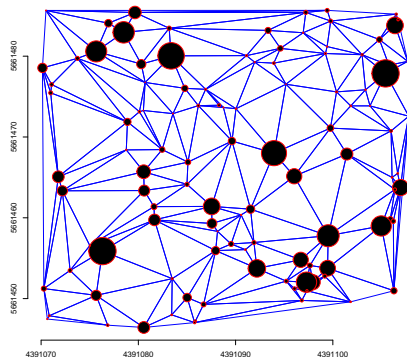
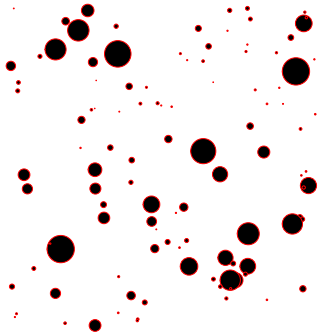
Full census: Wirth/Bauhuss Plot (1999, 2007, 2014)



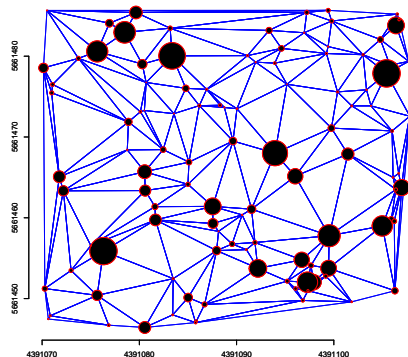
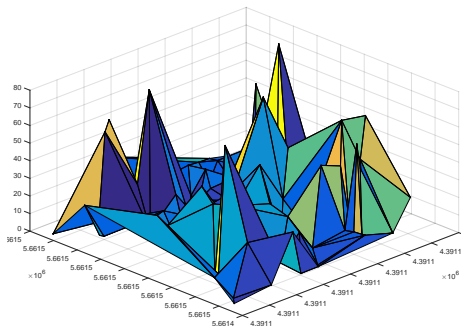
Grids of varying resolutions



Computing the indices



Computing the indices

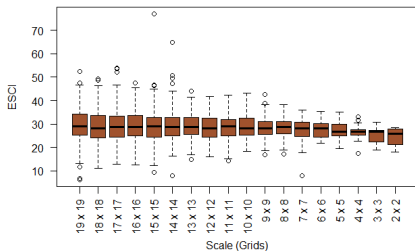
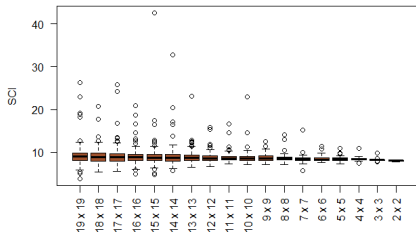
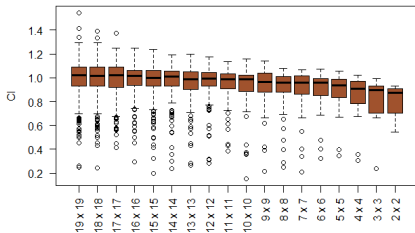


A fixed effects mixed model

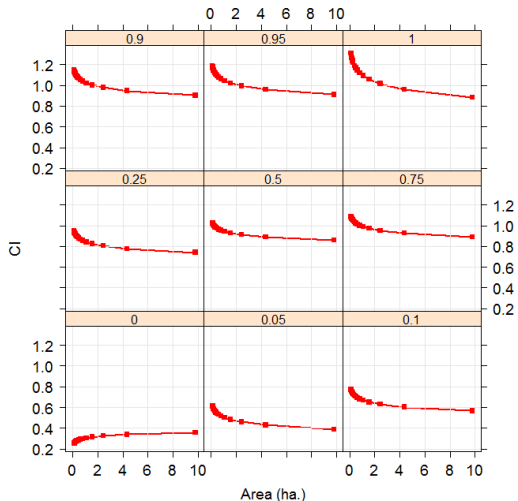
Are there scale-related confounding effects on the variability of index values for stands of varying levels of complexity?

$$y_{ij} = \beta_1 \log(\text{pixelarea})_{ij} + \gamma_{0j} + \epsilon_{ij}$$

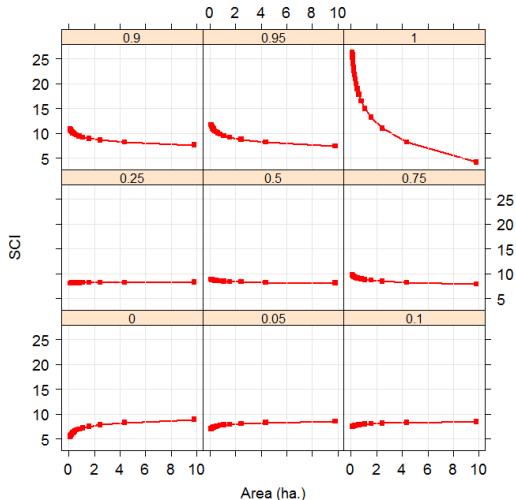
Robustness of indices to scales of observation



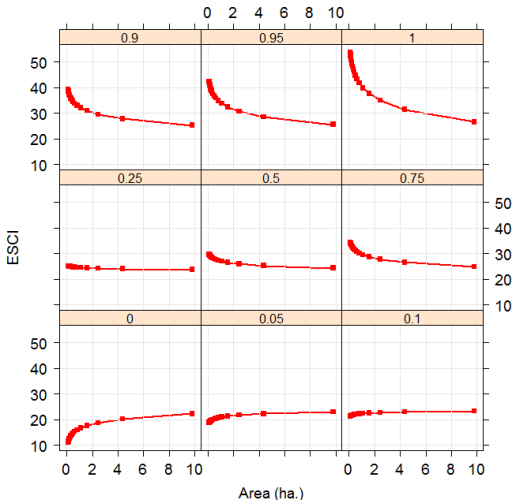
Indices vs Scale across complexity/aggregation



Indices vs Scale across complexity/aggregation



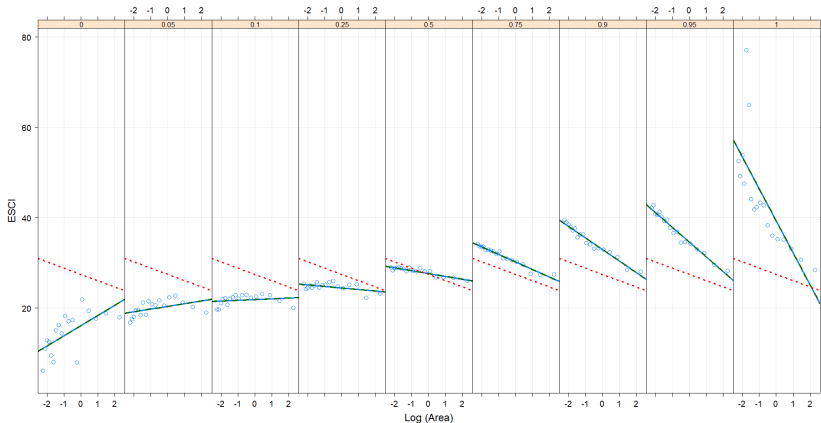
Indices vs Scale across complexity/aggregation



Scale effects across complexity - ESCI

	Estimate	Std. Error	t value	Pr(> t)	
Fixed intercept	27.64	0.84	32.89	0.00	***
Fixed slope	-0.65	0.58	-1.12	0.26	
Percentile 0	-11.54	1.19	-9.71	0.00	***
Percentile 0.05	-7.24	1.19	-6.09	0.00	***
Percentile 0.1	-5.72	1.19	-4.82	0.00	***
Percentile 0.25	-3.17	1.19	-2.67	0.01	**
Percentile 0.75	2.57	1.19	2.16	0.03	*
Percentile 0.9	5.31	1.19	4.46	0.00	***
Percentile 0.95	6.92	1.19	5.83	0.00	***
Percentile 1	11.60	1.19	9.77	0.00	***
Percentile 0	2.89	0.82	3.52	0.00	***
Percentile 0.05	1.26	0.82	1.53	0.13	
Percentile 0.1	0.82	0.82	1.00	0.32	
Percentile 0.25	0.31	0.82	0.38	0.70	
Percentile 0.75	-1.01	0.82	-1.23	0.22	
Percentile 0.9	-1.89	0.82	-2.31	0.02	*
Percentile 0.95	-2.63	0.82	-3.20	0.00	***
Percentile 1	-6.41	0.82	-7.82	0.00	***

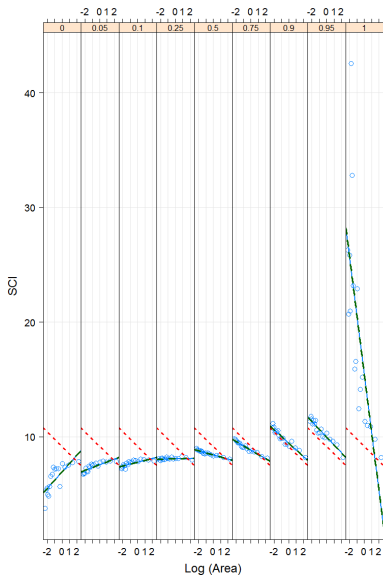
Scale effects across complexity - ESCI



Scale effects across complexity - SCI

	Estimate	Std. Error	t value	Pr(> t)	
Fixed Intercept	8.43	0.57	14.77	0.00	***
Fixed slope	-0.18	0.39	-0.46	0.65	
Percentile 0	-1.48	0.81	-1.84	0.07	.
Percentile 0.05	-0.85	0.81	-1.05	0.29	
Percentile 0.1	-0.63	0.81	-0.79	0.43	
Percentile 0.25	-0.33	0.81	-0.41	0.68	
Percentile 0.75	0.41	0.81	0.51	0.61	
Percentile 0.9	1.03	0.81	1.28	0.20	
Percentile 0.95	1.57	0.81	1.95	0.05	.
Percentile 1	6.93	0.81	8.58	0.00	***
Percentile 0	0.89	0.56	1.60	0.11	
Percentile 0.05	0.44	0.56	0.78	0.43	
Percentile 0.1	0.35	0.56	0.63	0.53	
Percentile 0.25	0.20	0.56	0.36	0.72	
Percentile 0.75	-0.19	0.56	-0.34	0.73	
Percentile 0.9	-0.40	0.56	-0.71	0.48	
Percentile 0.95	-0.50	0.56	-0.89	0.37	
Percentile 1	-4.88	0.56	-8.76	0.00	***

Scale effects across complexity - SCI

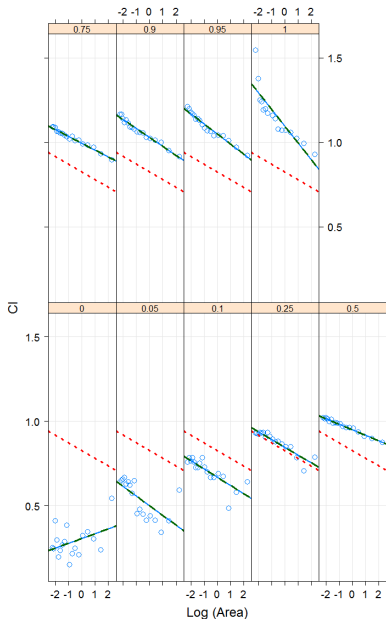


t value	Pr(> t)	
14.77	0.00	***
-0.46	0.65	
-1.84	0.07	.
-1.05	0.29	
-0.79	0.43	
-0.41	0.68	
0.51	0.61	
1.28	0.20	
1.95	0.05	.
8.58	0.00	***
1.60	0.11	
0.78	0.43	
0.63	0.53	
0.36	0.72	
-0.34	0.73	
-0.71	0.48	
-0.89	0.37	
-8.76	0.00	***

Scale effects across complexity - CI

	Estimate	Std. Error	t value	Pr(> t)	
Fixed Intercept	0.95	0.01	68.54	0.00	***
Fixed Slope	-0.03	0.01	-3.45	0.00	***
Percentile 0	-0.64	0.02	-32.84	0.00	***
Percentile 0.05	-0.45	0.02	-22.99	0.00	***
Percentile 0.1	-0.28	0.02	-14.31	0.00	***
Percentile 0.25	-0.10	0.02	-5.25	0.00	***
Percentile 0.75	0.05	0.02	2.36	0.02	*
Percentile 0.9	0.08	0.02	4.11	0.00	***
Percentile 0.95	0.10	0.02	5.18	0.00	***
Percentile 1	0.15	0.02	7.49	0.00	***
Percentile 0	0.06	0.01	4.56	0.00	***
Percentile 0.05	-0.02	0.01	-1.80	0.07	.
Percentile 0.1	-0.02	0.01	-1.18	0.24	
Percentile 0.25	-0.01	0.01	-0.93	0.35	
Percentile 0.75	-0.01	0.01	-0.57	0.57	
Percentile 0.9	-0.02	0.01	-1.44	0.15	
Percentile 0.95	-0.03	0.01	-1.99	0.05	*
Percentile 1	-0.07	0.01	-4.80	0.00	***

Scale effects across complexity - CI



t value	Pr(> t)	
68.54	0.00	***
-3.45	0.00	***
-32.84	0.00	***
-22.99	0.00	***
-14.31	0.00	***
-5.25	0.00	***
2.36	0.02	*
4.11	0.00	***
5.18	0.00	***
7.49	0.00	***
4.56	0.00	***
-1.80	0.07	.
-1.18	0.24	
-0.93	0.35	
-0.57	0.57	
-1.44	0.15	
-1.99	0.05	*
-4.80	0.00	***

Scale effects

- 1 Scale dependent efficiency of structural indices.
- 2 Small scale effects

Key message

Would the size of the plate influence the amount of food you would eat?



NGIYABONGA!!

Bibliography

- E.Zenner and D.Hibbs. A new method for modeling the heterogeneity of forest structure. *Forest Ecology and Management*, 129: 75–87, 2000.
- K.v.Gadow, C.Y.Zhang, C.Wehenkel, A.Pommerening, J.Corrall-Rivas, M.Korol, S.Myklush, G.Y.Hui, A.Kiviste, and X.H.Zhao. Forest structure and diversity. *Continuous Cover Forestry: Managing Forest Ecosystems*, 23:29–84, 2012.
- P.Beckschäfer, P.Mundhenk, C.Kleinn, Y.Ji, D.W.Douglas, and R.D.Harrison. Enhanced structural complexity index: an improved index for describing forest structural complexity. *Open Journal of Forestry*, 3:23–29, 2013.
- P.J.Clark and F.C.Evans. Distance to nearest neighbour as a measure of spatial relationships in populations. *Ecology*, 35: 445–453, 1954.