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Supplementary material

Moisture content variation of ground vegetation fuels in boreal mesic and sub-xeric mineral soil forests in Finland

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Supplement 1.

Description of Finnish Forest Fire Index

The Finnish Forest Fire Index (FFI) was constructed based on empirical tests in three clear-cut areas and one mature stand in southern Finland during summer 1995 when ground floor fuel samples with a depth of 6 cm were monitored. It is notable that the fuels monitored were a mix containing mostly raw humus, moss and litter

From this experimental data, drying and wetting curves were defined for estimating the volumetric moisture content (VMC) of samples. These were used to construct a model predicting the VMC of the top 6-cm surface layer using precipitation and potential evaporation as explanatory variables. The potential evaporation was calculated based on net radiation, wind speed, air temperature and relative air humidity, using the Pennman-Monteith equation (Monteith 1981). For operational use, the VMC was scaled to six wetness classes and respectively to FFI values ranging 1-6. Class 1.0-1.9 was defined as wettest with predicted VMC of 0.33-0.50 and class 5.0-6.0 as the driest with predicted VMC of 0.10-0.14. Value 4.0 predicting a VMC under 20% was chosen as threshold value based on forest fire statistics. (Heikinheimo *et al* 1998; Vajda *et al* 2014).

In operational use, the variables needed are obtained every three hours from meteorological field stations in Finland. The calculation of index uses gridded data spatially interpolated to 10 km x 10 km squares using the kriging method (Venäläinen and Heikinheimo 2003; Aalto *et al* 2013). Currently, the radiation is received from about 35 weather stations and is complemented by using data obtained from numeric weather prediction models. Precipitation is based on data from weather radars and rain gauges. (Vajda *et al* 2014). The FFI values are calculated for each grid square and respectively to county and province levels. The regional FFI values are used to estimate the need to start aerial surveillance flights, which usually begin with values near 4.0 (Vajda *et al* 2014). When a FFI value in a certain region exceeds 4.0, a forest fire warning defined in the Finnish Rescue Act is announced in the media e.g., prohibiting the use of open fire. The FFI has also been modified to predict grass fire danger in spring. For this purpose, the model has been adjusted to predict the VMC of a layer with a thickness of 3 cm. As in FFI, if the index raises over value of 4.0, a grass fire warning is announced in a similar way as in forest fire warnings. After green-up grass fire risk is low and not estimated. In the recent update of Finnish Rescue Act in 2019, the nature of grass fire warnings was changed to be more obliging as it currently also forbids the use of open fires.

The FFI is based on relatively small empirical experiment, so e.g. no ignition tests, nor monitoring of different stands or different fuels was done when the index was constructed. It is also notable that the FFI is based on volumetric moisture content, so the values are not directly comparable with gravimetric moisture content values. Yet later these gaps have been partially filled. Using destructive sampling, gravimetric moisture content and ignition tests Tanskanen *et al* (2005) defined the ignition thresholds values for ground layer fuel and showed the different ignition potential of Scots pine (*Pinus sylvestris L.*) and Norway spruce (*Picea abies L.*) H.Karst. dominated stands, which were supported by the Tanskanen's *et al* (2006) results of the impact of stand structure on surface fuel moisture variation. Yet in these studies, the examined surface fuels were not specified, but handled as surface layer or moss as general.

Several studies have compared the suitability of the Canadian Fire Weather Index (FWI) and FFI in Finnish conditions. Since FFI is designed to predict the layer of 6 cm, it does not have a directly comparable component in FWI since Fine Fuel Moisture Code is estimated to predict the 1-2 cm, Duff Moisture Code the 5-10 cm and Drought Code the 10-20 cm thick layer (de Groot 1987). Based on correlations with indices and the occurrence of fires, both Tanskanen and Venäläinen (2008) and Vajda *et al* (2014) concluded that the ability of the FWI and FFI to predict potential fire risks is fairly similar. Yet Tanskanen *et al* (2005) noticed that, based on ignition tests, the FWI predicted the moisture variation and potential ignitions better.

It is notable that the FFI is merely a flammability index predicting times of potential ignition, so it cannot be used to estimate e.g. the spread rate or intensity of fires. This is partly because that during the past decades there has been a practical absence of large forest fires in Finland, so there has not been a need to adapt a wider fire weather index.

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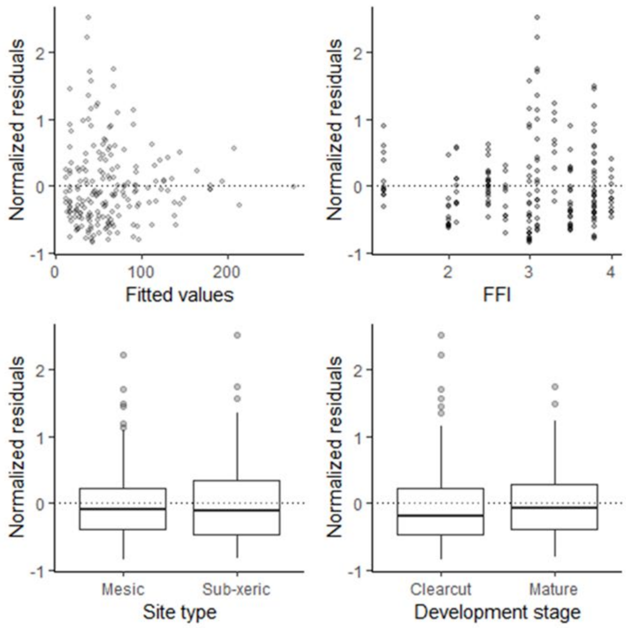
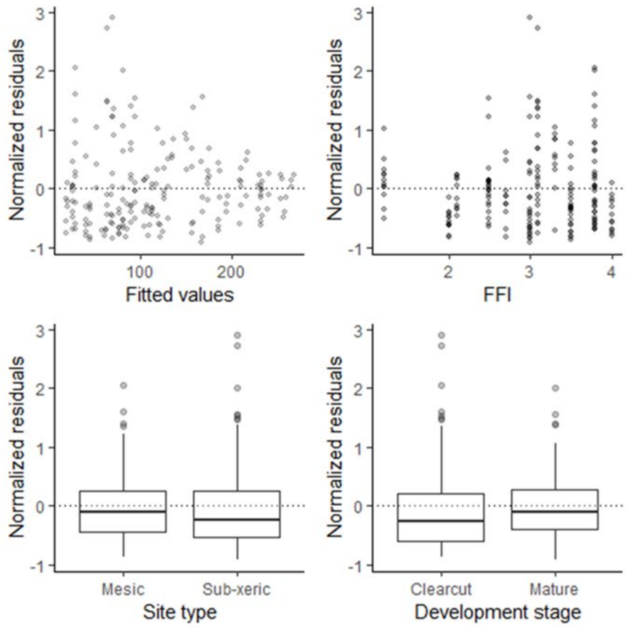
Supplement 2

Residuals of used models

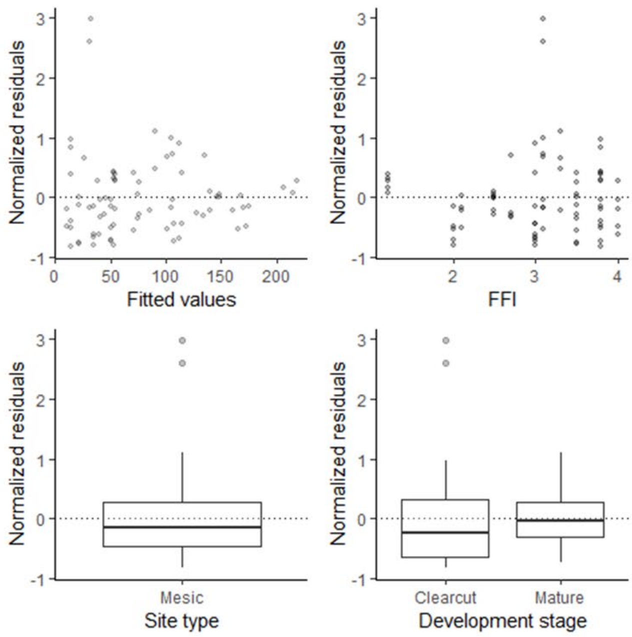
Surface layer/*Pleurozium*



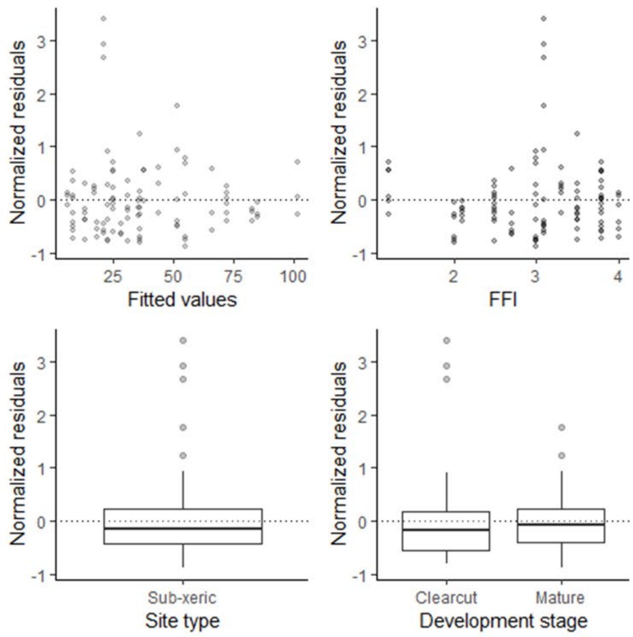
Surface layer/*Dicranum*



Surface layer/*Hylocomium*

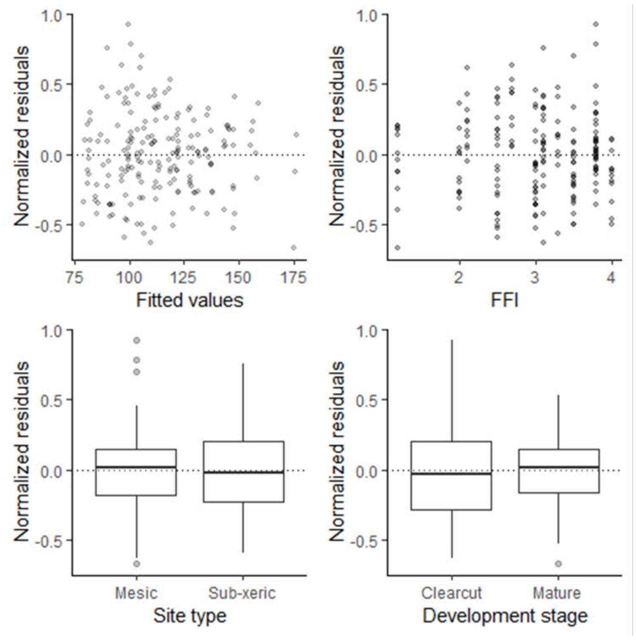


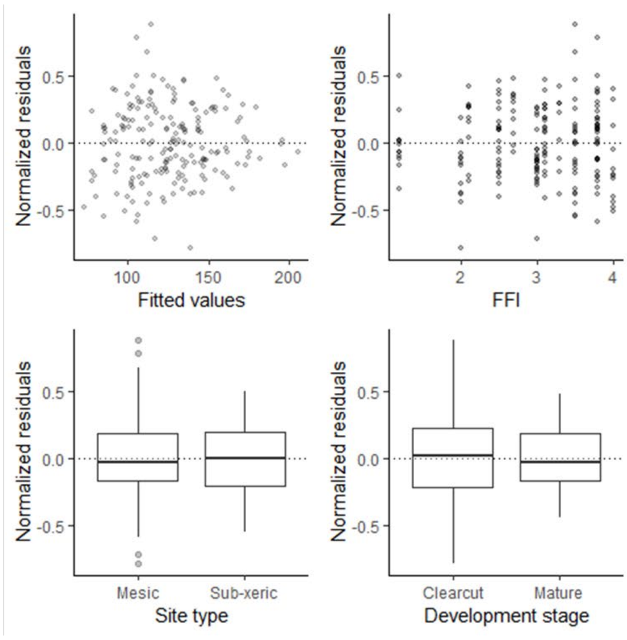
Surface layer/*Cladonia*



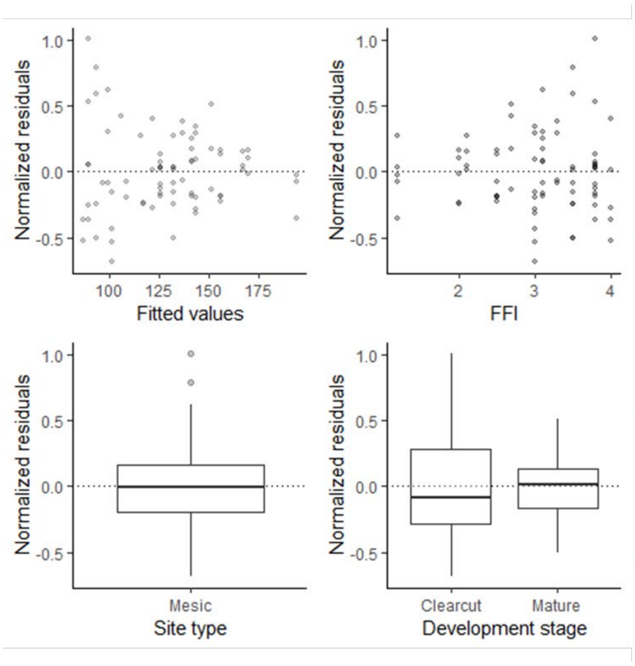
Raw humus/*Pleurozium*

Raw humus/*Dicranum*

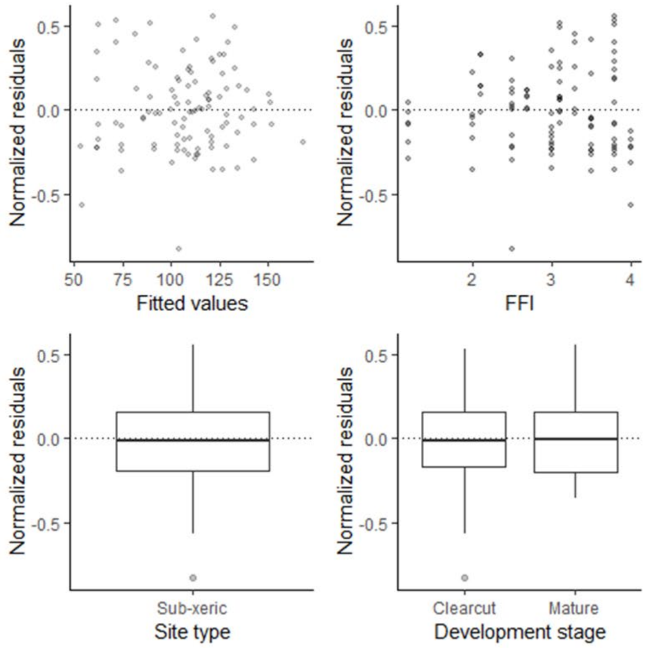


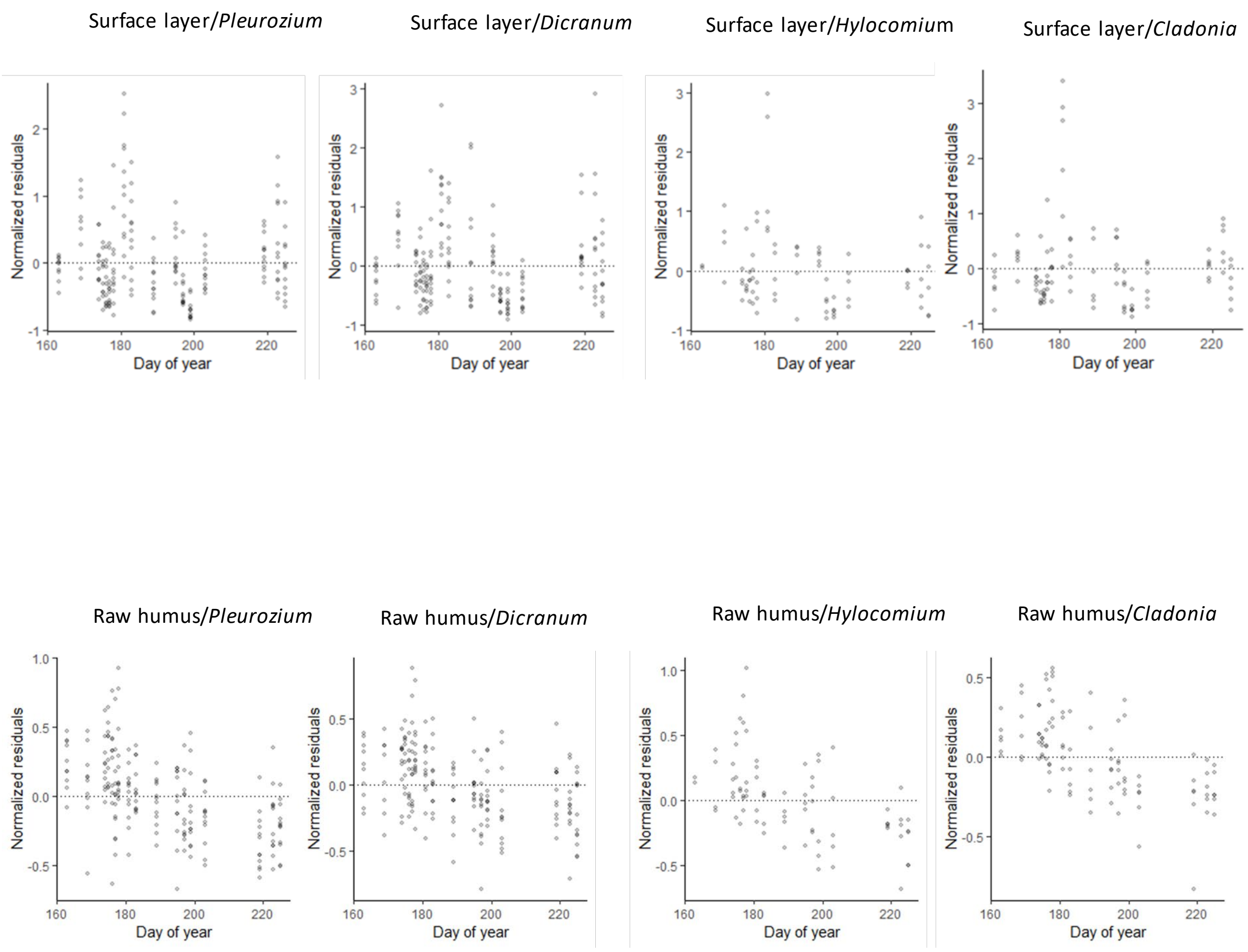


Raw humus/*Hylocomium*



Raw humus/*Cladonia*




Surface layer/*Pleurozium*
Surface layer/*Dicranum*
Surface layer/*Hylocomium*
Surface layer/*Cladonia*
Raw humus/*Pleurozium*
Raw humus/*Dicranum*
Raw humus/*Hylocomium*
Raw humus/*Cladonia*
Normalized residuals
Day of year

Supplement 3.

The predicted fuel moisture content (%) of each studied species, as a function of Canadian Fire Weather Index

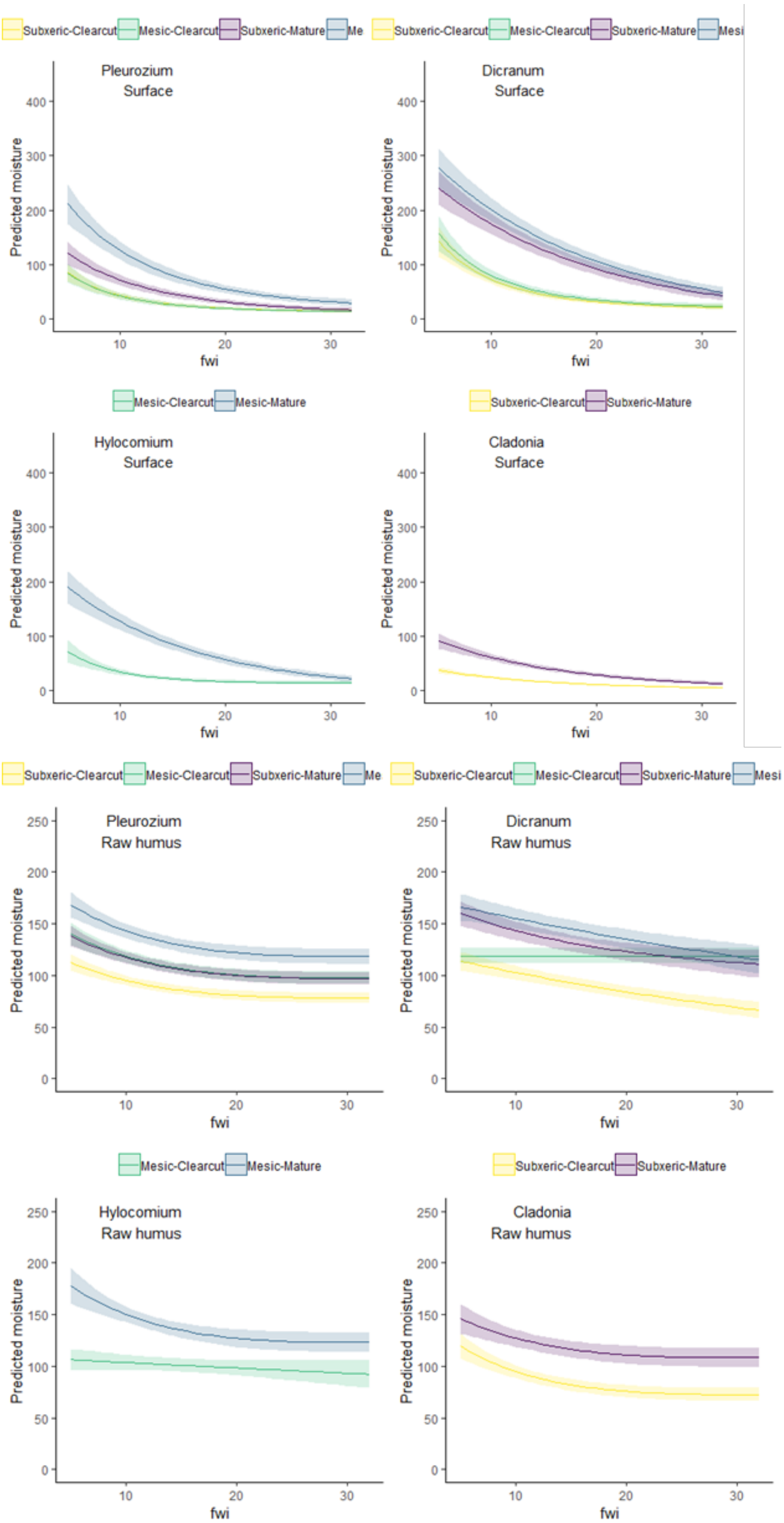


Figure S1. The predicted fuel moisture content (%) of each studied species, by stand type and developmental stage, as a function of Canadian Fire Weather Index (fwi).

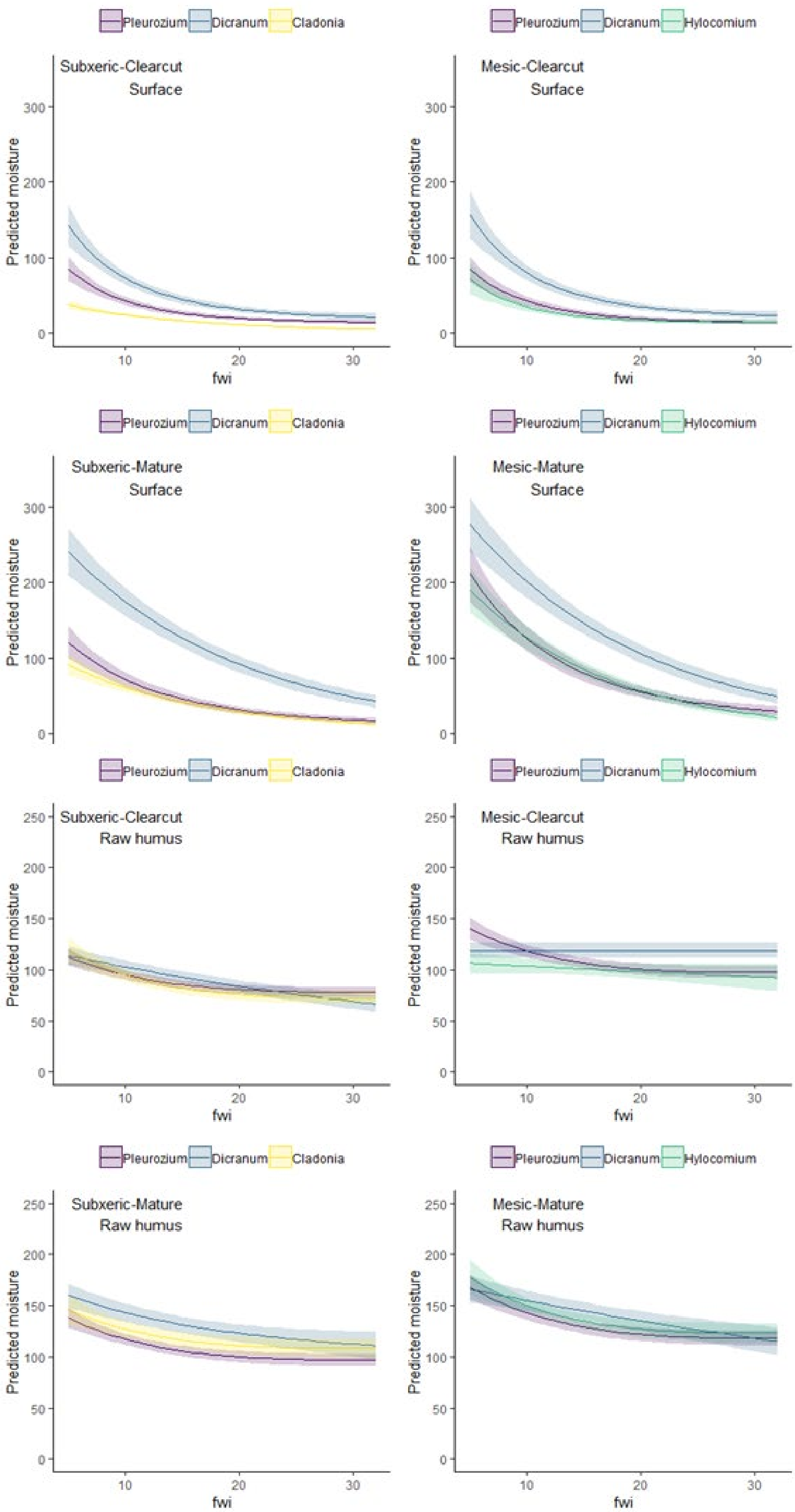


Figure S2. The predicted fuel moisture content (%) by studied species, as a function of Canadian Fire Weather Index (fwi) on different stand types and developmental stages.