THE GROWTH RESPONSE OF SITKA SPRUCE FOREST STANDS TO SEVERE DROUGHT EVENTS

Armand Tene[1,2], Brian Tobin[1], Jens Dyckmans[4], Duncan Ray[2], Kevin Black[3] and Maarten Nieuwenhuis[1]

[1] School of Agriculture, Food Science & Veterinary Medicine, University College Dublin, Ireland
[2] Ecology Division, Forest Research, Roslin, Scotland
[3] FERS Ltd, Bray, Dublin, Ireland
[4] Centre for Stable Isotope Research and Analysis, University of Göttingen, Germany

INTRODUCTION

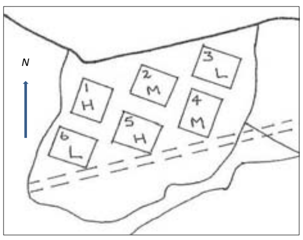
Using data from tree ring series and stable isotope analysis, meteorological records were analysed to determine tree responses to adverse conditions. The results will eventually be used to model their future adaptability to changes in our environment following IPCC scenario predictions. This study will contribute to a better understanding of the consequences of long-term climatic fluctuations; its expected outcome will inform advice on the implementation of better forest management practices and prediction of species suitability and adaptability to changing climatic conditions. These issues are believed to have implications for future species choice in afforestation programmes as well as timber supply forecasting.

The aim of this study is to understand and explain, using dendrochronological procedures, stable isotopes and blue light reflectance, tree adaptability to severe climatic conditions.

METHODS

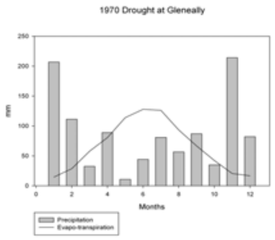
Using data from tree ring series and stable isotope analysis, meteorological records from local stations were analysed on and around two non-continuous periods of local drought (one year before and three years after each drought event). The methodology developed throughout this early stage of experimentation will later be extended to a wider area across Ireland, England, Scotland and Wales, and to three different species (Sitka spruce, Douglas fir and Scots pine), on similar soil types (brown earth soils) and across a climatic transect varying in moisture deficit.

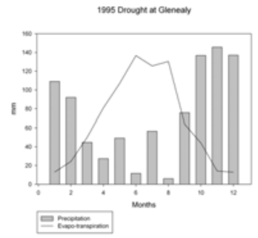
- Study sites selection
  5 sites will be selected per tree species, following a west-east gradient, from wet to dry.
- Soil description
  - Soil and site type (ESC survey method SOP) – at least one 70-80 cm deep soil pit per site.
  - Description of soil profile and test soil physical attributes (rooting depth, texture, stoniness).
- Inter-annular tree ring analysis
  - 2 cores per tree x 5 dominant trees per site x 5 sites = 50 cores per species x 3 species = 150 cores.
- Dendroclimatology
  - Core scanning and analysis with WinDendro™.
  - Development of a master chronology for each site.
- Stable Carbon and Oxygen isotope analysis
  - Intra-annular samples for Isotope analysis: 10 annual periods x 2 slices per annum (early and latewood) x 2 samples per slice (C and O) x 5 trees per site x 5 sites per species x 3 species = 3000 samples for analysis.
  - For this pilot phase of the study: 10 annual periods x 2 slices per annum x 2 samples per slice x 5 trees per plot x 6 plots = 1200 samples for analysis.
- Blue reflectance analysis:
  - Blue reflectance data will be obtained by scanning colour images of cores at high resolution (1000 dpi, 48 bits), using a flat bed scanner.



H: Heavy Thinning
M: Intermediate thinning
L: Light Thinning
Management was assigned randomly to treatment blocks at the Avoca site in Co. Wicklow during the spring of 1964.
The crop was established in the spring of 1943 at an average spacing of 1.5m x 1.5m on a brown soil.

PRELIMINARY RESULTS



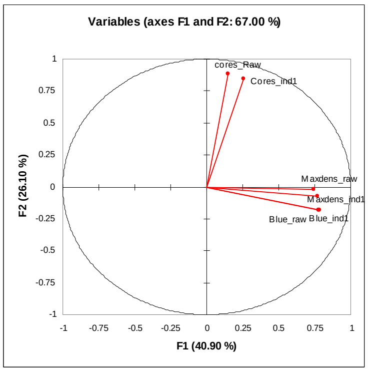


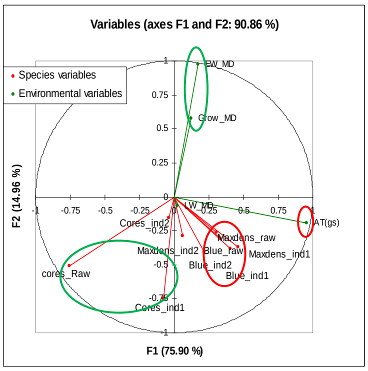
•Stress experienced when evaporation exceeded precipitation *i.e.* moisture deficit during the growing season, was the main driver for the choice of pointer years for Gleneally (the closest Met station to the study site): 1970 and 1995.

•Expressed population signal (EPS), defined as the degree to which our sample chronology portrayed the hypothetically perfect chronology, demonstrated good chronology confidence:

$$EPS(t) = \frac{\text{t. RBAR}}{\text{t. RBAR} + (1 - \text{RBAR})} = 0.98$$

•Master Chronology showed a coherent tree growth response to climatic stress.
•Principal component and canonical correlation analysis elicited a clear pattern of measured parameters responding to environmental variables.





•Tree response to moisture deficit was discernible in radial growth (negative correlation) whilst the response to temperature was discernible in tree ring density and Blue reflectance data (positive correlations).

Isotope pattern	Climatic variables for corresponding period			
	Rainfall	PET	MD	Mean T°
^{13}Cc EW	-0.15 (0.67)	0.39 (0.27)	0.01 (0.97)	0.31 (0.12)
^{13}Cc LW	-0.41 (0.22)	0.19 (0.76)	0.42 (0.22)	-0.07 (0.83)
^{18}Oc EW	0.24 (0.49)	0.07 (0.84)	-0.19 (0.54)	0.51 (0.11)
^{18}Oc LW	-0.59 (**0.04**)	0.17 (0.69)	0.58 (0.05)	0.05 (0.84)

•Pearson correlation coefficients with P-values (in parenthesis) showing the relationship between isotopic signals and climatic variables (n = 10). PET potential evapotranspiration, MD moisture deficit, and mean T° represents the temperature in corresponding periods for latewood (LW) and earlywood (EW) synthesis.

•Preliminary analysis suggested that latewood ^{18}Oc had the largest variation in isotopic fractionation (37.4 to 40.5 ‰). The pattern determined in the ^{18}Oc could well be explained by specific events such as moisture deficits (MD) and high rainfall, particularly for late wood samples.

COFORD
NATIONAL COUNCIL FOR FOREST RESEARCH & DEVELOPMENT
AN CHOMHAIRLE NÁISIÚNTA UM THAIGHDE AGUS FORBAIRT FORAOISE

Dublin Castle, 7th December 2009

NDP National Development Plan 2007 - 2013