Scientific Inference

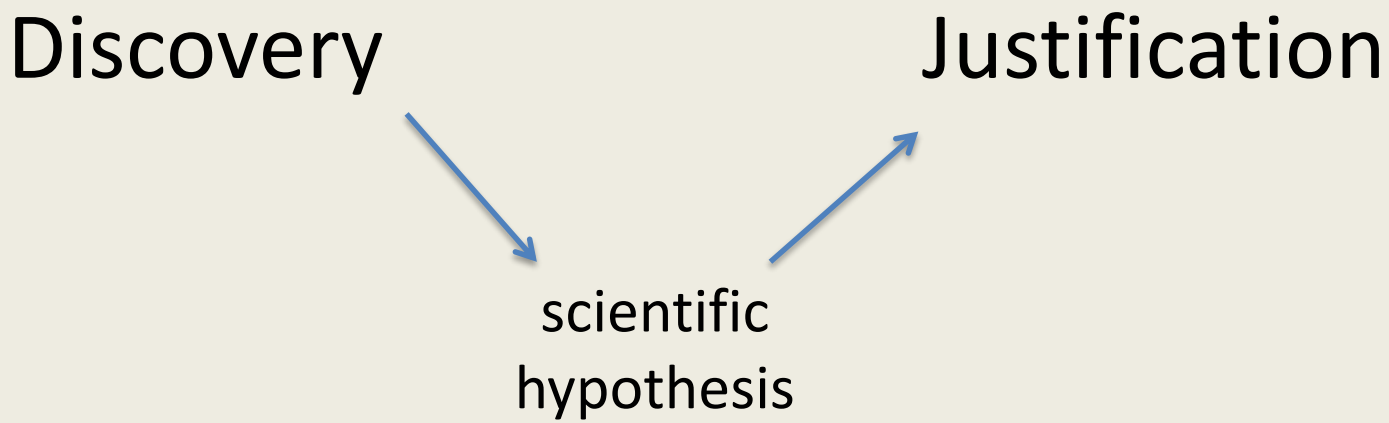
“Scientists these days tend to keep up a polite fiction that all science is equal.”

“Whether it is hand-waving or number-waving or equation-waving, a theory is not a theory unless it can be disproved.”

John R. Platt

Thanks to Dr. Ron McRoberts, St. Paul, MN for the framework discussed.

Phases of scientific research (Reichenbach 1938):

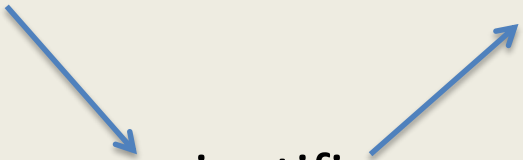


Phases of scientific research (Reichenbach 1938):

Discovery

Trial and error
Systematic search
Serendipity
Inspiration
Analogy
Derivation from theory
Induction
Retroduction[1]

Justification



Retroduction is similar to induction, ….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Retroduction is a "...mode of inference in which events are explained by postulating (and identifying) mechanisms which are capable of producing them...". ……. Sayer (1992, p.107).

Forestry example:

Interior of sugar maple tree trunk that will produce the birdseye pattern when wood is finished :

Birdseye pattern in sugar maple (*Acer saccharum).*

Normal maple wood grain

Birdseye maple wood grain

Phases of scientific research (Reichenbach 1938):

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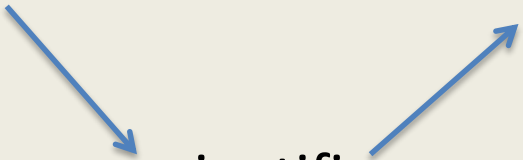
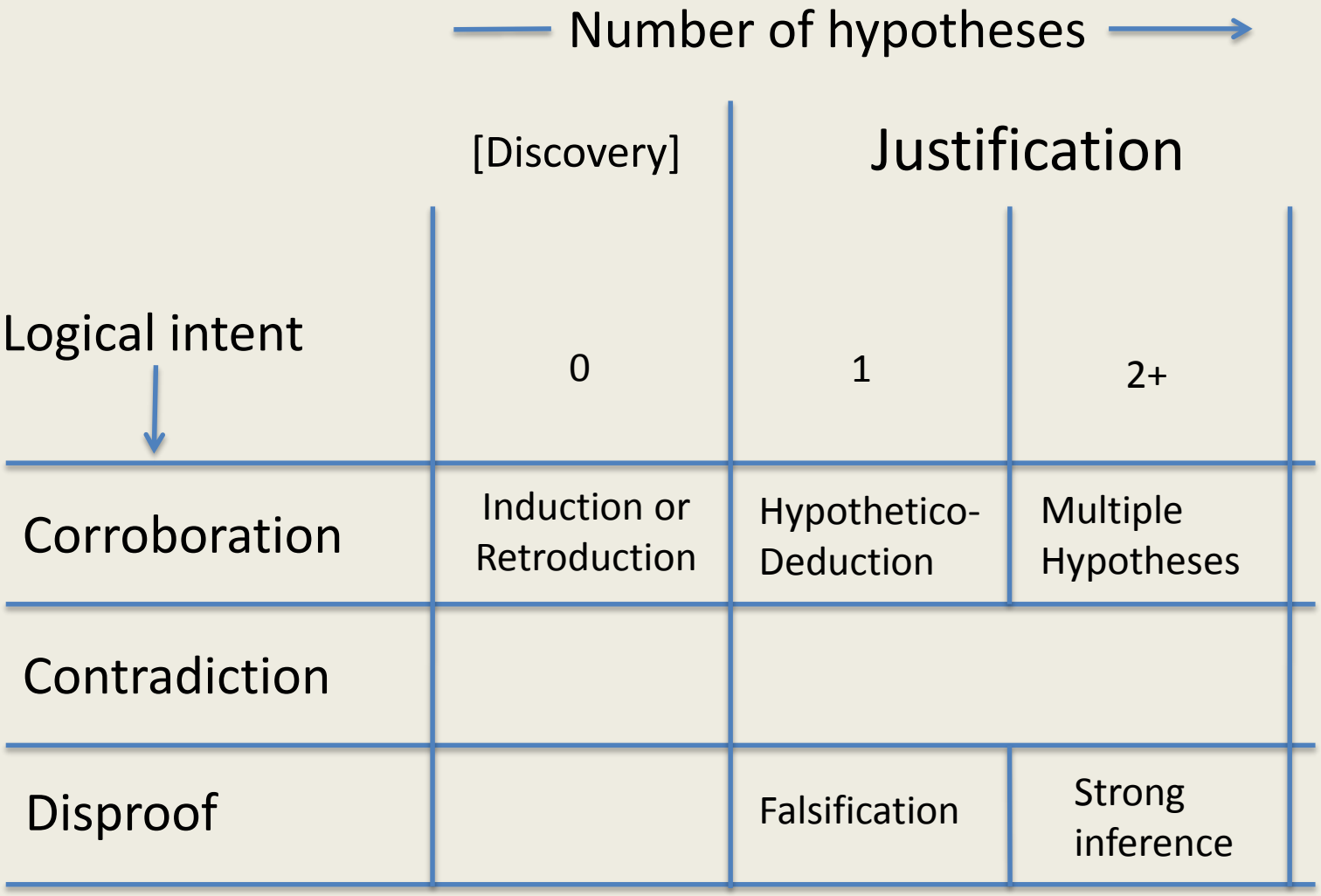
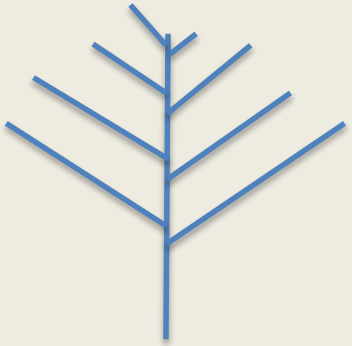
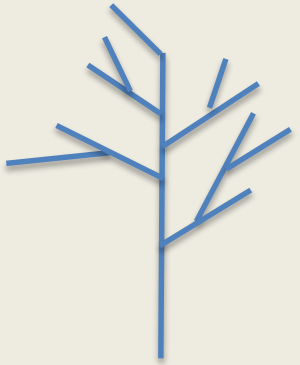
Induction

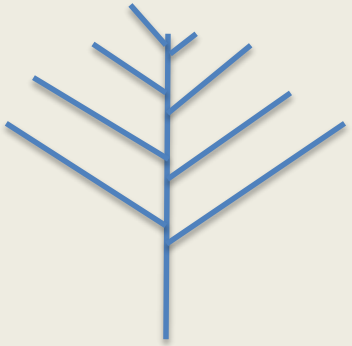
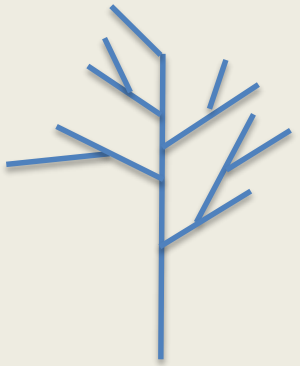
Justification

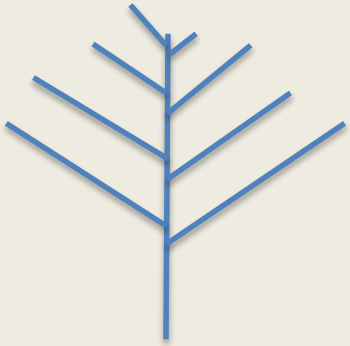
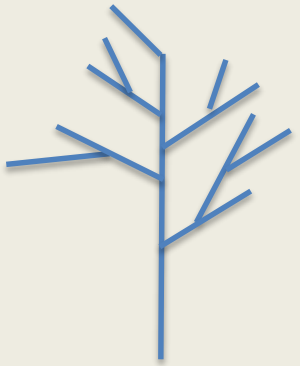
?

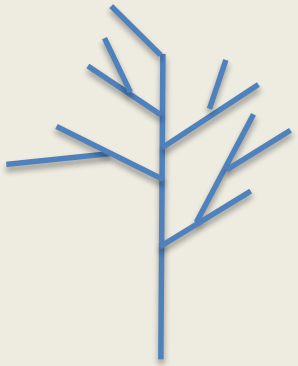



Number of hypotheses
[Discovery]
Justification
Logical intent
0
1
2+
Corroboration
Induction or Retroduction
Hypothetico-Deduction
Multiple Hypotheses
Contradiction
Disproof
Falsification
Strong inference

Logical intent	Number of hypotheses		
	0	1	2+
Corroboration		Hypothetico-Deduction ?	Multiple hypotheses 
Contradiction			
Disproof		Falsification 	Strong inference 

Logical intent	Number of hypotheses: 1	Number of hypotheses: 2+
Corroboration	Hypothetico-Deduction 	Multiple hypotheses 
Contradiction		
Disproof	Falsification ?	Strong inference 

Logical intent	Number of hypotheses	
	1	2+
Corroboration	Hypothetico-Deduction 	Multiple hypotheses 
Contradiction		
Disproof	Falsification ? $h' = \alpha h e^{-\beta h}$	Strong inference 

Logical intent	Number of hypotheses: 1	Number of hypotheses: 2+
Corroboration	Hypothetico-Deduction 	Multiple hypotheses ?
Contradiction		
Disproof	Falsification 	Strong inference 

1. Used 18 different growth models from forestry literature (Kivist, Zeide, etc.)

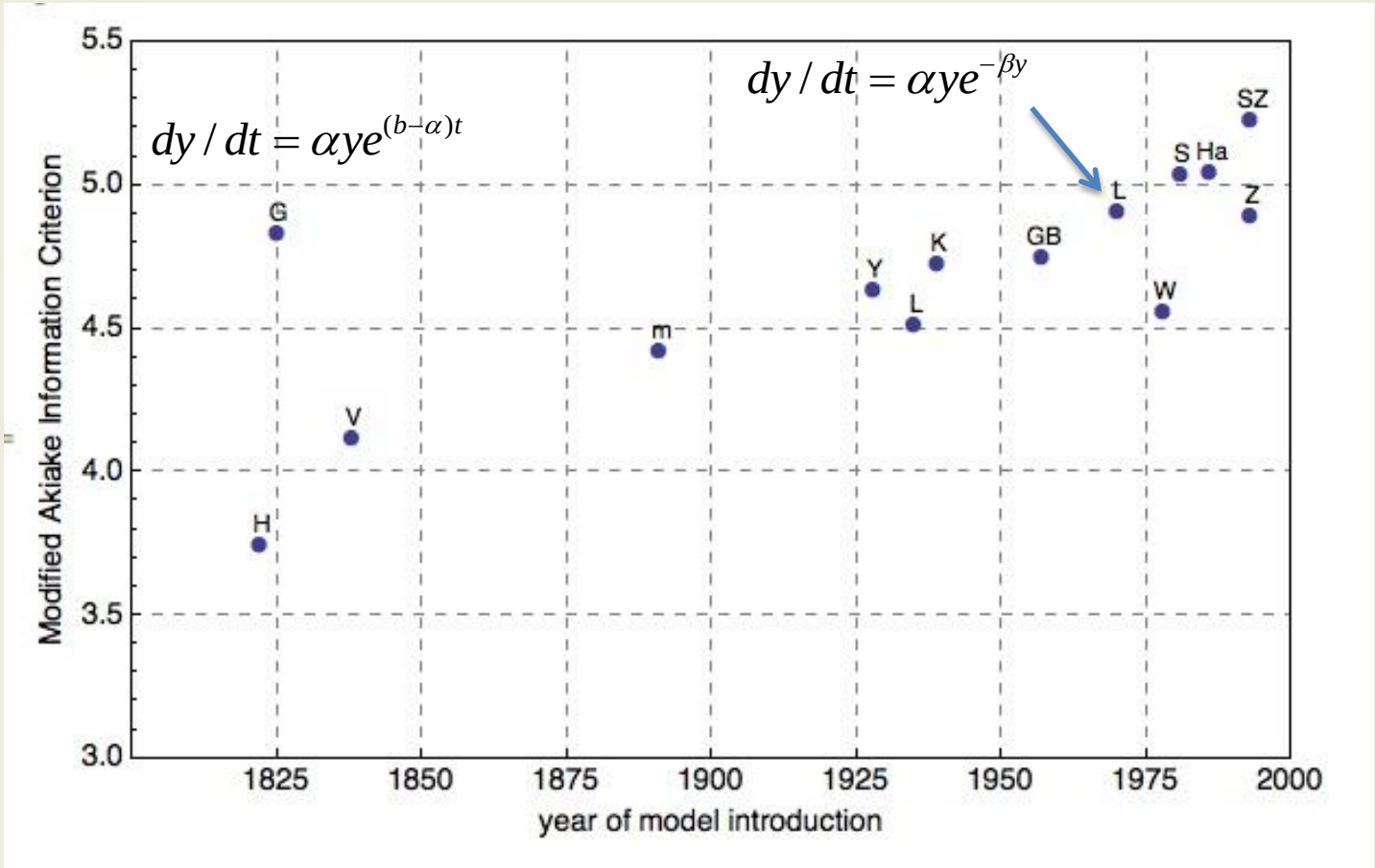
2. Used total height vs age data for a cohort of 3-5 sugar maple trees at least 60 years on 54 plots in Northern USA.

3. Set SAS program to estimate identical (global) model parameters, but tree-specific initial heights

1. Models were evaluated according to ‘standard’ goodness of fit characteristics.

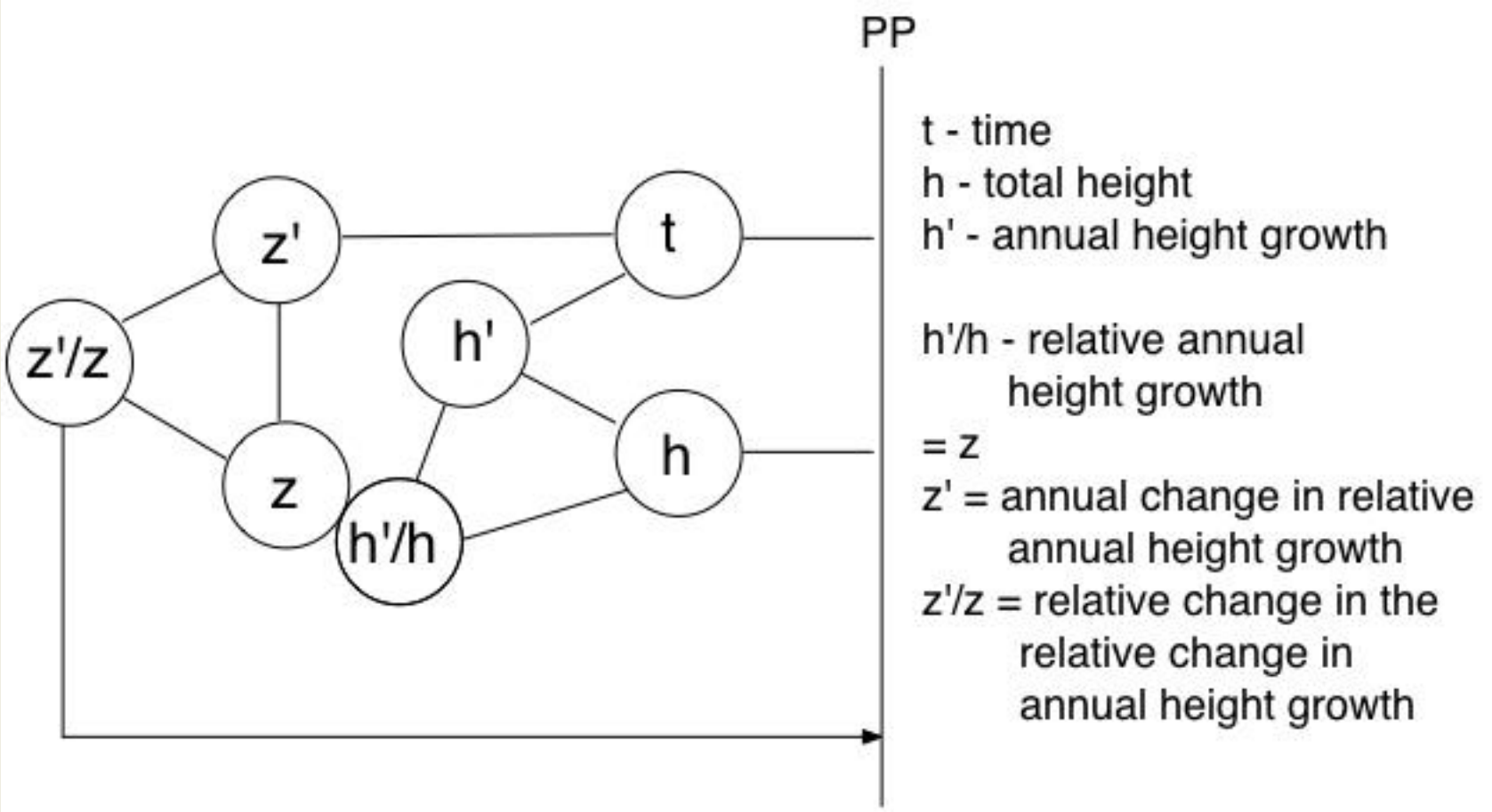
Are we making progress – 185 years of growth modeling?

?



Charles P. Winsor. 1932. The Gompertz as a growth curve. Proceedings National Academy of Sciences 18(1): 1-8

Why did the Schnute equation (as modified by Zeide) perform so well?




RMSE
AIC

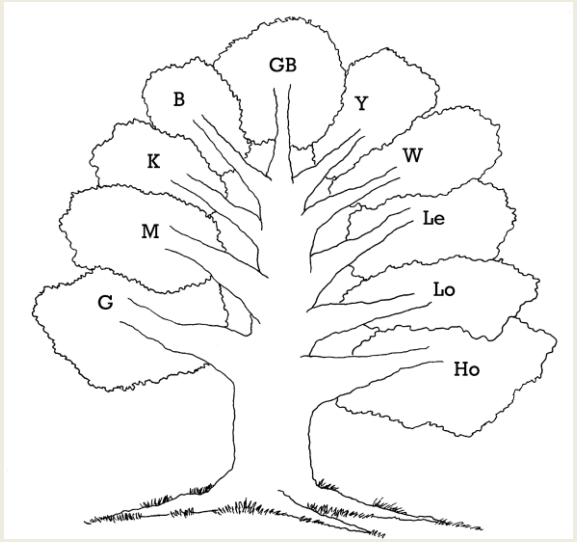
Logical intent	Number of hypotheses: 1	Number of hypotheses: 2+
Corroboration	Hypothetico-Deduction 	Multiple hypotheses 
Contradiction		
Disproof	Falsification 	Strong inference ?

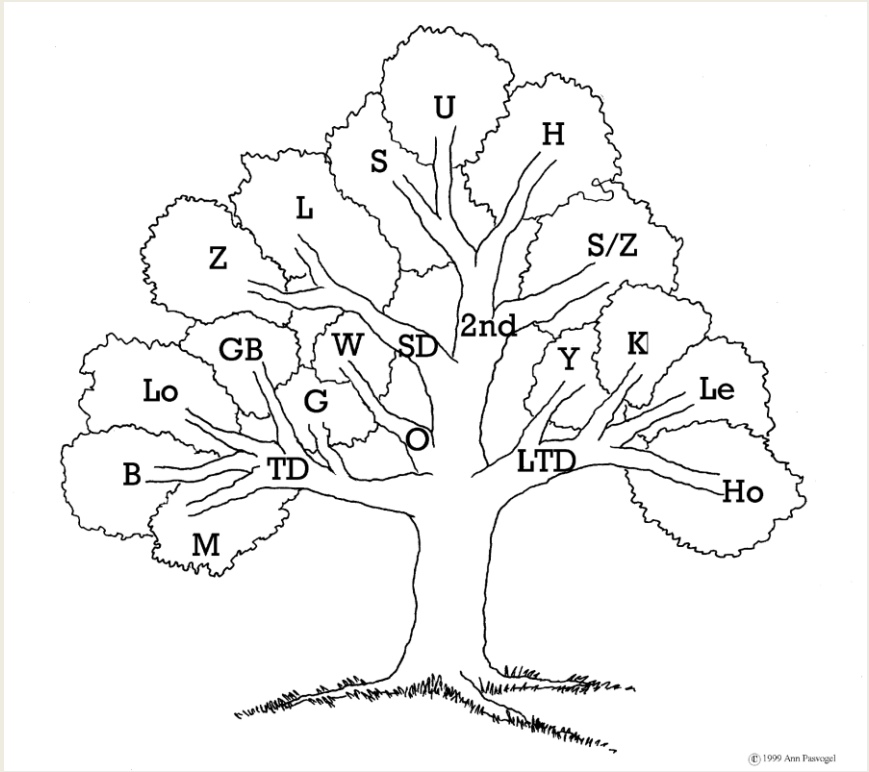
(1) $\ln(y') = k + p\ln(y) + q\ln(t)$ Log time decline (Hosfeld IV, Levakovic I, Korf, Yoshida I)

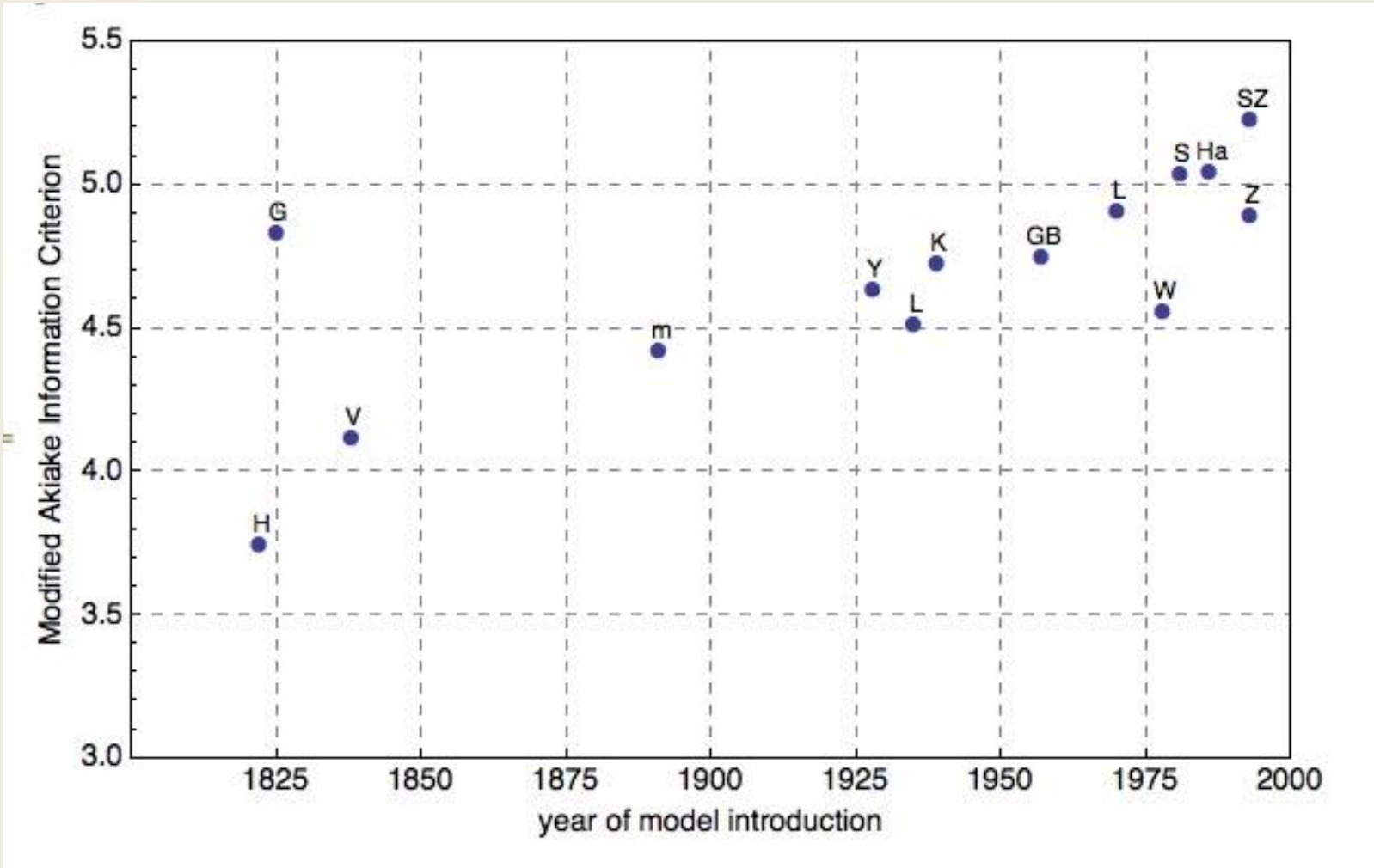
(2) $\ln(y') = k + p\ln(y) + q\,t$ Time decline (Gompertz, logistic, monomolecular, Bertalanffy)

(3) $\ln(y') = k + p\ln(y) + q\,y$ Size decline (Leary, Zeide)

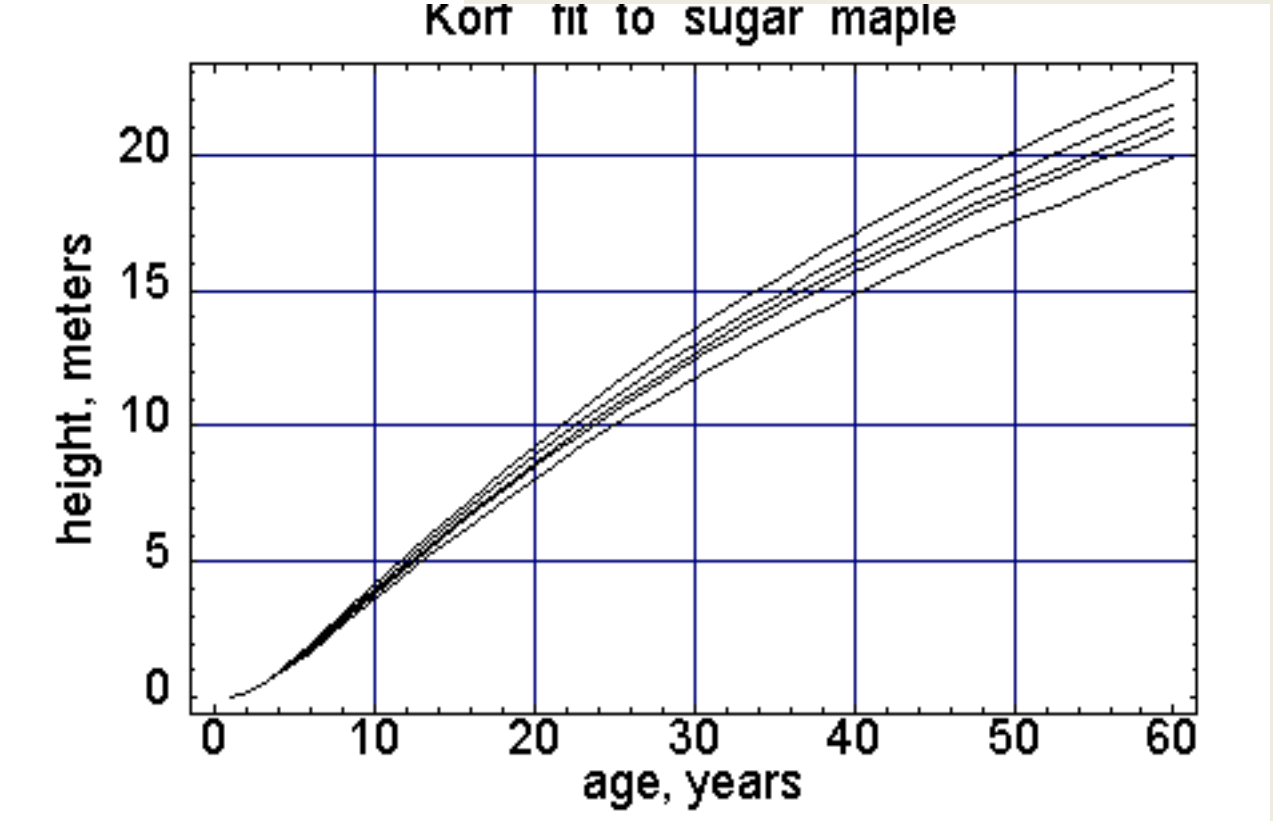
R. Leary (1970), B. Zeide (1993)



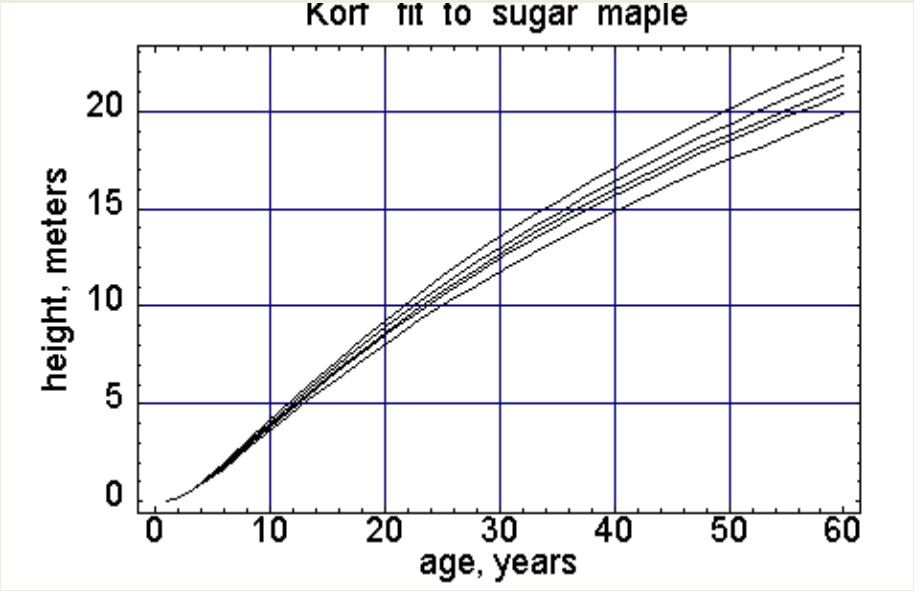


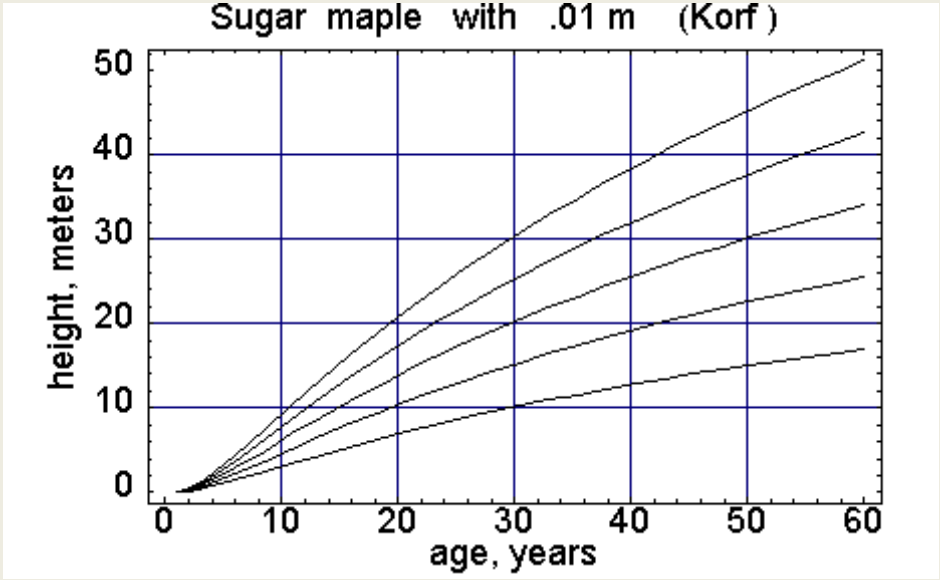

Modified Akiake Information Criterion
5.5
5.0
4.5
4.0
3.5
3.0
1825
1850
1875
1900
1925
1950
1975
2000
year of model introduction
G
V
H
m
Y
K
L
GB
L
W
S
Ha
SZ
Z

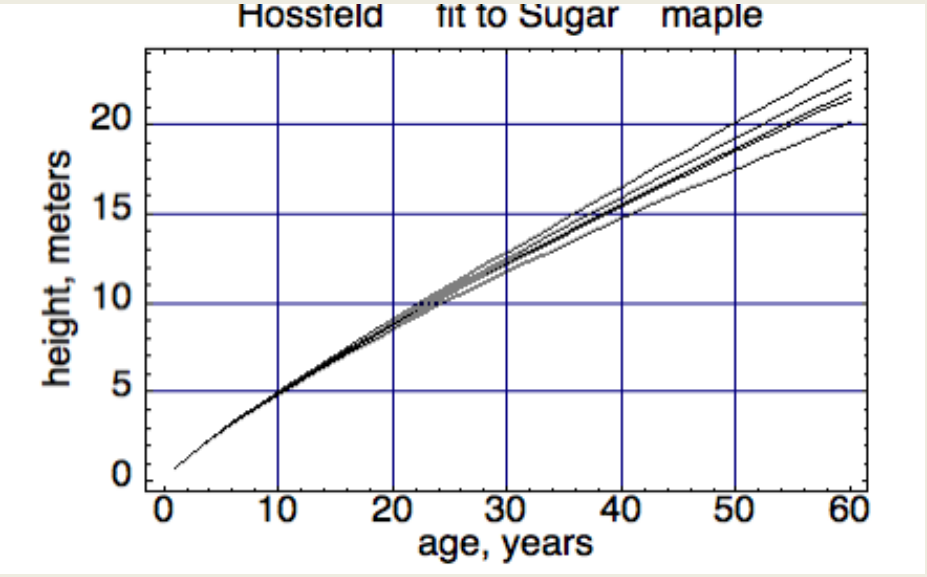
Korf	
INI1	0.283474
INI2	0.282874
INI3	0.284178
INI4	0.283326
INI5	0.283829
Average	0.2835362
Range	0.001304

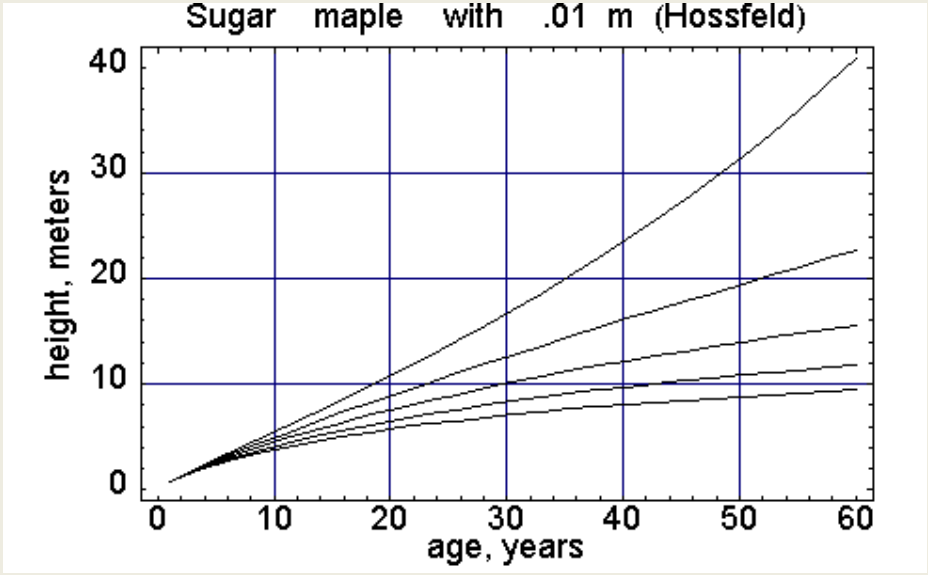


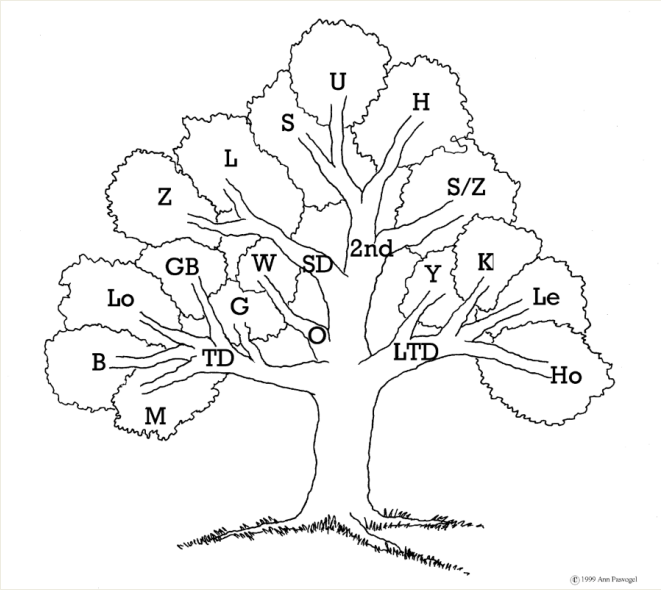
Deductions


Korf fit to sugar maple
height, meters
0
5
10
15
20
0
10
20
30
40
50
60
age, years


Sugar maple with .01 m (Korf)
height, meters
0
10
20
30
40
50
0
10
20
30
40
50
60
age, years


Hossfeld fit to Sugar maple
height, meters
0
5
10
15
20
0
10
20
30
40
50
60
age, years


Sugar maple with .01 m (Hossfeld)
height, meters
0
10
20
30
40
0
10
20
30
40
50
60
age, years



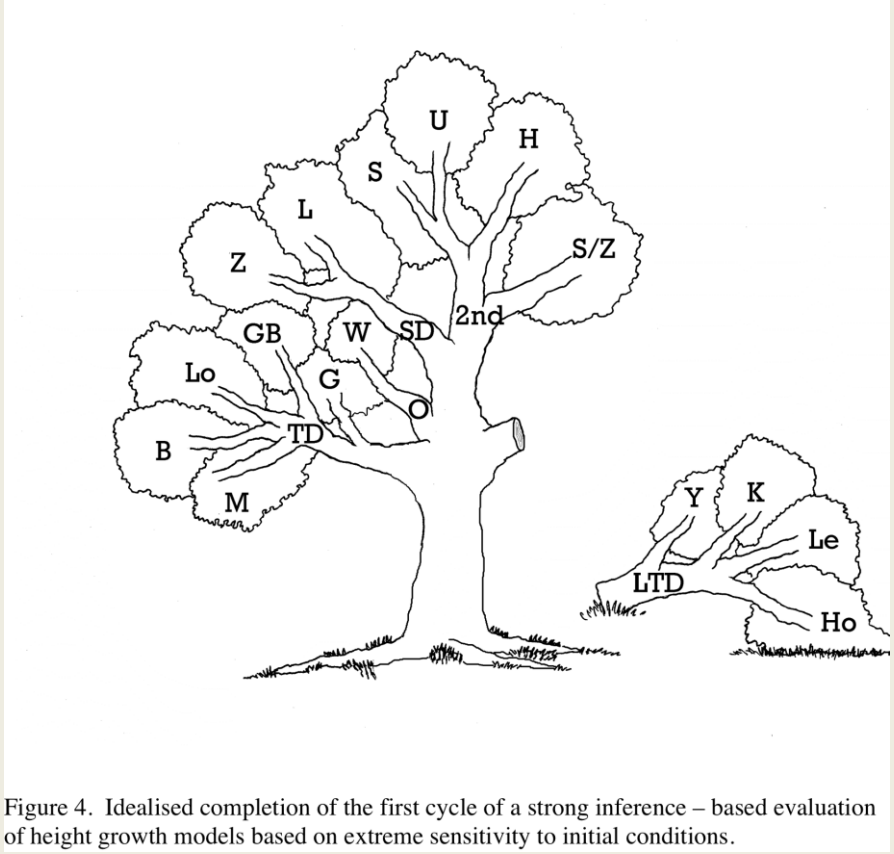


Figure 4. Idealised completion of the first cycle of a strong inference – based evaluation of height growth models based on extreme sensitivity to initial conditions.

Leary, R. A. and V. K. Johannsen 2009.

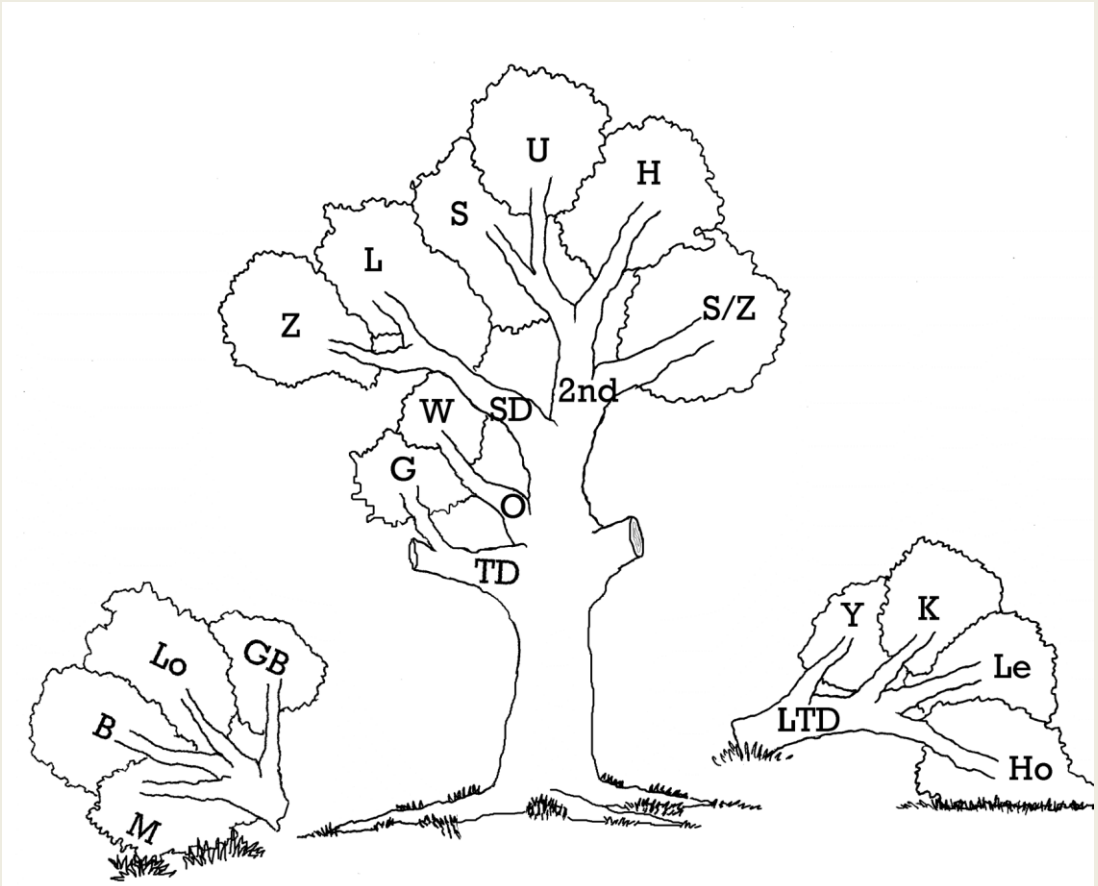
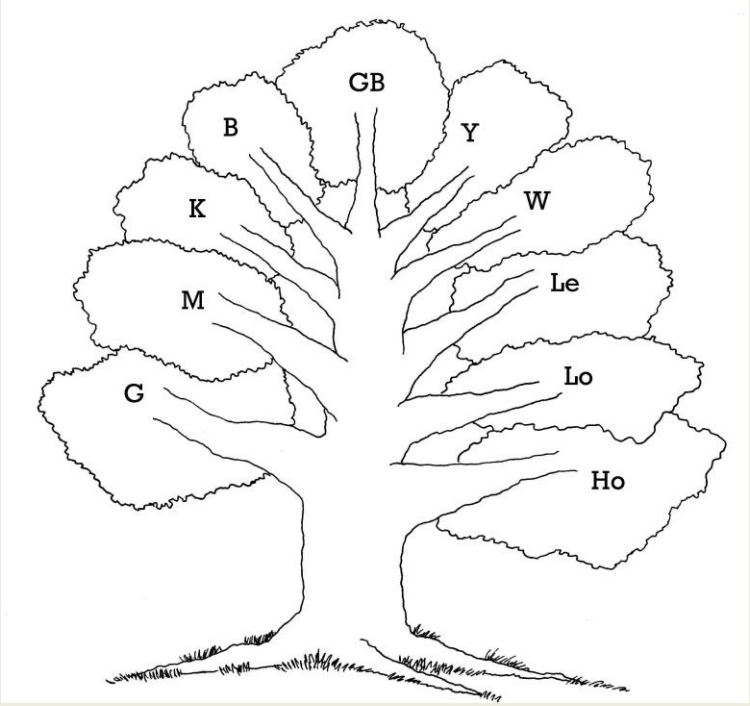
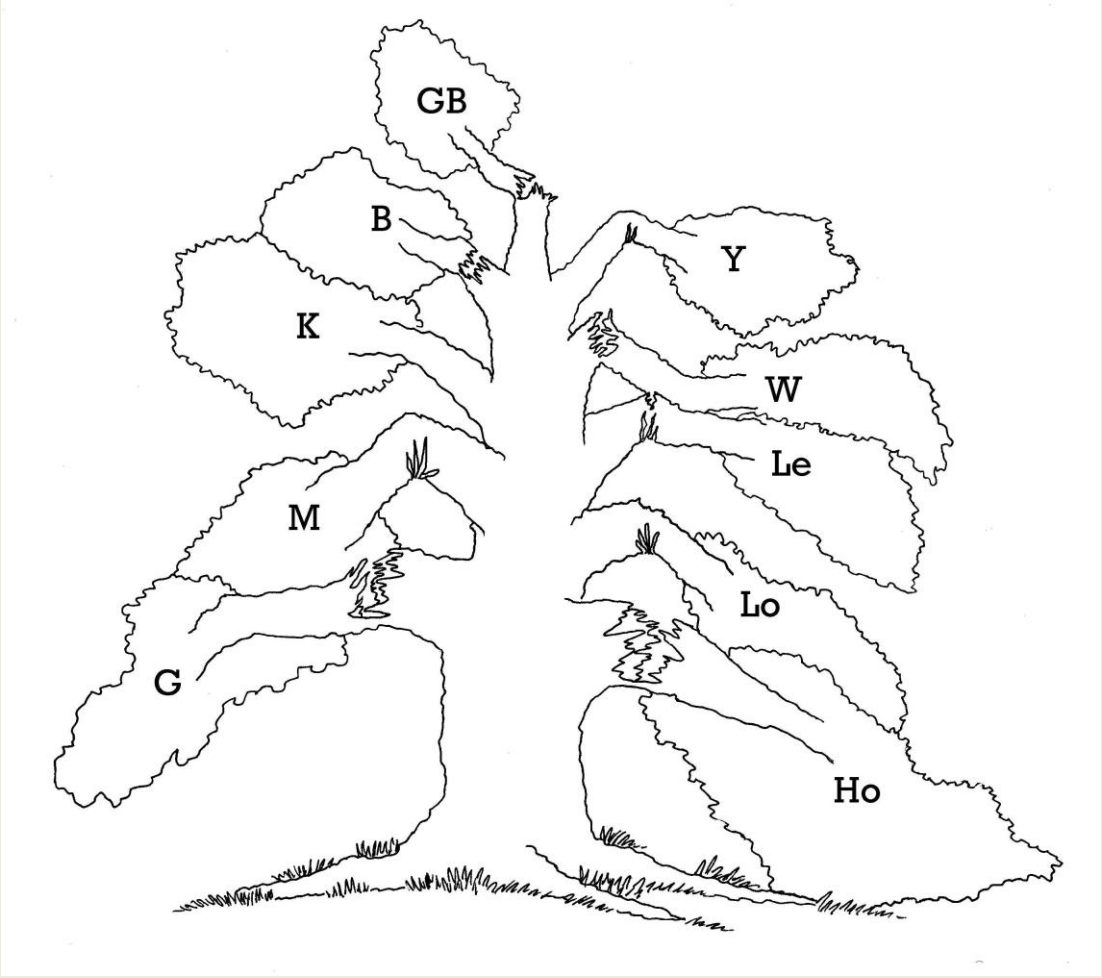


Figure 5. Idealised execution of the second iteration of a strong inference strategy based on the large range in initial heights predicted by TD equations. The Gompertz equation is not falsified.

Avoid this kind of hypothesis ‘tree’:






C.E.

Logical intent	Number of hypotheses: 1	Number of hypotheses: 2+
Corroboration	Hypothetico-Deduction 	Multiple hypotheses 
Contradiction		
Disproof	Falsification 	"Strong inference" 

Takeaways:

1. Discovery is different than justification, because there are no ‘rules’. ‘Anything goes’!

2. Justification strategies can be organized by
    a. how many hypotheses are being tested, and
    b. logical intent of the scientist.

3. Corroboration may work as a ‘logical intent’ for young scientists in young sciences.

Thank you