TASS III:
The Next Generation…

of a Growth & Yield Model
for Complex Stands

TASS Trek - we're going where few have gone before….

Jim Goudie, Research Leader
Stand Development Modelling Group
Research and Knowledge Management Branch

BRITISH COLUMBIA
The Best Place on Earth
Ministry of Forests and Range
Forest Science Program

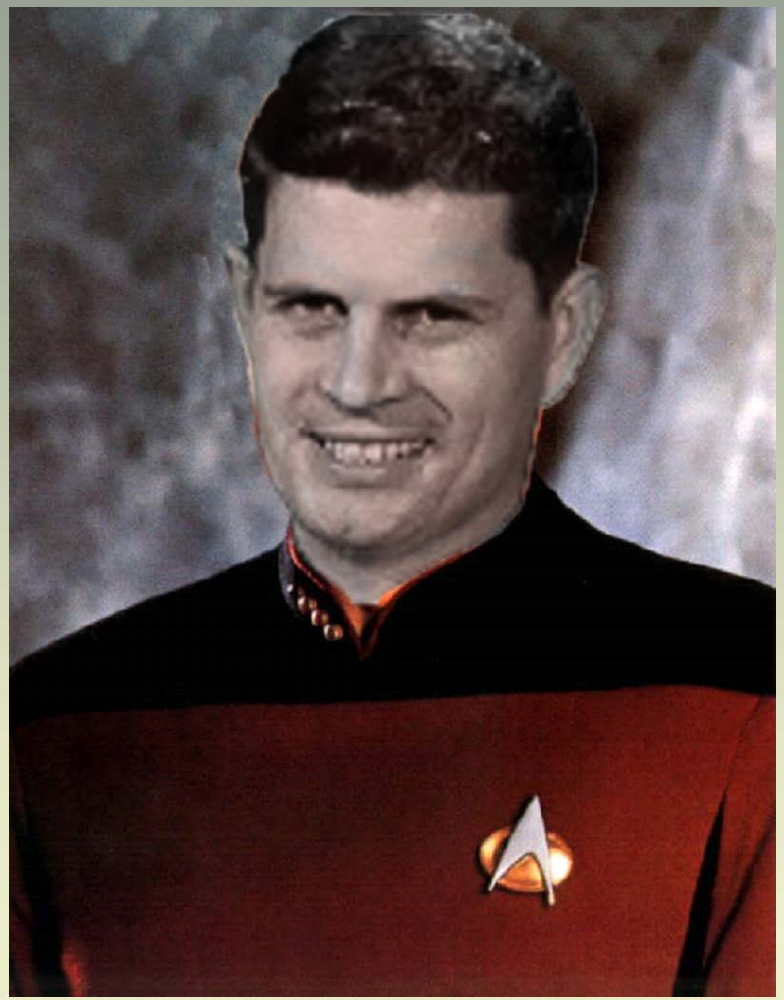
The star ship TASS crew

- Ken Mitchell (scientist emeritus, Captain Kirk)
- Jim Goudie (SDMG research leader, Captain Picard)
- Catherine Bealle Statland (complex stand development, Counselor Deanna Troi)
- Mario Di Lucca (G&Y applications specialist, Lt. Commander Data)
- Roberta Parish (Quantitative population biology, Dr. Beverly Crusher)
- Ken Polsson (programmer/analyst, Geordi La Forge)
- Shelley Grout (software application specialist – TIPSY, Lt. Tasha Yar, security)

- George Harper (hardwoods) (Q)

- Ian Cameron (Azura Formetrics; biometrics/modelling, Commander Riker)
- Stephen Stearns-Smith (SSS and Assoc.;extension specialist Worf)
- Past member: Albert Nussbaum

Ken “Geordi La Forge” Polsson



Ken “Captain Kirk” Mitchell
Circa 1975

Outline

- About TASS
- TASS I – II – III history
- TASS III modifications
  - tRAYci light model
  - Crown profiles
  - Crown competition
  - Mortality
- TASS Graphical User Interface
- PLOTSY

TASS – Tree And Stand Simulator

40+ years and still exploring space

(because it is spatial)

TASS and TIPSY provides managed stand yield tables for use in:

- **Timber Supply Review (AACs)**
- **Silvicultural prescriptions and strategies**
- **Predictions of non-timber forest values**

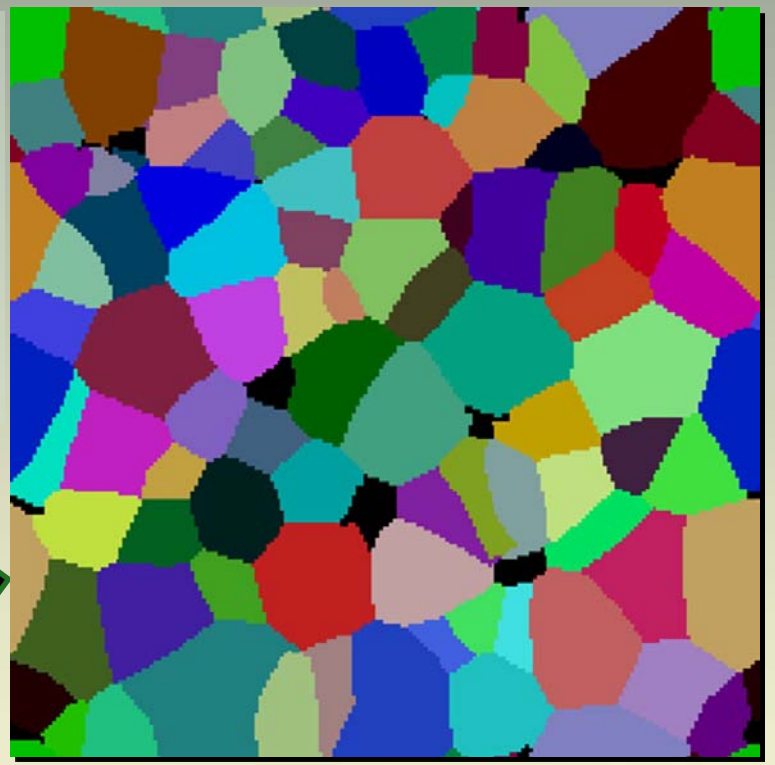
TASS I:

1963-1968

Dr. Ken Mitchell,

UBC grad and Yale PhD (1968)
(Yale Bulletin No. 75)

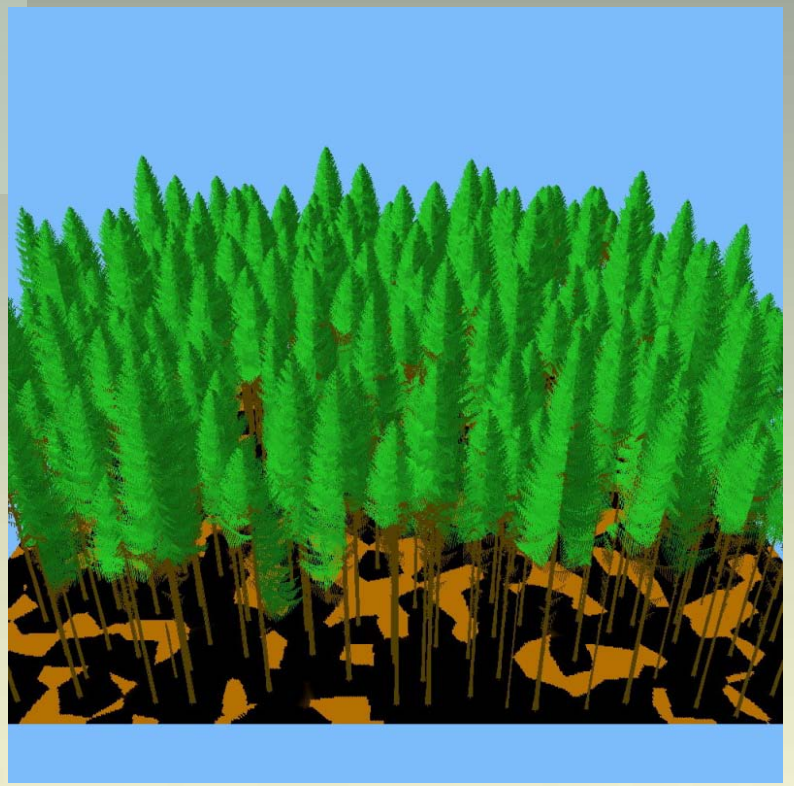
Two-dimensional crown modelling



TASS II:

1968 – present
1975 For. Sci. Monograph 17

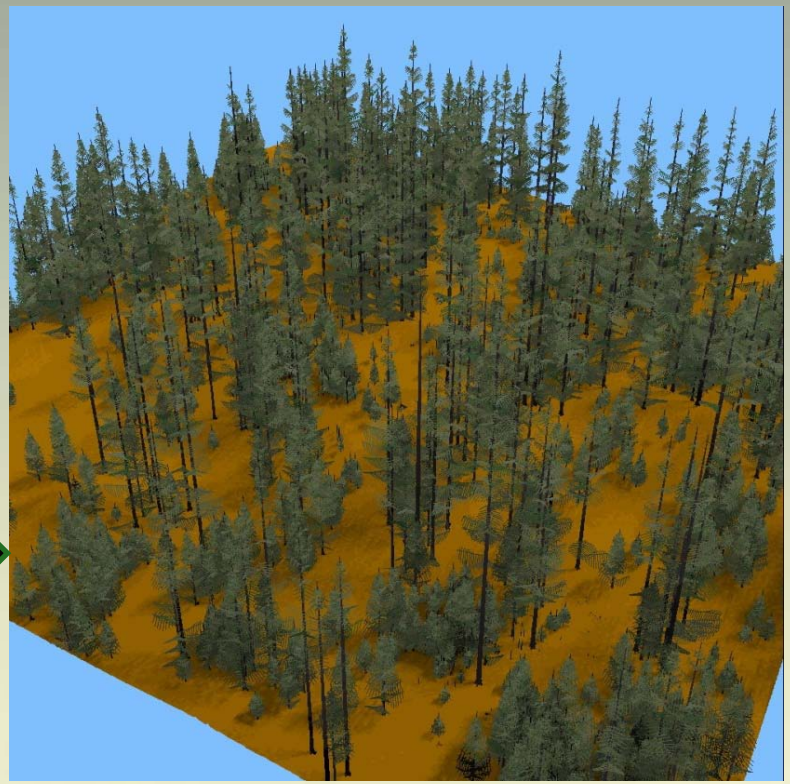
Three-dimensional crown modelling



TASS III

1996 – present

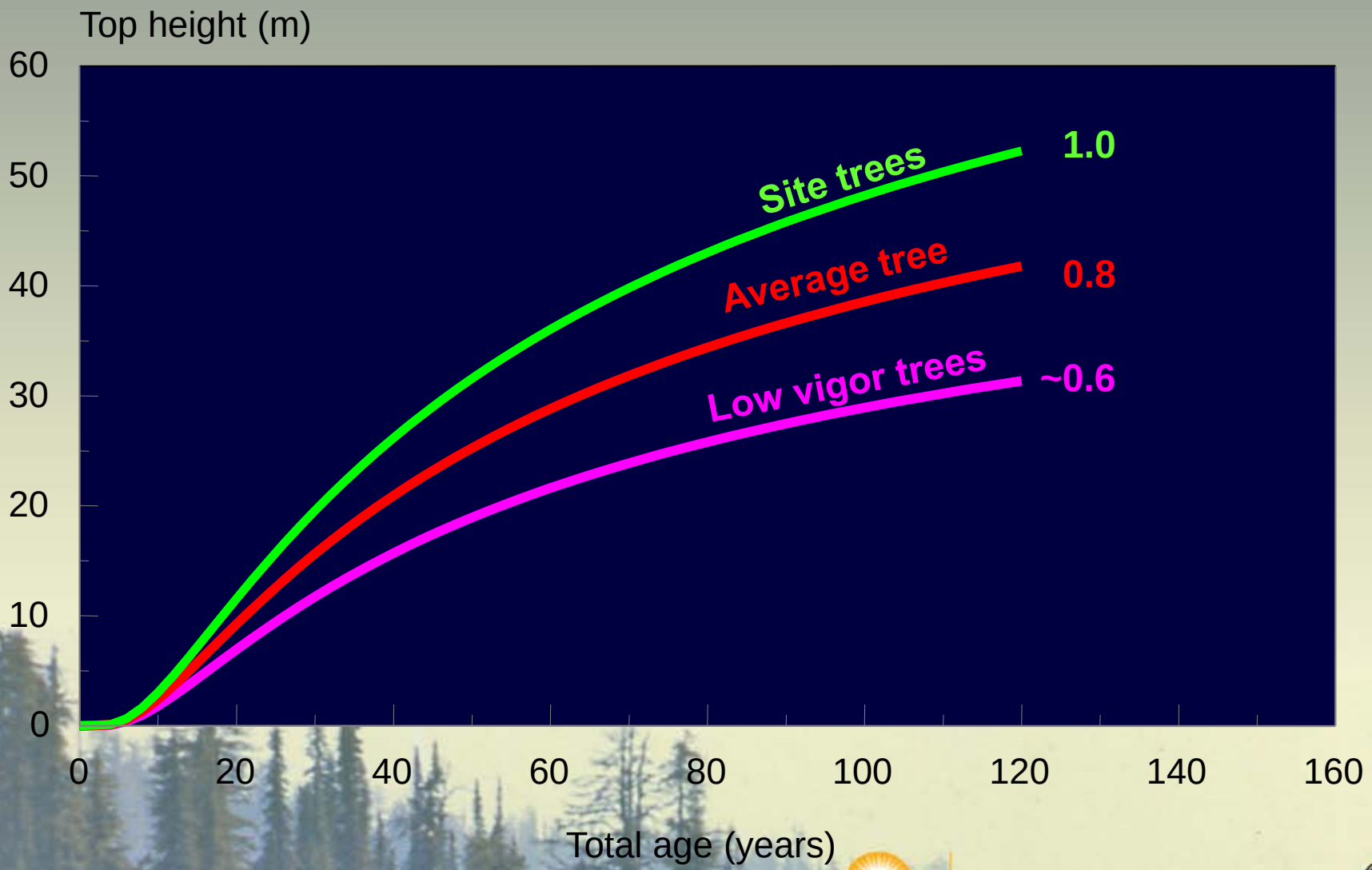
Three-dimensional crown modelling and light model (tRAYci)



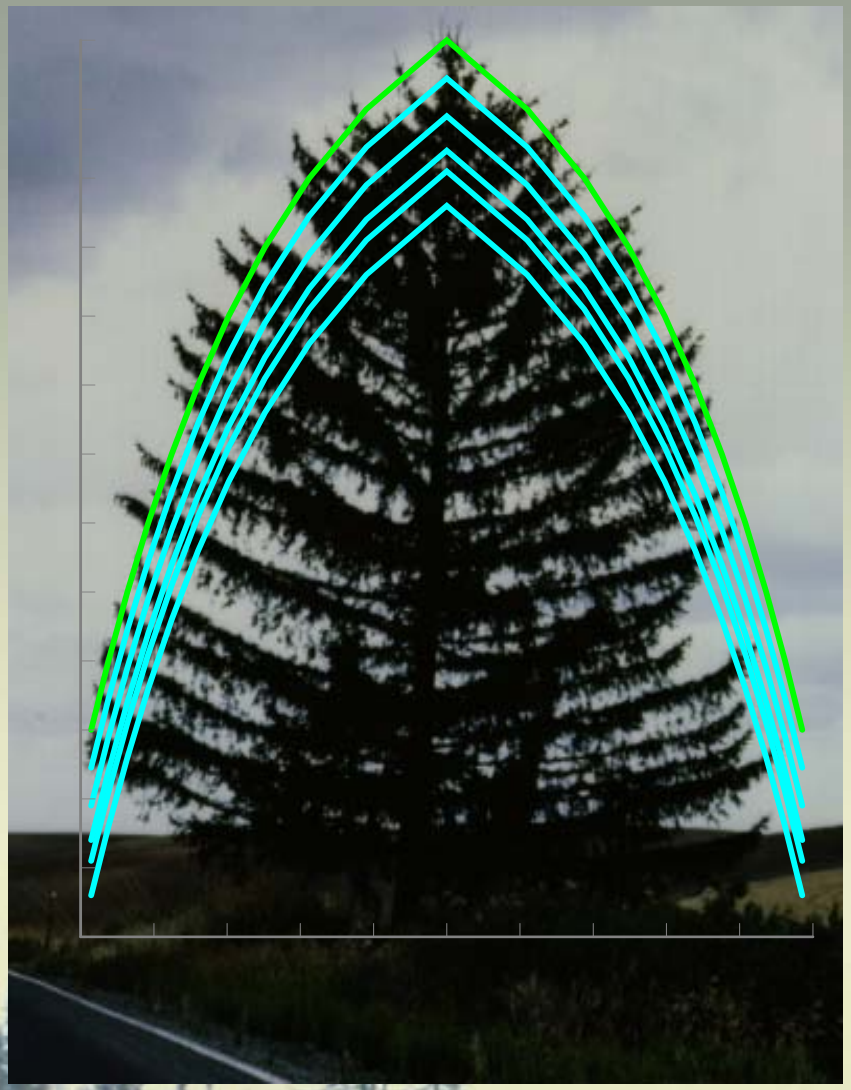
TASS II Key Components

- Height Growth = f(potential, light)
- Crown morphology (branch extension)
- Competition
- Mortality
- Ring characteristics
  size, juvenile-mature wood, relative density, strength, cell characteristics

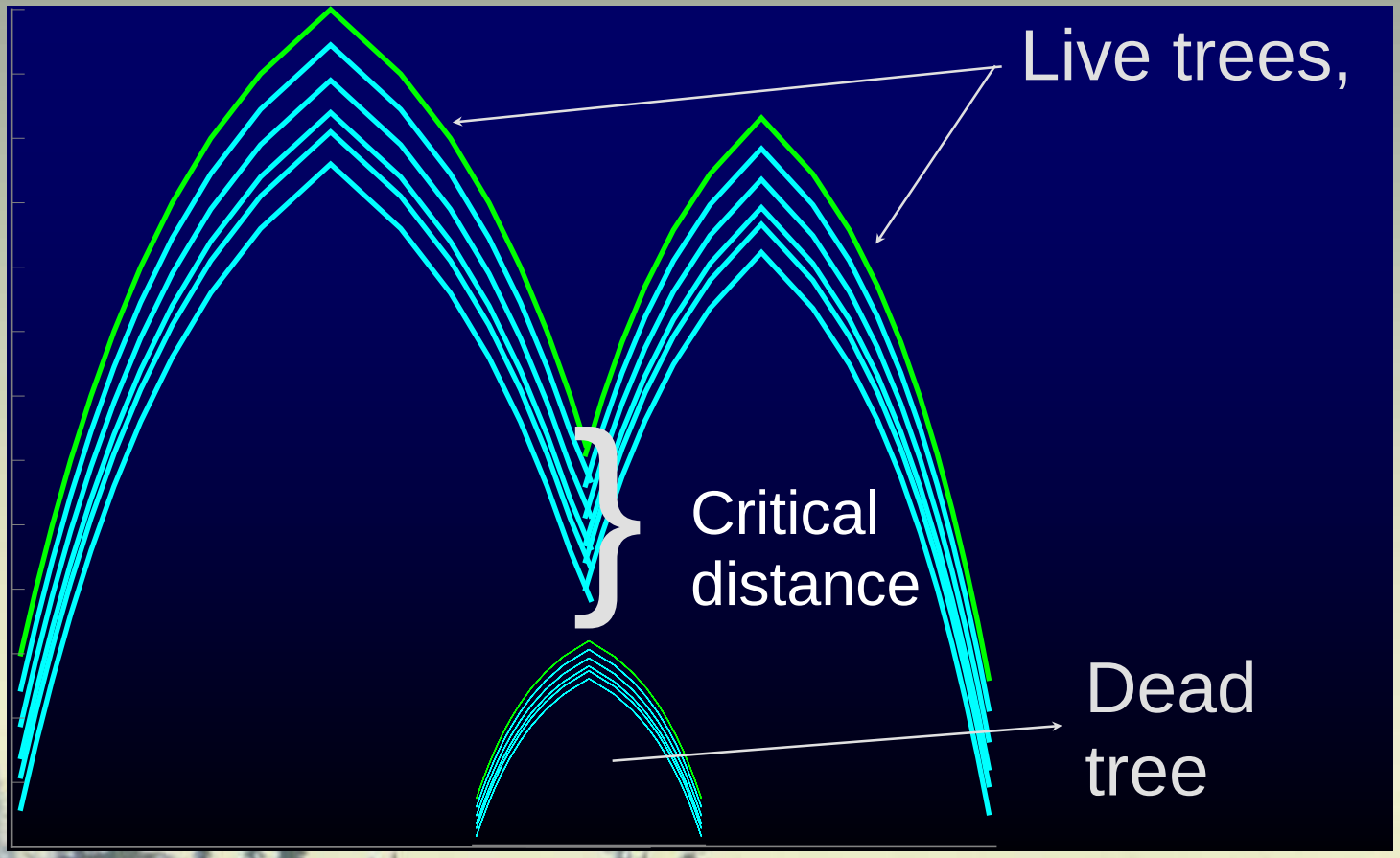
Height Growth



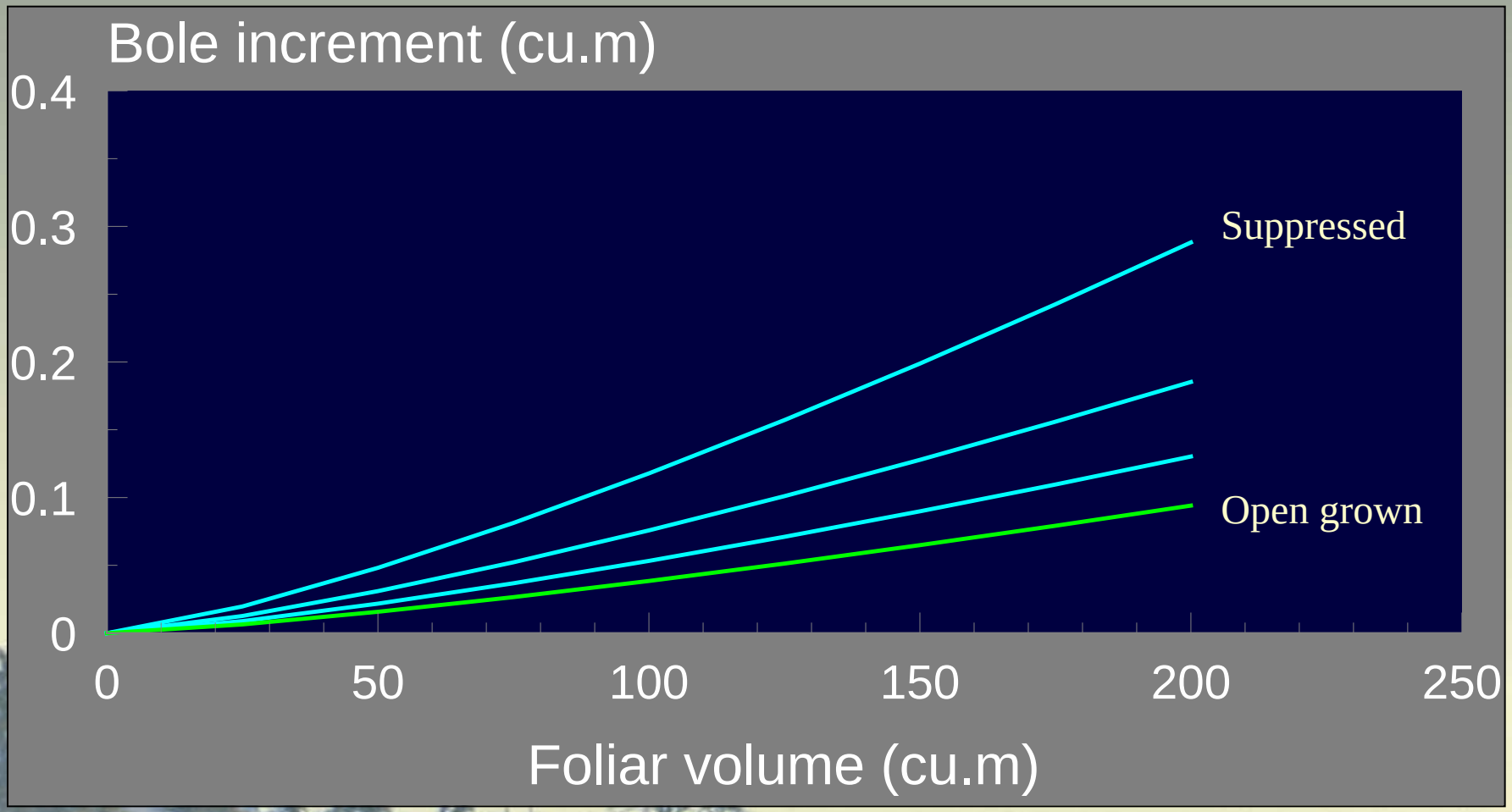
Crown Growth



Competition - Mortality



Bole Increment



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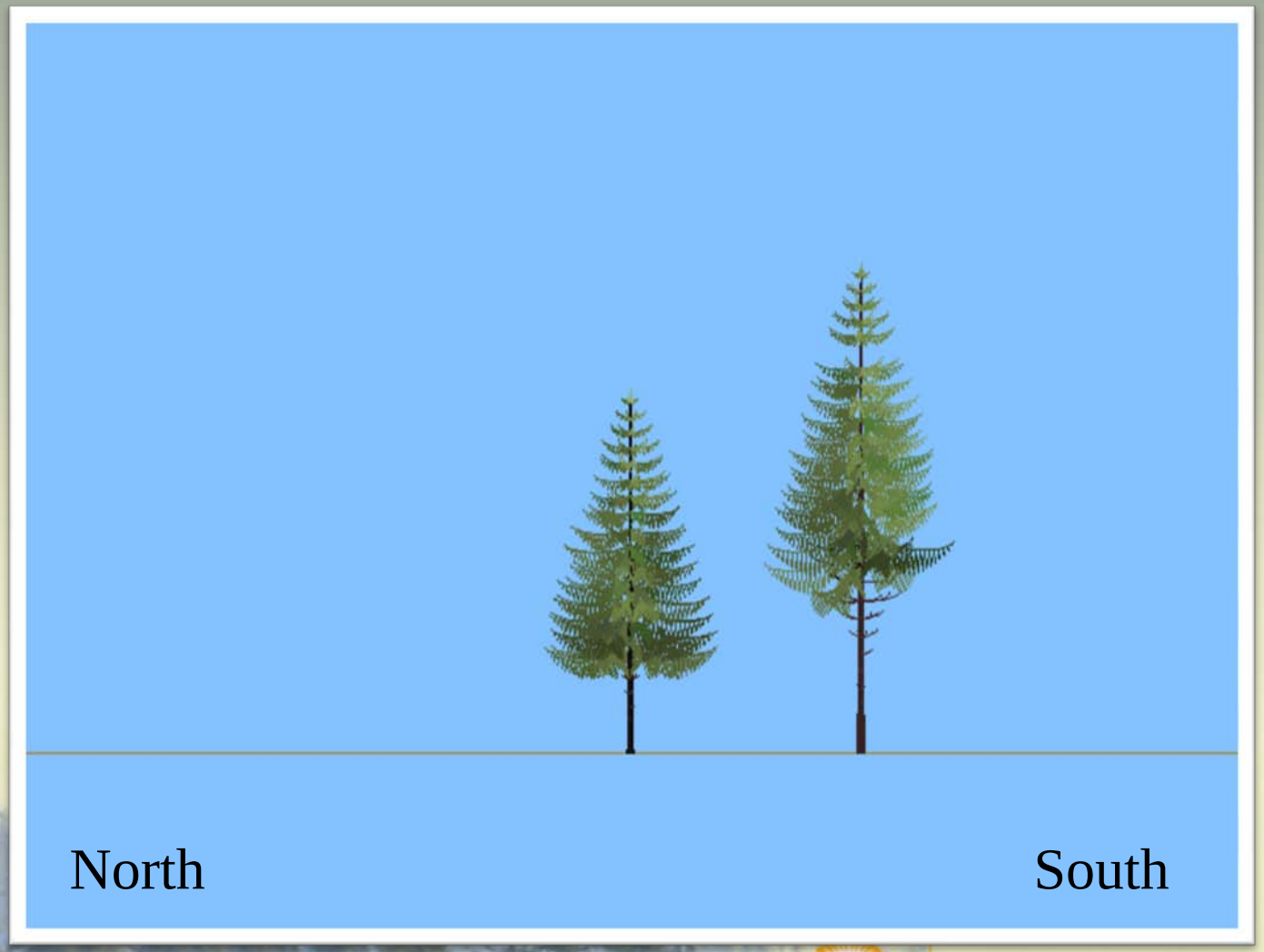
tRAYci light model (Brunner, 1998)



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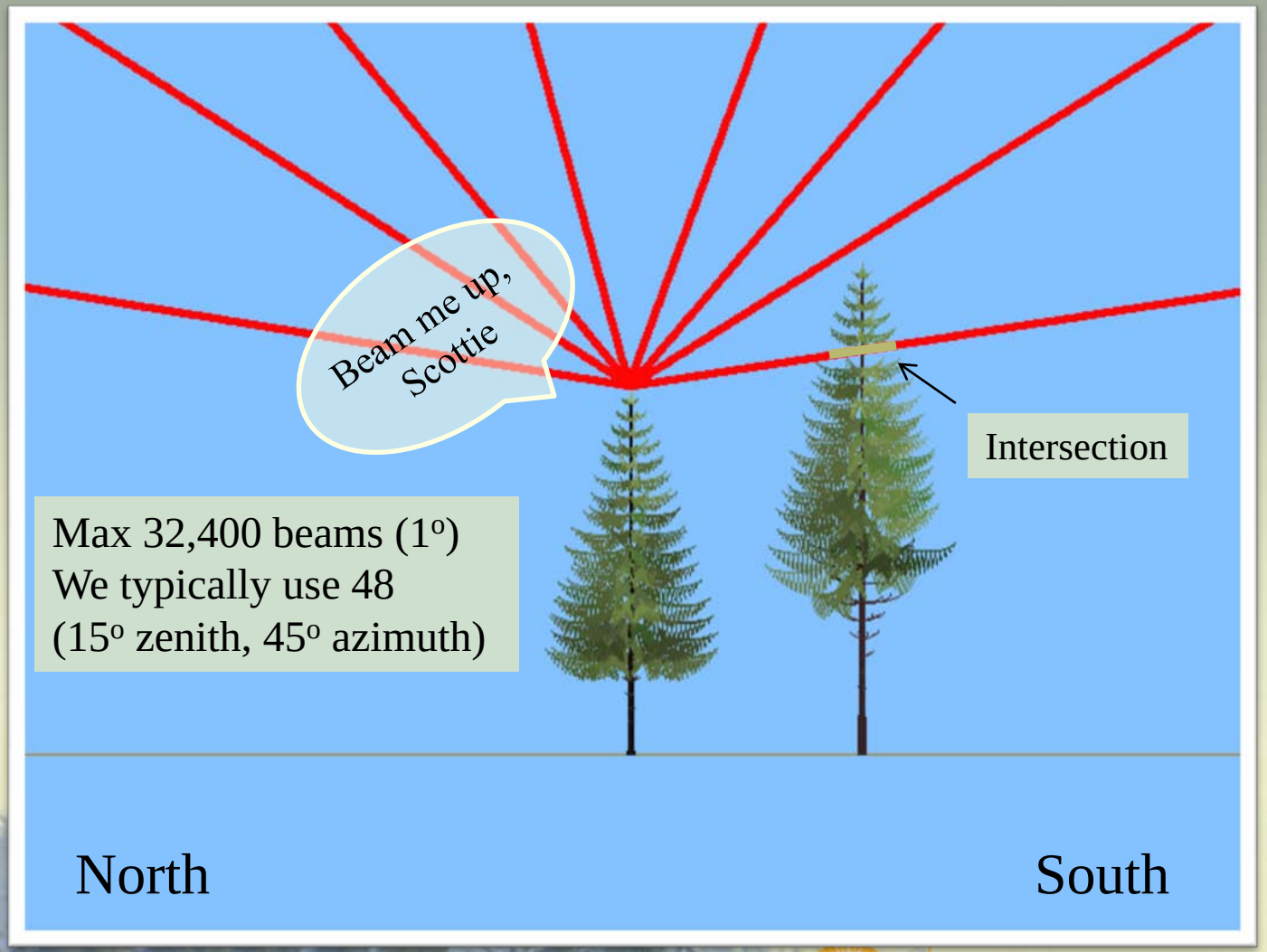

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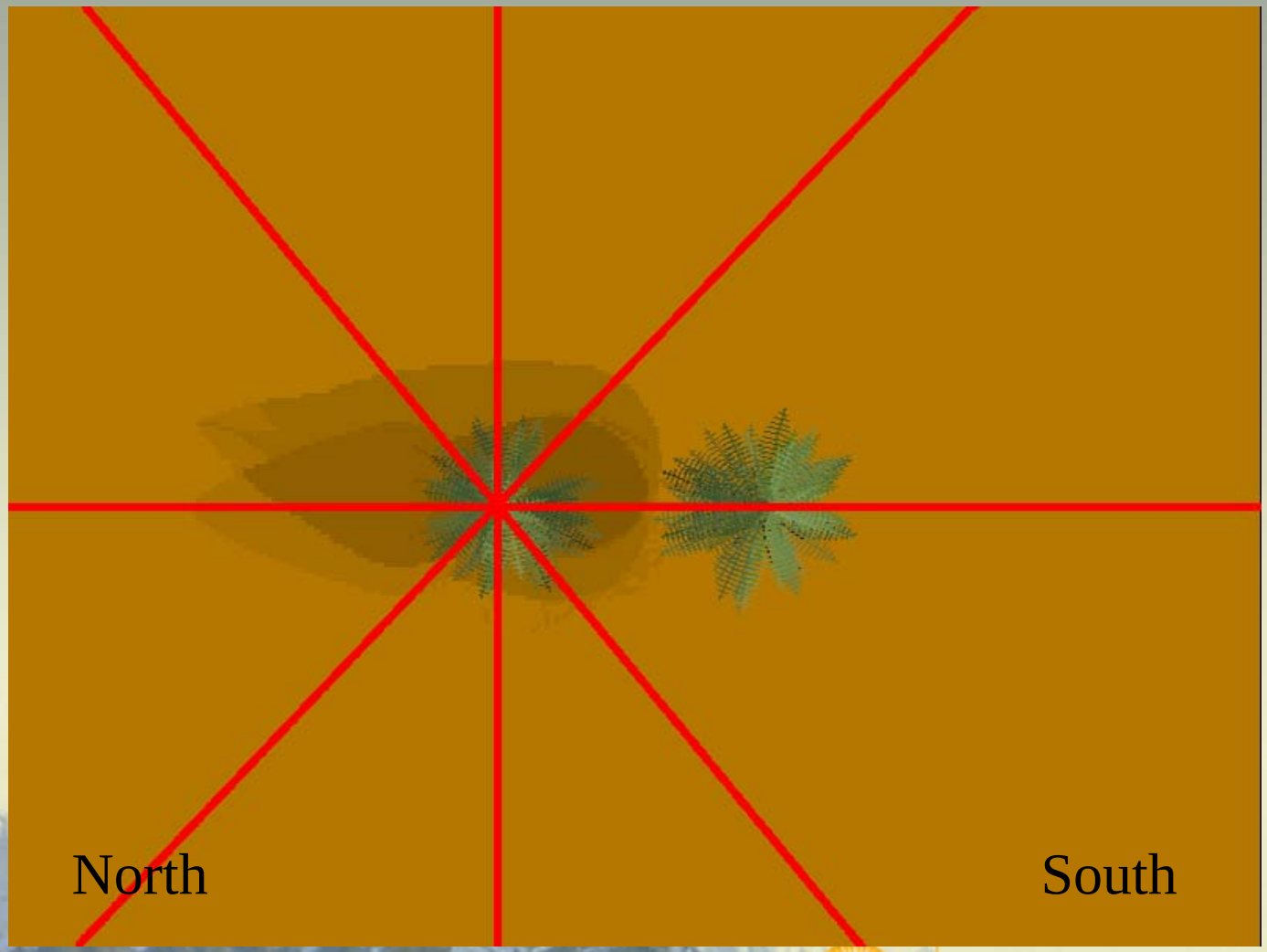
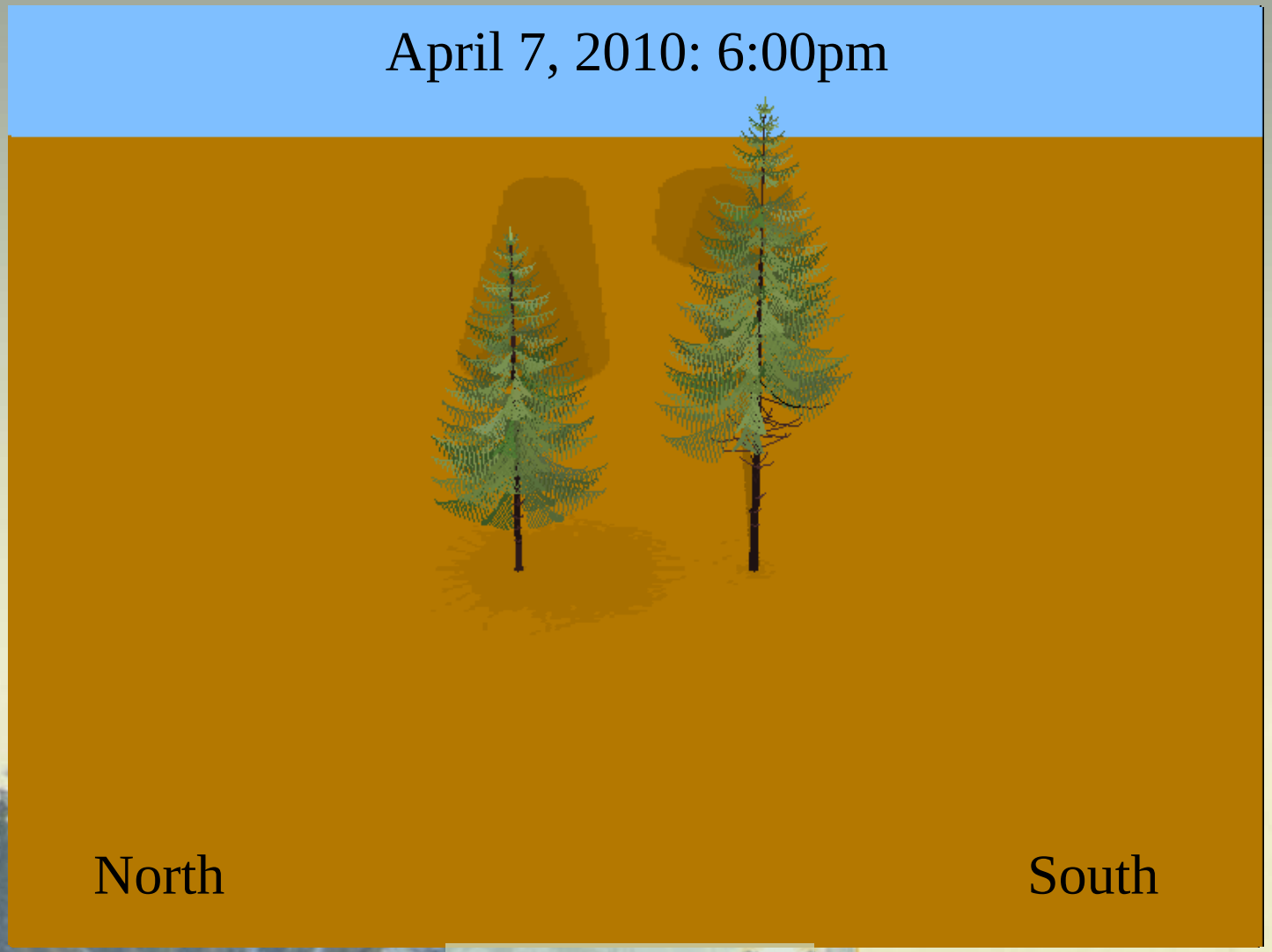
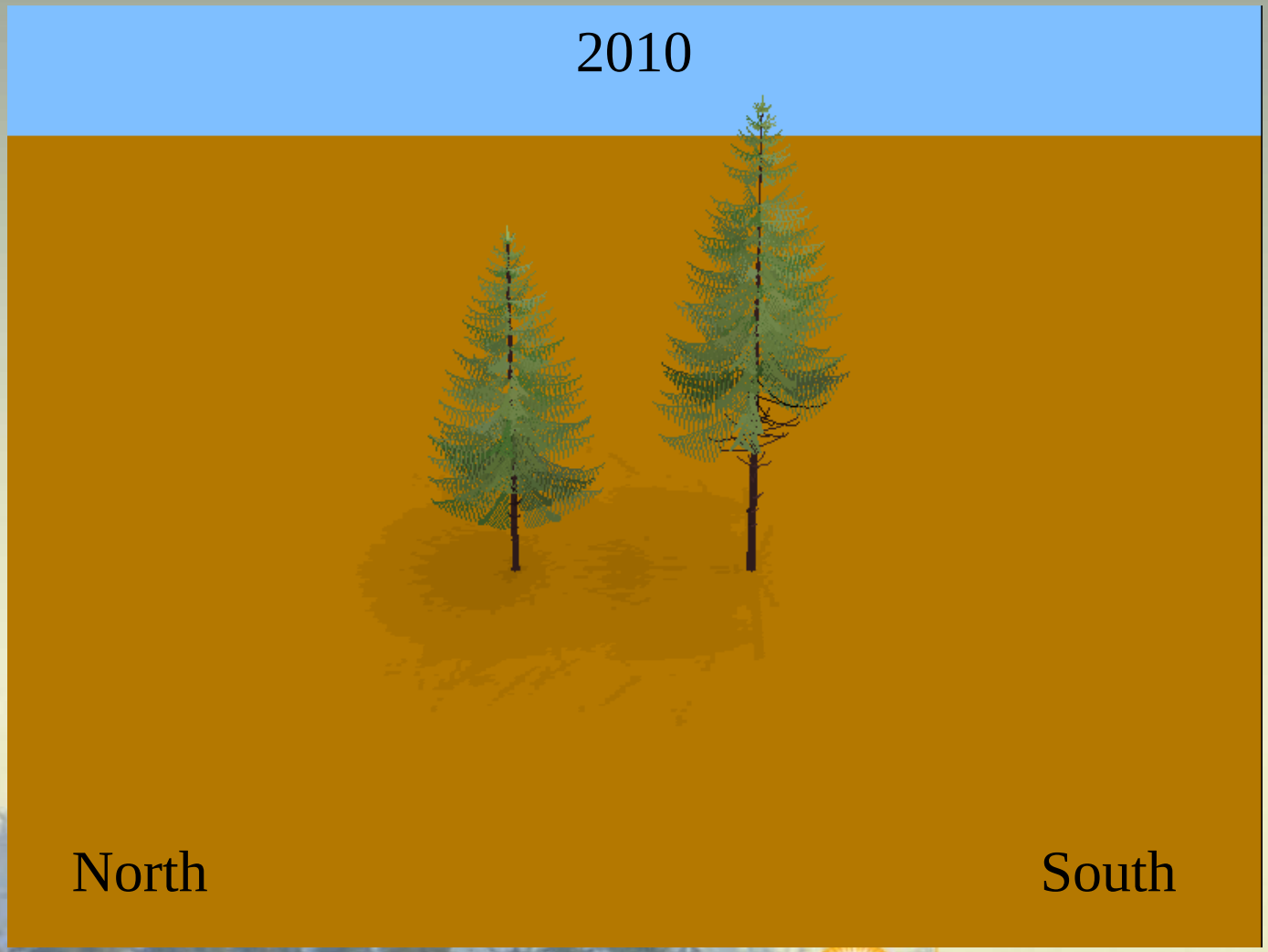


tRAYci light model (Brunner, 1998)



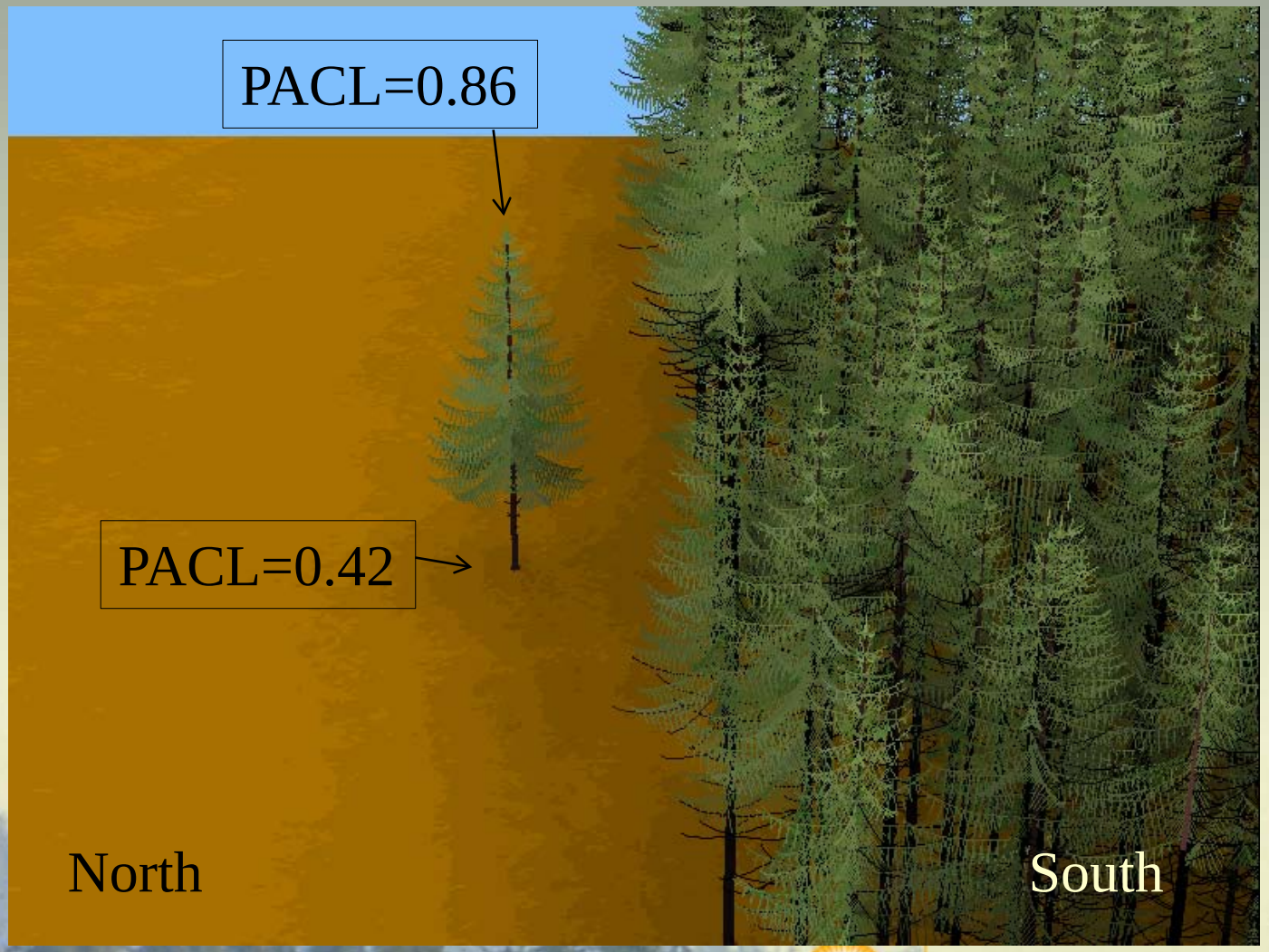
Latitude 50º N

tRAYci light model (Brunner, 1998)



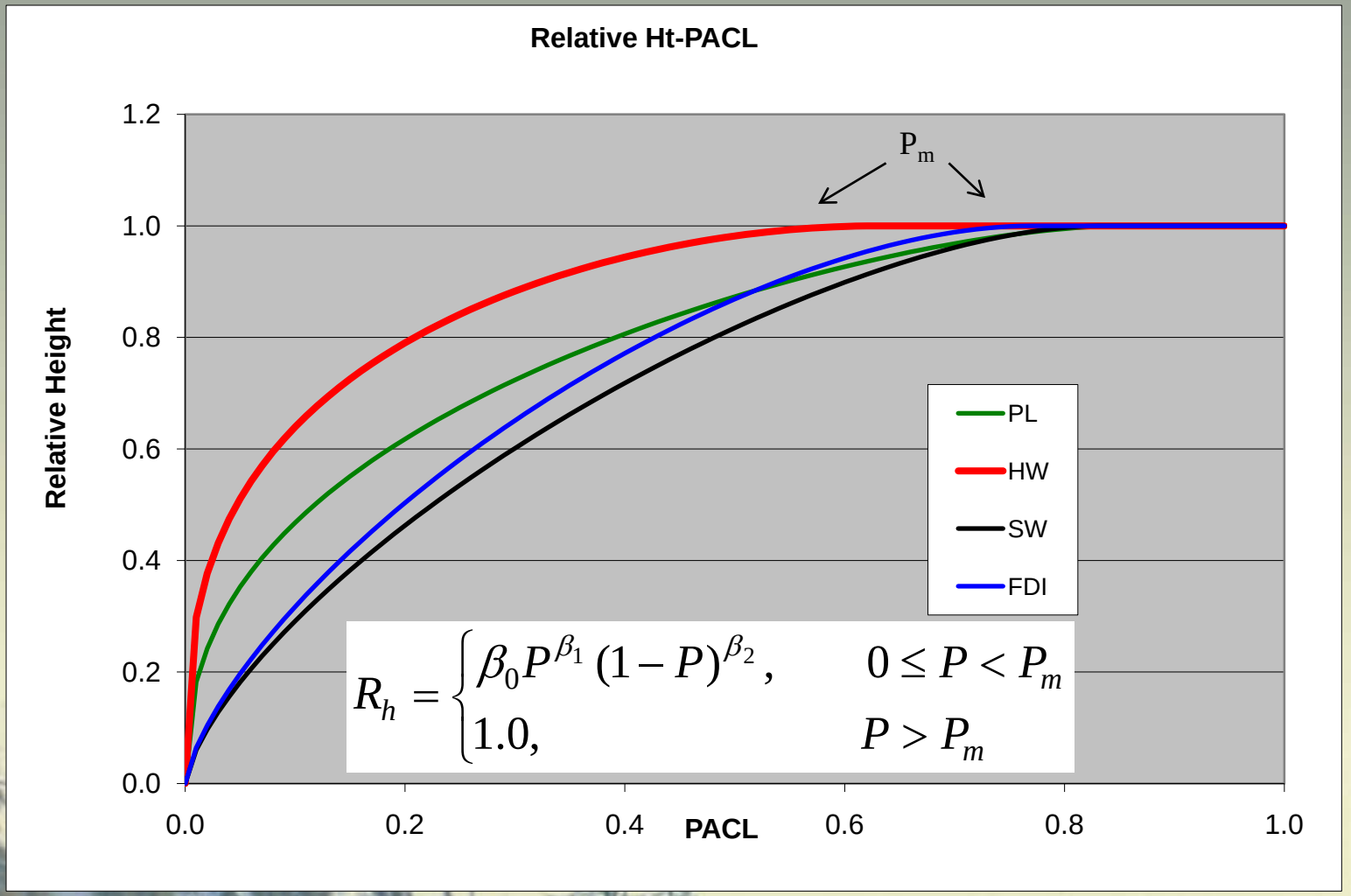
Latitude 50º N

tRAYci light model (Brunner, 1998)



Latitude 50º N

Relative height growth



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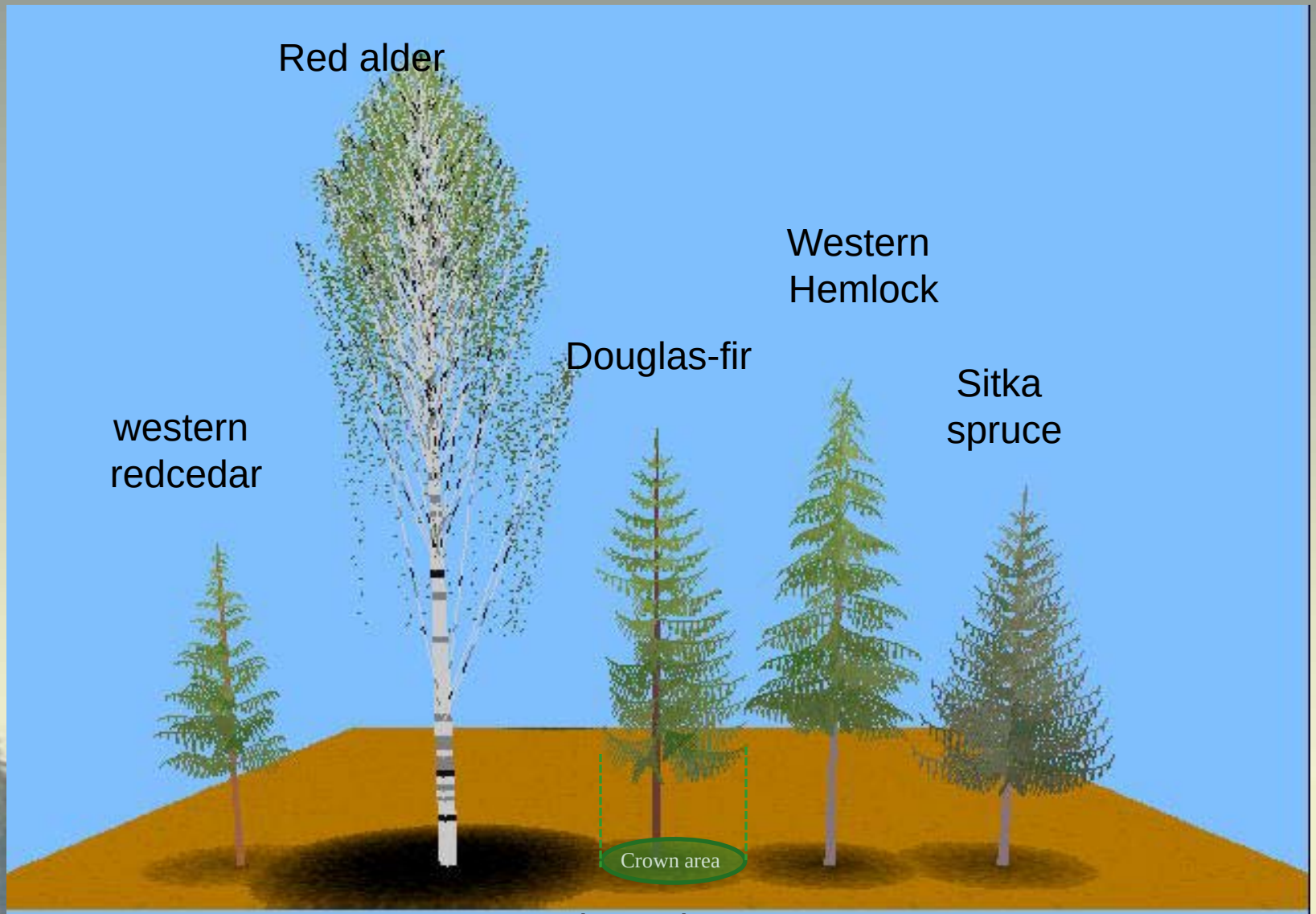
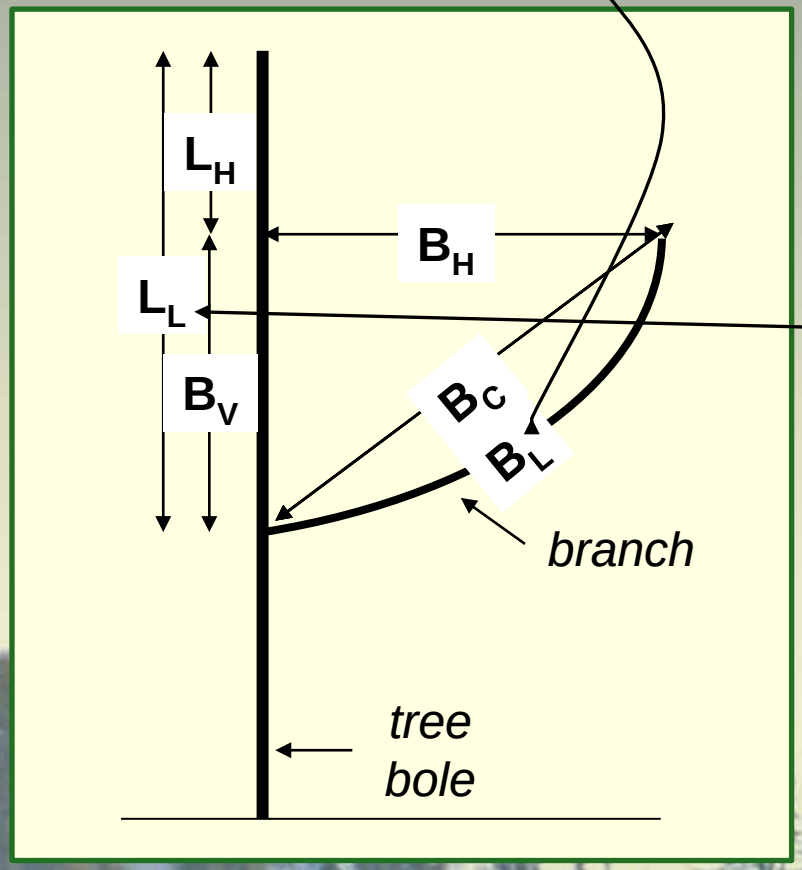
Crown Profiles



Coastal species

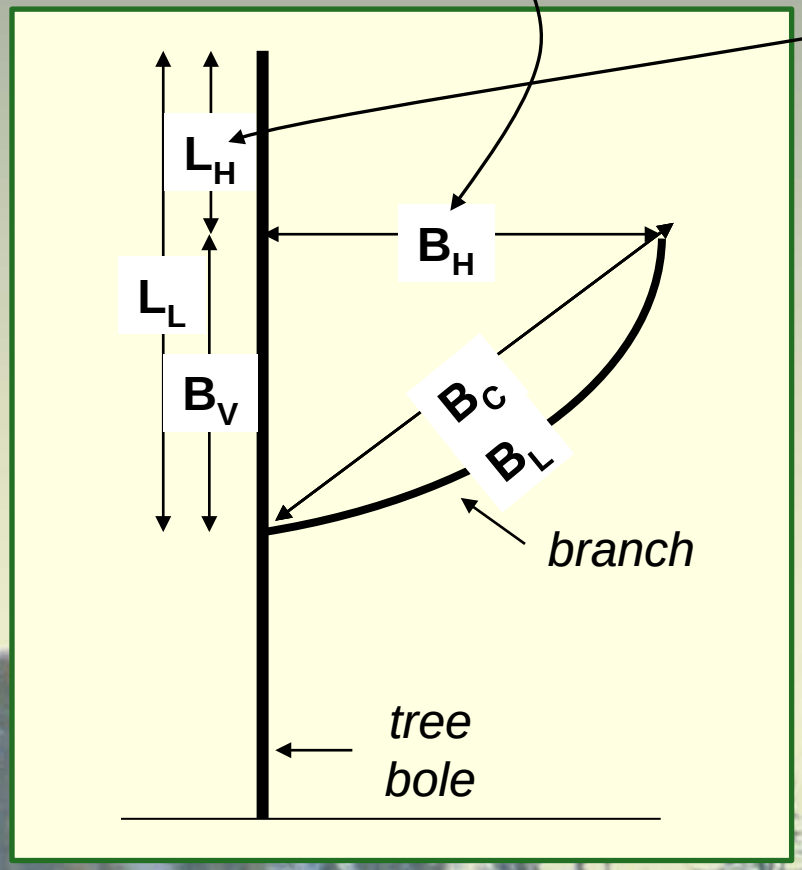
TASS II:

$$B_L = b \bullet d \bullet \ln(1 + L_L / c)$$



TASS III:

$$B_{Hi} = (b_0 + u_{0,j}) \bullet R_{Hi}^{b_2} \bullet \ln\left(1 + \frac{L_{Hi}}{b_1}\right) + e_{i,j}$$

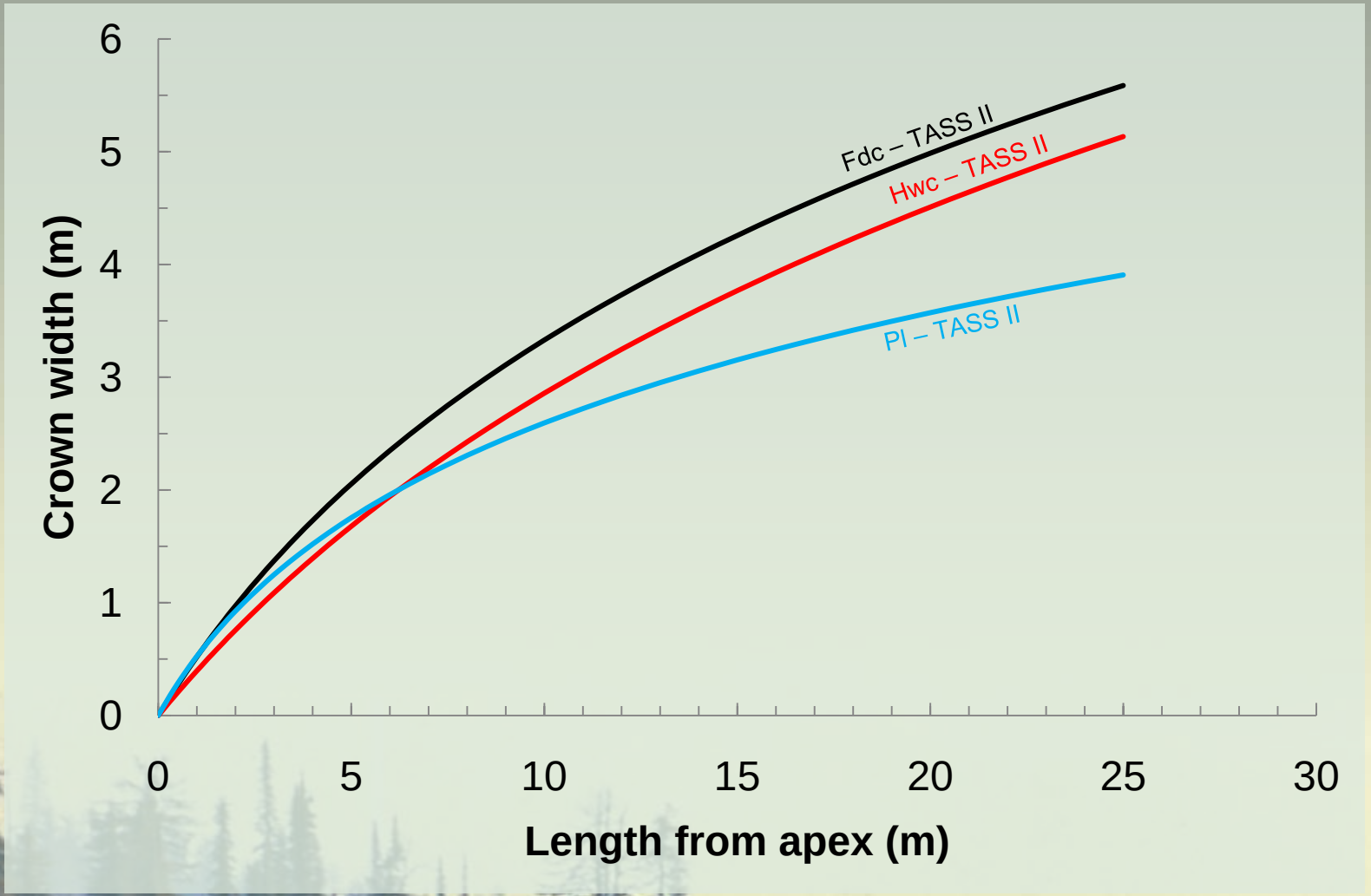


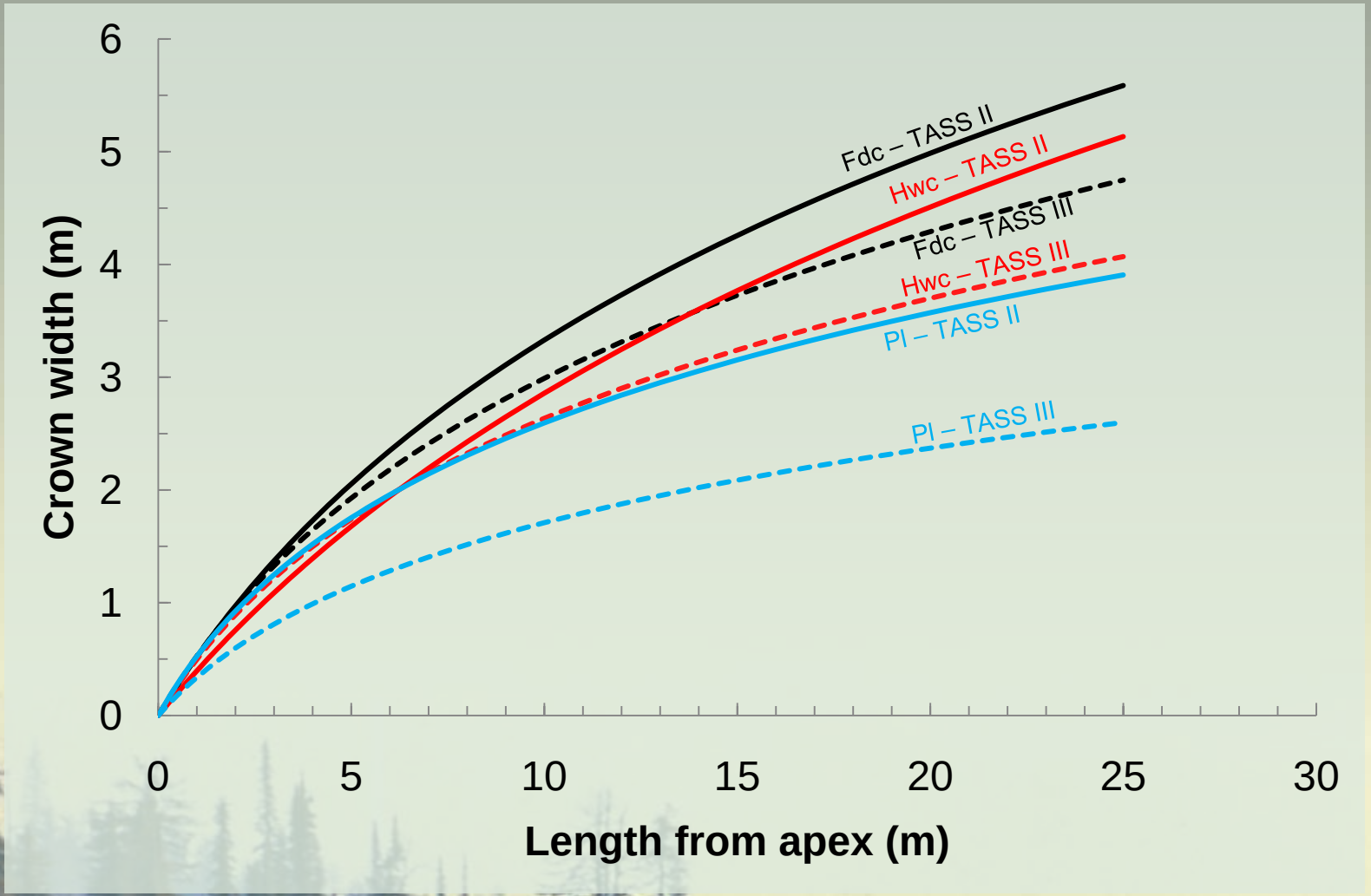
Four major changes:

- Used all data (600+ trees)
- Mixed effects model.
- Predict horizontal extension rather than B_L
- Solved b_2 to minimize the difference between measured and predicted crown area

Crown profile samples

Species	No. trees	No Branches	
		Radius	Total
Hwc	154	1619	8307
Fdc	150	1302	3751
Ba	63	510	1121
Ss	96	504	2006
Si	60	863	2763
Pl	115	1106	1761
Total:	638	5904	19709





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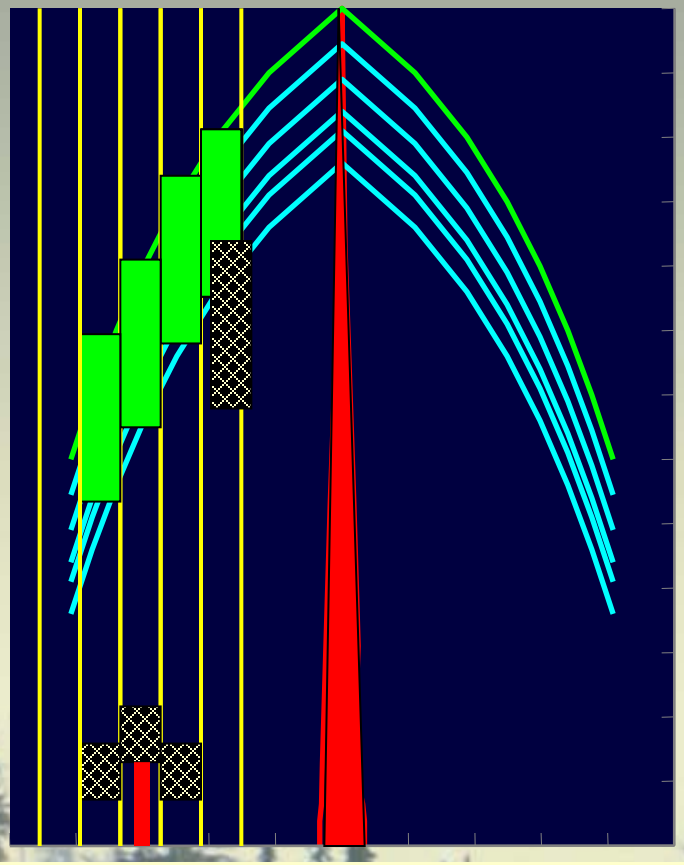
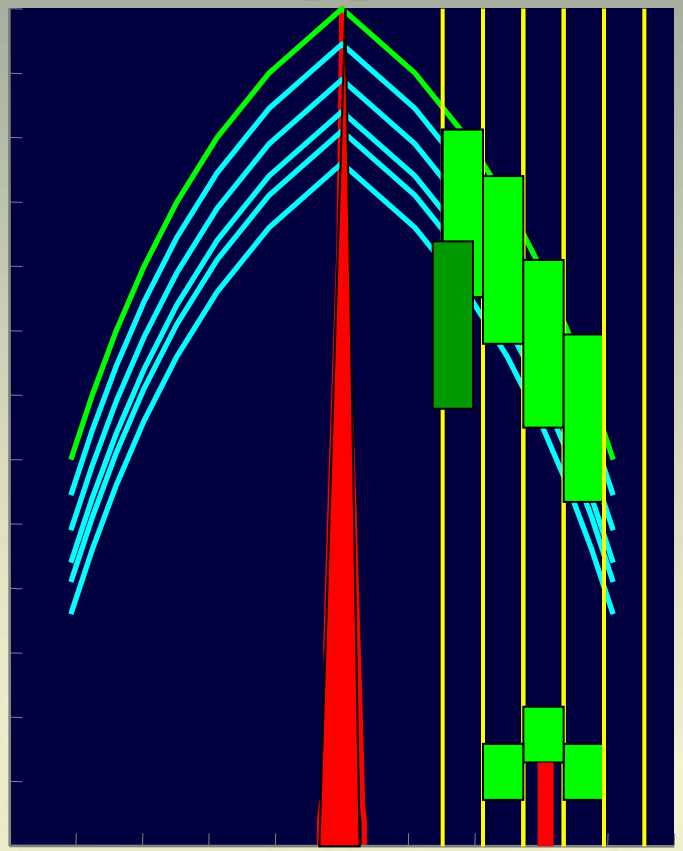
Crown - columns of growing space

TASS II



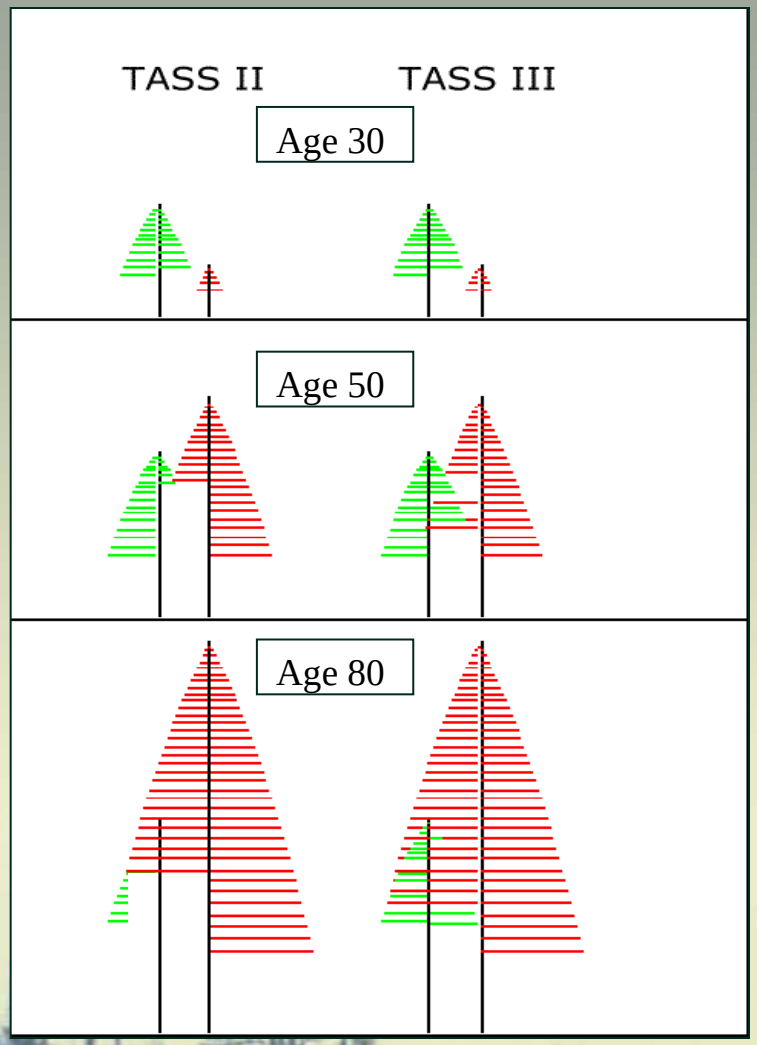
Allows only <u>one</u> live canopy layer per grid column – Overtopped canopy layers die

TASS III



Supports <u>multiple</u> live canopy layers per grid column - Light governs understory growth and mortality

Crown - Competition



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  - Mortality (our nemesis, the Borg)
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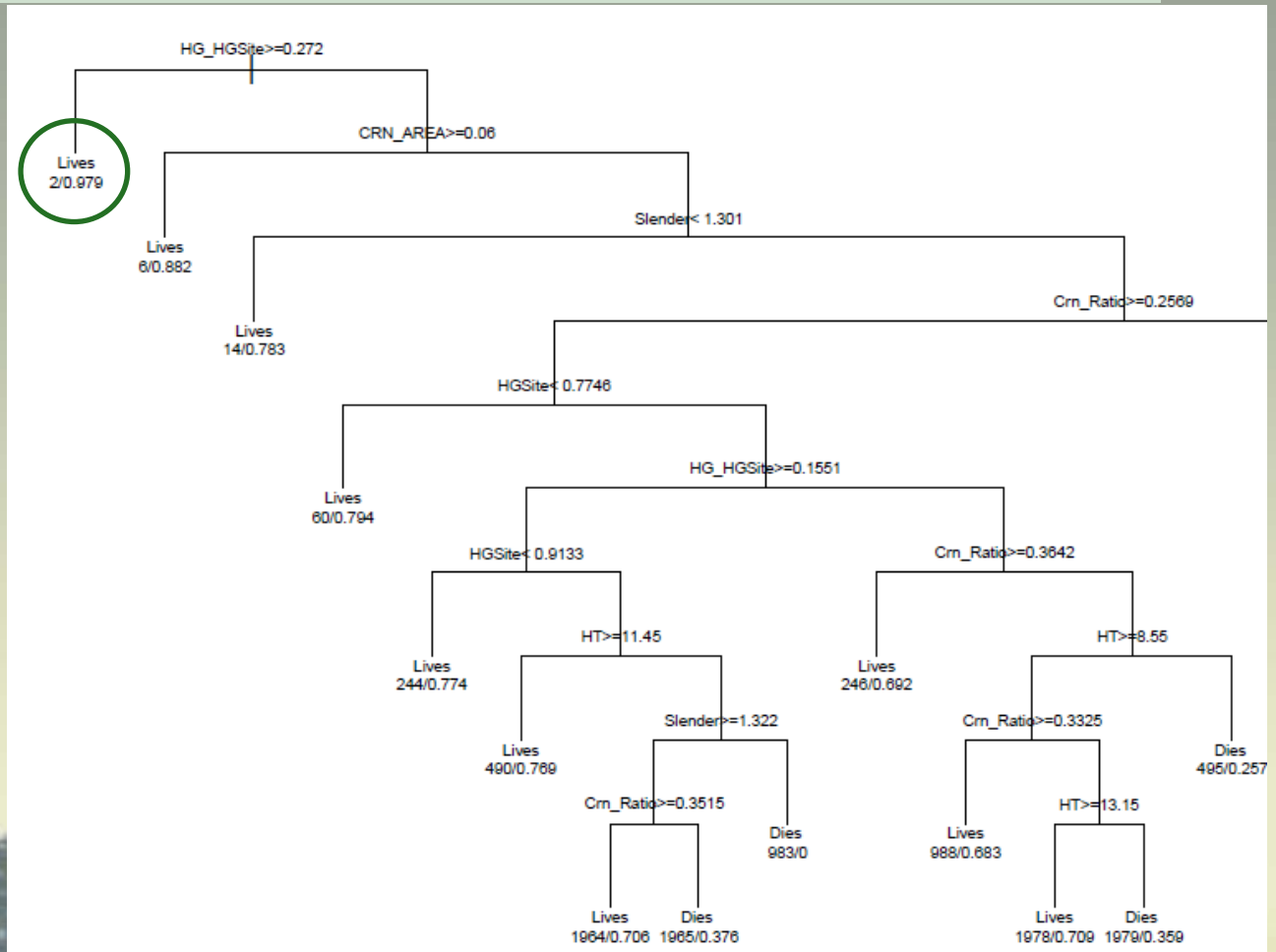
Mortality steps

- Collected all stem-mapped PSPs
- Input tree list and x-y coordinates into TASS
- Estimated the PACL of each tree at each measurement
- Used this derived PACL and other variables to predict the probability of death (or survival).
- Tried several approaches but now,

Classification And Regression Trees (CART)

- *Classification* for categorical variables (i.e. live or dead) or *Regression* for continuous variables
- *Random forests* is the most well known software
- While similar in concept to principle components analysis (which creates linear combinations of variables), this routine is non-paramentric (no assumptions necessary about the underlying distribution) and uses if-then-else logic.
- Results are fairly straightforward to interpret, however, the algorithms are very complex
- Need to decide:
  - The criteria for predictive accuracy
  - When to stop splitting
  - What is the "right-sized" tree (i.e., over fitting can be a problem)

Classification And Regression Trees (CART)



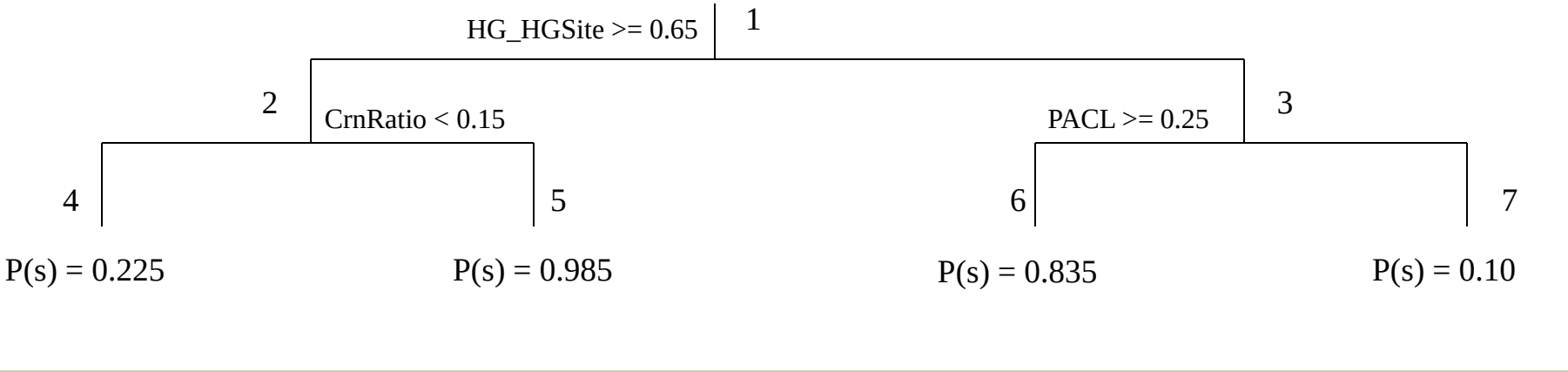
Moving through the Tree
- If the test statement is True, go left

Leaf Label is node number and probability of survival

Lives/Dies label is simply based on probability of survival:
e.g., at node 2
< 0.979 → Dies

Individuals will live or die based on probabilities and random draws, not the Lives/Dies label.

Simple Tree



We have coded in the CART mortality algorithm for testing purposes. When satisfied that it is working "correctly" (i.e., passes test of reasonableness), then we use the information (e.g., variables, interactions) to conduct logistic regression.....

Logistic Regression

- generic tool for fitting a dichotomous dependent variable (e.g. Live-Dead) to categorical and continuous independent variables .

$$P_s = \left(\frac{1}{1 + e^{\beta X}} \right)^L$$

$\beta X = b_0 + b_1C_1 + b_2C_2 \ \ldots + b_nC_n + b_{12}C_1C_2 + \ \ldots + b_{nm}C_nC_m$

with individual covariates (C_i) and possible interaction terms that are selected in part from the CART results.

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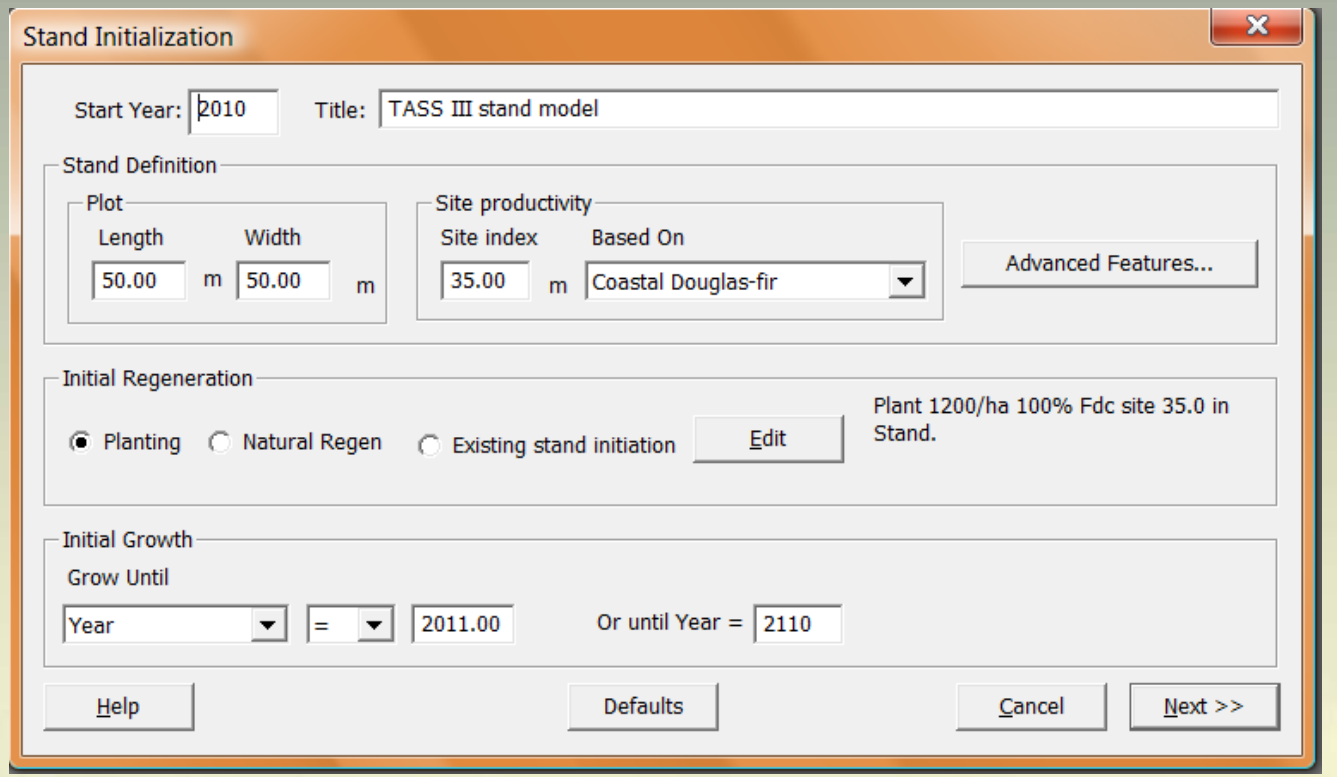
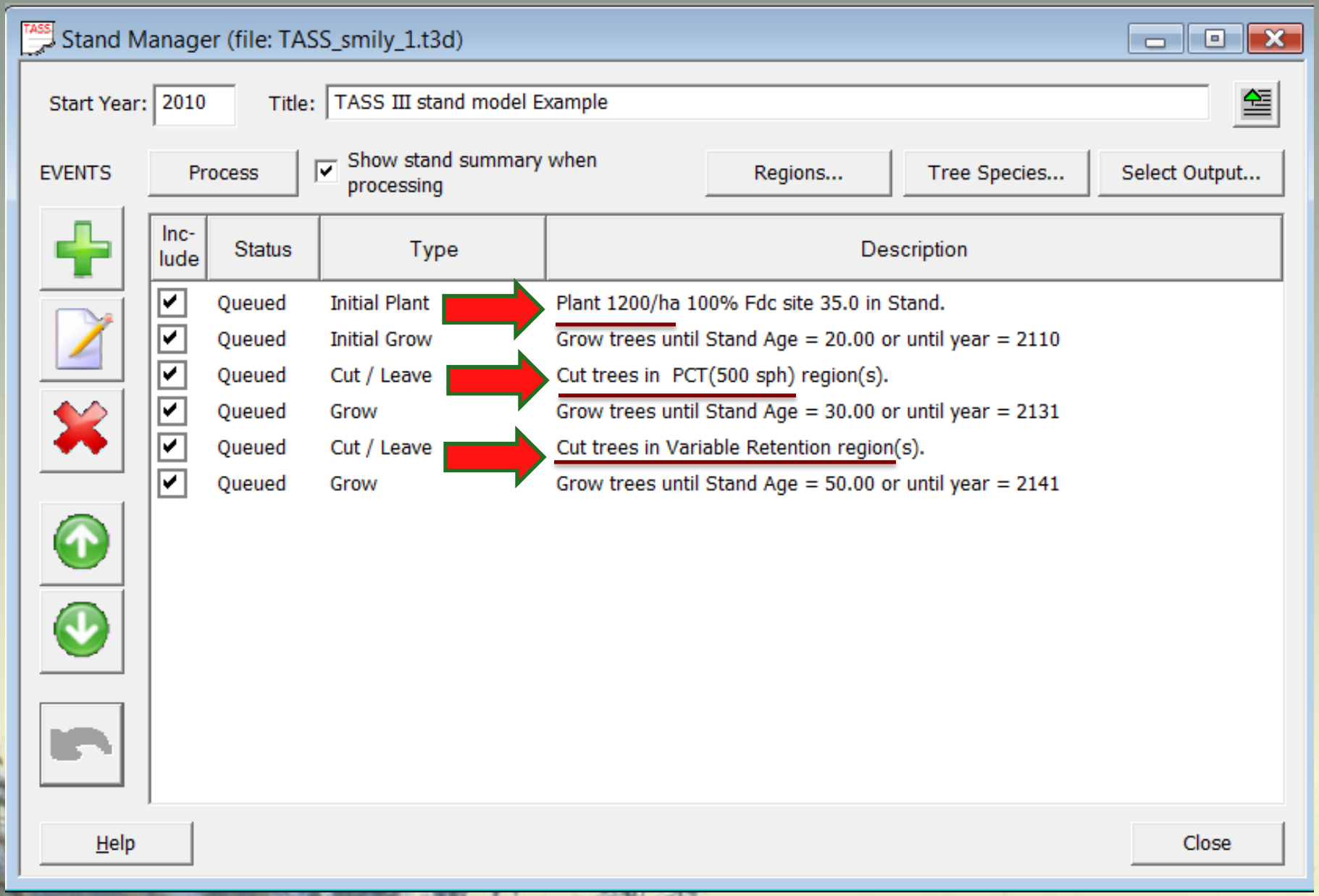
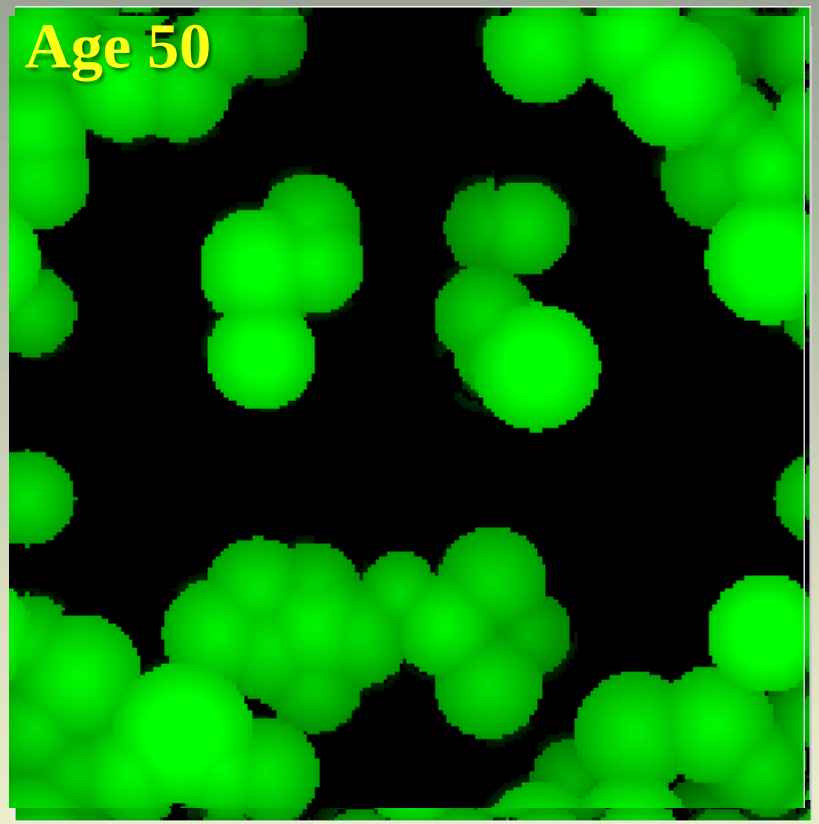
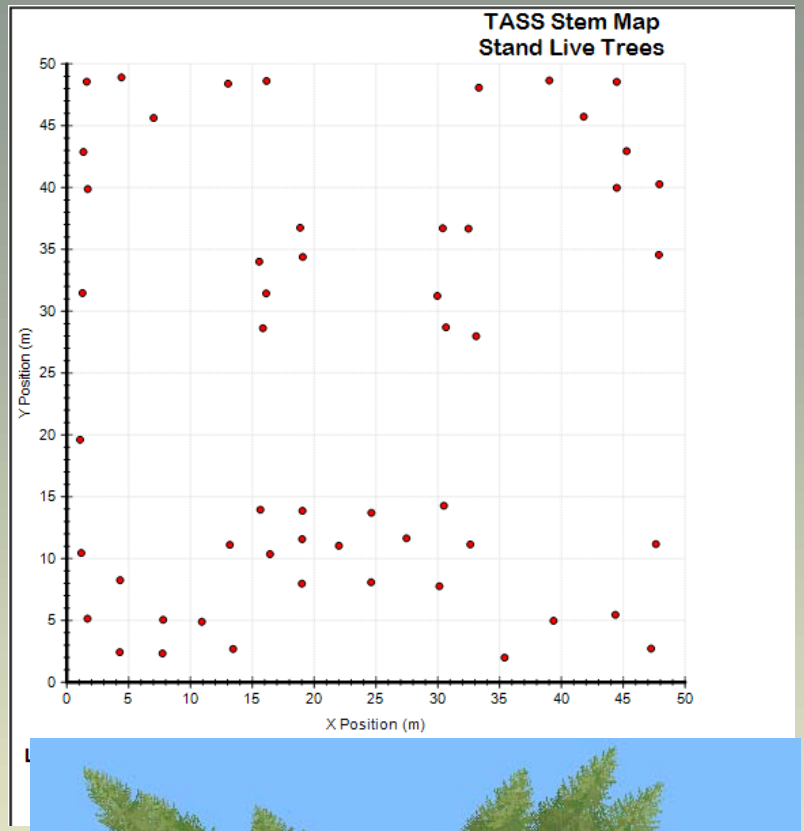
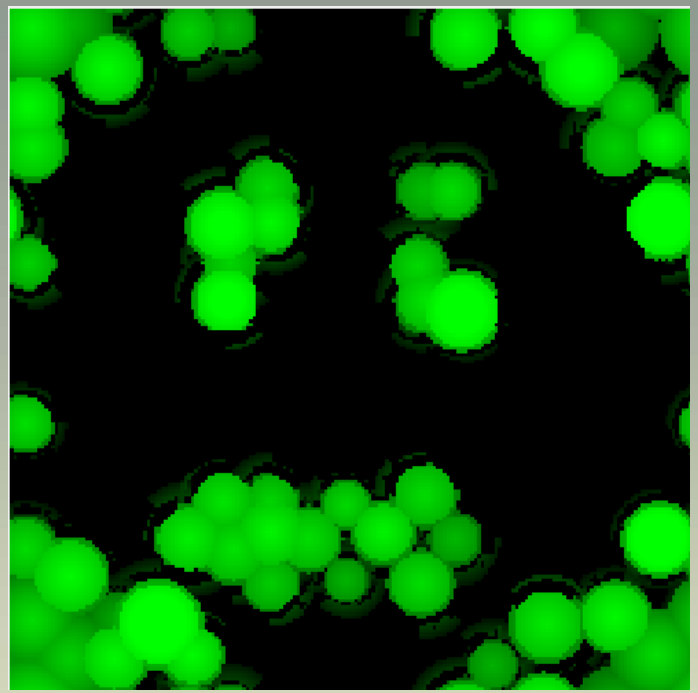
TASS Graphical User Interface (the holodeck)

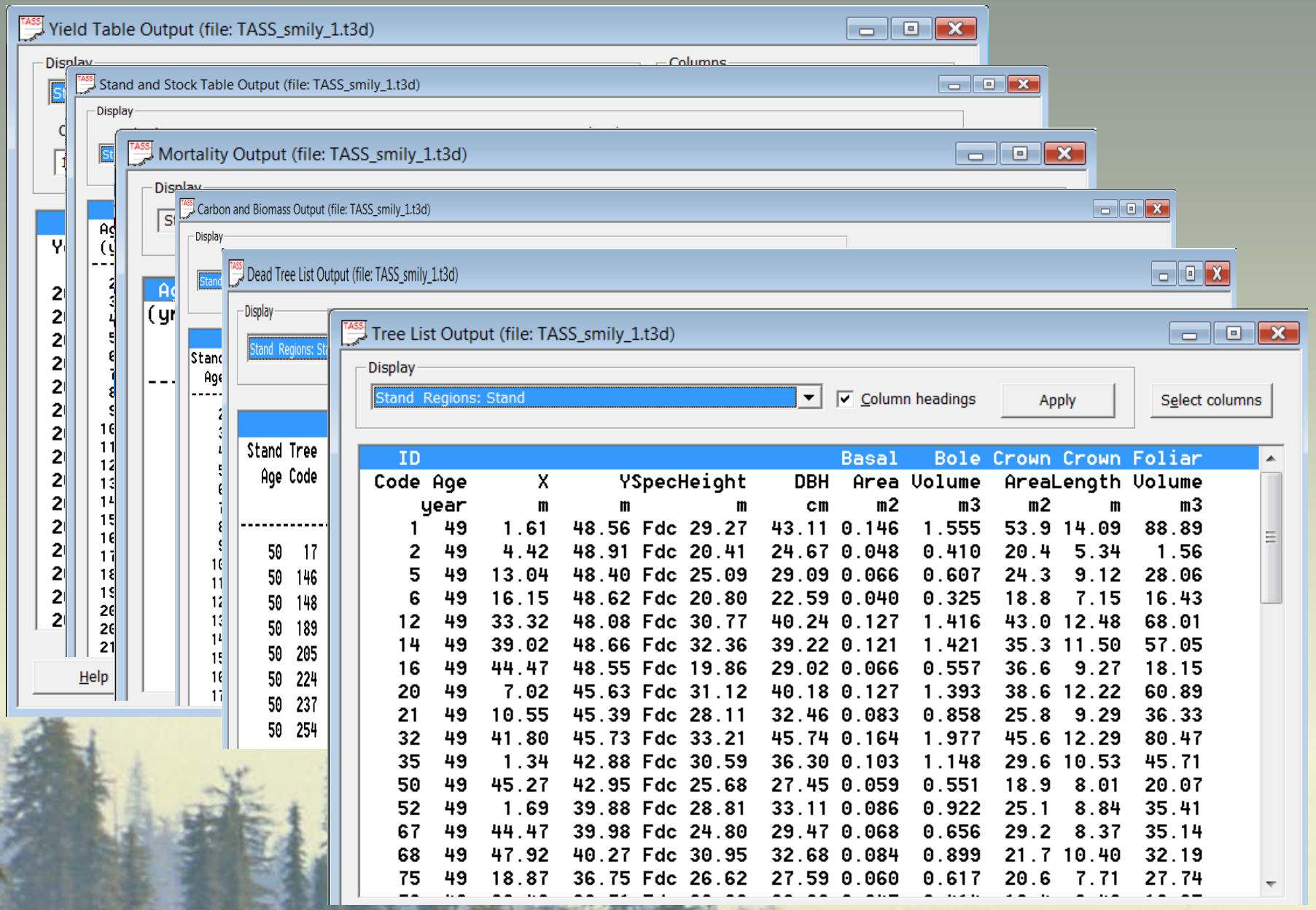




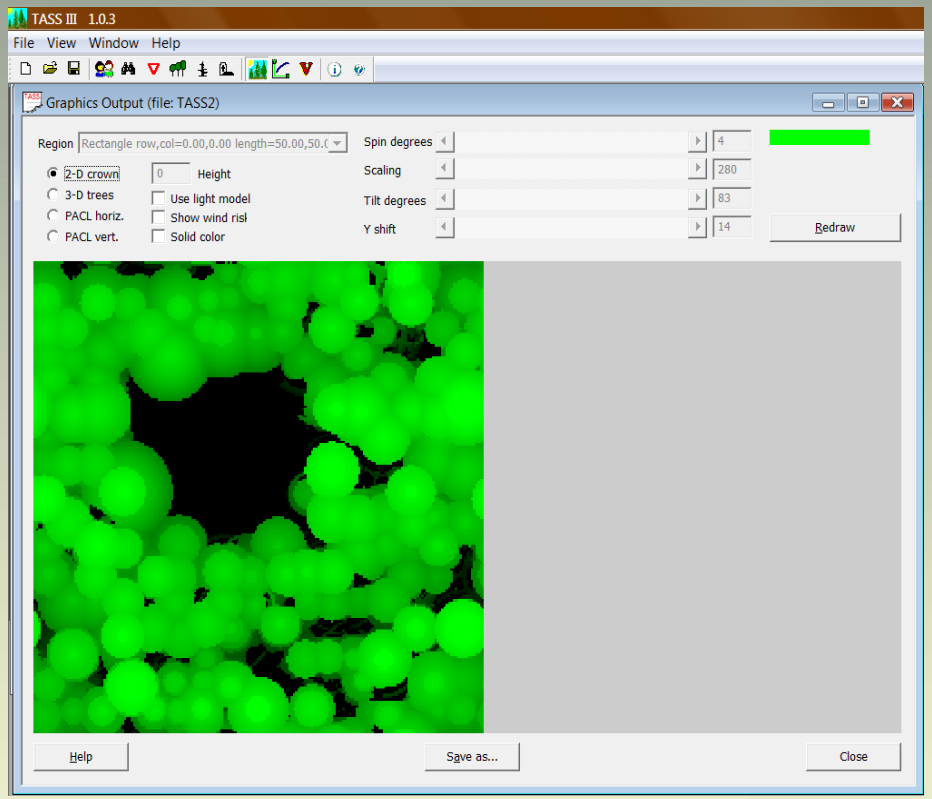

Age 50

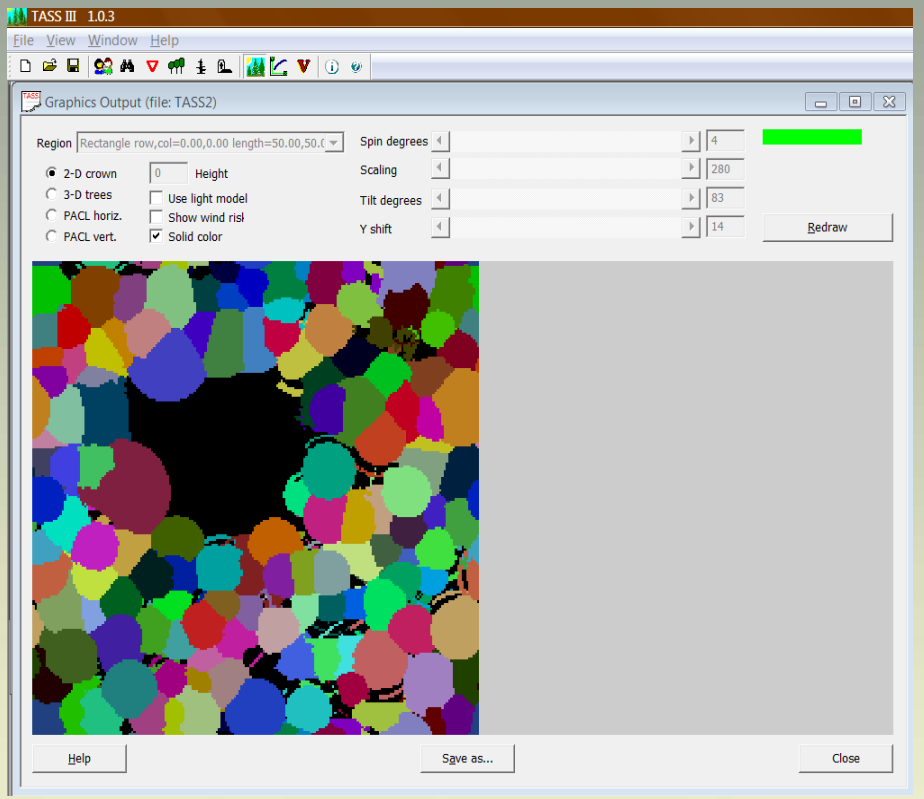

TASS Stem Map
Stand Live Trees
Y Position (m)
X Position (m)
0
5
10
15
20
25
30
35
40
45
50

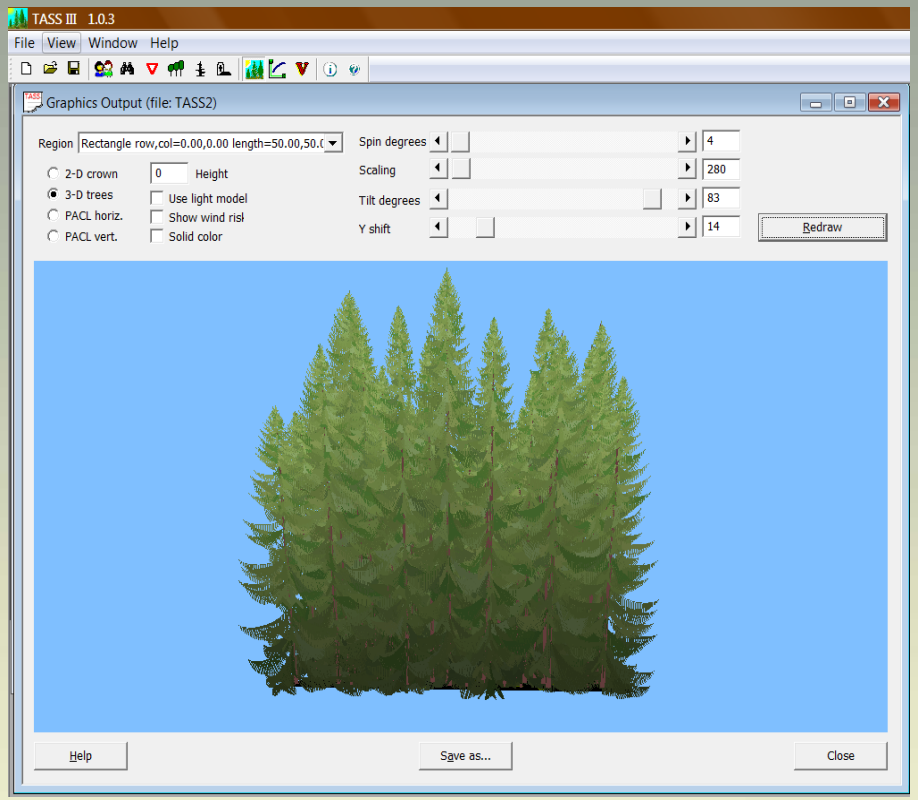


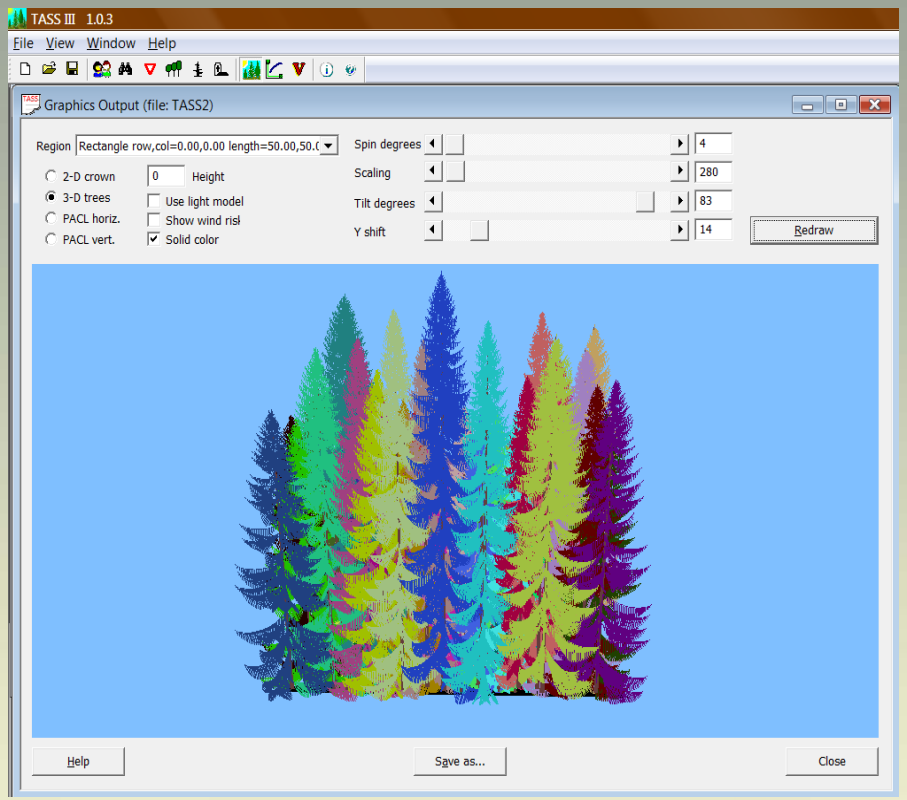


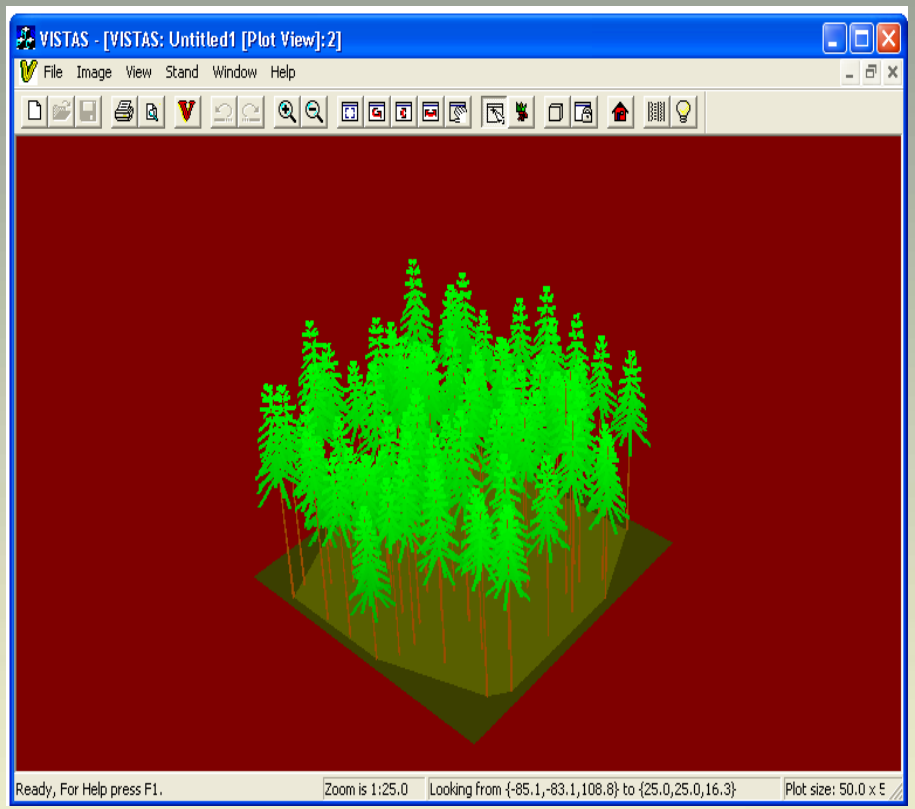
ID						Basal	Bole	Crown	Crown	Foliar
Code	Age	X	YSpecHeight		DBH	Area	Volume	AreaLength		Volume
	year	m	m		cm	m2	m3	m2	m	m3
1	49	1.61	48.56	Fdc 29.27	43.11	0.146	1.555	53.9	14.09	88.89
2	49	4.42	48.91	Fdc 20.41	24.67	0.048	0.410	20.4	5.34	1.56
5	49	13.04	48.40	Fdc 25.09	29.09	0.066	0.607	24.3	9.12	28.06
6	49	16.15	48.62	Fdc 20.80	22.59	0.040	0.325	18.8	7.15	16.43
12	49	33.32	48.08	Fdc 30.77	40.24	0.127	1.416	43.0	12.48	68.01
14	49	39.02	48.66	Fdc 32.36	39.22	0.121	1.421	35.3	11.50	57.05
16	49	44.47	48.55	Fdc 19.86	29.02	0.066	0.557	36.6	9.27	18.15
20	49	7.02	45.63	Fdc 31.12	40.18	0.127	1.393	38.6	12.22	60.89
21	49	10.55	45.39	Fdc 28.11	32.46	0.083	0.858	25.8	9.29	36.33
32	49	41.80	45.73	Fdc 33.21	45.74	0.164	1.977	45.6	12.29	80.47
35	49	1.34	42.88	Fdc 30.59	36.30	0.103	1.148	29.6	10.53	45.71
50	49	45.27	42.95	Fdc 25.68	27.45	0.059	0.551	18.9	8.01	20.07
52	49	1.69	39.88	Fdc 28.81	33.11	0.086	0.922	25.1	8.84	35.41
67	49	44.47	39.98	Fdc 24.80	29.47	0.068	0.656	29.2	8.37	35.14
68	49	47.92	40.27	Fdc 30.95	32.68	0.084	0.899	21.7	10.40	32.19
75	49	18.87	36.75	Fdc 26.62	27.59	0.060	0.617	20.6	7.71	27.74







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File Image View Stand Window Help
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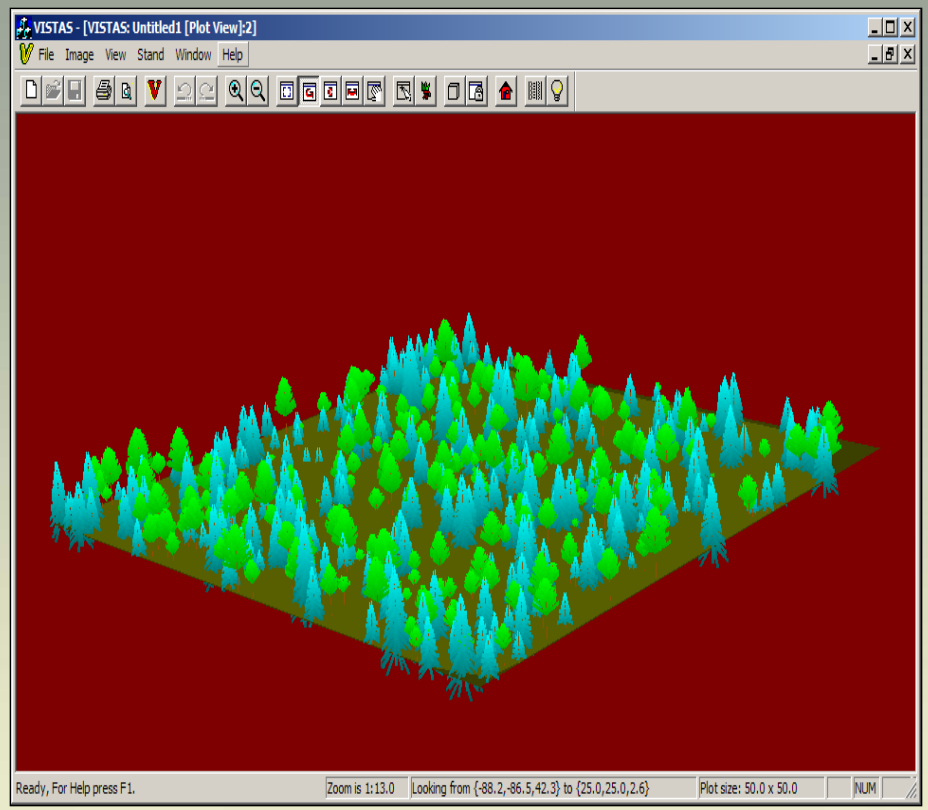
Looking from {-85.1,-83.1,108.8} to {25.0,25.0,16.3}
Plot size: 50.0 x 5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File Image View Stand Window Help
Ready, For Help press F1.
Zoom is 1:13.0
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Plot size: 50.0 x 50.0
NUM

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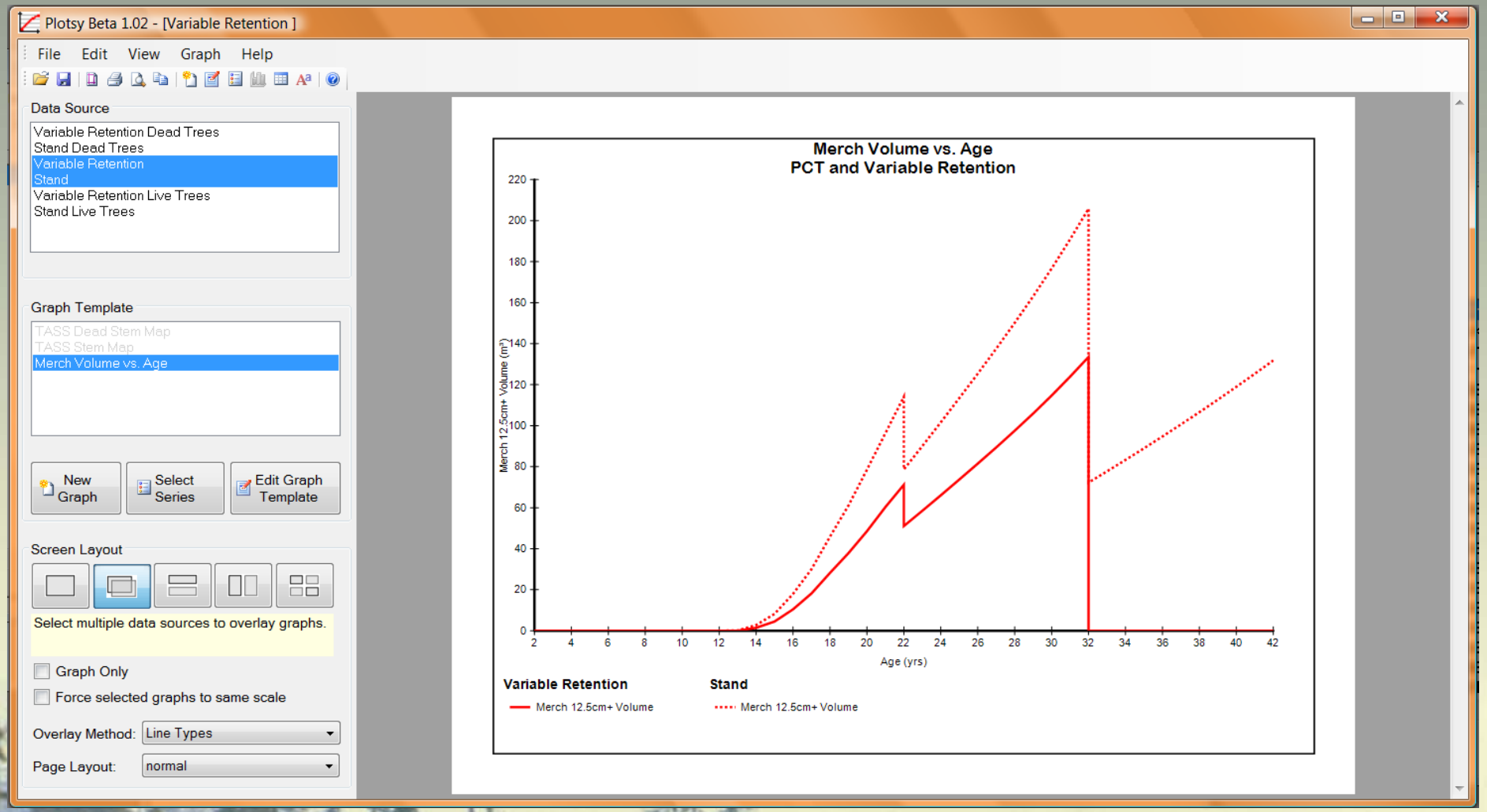
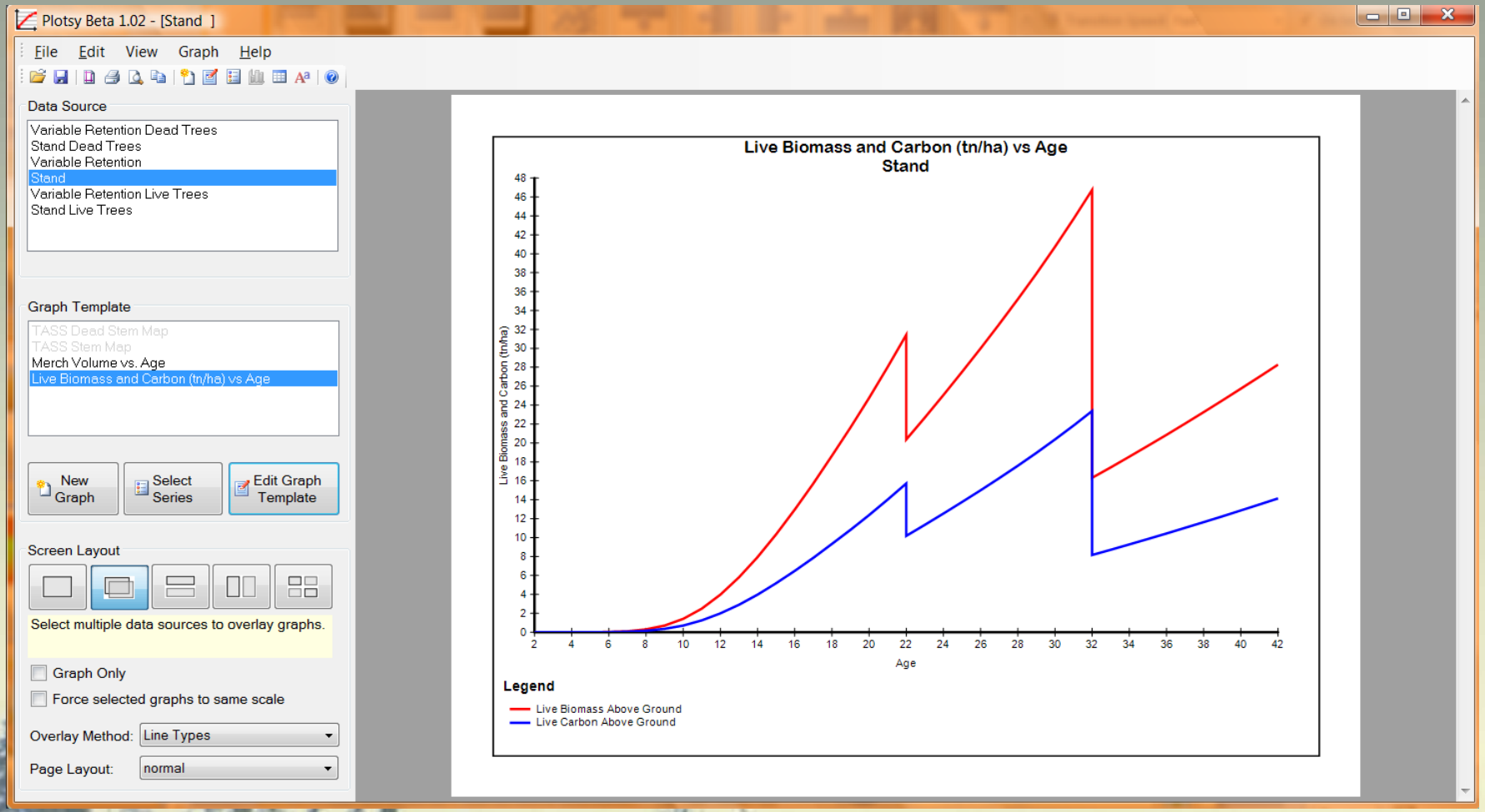
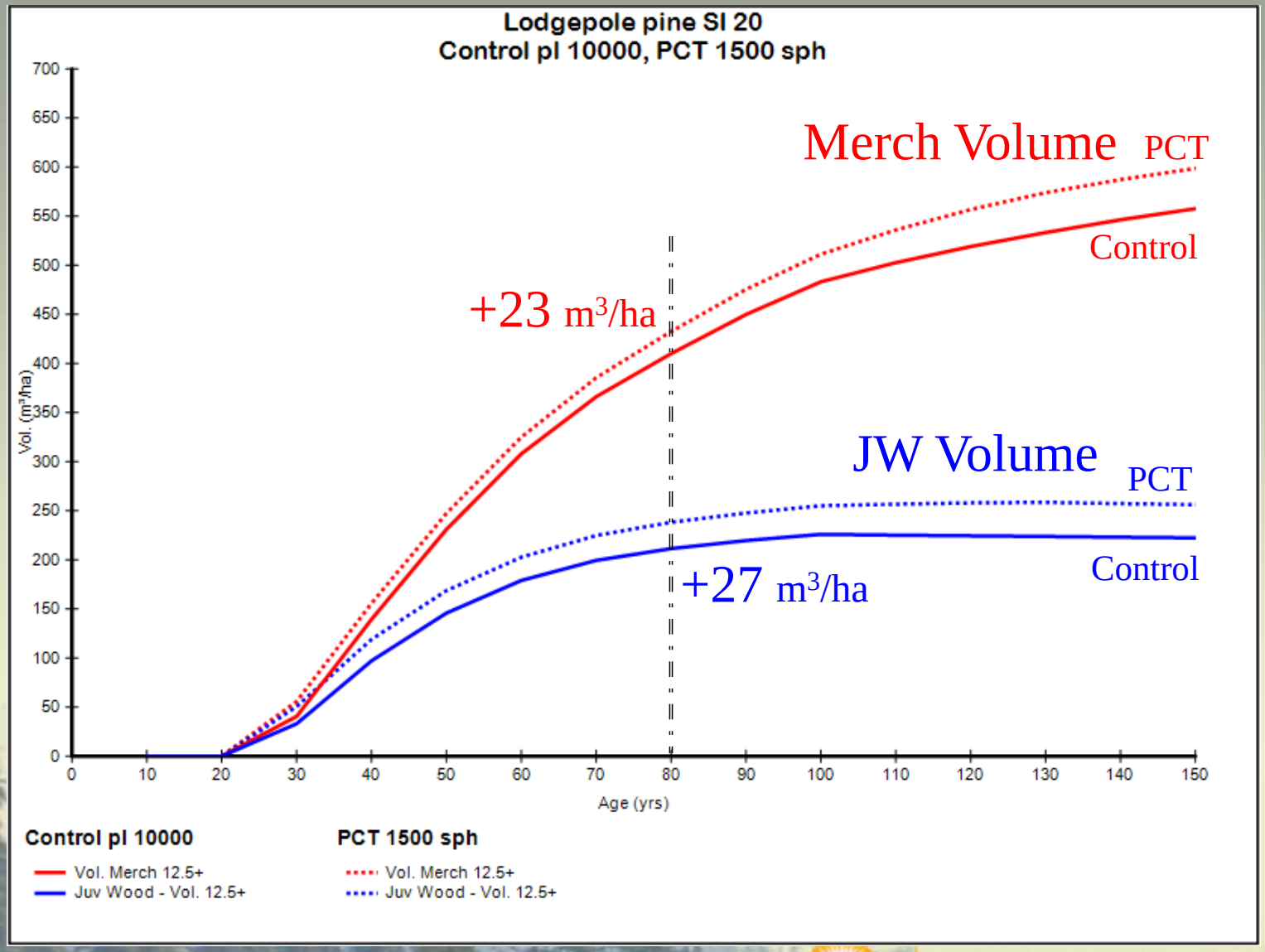




Merch Volume & Juvenile Wood Volume



TASS III

Underlying philosophy unchanged:

Advancing the prediction of stand growth and yield by focusing on the spatial dynamics of individual tree crowns, the biological engine of tree growth.

TASS is a framework for synthesis of world-wide research on tree growth and stand development, with a focus on treatment response.

Thank you for your attention