

Development of a mixed-species forest growth model

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Background

Establishing robust mixed-species forests in the UK is key for **effective carbon capture**, as evidence suggests they can provide **greater resilience** to natural disturbances (Pretzsch, 2017; Bauhus et al., 2017).

However, a lack of **process-based modelling** for mixed-species stands limits our ability to fully understand the role of woodlands in **greenhouse gas removal**.

Aim

Enhance the capabilities of a stand-level forest growth model (3PG-SoNWaL) into a mixed-species model.



Figure 1. The Norway spruce/sessile oak mixture at Gisburn, northeastern England at 23 years.

Methodology

- First implementation of **3PG-SoNWaL-MIX** with above ground partitioning adapted from Forrester and Tang (2016)
- Below-ground resource partitioning** developed with several distinct allocation schemes
- Validation using long-term growth measurements from the **Gisburn mixed-species trial**
- Developed and tested a **fast, flexible emulation calibration framework** leveraging deep Gaussian Process (DGP) technologies (Ming et al., 2023)

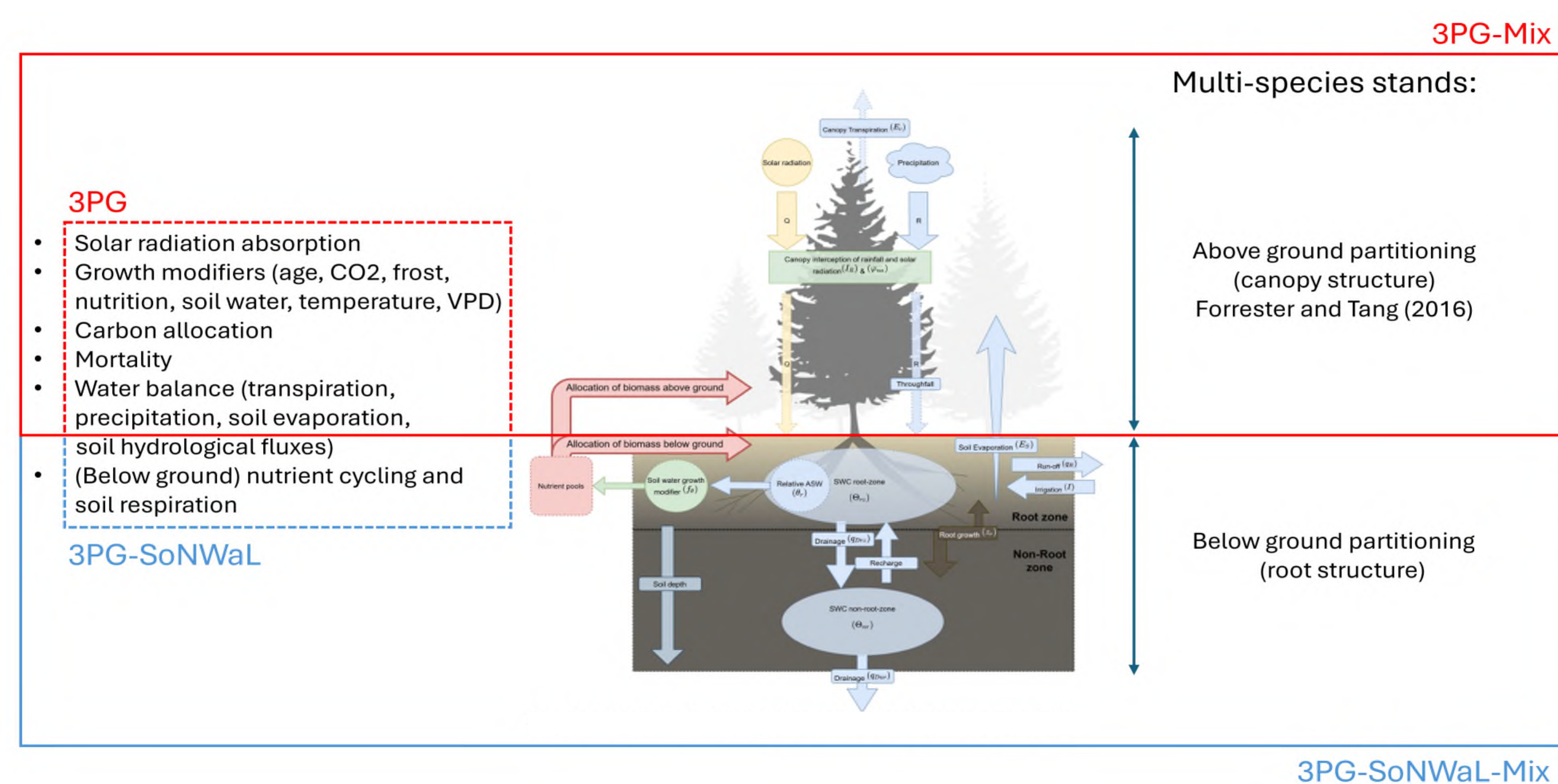


Figure 2. Schematic of the main processes represented in the stand-level forest growth model.



Figure 3. Examples of forest development types that define long-term pathways for resilient forests including potential species, mixtures, and stand structure. Top: Scots pine/beech and bottom: Sitka spruce/long-lived broadleaf.

Results

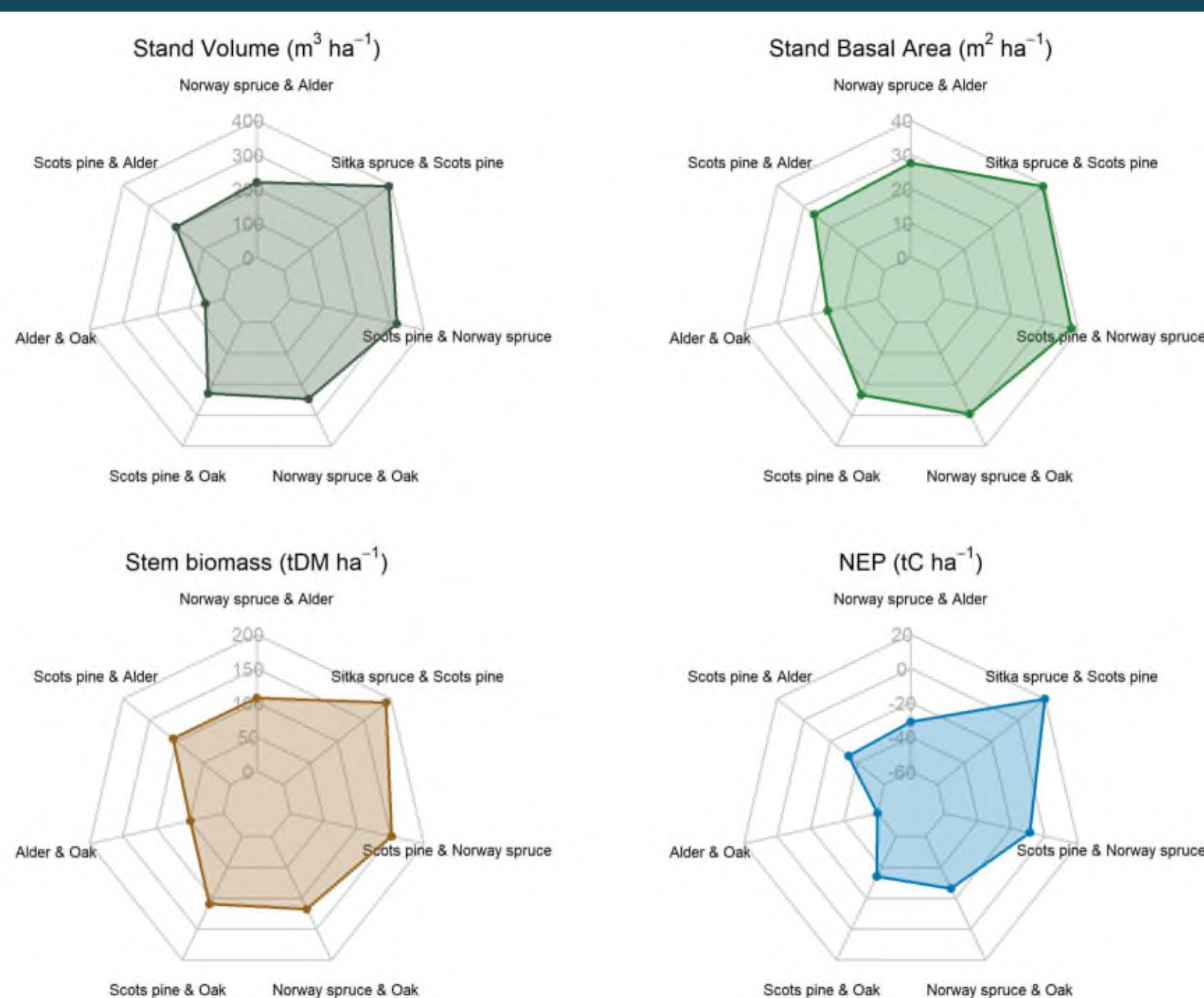


Figure 4. Radial plot showing stand biomass and carbon sequestration at the end of the 28 simulated years for the species mixtures at Gisburn.

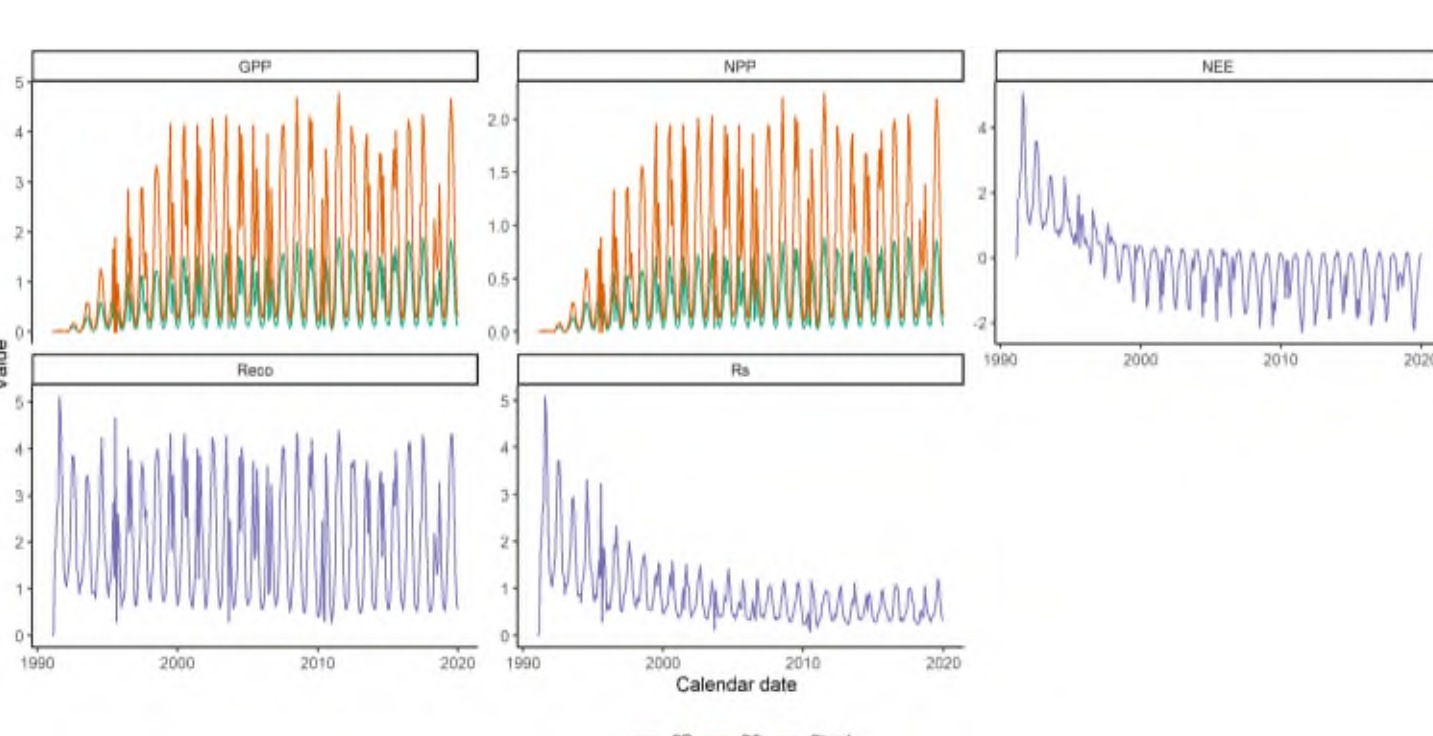


Figure 5. Predicted ecosystem fluxes (gC m² day⁻¹) for a Scots pine (SP)/Sitka spruce (SS) mixture at Gisburn. Gross primary production (top left), net primary production (top middle), net ecosystem exchange (top right), ecosystem respiration (bottom left) and soil respiration (bottom right).

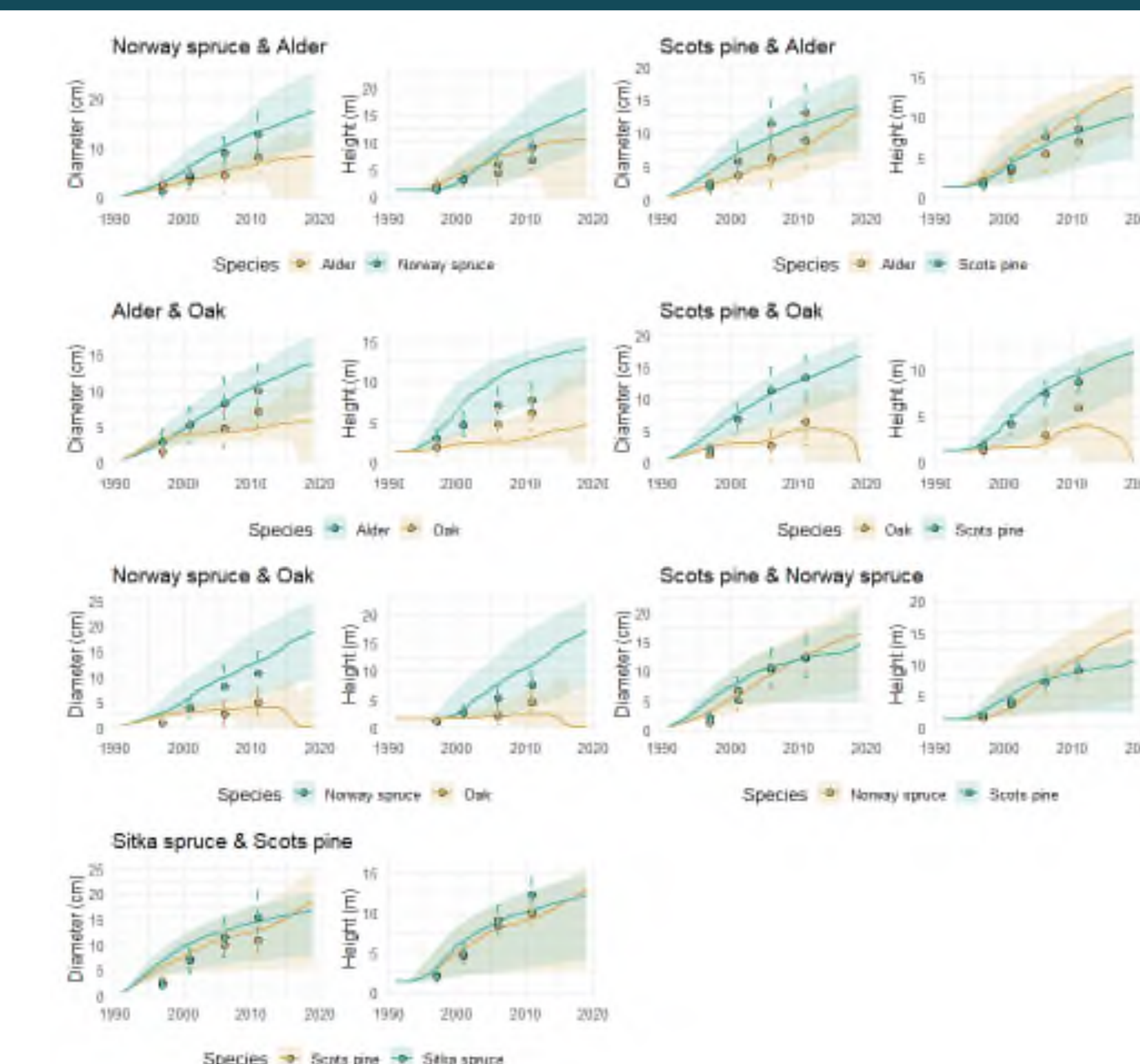


Figure 6. Predicted and measured diameter and height values at Gisburn. Solid line is median predicted values and bands reflect 10th and 90th percentiles. Error bars are the mean and standard deviation of measurements.

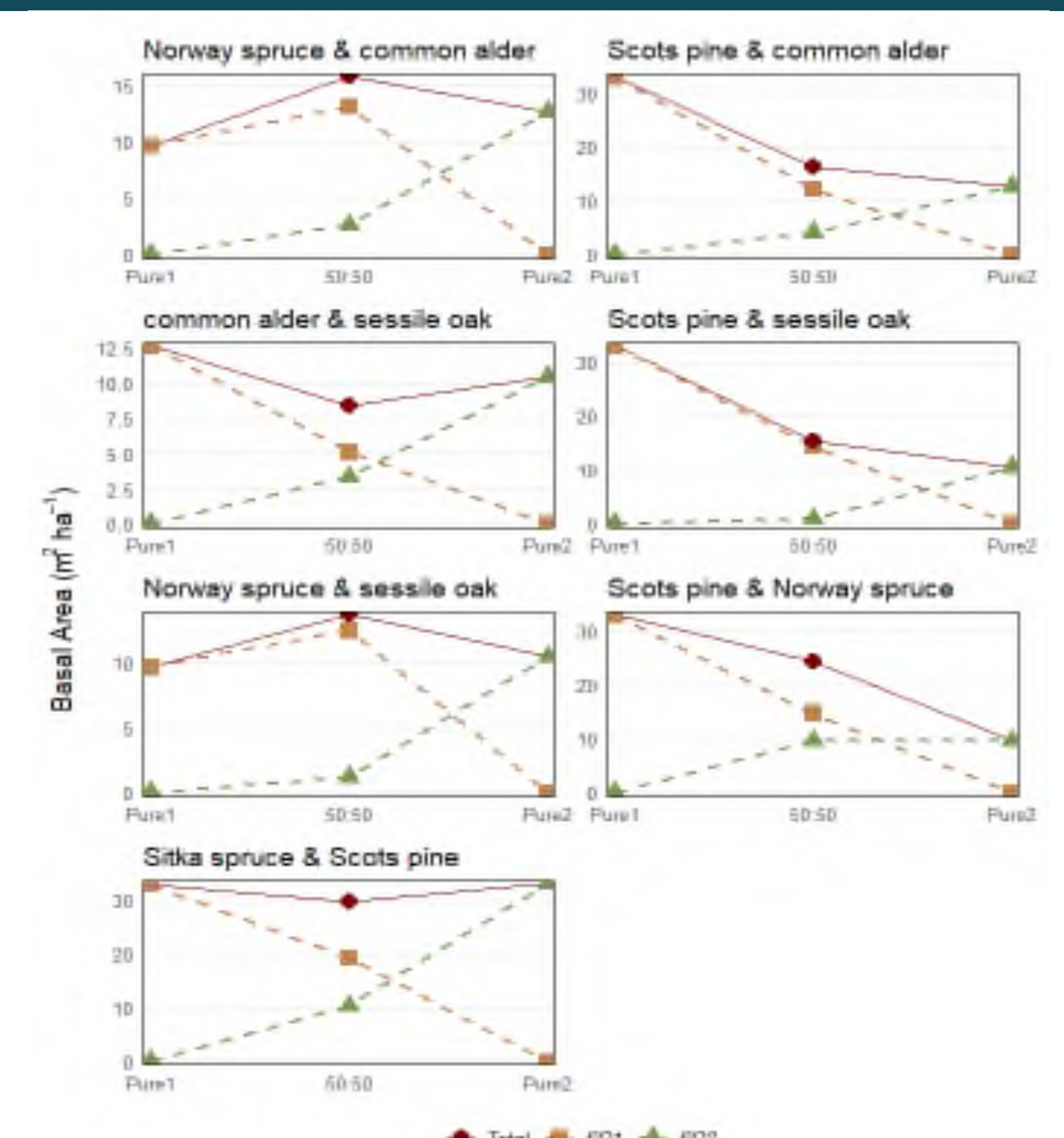


Figure 7. Cross diagrams showing mixing effects of predicted basal area at 20 years for pure and mixed plots for the seven different species mixtures at Gisburn.

Next Steps

- Continued development of 3PG-SoNWaL-MIX to incorporate shade tolerance and open canopy dynamics and test below ground partitioning
- Investigate how forest management could improve carbon sequestration and resilience under environmental change
- Inclusion in NetZeroPlus decision support tools