

WINDFIRM: A spatial, mechanistic windthrow risk model

Ken Byrne
October 24, 2008



Forest Research





Outline

- **Functional changes in ForestGALES**
- **ForestGALES_BC goes spatial with WINDFIRM**
- **Simulation/Validation of model outputs**

Why make these changes?

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- *Adapt for British Columbia species*

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- *Characterize heterogeneous and upwind conditions*

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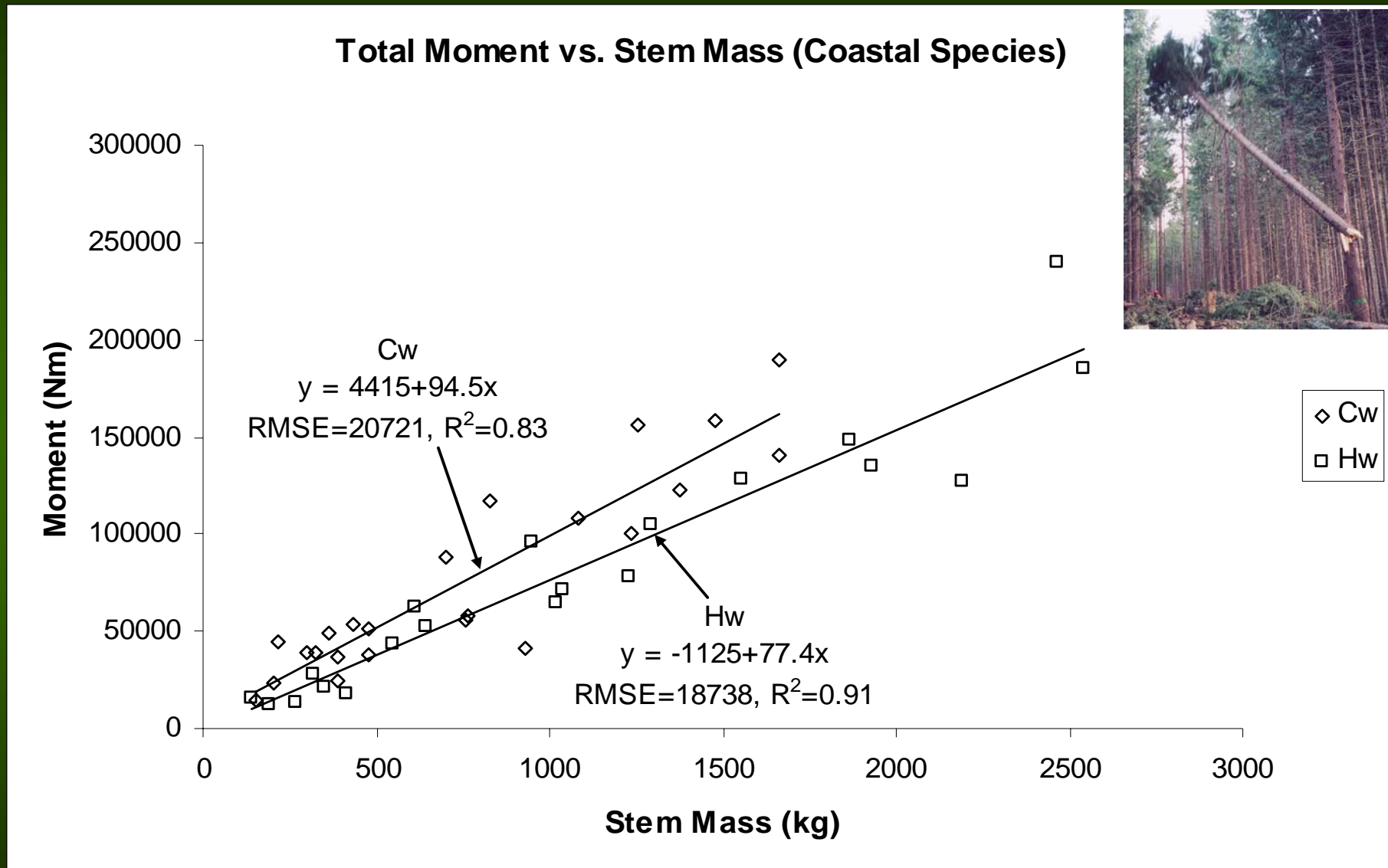
- *Adapt for British Columbia species*
- *Characterize heterogeneous stand conditions and variable upwind conditions*
- *Facilitate tree lists and characterize damage propagation*
- *Not trying to calculate c.w.s for each tree but response of tree to imposed wind speed*



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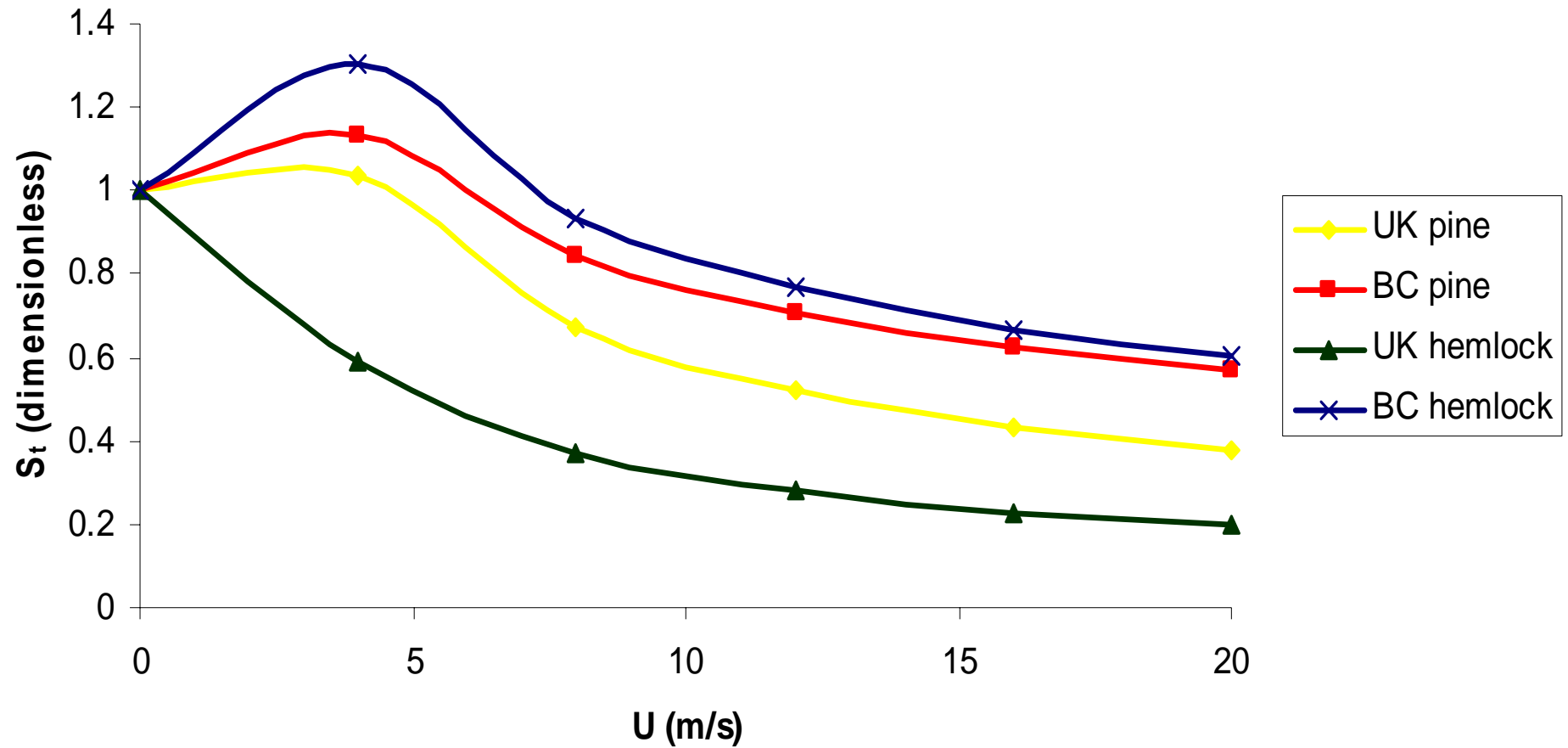
BC resistance functions



Cw $n = 23$, range(15 – 57 cm); *Hw* $n = 20$, range(15 – 52 cm)

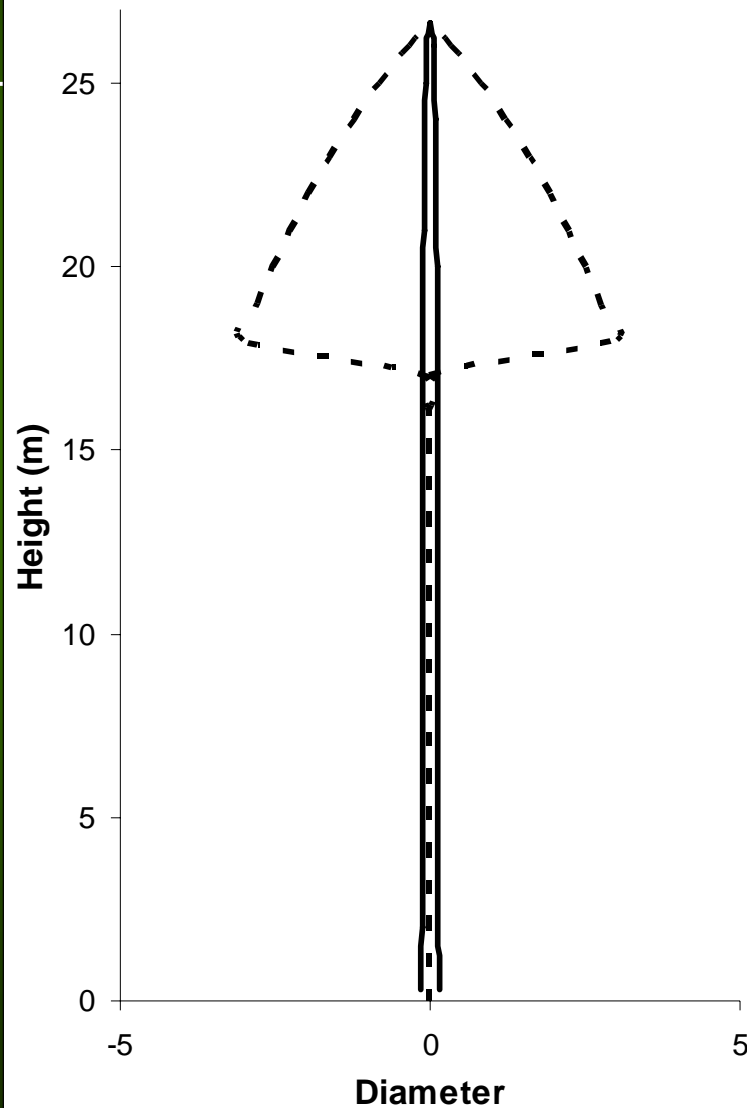
Crown streamlining functions

Streamlining coefficients for BC and UK species



Equation for crown shape

Fd
H = 26.63m
DBH = 31.06cm



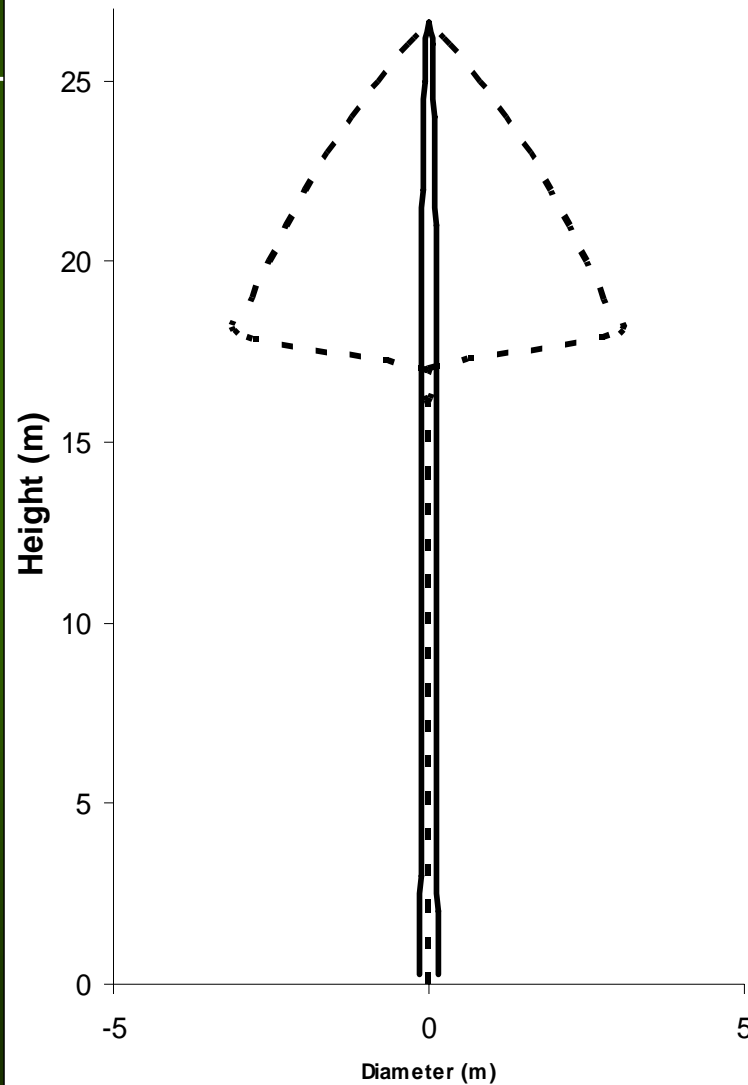
Equation for stem shape

Equation for crown shape

$$I_{BRANCH} = A * \ln$$
$$(I_{CROWN} / C + 1) *$$
$$B$$

(courtesy BCMoF)

Fd
H = 26.63m
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Equation for stem shape

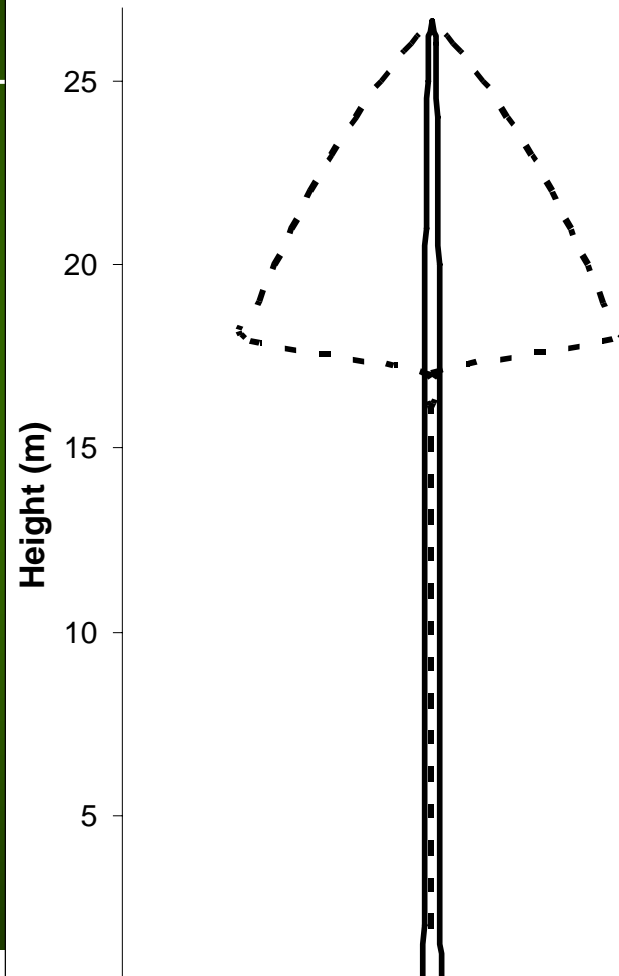
Equation for crown shape

$$I_{BRANCH} = A * \ln \left(\frac{I_{CROWN}}{C + 1} \right) * B$$

(courtesy BCMoF)

$$d_i = a_0 D^{a_1} a_2 X^{b_1 Z^2 + b_2 \ln(Z + 0.001) + b_3 \sqrt{Z} + b_4 e^Z + b_5 (D/H)}$$

Fd
H = 26.63m
DBH = 31.06cm



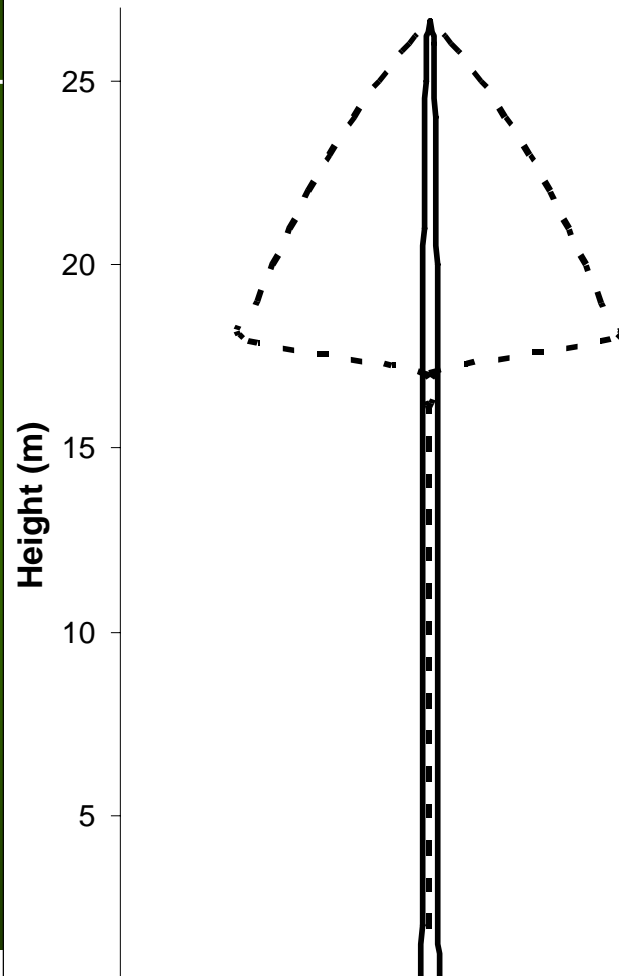
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Equation for stem shape

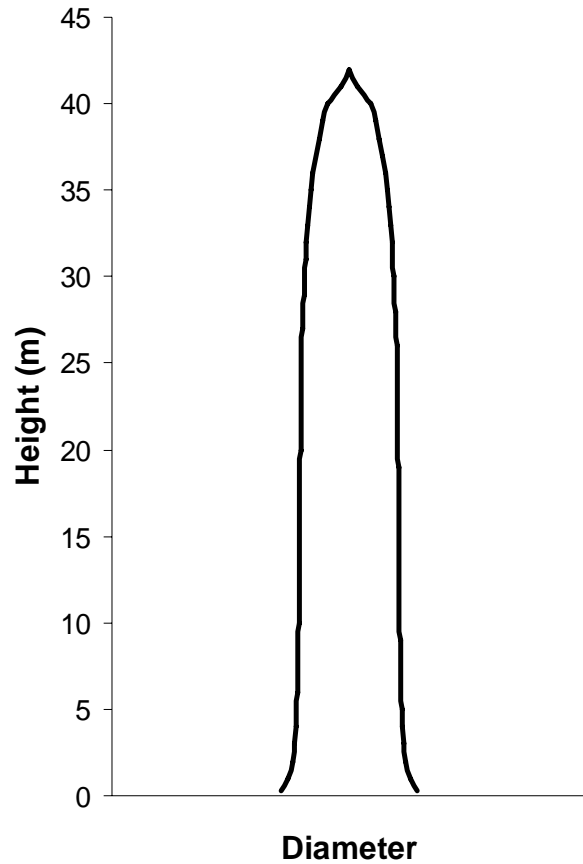
$$d_i = \text{function}\{D, H\}$$

(Kozak 1988)

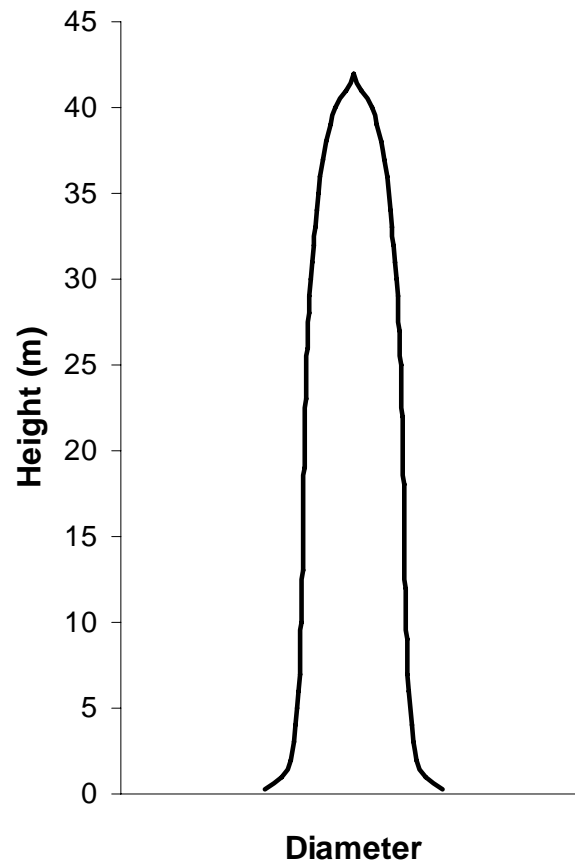
$$d_i = a_0 D^{a_1} a_2 X^{b_1 Z^2 + b_2 \ln(Z + 0.001) + b_3 \sqrt{Z} + b_4 e^Z + b_5 (D/H)}$$

Representation of stem shape

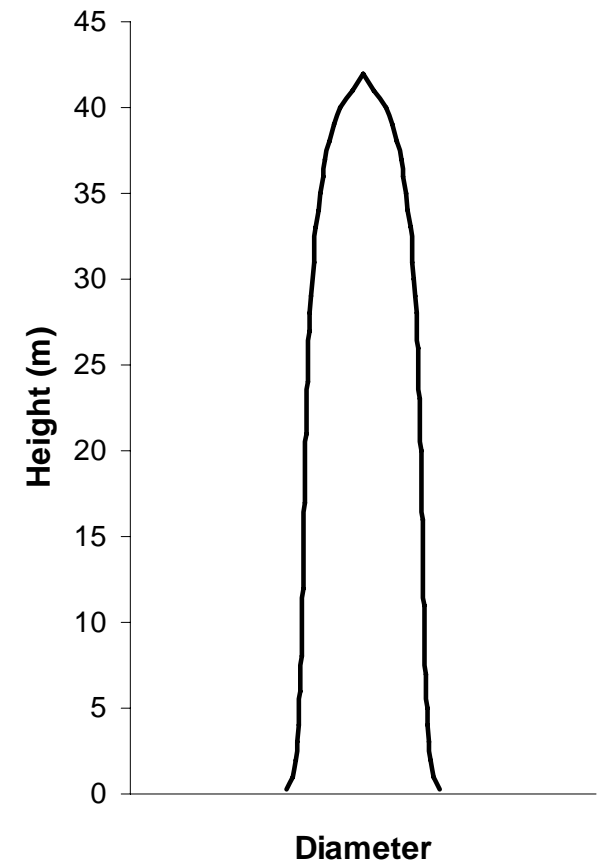
Fd
H=41.1m
DBH=55.8cm



Cw
H=41.1m
DBH=55.8cm



PI
H=41.1m
DBH=55.8cm



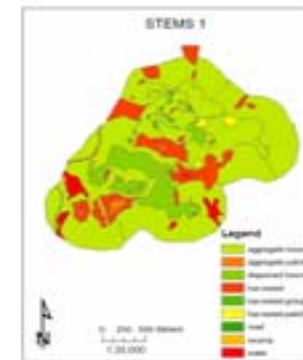
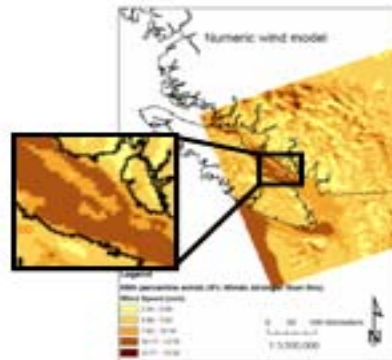
****Note – Diameters are exaggerated relative to height**



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Incorporating spatial effects



Tree List Source:

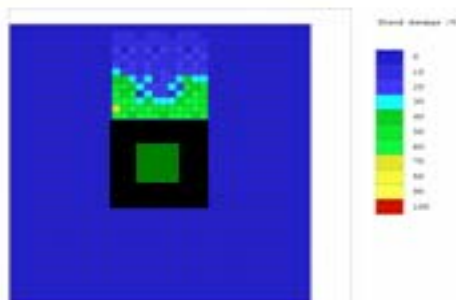
- TASS
- LiDAR
- Ground Survey

Wind Model:

Wind speeds associated with return period of interest

GIS Layers:

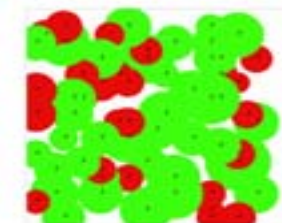
Soils, Topographic, Cutblock Layout (eg. gap size, edge location, retention)



Windfirm

ForestGALES_BC

Final Spatial Tree List





test.txt - WordPad

File Edit View Insert Format Help



Plot size: 100.00 x 100.00 = 1.00 hectares.
 Reference site index and species 35.00m (Fdc).

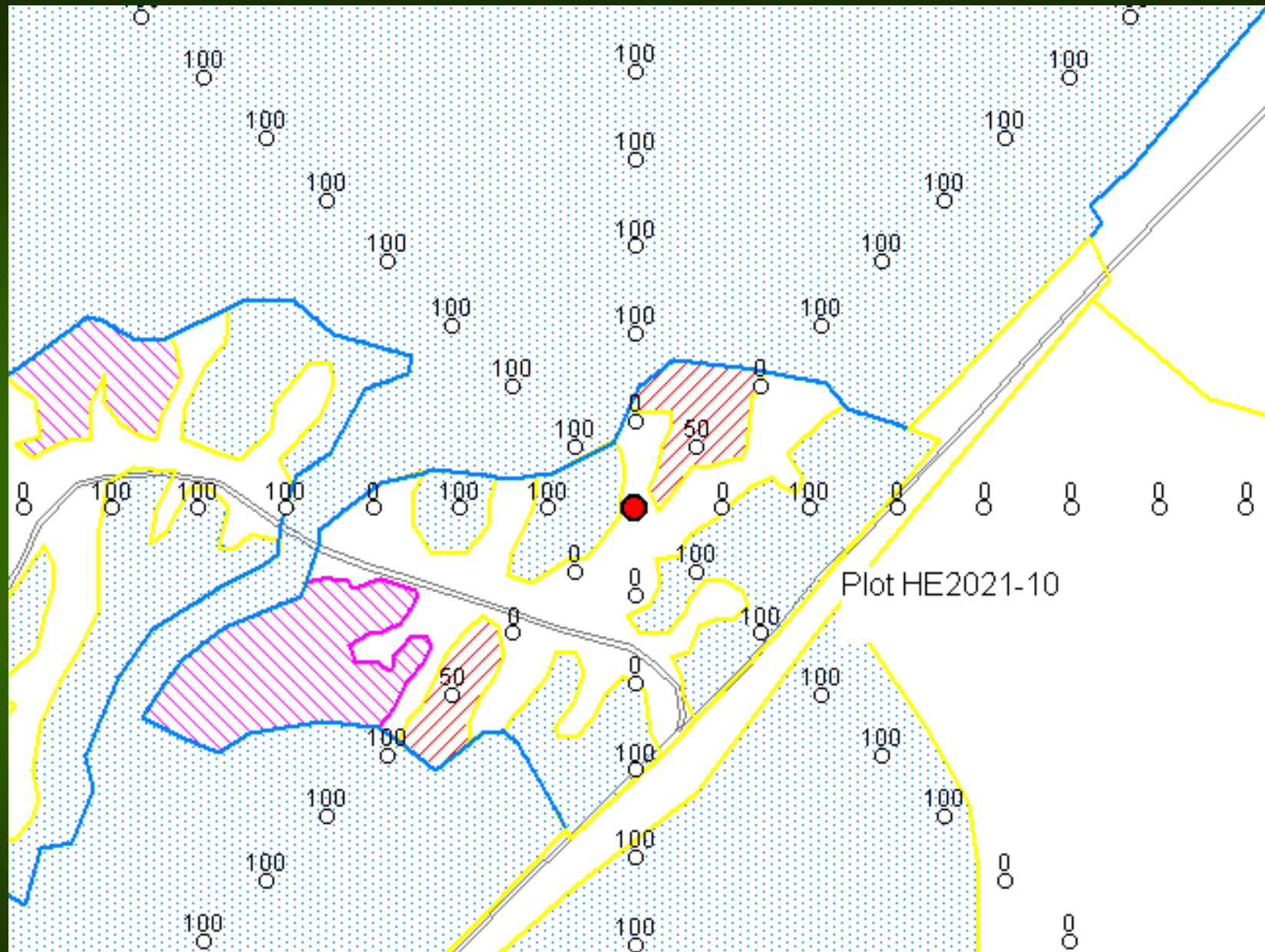
ID	Basal	Bole	Crown	Crown	Foliar						
Code	Area	Volume	Area	Length	Volume						
Age	m ²	m ³	m ²	m	m ³						
X	DBH	YSpec	Height	DBH	Area						
m	cm	m	m	cm	m ²						
2	42	4.42	98.91	Fdc	29.31	43.78	0.151	1.583	29.8	12.17	72.30
3	42	7.06	98.51	Fdc	24.08	24.15	0.046	0.434	5.8	5.29	9.92
4	42	10.40	98.88	Fdc	23.78	24.66	0.048	0.451	8.4	6.66	16.06
5	42	13.04	98.40	Fdc	26.63	31.06	0.076	0.771	14.4	8.68	31.47
6	42	16.15	98.62	Fdc	28.61	39.92	0.125	1.313	28.5	12.71	67.59
7	42	18.90	98.24	Fdc	17.71	18.03	0.026	0.192	23.6	12.64	36.54
8	42	21.54	98.52	Fdc	18.13	22.36	0.039	0.299	0.1	1.70	0.05
9	42	25.04	97.88	Fdc	27.81	38.43	0.116	1.235	29.3	11.71	67.58
10	42	27.80	98.21	Fdc	12.92	20.03	0.032	0.188	1.8	1.67	0.24
11	42	29.90	98.84	Fdc	21.66	16.66	0.022	0.191	2.6	4.40	3.73
12	42	33.32	98.08	Fdc	20.35	33.42	0.088	0.686	53.8	15.47	90.75
13	42	35.70	98.58	Fdc	28.54	36.44	0.104	1.124	23.6	11.37	55.83
14	42	39.02	98.66	Fdc	18.97	19.80	0.031	0.239	1.6	2.56	1.28



(Scott 2005)

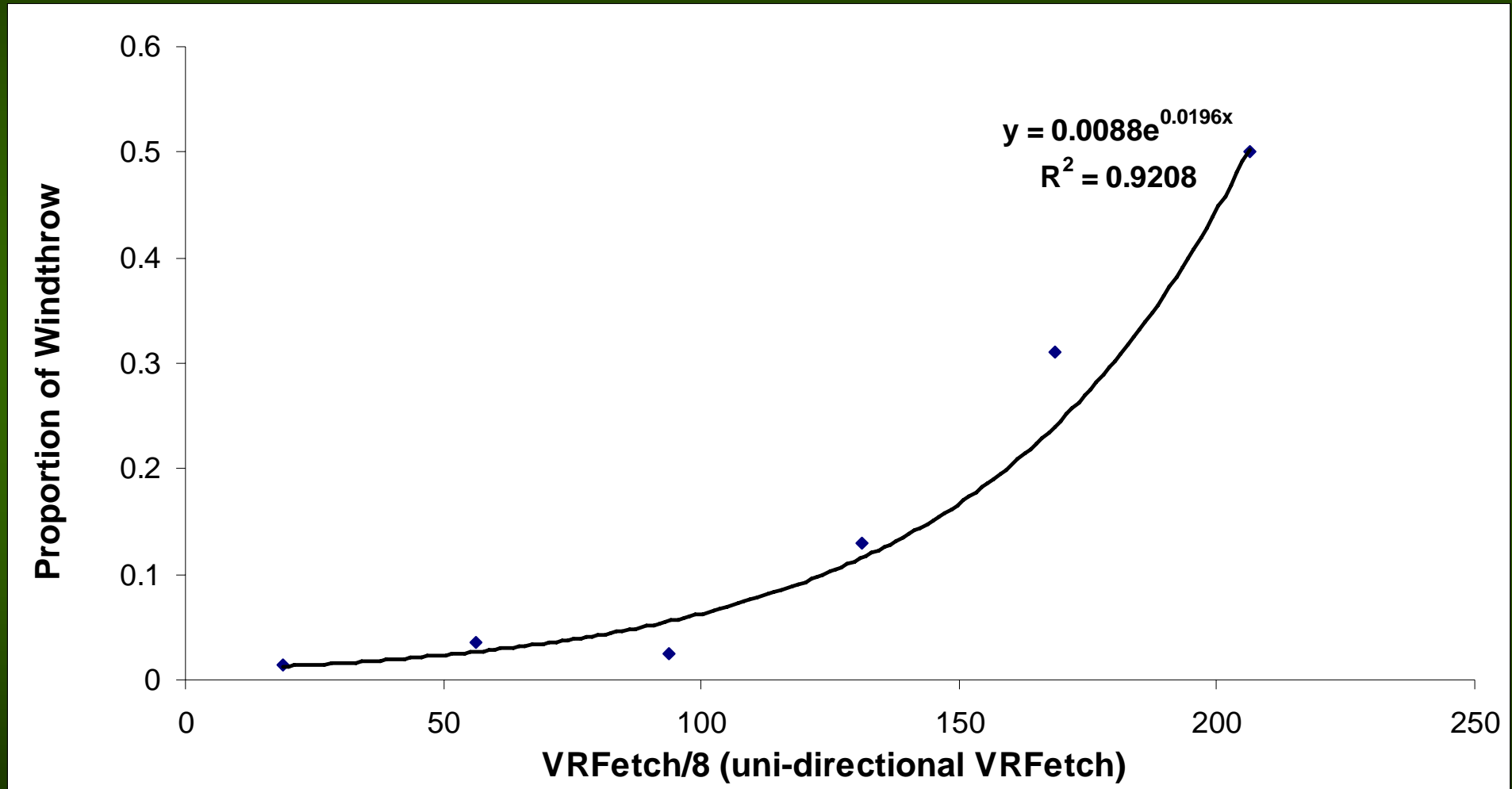


(Scott 2005)



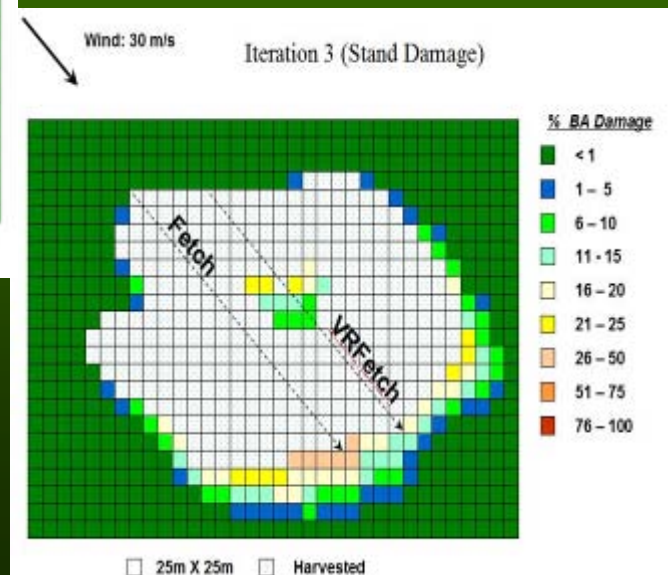
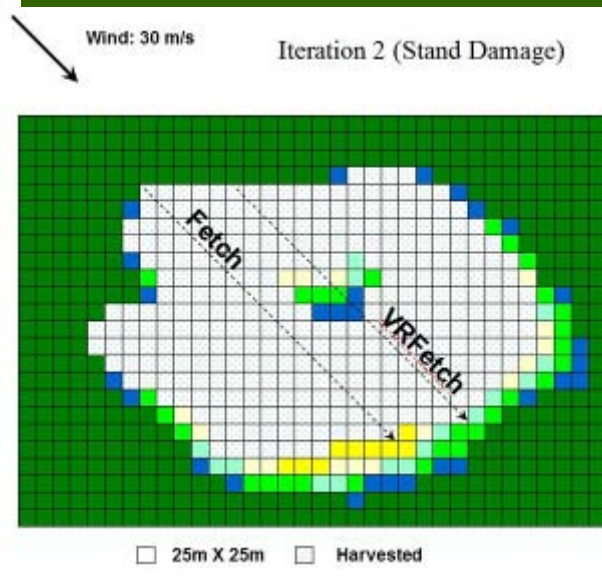
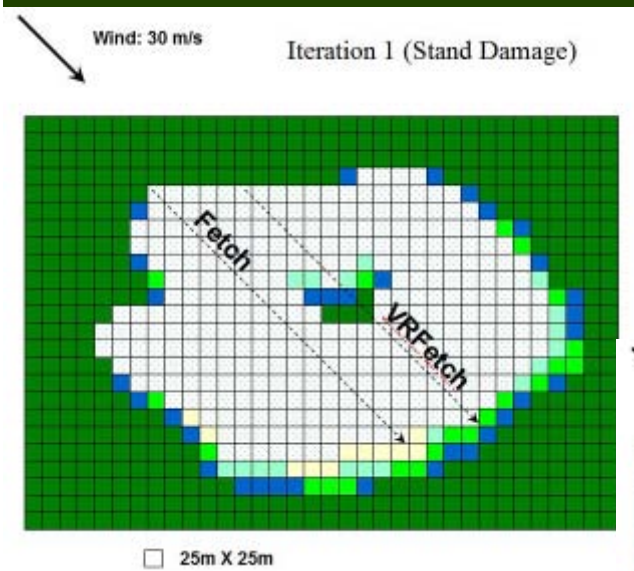
VRFETCH = distance X removal level every 30m for 300m in eight cardinal directions surrounding the plot (this calculation done in WINDFIRM).

GF 2: Increase of moment due to VRFetch

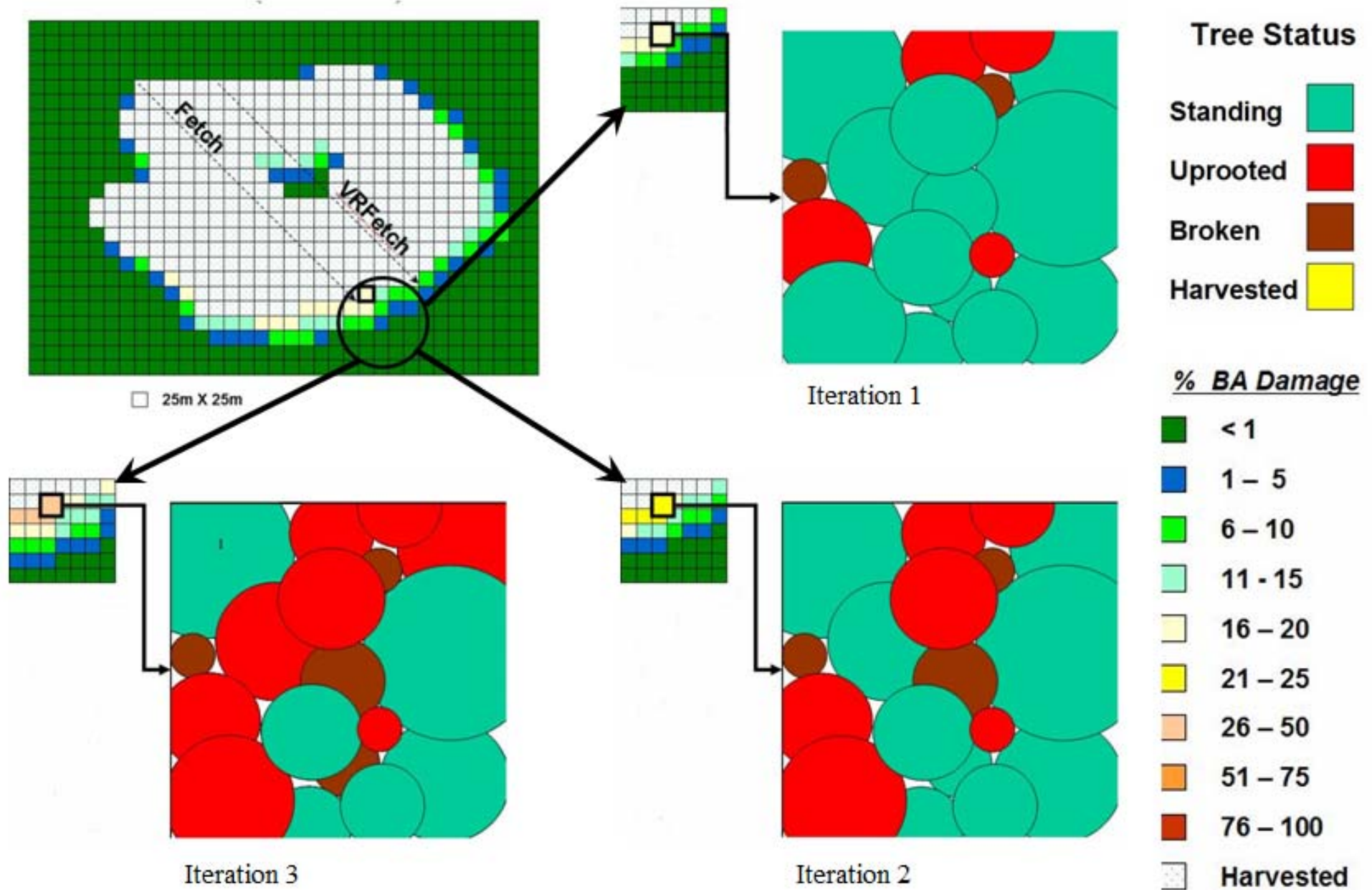


Moment multiplier = VRFetch

Iteration of tree lists through ForestGALES_BC using WINDFIRM



Individual tree damage output





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STEMS: Silviculture Treatments for Ecosystem Management in the Sayward

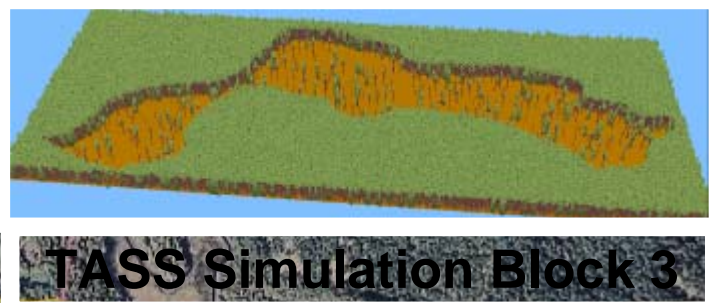
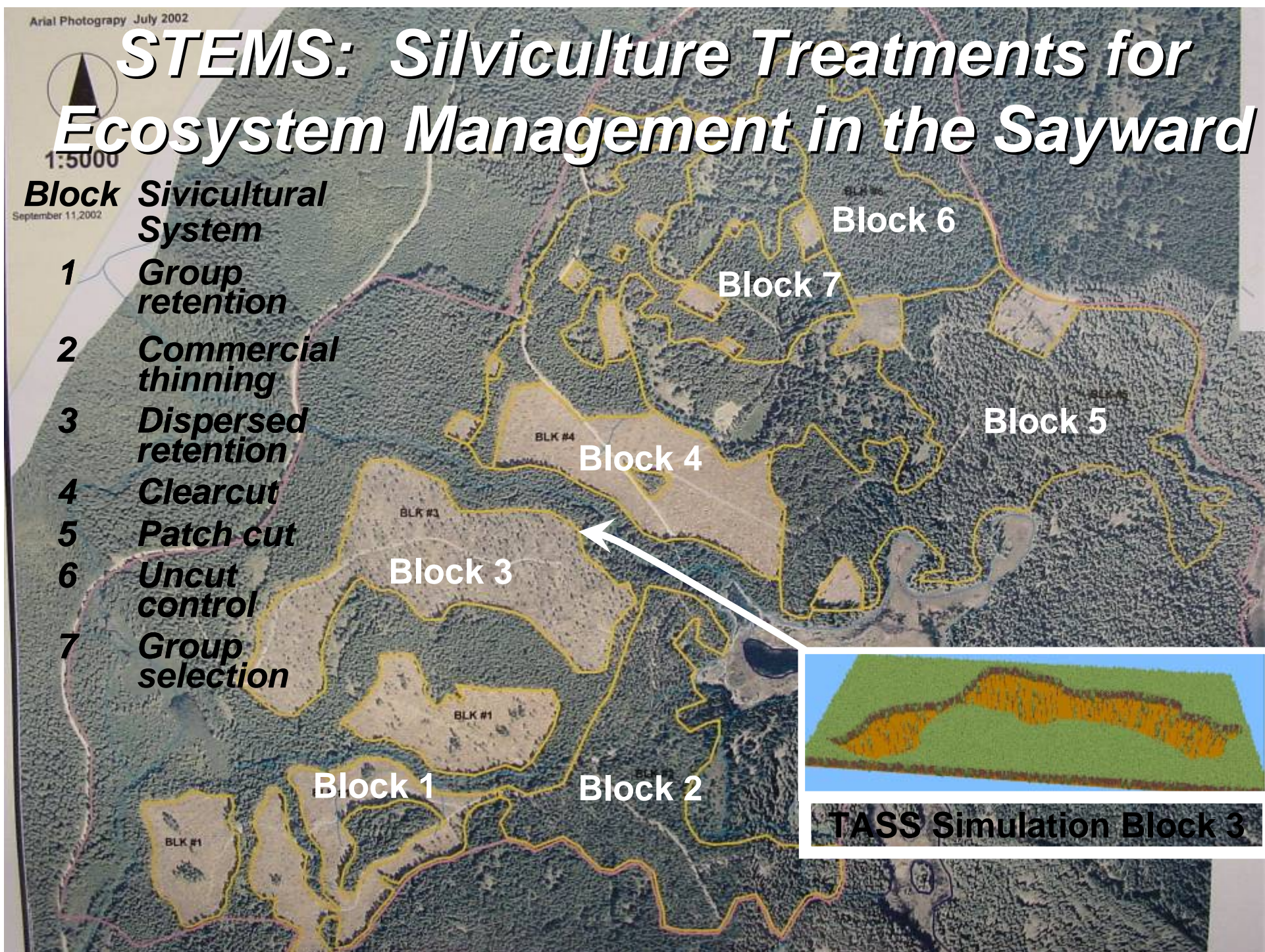


1:5000

Block **Silvicultural System**

September 11, 2002

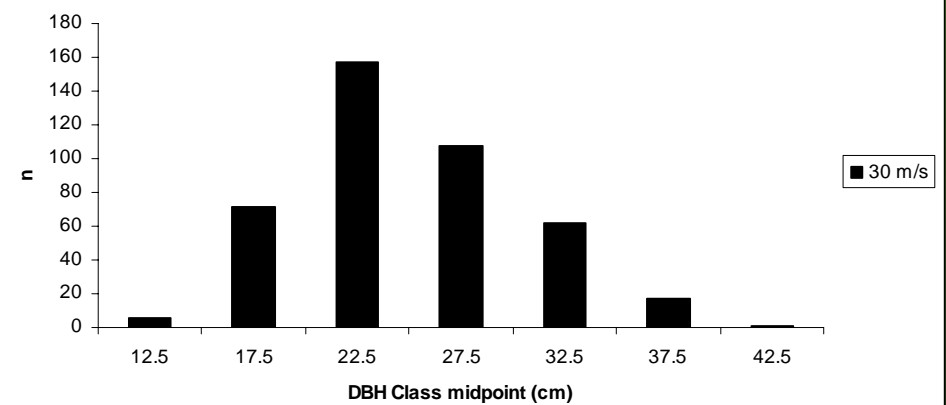
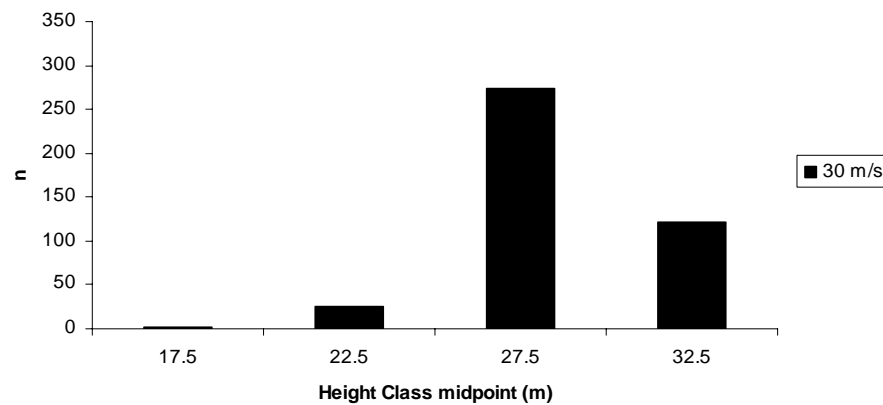
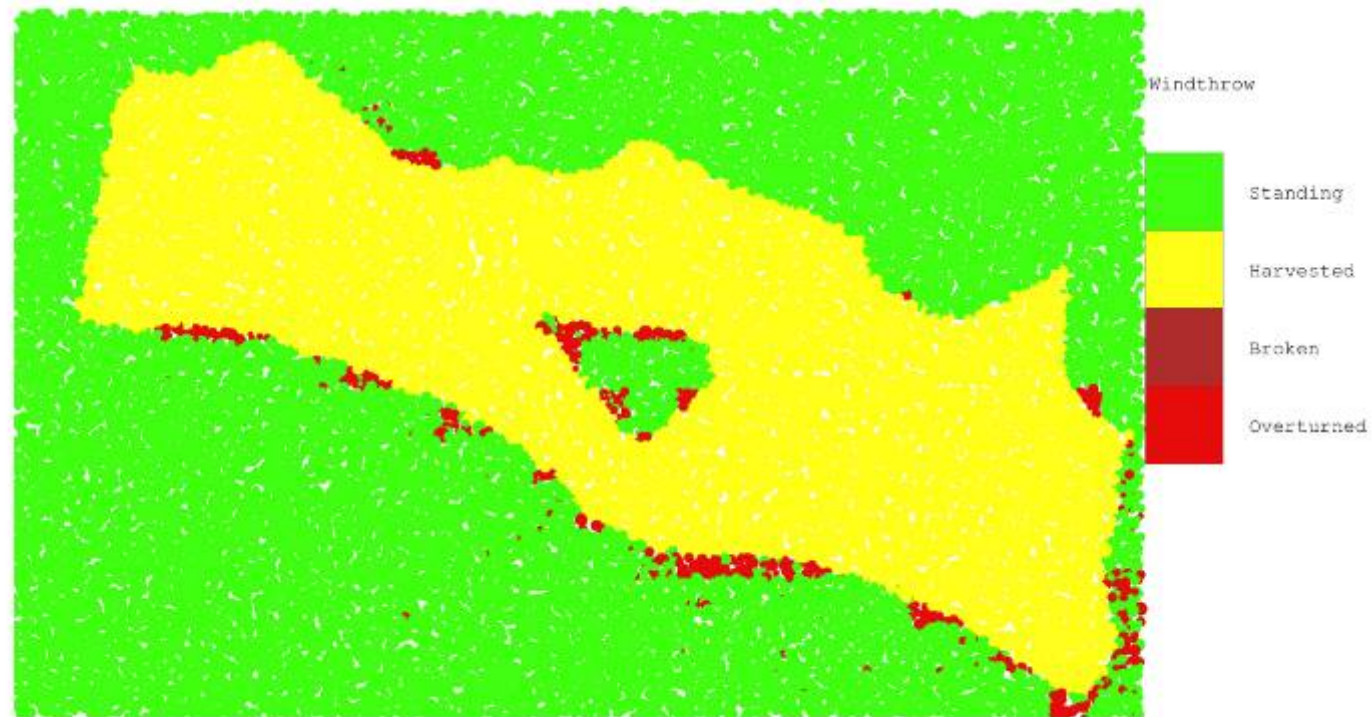
- 1** **Group retention**
- 2** **Commercial thinning**
- 3** **Dispersed retention**
- 4** **Clearcut**
- 5** **Patch cut**
- 6** **Uncut control**
- 7** **Group selection**



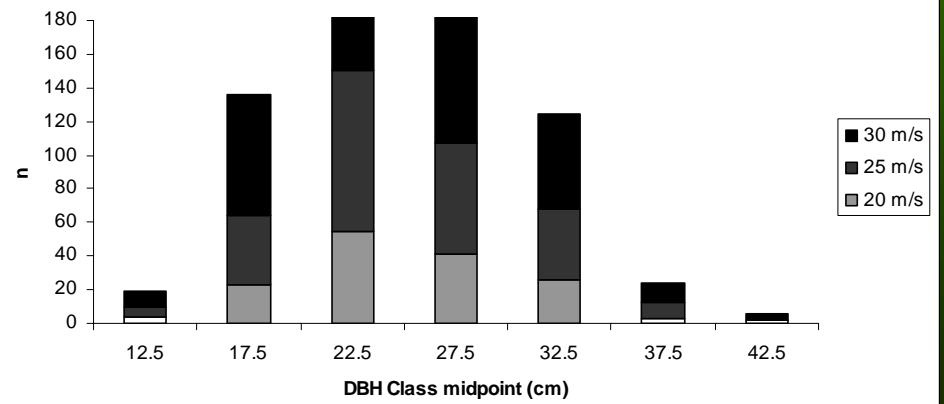
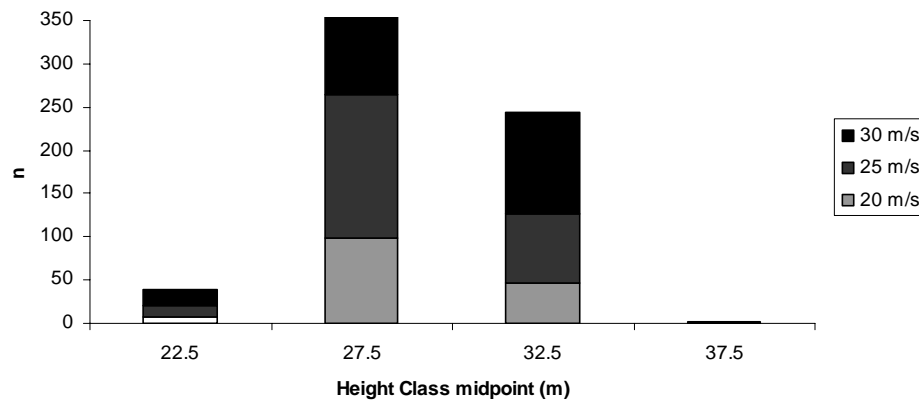
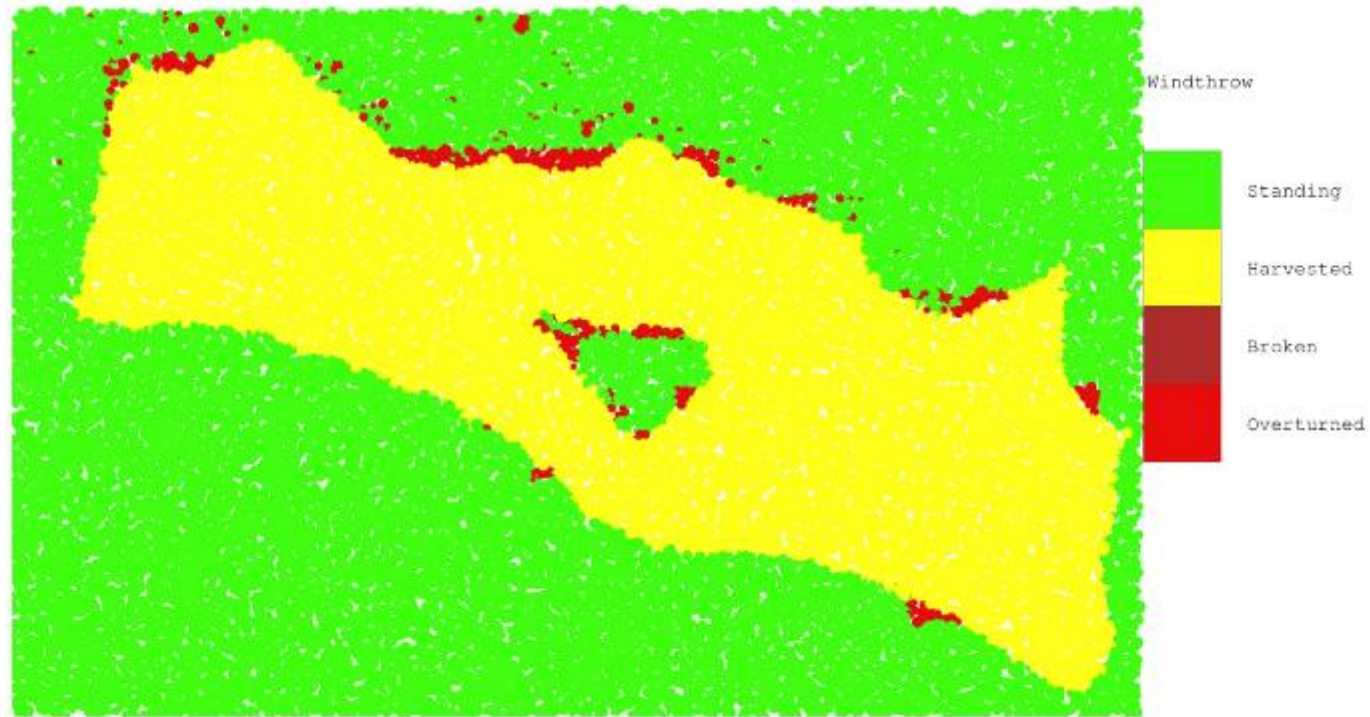
TASS Simulation Block 3

Simulated trees = 12914

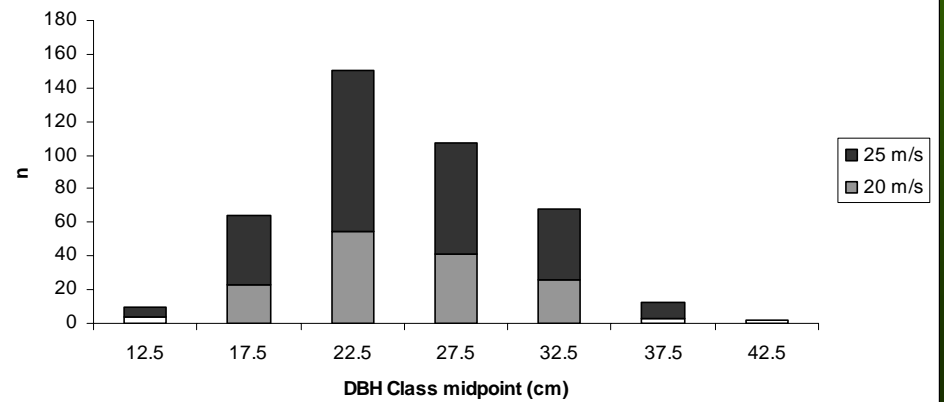
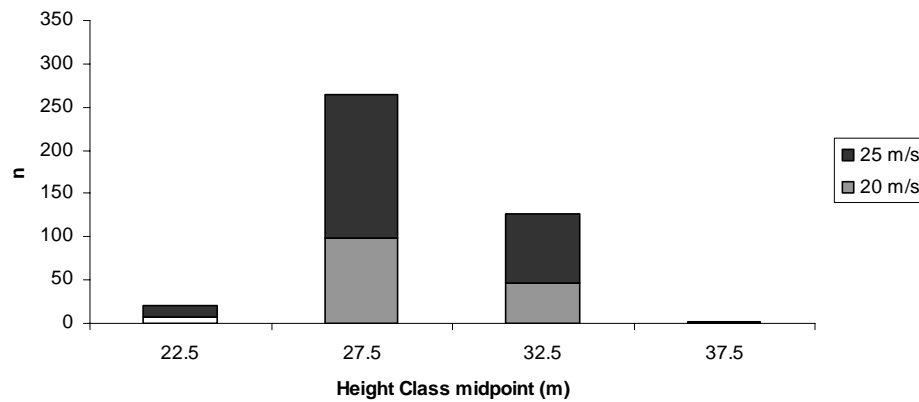
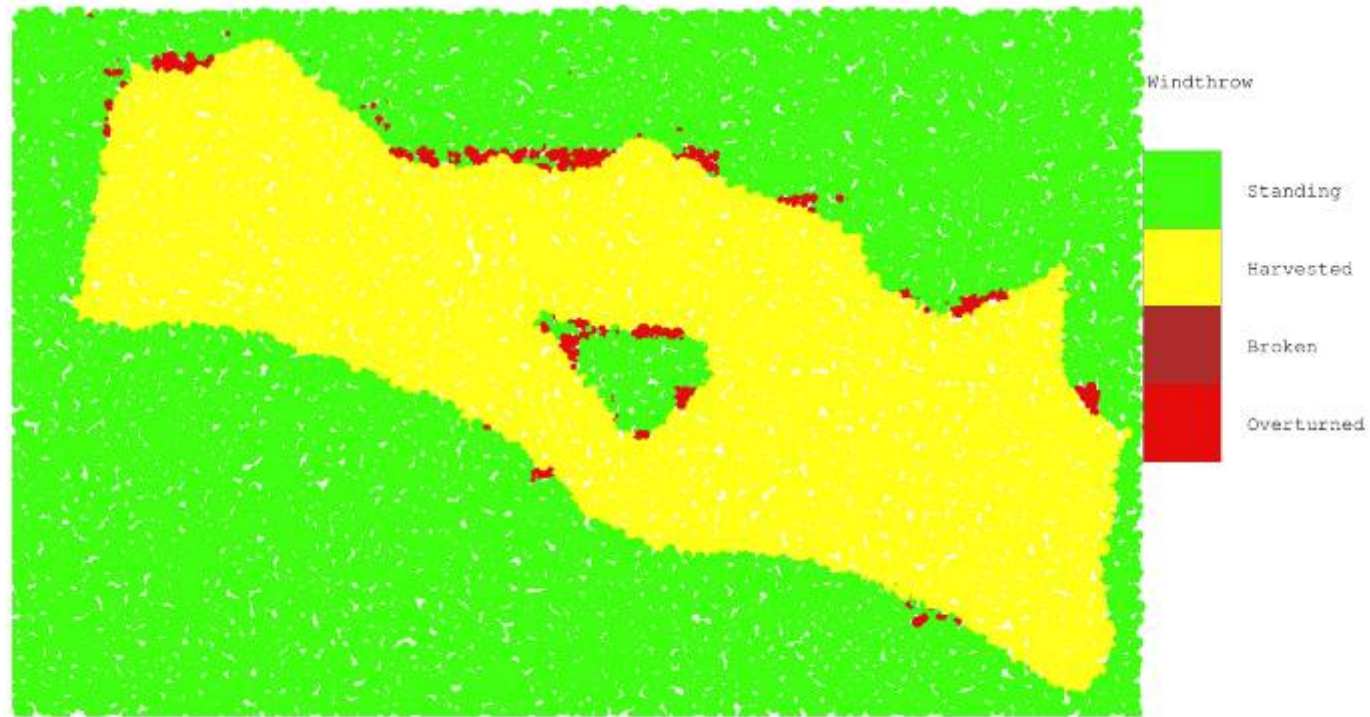
Area = 22.3 Hectares



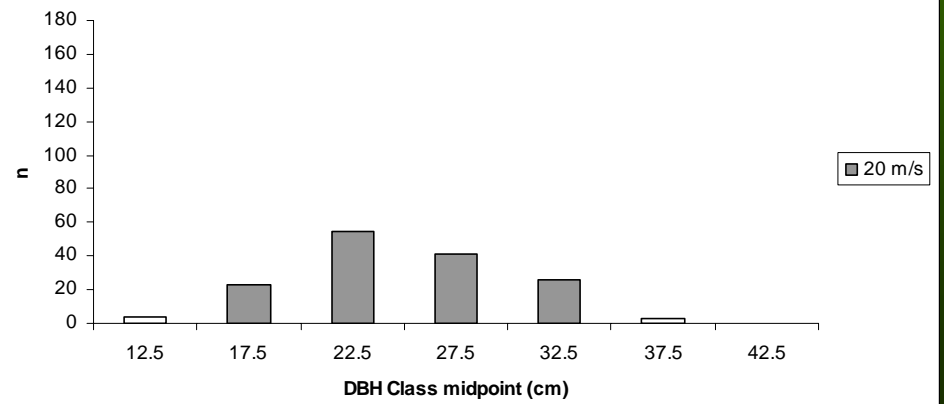
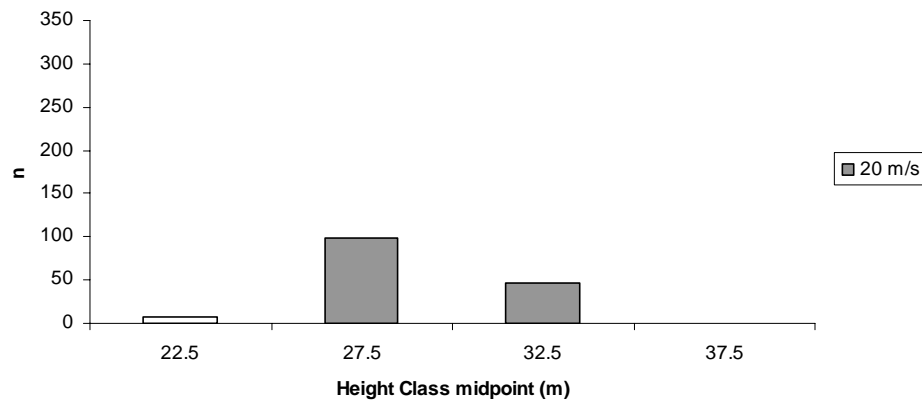
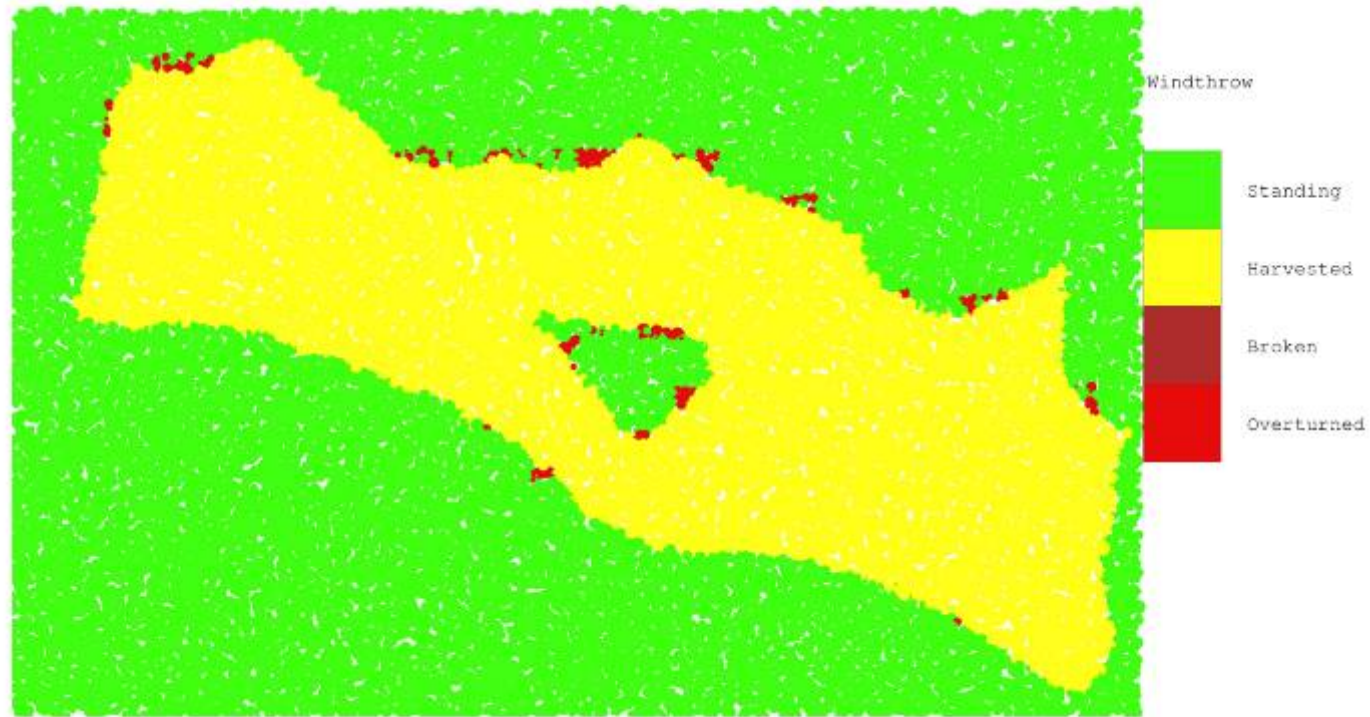
↖ 30 m/s



↖ 25 m/s



↖ 20 m/s



Validation

➤ Aggregated stand results:

	<i>Windthrown Stems/Ha</i>
<i>Plot data from stands with similar edge and opening attributes</i>	<i>5.9 – 9.5</i>
<i>WINDFIRM/ForestGALES_BC Simulation (using TASS tree list)</i>	<i>6.8</i>

➤ Ongoing validation includes:

- ✓ Comparing predicted damage with plot-level damage
- ✓ Replacing simulated trees with actual plot trees from STEMS dataset

Acknowledgements

- *UK Forestry Commission including Barry Gardiner, Juan Suarez, Bruce Nicoll (plus many others)*
- *BC Ministry of Forests including Mario DiLucca and Ken Polsson*
- *UBC Forestry including Steve Mitchell, Tim Shannon, Naa Lanquaye (plus many others)*
- *Forest Sciences Program (FSP)*
- *Sustainable Forest Management Network/National Centres for Excellence (SFMN – NCE)*