Flammability properties of British moorland and heathland vegetation: models for predicting fire ignition and spread

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AIMS

Changes associated with global climate-change predict that British moorlands will experience an increase in wildfire frequency. The development of fire ignition models that incorporates the Fuel Moisture Content (FMC) of the peat/litter fuels and *Calluna* vegetation are needed to develop fire rating systems.

Specifically we determined:

- Predictive models for the probability of fire ignition and spread in peat/litter fuel beds, using FMC as predicting variable.
- Predictive models for the probability of ignition in *Calluna vulgaris* (heather) – as a functions of its dead fuel proportion and FMC
- The efficiency of standard smouldering and flaming ignition sources in developing self-sustaining fires.

METHODS

Peat/litter fuel beds

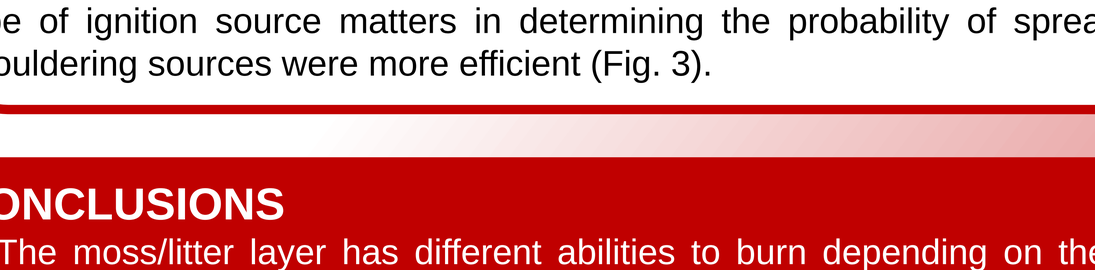
We used litter of 5 **species** (*Calluna vulgaris*, *Empetrum nigrum* and *Ulex europaeus*, *Vaccinium myrtillus*, *Sphagnum*) and peat to simulate fire ignitions in the laboratory (Fig. 1).

- **Ignition** was considered successful if flames appeared after the ignition source was applied.
- **Spread** was considered positive if the fire front reached the tray edge.

Two main types of **ignition sources** were tested:

- **Smouldering** sources were created with an electrically nichrome wire connected to a power supply - simulates the effect of a cigarette end or a stray ember.
- **Flaming** sources were provided through the use of commercial kerosene barbecue ignition pills.

Figure 1. Experimental tests performed in the laboratory to assess the flammability properties of peat/litter fuel beds.



Calluna vegetation

Stands of *Calluna* vegetation were simulated in the laboratory to asses the probability of ignition.

- Stands were 30 cm tall and with a bulk density of 4 kg·m^{-3}; this was kept constant in all experimental (Fig. 1).
- Two key variables were manipulated in this study: (1) the proportion of dead-fuel in the vegetation, and (2) the FMC of the dead-fuel. Three levels of dead-fuel proportion were provided (20, 40 and 60%).
- The stratified structure of *Calluna* vegetation was reproduced, with the dead-fuel accumulating in the lower part of the canopy. Live shoot clippings were cut to a height of 30 cm and dead-fuels shoots to a height of 15 cm.
- Ignition was considered successful if fire reached the bottom part of the cage (20 cm).

Figure 2. Experimental tests for assessing probability of ignition in *Calluna* vegetation.

RESULTS

There is a narrow range of FMC where fuel beds start to ignite as flame (M_{50} from 53 to 59%), except peat that had a lower value (35%). The probability of spread self-sustained fires varied along a wide range of FMC (M_{50} from 19 to 55%) (Table 1).

Species	Ignition M_{50}	Spread M_{50}
C. vulgaris	53.6%	26.9%
E. nigrum	59.2%	19.1%
U. europaeus	51.4%	34.5%
V. myrtillus	46.8%	25.1%
Sphagnum	56.5%	54.6%
Peat	34.9%	21.6%

Table 1. M_{50} values (FMC at which 50% of ignitions are successful) for the probability of ignition and spread in peat/litter fuel beds.

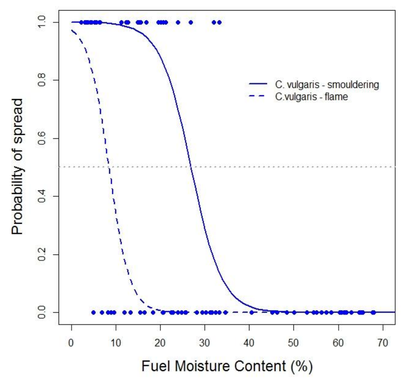


Figure 3. Probability of fire spread in *C. vulgaris* litter under different ignition sources. M_{50} values decreased from 26.9% to 15.2%.

Type of ignition source matters in determining the probability of spread; smouldering sources were more efficient (Fig. 3).

M_{50} values were variable depending on the source of ignition for *Calluna* vegetation. When a smouldering source was used, an increasing dead-fuel proportion increased the M_{50} from 19% to 35%. In contrast, the proportion of dead fuel had little effect when a flaming source was used, where M_{50} remained stable at *ca.* 30%.

M_{max} values increased *ca.* 5-10% over M_{50} values.

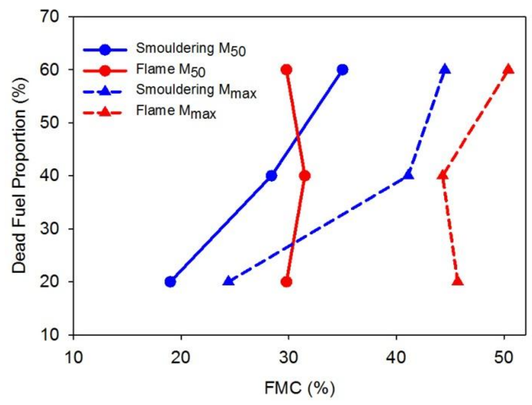


Figure 4. M_{50} values and M_{max} (the maximum FMC at which a successful ignition occurred) for the probability of ignition in *Calluna* vegetation.

CONCLUSIONS

- The moss/litter layer has different abilities to burn depending on the intrinsic characteristics of species. In addition, these properties are strongly modulated by their FMC.
- In *Calluna* vegetation the probability of ignition was influenced both by the proportion of dead fuel accumulated within the vegetation and their FMC.
- The different efficiency of ignition sources highlights the importance of knowing the main causes of wildfires in British moorlands for understanding fire danger.
- This work contributes to assessing moorland fire hazard. Further efforts in modeling moisture content of the moss/litter layer as a function of meteorological conditions is needed to improve fire danger rating systems.