Productivity performances in spruce plantations:
DTW versus TWI comparison

This presentation details how height increments of spruce plantations vary in relation to two rasterized LiDAR-DEM derived indicators of soil wetness / drainage (Slide 2), i.e.,

- the cartographic **Depth-to-Water** index DTW, referring to the elevational rise away from nearest streams and other surface water bodies, and
- the **Terrain Wetness Index**, referring to the logarithm of the upslope flow accumulation area over slope ratio at each raster pixel.

Slide 3 shows how height increments within the JDI Black Brook Forest Management area in New Brunswick vary with DTW and TWI by way of

- box plots, with DTW and TWI grouped by classes, and
- best-fitted regression plots
- the corresponding DTW-based equations for the resulting annual height, basal area and total volume increments are shown on the right.

Slides 4 and 5 present an example area depicting the annual 90th percentile height increments per 20x20 m cells (shown as dots) overlain on the DTW and TWI rasters. Slides 5 indicates that TWI, in contrast to DTW (Slide 4), is too detailed to correspond to the overall plantation growth pattern.

The conclusion is that elevation-induced differences in soil wetness and drainage (as captured by log_{10}DTW) away from flow channels affect plantation growth more than the log_{10}-differences of upslope flow accumulation over slope ratio (TWI).

Dependent variable	R^2	Equation
Height (90th percentiles per 20x20 raster cell) / Age, m/year	0.56	$y = 0.18 + 0.009\ Age + 0.026\ log_{10}(DTW, m) - 0.12\ BS - 0.028\ RS - 0.00014\ Age^2$
Basal Area / Age, m^2/year	0.48	$y = -0.17 + 0.12\ Age + 0.19\ log_{10}(DTW, m) - (0.17\ BS - 0.03\ WS - 0.36\ RS - 0.002\ Age^2$
Total Volume / Age, m^3/year	0.47	$y = 0.33 + 0.35\ Age + (0.77\ log_{10}(DTW, m) - 0.57\ BS - 0.07\ WS - 1.34\ RS - 0.006 * Age^2$

Technical details

- Raster resolution: 1m.
- Growth metrics (tree height, basal, area, total volume): per 20 x 20 m raster cells.
- Best-fitted regression results restricted to cells for which 90th percentile height residuals < 0.4 m.
- Red, Black, Norway, and White species (RS, BS, NS, WS) each coded 0 when absent, and 1 when present.
- DTW classes generated by geometric progression:
- 1: 0-10 cm, 2: 10-25 cm; 3: 25-50 cm; 4: 50-100cm; etc.
- TWI classes grouped linearly.
- TWI focally smoothed using a circular neighborhood (40 m radius) for each raster cell.

Main caveat: the above results need to be further improved by addressing the effects of species, soil, and pre-LiDAR plantation thinning on the 20 x 20 m cell analyses.

Acknowledgements

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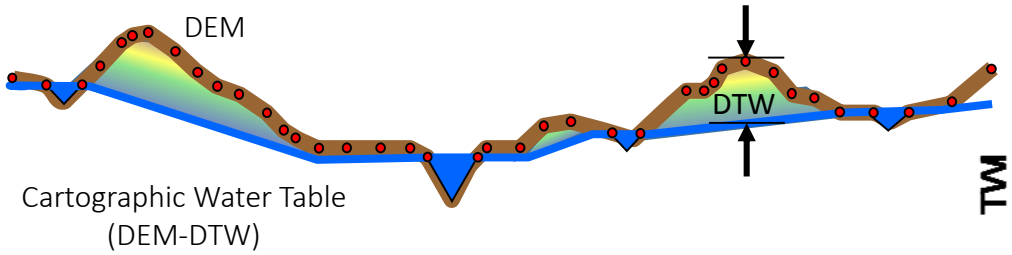
Definitions and Scatter Plot of TWI versus $\log_{10}$(DTW, m)

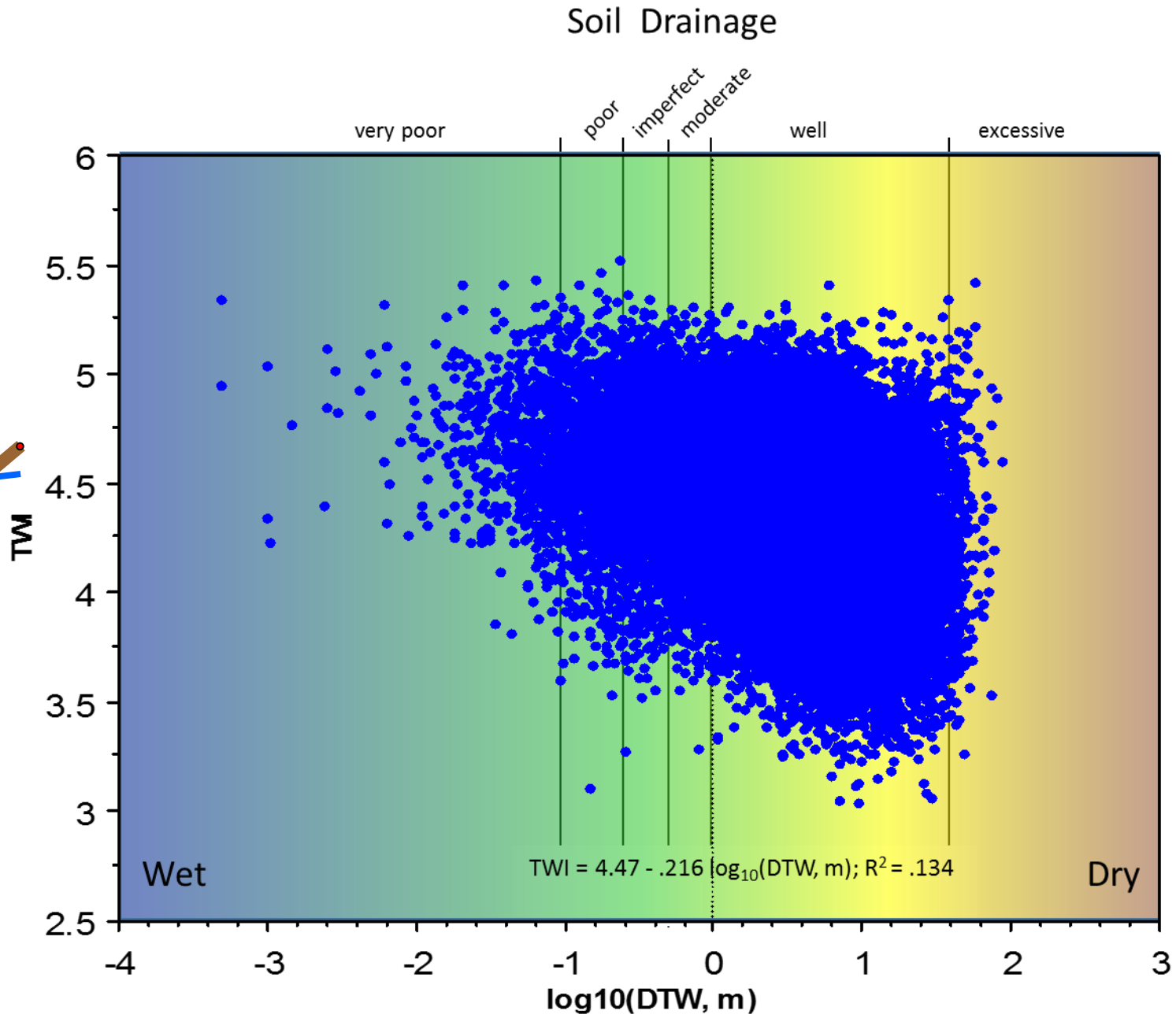
DTW: cartographic depth-to-water index, m:



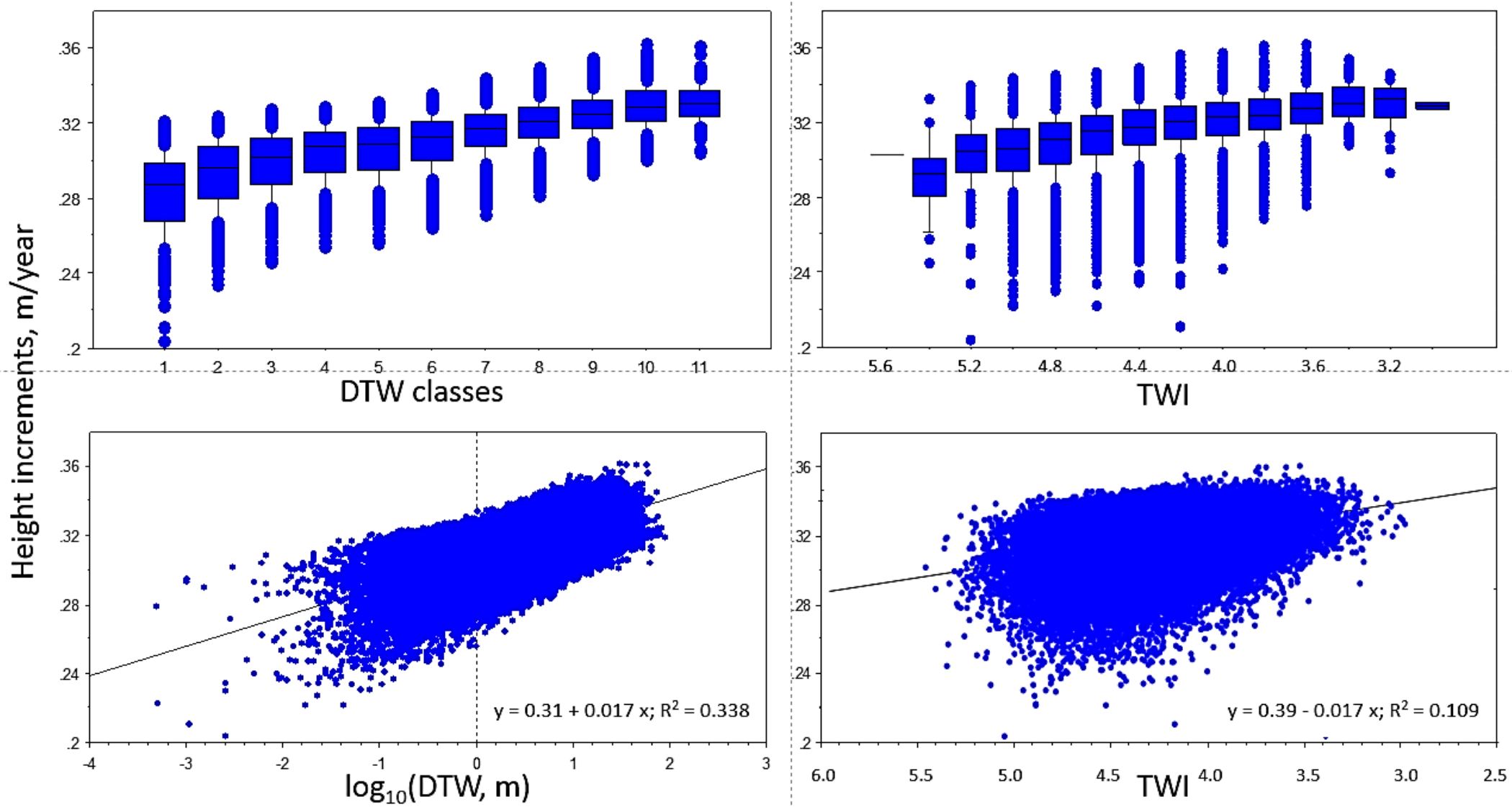
Soil drainage

- excessive
- moderate
- very poor

$$TWI = \log_{10}\left(\frac{\text{upslope flow accumulation, ha}}{\text{slope, \%}}\right)$$



Spruce plantations: Height increments



Spruce plantation height increments overlain on the Depth-to-Water Index DTW

DTW, m

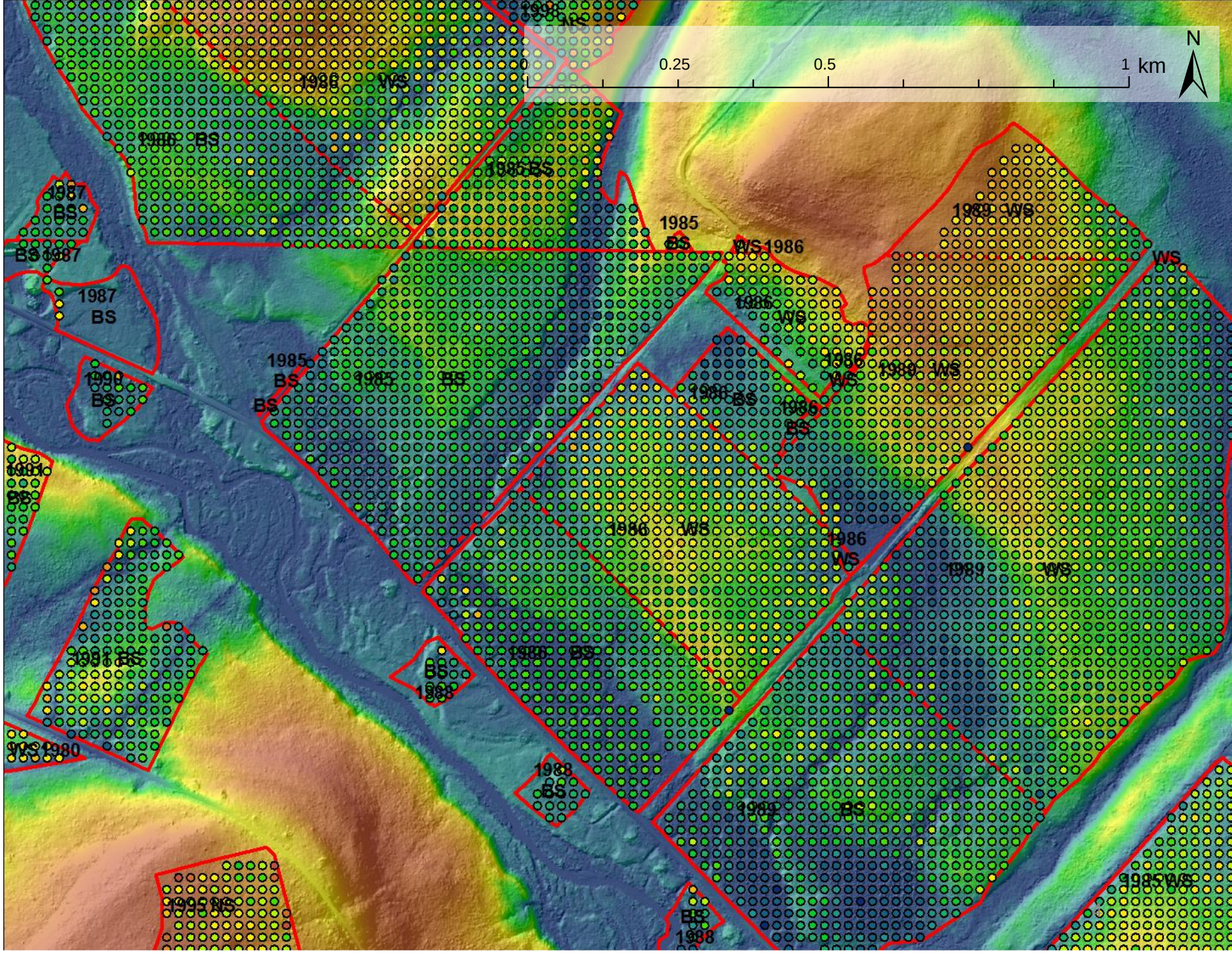
0

30

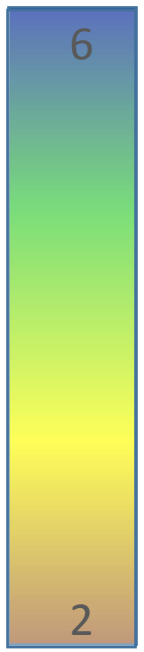
Height increment m/year

0

1



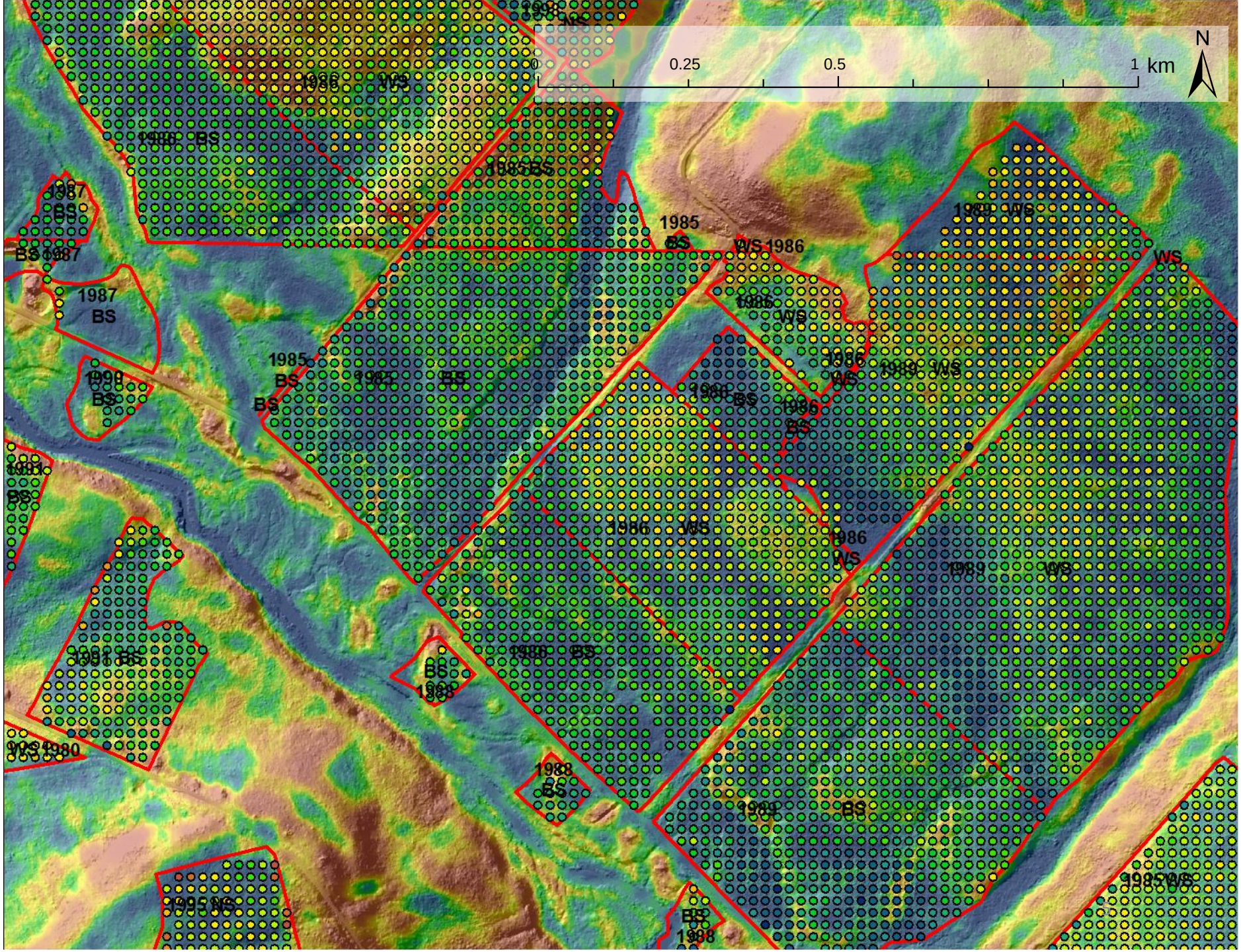
Spruce plantation height increments overlain on the Terrain Wetness Index TWI



Height increment m/year

0

1



Statistical representation of the cell-based height increment overlay on the DTW raster in Slide 4, using curvilinear regression analysis