Climate Change

FitForests – Looking At How Ireland's Forests Are Shaping Up To Climate Change

Climate change is already having impacts on the health of the world's forests. Healthy forests are critical to mitigate climate change. So how are Ireland's forests shaping up? Dr.Niall Farrelly, Teagasc outlines the FitForest project that examines if the trees we use in Irish forestry are ready for climate change.

CLIMATE CHANGE

Changing environmental conditions associated with climate change are creating uncertainties about the suitability of the current choice of species and provenances (geographical origin of the seed) for use in Irish forestry. Climate projections include an increase in seasonal temperatures, a decrease in summer rainfall in the easterly regions, coupled with an increasing frequency of extreme rainfall, drought and winter storms events (https://www.met.ie/epa-climate-projections-2020). It is likely that climate change will increase the abiotic and biotic stresses to tree species, especially those which have limited adaptive capacity. Therefore, a new research project called Fit Forests aims to provide critical information on the adaptive capacity of key forest tree species to climate change.

THE FITFOREST PROJECT

The FitForest is a DAFM-funded project which aim to address knowledge gaps in species and provenance selection to identify those that may be more adapted to future climatic conditions. High diversity among populations that may have phenotypic plasticity and/or adaptive potential may be better adapted to capitalize on changing environmental conditions. This adaptive capacity is commonly assessed by studying the traits of trees which convey some inherent advantage over other populations which allows them to prosper in certain environments (e.g. late bud flush or water use efficiency). The project is a collaboration between a team of researchers from Teagasc, the Agri-Food and Biosciences Institute (NI), UCD, and climatologists from NUI-Maynooth.

PROJECT OBJECTIVES

Objectives of the project and included in four work packages (WP) as follows:

- WP1 - Assess the adaptability of various species and provenances to climate change from provenance test and related data
- WP2 - Conduct new experiments to assess the impact of climate parameters on the phenology and physiology of key species of importance to Irish forestry
- WP3 - Assess the impact of extreme climatic events on the phenology of known tree species
- WP4 - Investigate response of key species to drought events in Ireland

WP1: Assess the adaptability of various species and provenances to climate change

This work package will assess whether the current range of native and non-native trees have evidence of adaptation by studying species which have been established in provenance experiments or demonstration areas (Table 1). New information will be used to assess species and provenance suitability for current and future conditions (Figures 1 & 2). For broadleaved tree species (e.g. Oak) we aim to evaluate adaptive traits such as timing of flushing and flowering across a geographical range (for oak, sweet chestnut, sycamore and birch) to determine the fitness of the current range of broadleaved trees and seed orchards for future use and for seed production as a result of a change in climate. Finally, we aim to assess if diverse material of Douglas fir and Sitka spruce which may have undergone natural selection and adaption in warmer conditions is suitably adapted to current and future climatic conditions in Ireland

Figure 1: A good example of a demonstration plot of Oriental beech (Fagus orientalis) in JFK Arboretum, Wexford showing good adaptation to site and the Irish climate

Type	Species	Botanic name	Provenance Expts.
Broadleaf	Peduncluate Oak	Quercus robur	Provenance expt.
Broadleaf	Sessile Oak	Quercus petraea	Provenance expt.
Broadleaf	Silver Birch	Betula pendula	Provenance expt.
Broadleaf	Beech	Fagus sylvatica	Provenance expt.
Broadleaf	Cherry	Prunus avium	Demonstration plots
Broadleaf	Red Oak	Quercus rubra	Demonstration plots
Broadleaf	Sweet chestnut	Castanea sativa	Demonstration plots
Broadleaf	Sycamore	Acer pseudoplatanus	Demonstration plots
Conifer	Douglas fir	Pseudotsuga menziesii	Provenance expt.
Conifer	Lodgepole pine	Pinus contorta	Provenance expt.
Conifer	Norway spruce	Picea abies	Provenance expt.
Conifer	Scots pine	Pinus sylvestris	Provenance expt.
Conifer	Sitka spruce	Picea sitchensis	Provenance expt.
Conifer	European silver fir	Abies alba	Demonstration plots
Conifer	Grand fir	Abies grandis	Demonstration plots
Conifer	Japanese red cedar	Cryptomeria japonica	Provenance expt.
Conifer	Monterey pine	Pinus radiata	Provenance expt.
Conifer	Western Hemlock	Tsuga heterophylla	Provenance expt.
Conifer	Western red cedar	Thuja plicata	Provenance expt.
Conifer	Coast redwood	Sequoia sempervirens	Demonstration plots
Conifer	Giant redwood	Sequoiadendron giganteum	Demonstration plots
Conifer	Pacific silver fir	Abies amabilis	Provenance expt.
Conifer	Noble fir	Abies procera	Provenance expt.

Table 1: Examples of species with provenance experiments or demonstration plantings to be assessed in the project.

WP2: Assessing the impact of climate parameters on the phenology and physiology of key species of importance to Irish forestry

An understanding how seedlings respond to a changing climate will be vitally important in developing adaptive strategies for sourcing appropriate forest genetic material for use in forests of the future. A diverse range of Sitka spruce seed origins which have been assembled in Ashtown Research centre in Co. Dublin in June 2021 with the aim of monitoring seedling growth phenology (timing of budburst, growth cessation, shoot elongation) in relation to current (outdoor environment) and altered temperature condition (indoor environment) (Figure 3). The data will be used to compare the phenology of the different seed origins in relation to the two environments to assess what effect if any effect of elevated temperatures on growth phenology of different seed sources.

Figure 2: Species like Japanese red cedar (Cryptomeria japonica) here in Deputy's Pass, Co. Wicklow may have increased potential in Ireland as the climate warms.

Figure 3: A Sitka spruce growth and phenology experiment at Teagasc research centre in Ashtown, Co. Dublin.

A growth chamber manipulation experiment will be used to investigate the impact of changes to water availability, increased temperature and increased CO_2 concentration on the growth and physiological activity of Oak, beech, Douglas fir and Sitka spruce. Measurements of phenological development and physiological activity (using measurements such as whole-plant respiration, water use, photosynthetic activity, chlorophyll fluorescence) in response to the altered environmental parameters will be conducted. Physiological measurements will be taken to assess if differences in chlorophyll fluorescence or photosynthetic activity are detected owing to the different treatments.

WP3: Assess the impact of extreme climatic events on the phenology of known tree species

In conjunction with Maynooth University, scientists are investigating the likely phenological response (e.g. bud burst, leaf unfolding, and growing season) of selected tree species to temperature and temperature extremes using climate data from the Earth System Grid Federation (ESGF) data centre (WCRP CORDEX, 2020). Analysis of bud burst for three different climate change scenarios is in the process of being evaluated using data from the Phonological Network covering 50 years of assessment across hundreds of sites in Europe for Norway spruce, Oak, Larch, Ash and Beech. For Sitka spruce, flushing data has been collected for 7 consecutive years in Ireland and suggest inter annual variability in flushing in greater than variability between sites (Figure 4). Outputs of this WP will include maps displaying the change in days of budburst for Ireland for different climate scenarios.

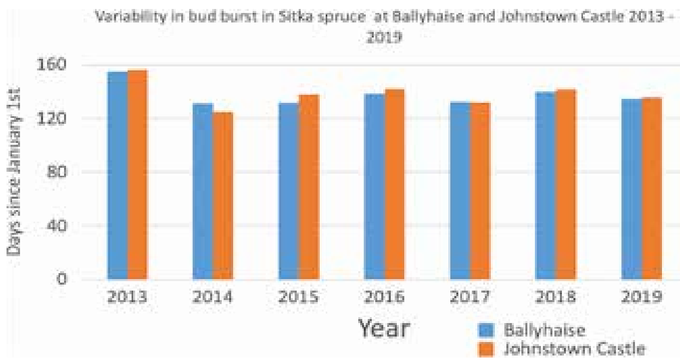

Figure 4: Flushing data in Ireland is being used to assess the impact of warmer temperatures on bud burst.

Research to assess the future suitability of species under an altered climate using a bio/geo-climatic modelling software called ClimexTM, which uses data based on biological parameters of the species concerned, along with climatic information to infer how suitability might change over time and space for regions of interest. Locations of climatic suitability are identified by modelling the mechanisms that impact species growth via climatic variables and soil moisture, while simultaneously incorporating a measure of stressors such as heat, cold or dry stress experienced.

WP4: Investigate response of key species to drought events in Ireland

To assess the response of key species to drought events we have chosen to examine Sitka spruce forests to understand if Sitka spruce planted on gleyed soils, subject to shallow rooting, can be subjected to localise drought conditions. Four sites have been chosen for the study, JFK arboretum, Frenchpark, Co. Roscommon. To characterise drought conditions at each site a Standardised Precipitation and Evapotranspiration Index (SPEI) has been derived from daily precipitation, temperature data from local meteorological stations. The analysis has indicated that drought events are site specific with spatial and temporal variations in the onset, frequency, intensities and durations of droughts at different sites. For example at Frenchpark, drought intensity showed an increasing trend. 2003 and 2018 were identified as severe drought years. For JFK, Drought intensity shows a decreasing trend. 1969, 1971 and 1990 were identified as severe drought years with 1975 was identified as an extreme drought year with the longest drought events lasted for 50 months (November 1969 –December 1973).

At each of the study sites stem coring and/or tree discs have been collected for detailed dendrochronogical analysis to assess annual ring development (earlywood and latewood, density, etc.) using the WindendroTM tree ring analysis system. Potential also exists to study carbon and oxygen isotope analysis will be used to investigate the relative contribution of water stress versus high temperatures to known drought events and investigate if differences between Douglas fir and Sitka spruce and their response to drought events exists using data from JFK Park.

Figure 5: Felling and taking discs from sample Sitka spruce for tree ring analysis to study if drought conditions can be detected.

CONCLUSION

This research is a key recommendation of the COFORD forest genetic resources working group (FGRWG) to inform the Sustainable Development and Conservation of Forest Genetic Resources in Ireland from 2020-2030. As forests are an important part of the Irish government's climate action plan, it is important that future forests are adapted to future conditions so that they can continue to provide economic and social benefits.

ACKNOWLEDGEMENTS

The Fit Forests Project is a collaboration between academic researchers from Teagasc, Agri-Food and Biosciences institute, UCD forestry and NUI-Maynooth. The research is funded by the Department of Agriculture, Food and the Marine (DAFM) under grant number 2019R511.

Thanks to Dr. Richard Walsh, Forestry Division, DAFM, Coillte and the Forest Genetic Resources Trust for assistance with the study.

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