Establishing the relative contribution of structure and function in mixed-species forests under climate change

Abstract

Expected increases in the frequency, severity and duration of extreme drought and other climate events has seen a growing interest in the mechanisms by which resilience to such events can be improved. For resilience concepts to be operationalised by forest professionals, approaches that build climate resilience need to be silviculturally tractable without significantly compromising productivity.

Drawing on decades of ecological research around functional redundancy, response diversity, complementarity and facilitation, the diversification of forest structure and species composition has received considerable attention as a potential mechanism to future-proof our forests to the challenges of a changing climate. Theory suggests that we could expect more structurally diverse forests, such as multi-aged stands, to be more efficient at capturing resources such as light and water, while species mixtures with complimentary functional traits could help to reduce direct competition for limited resources compared with more homogenous stands. As a result, a diverse suite of structural and functional traits is expected to allow forests to adapt to change and persist under stressful conditions (e.g. drought).

Complicating the implementation of these approaches is the large variability in both normal growth and growth stability under stress observed between mixtures of different species, between species within a mixture and between similar mixtures under both average and contrasting conditions. Compounding the difficulty in the interpretation and operationalisation of the accumulating body of knowledge is that the relative contributions of different structural or functional variables is rarely established, making it difficult to ascertain whether an observed growth trajectory or stress response is attributable to processes relating to structure (e.g. stand density), function (e.g. niche differentiation) or both.

Contrasting correlations between growth and different structural attributes have recently been shown to converge when considered in a simple framework as a function of three variables; stand density, size distributions and size-growth relationships. This new framework presents an opportunity to start disentangling the complex interacting dynamics of the structural and functional elements of mixed-species forest growth and combine this framework with common approaches to measuring forest resilience. To address this challenge, we will use an existing and complete DBH and mortality assessment of an intimate mixtures experiment of *Pinus sylvestris* and *Picea sitchensis* in conjunction with a dataset of recently collected tree-cores and historic climate data from the same sample plots. This experiment consists of several replicates of different combinations of these species in mixture in addition to monospecific plots of the two species. Using high resolution true colour imagery and LiDAR captured using drone technology, canopy delineation algorithms will be used to establish the exact location of individual trees relative to their neighbours and precisely measure individual tree height. Mortality data and annual increment values will be used to reconstruct stand attributes (tree height, volume etc.) through time using a recently developed method, allowing the recreation of the developmental history of each mixture. Competition, complementarity and resilience indices will then be combined with the identity and biometrics of individual tree neighbourhoods through the aforementioned structure-growth framework to understand the functional and structural processes underlying stand development and the resistance, recovery and resilience to any identified climate events.

Through this approach, we will develop a more comprehensive understanding of the differential growth and stress response of mixed-species forests. This improved will advance the operationalisation of species mixtures in climate resilient forestry by combining this knowledge with silvicultural prescriptions that modify stand structure such as thinning or re-structuring. Furthermore, this improved understanding will deliver complimentary advances to other current projects looking to predict both species site suitability and growth under alternative climate change scenarios through empirical and processed based modelling.