

**Fire intensity,  
the threshold of control and  
fuels management.**

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# Introduction

- Fire intensity / flame length
- Fire suppression tools and techniques
- Thresholds of control
- Fuels management role in prevention

# With thanks to:

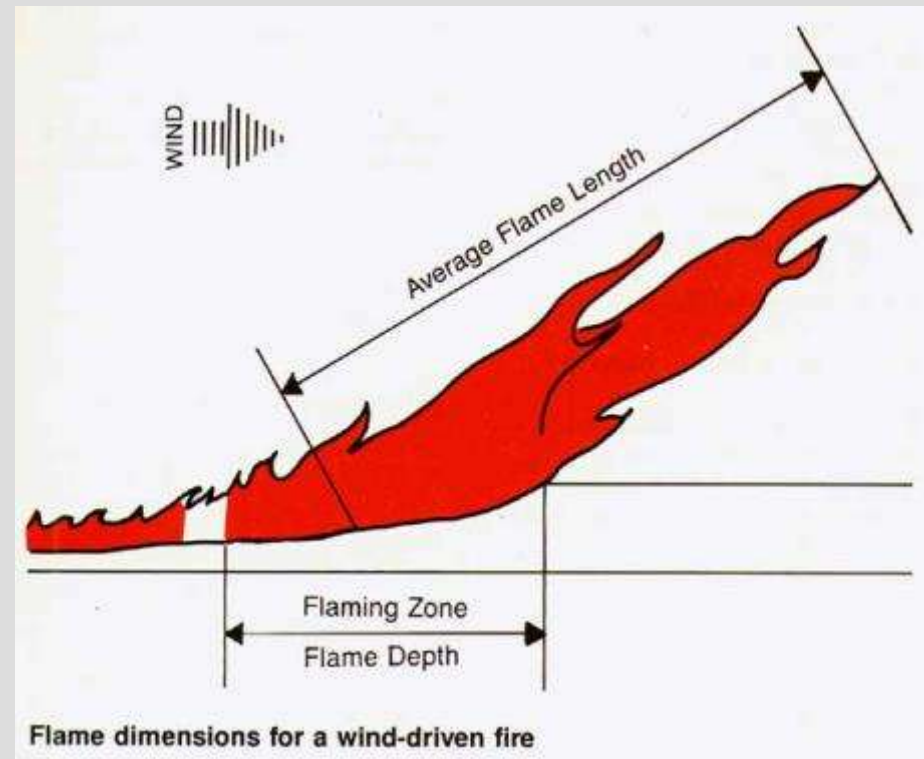
- Matt Davies (Ohio State University)
- Wendy Anderson (Aus. Defence Force Academy)
- Marty Alexander (Natural Resources Canada retd)
- Ian Murgatroid (Forestry Commission)
- Scottish Natural Heritage

# Fire intensity / Flame Length

## Fire intensity

- The rate of energy release per unit length of fire front
- Represented as kW/m
- $I = Hwr$ :
  - $H$  = Heat yield of fuel (kJ/kg)
  - $w$  = dry weight of fuel consumed (kg/m<sup>2</sup>)
  - $r$  = forward rate of spread (m/s)

## Flame Length



# Fire behaviour – key factors

- Wind
- Slope
- **Fuels**

# Ardnamurchan, 2003

- origin



# Ardnamurchan, 2003

- rapid fire spread uphill



# Ardnamurchan, 2003

- landscape scale, high intensity





# Land-use changes – higher fuel loads

- Reduced livestock numbers in marginal farming areas
- Active deer reduction programmes
- Land abandonment / Re-wilding,
- Large scale native woodland schemes at low stocking densities
- **All leading to increased surface fuels**

# Fuel quantity x2 ROS x2 & fire intensity x4

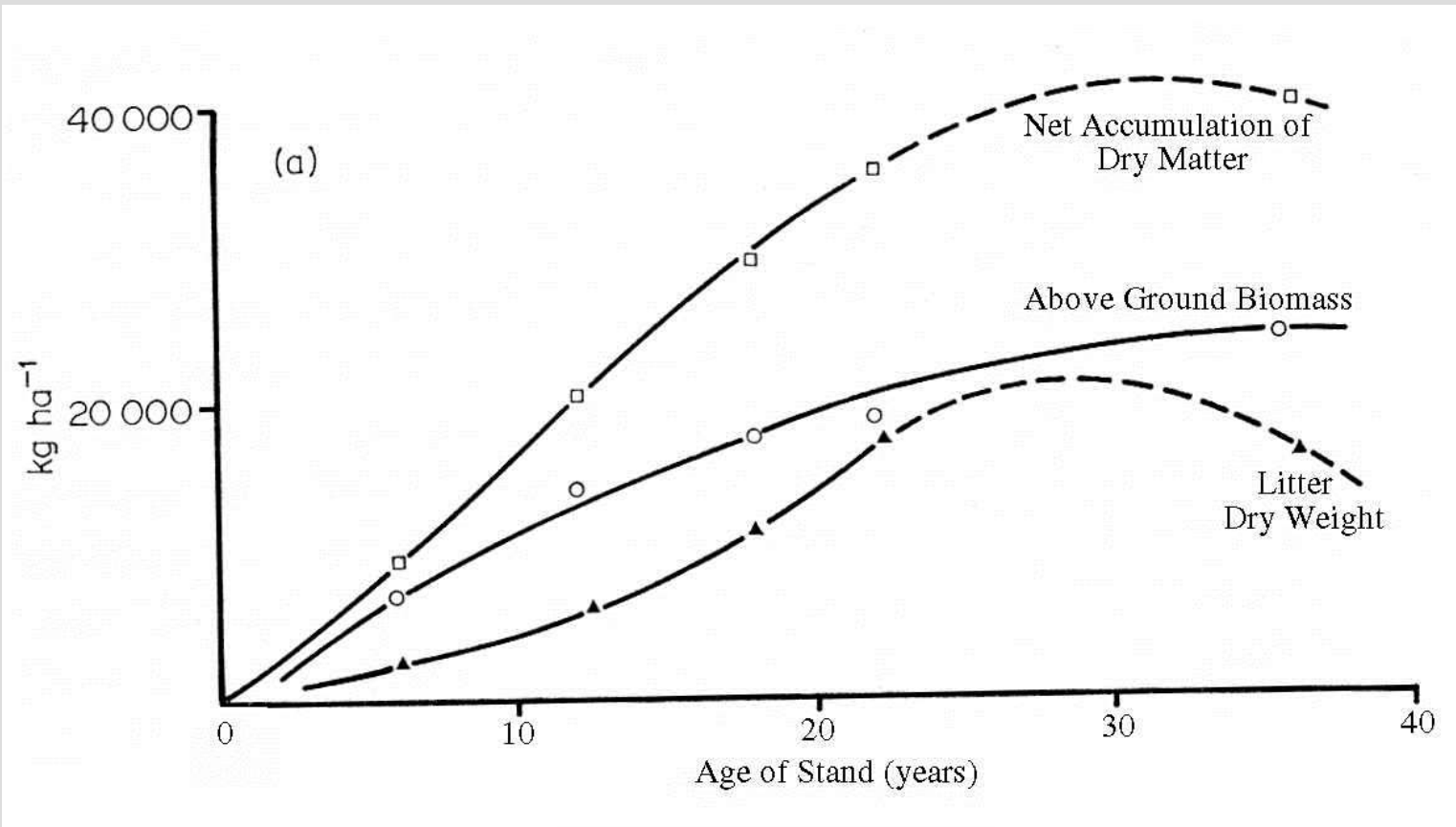
**High fuel quantity**



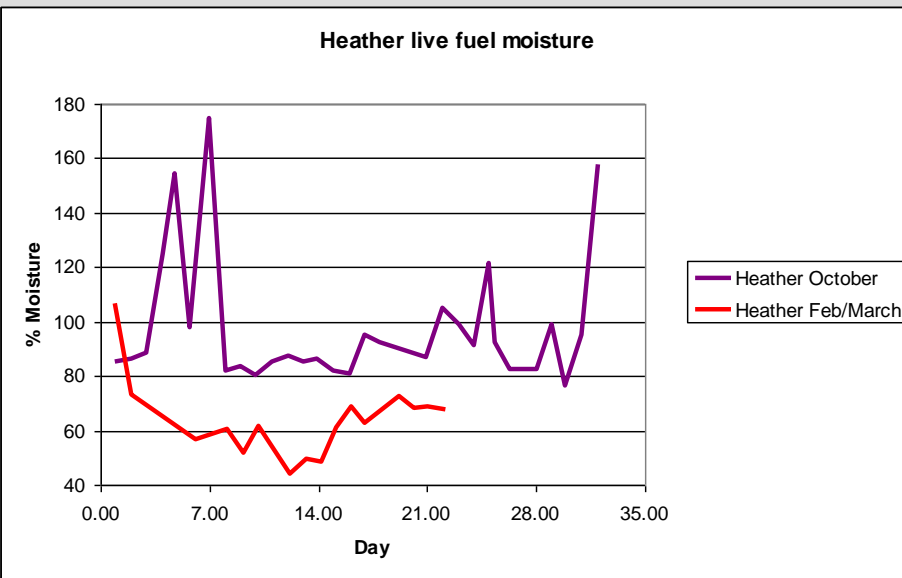
**High fire intensity**



# Heather fuel loads

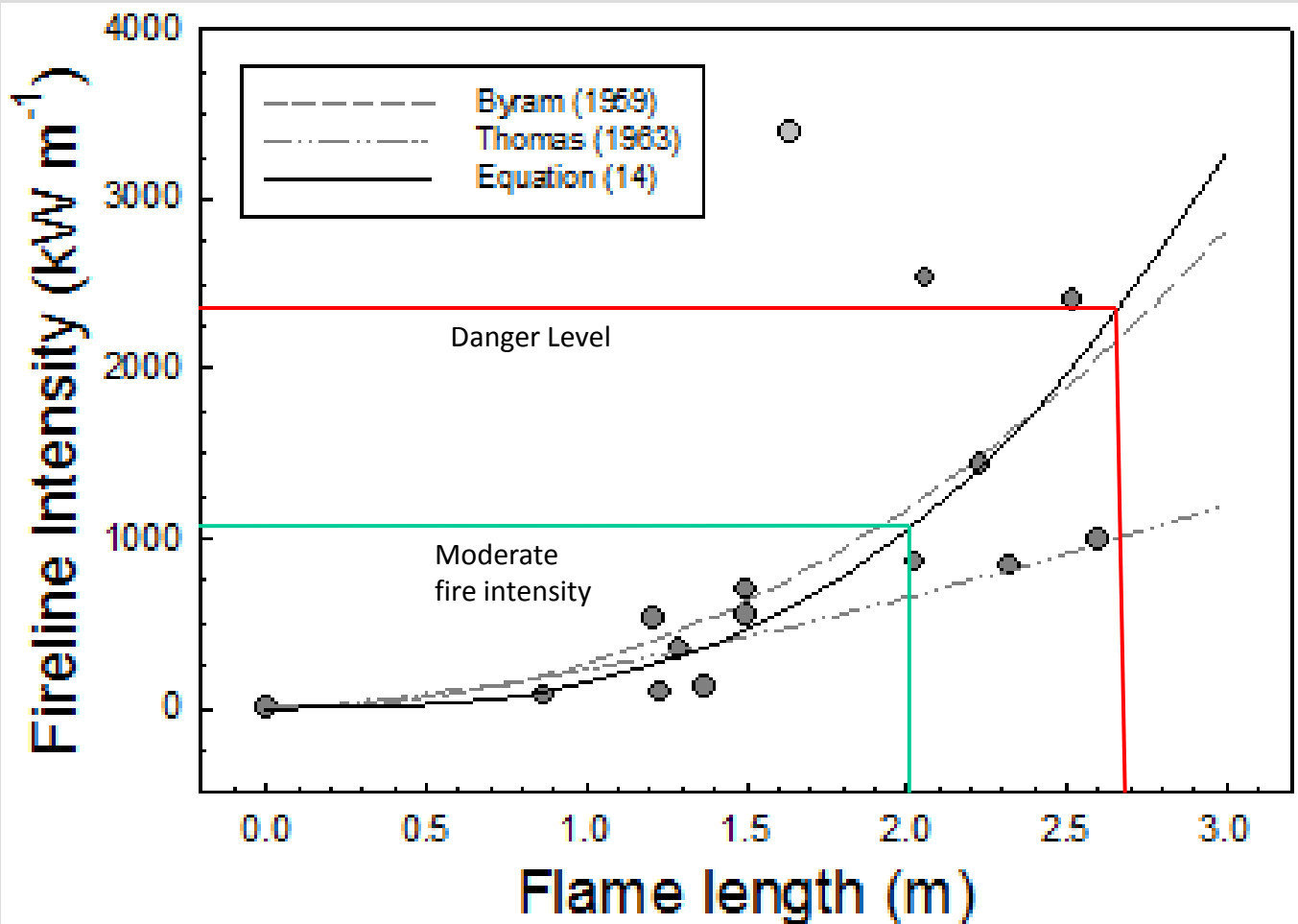


# Seasonal influences on fuel moisture



- **Available fuel** – dry enough to burn
- Different fuels react in different ways
- Also effect of drought on fuels e.g. spring & summer (curing)
- Effect of frost on heather

# Moderate Heather Headfires <2m flame length

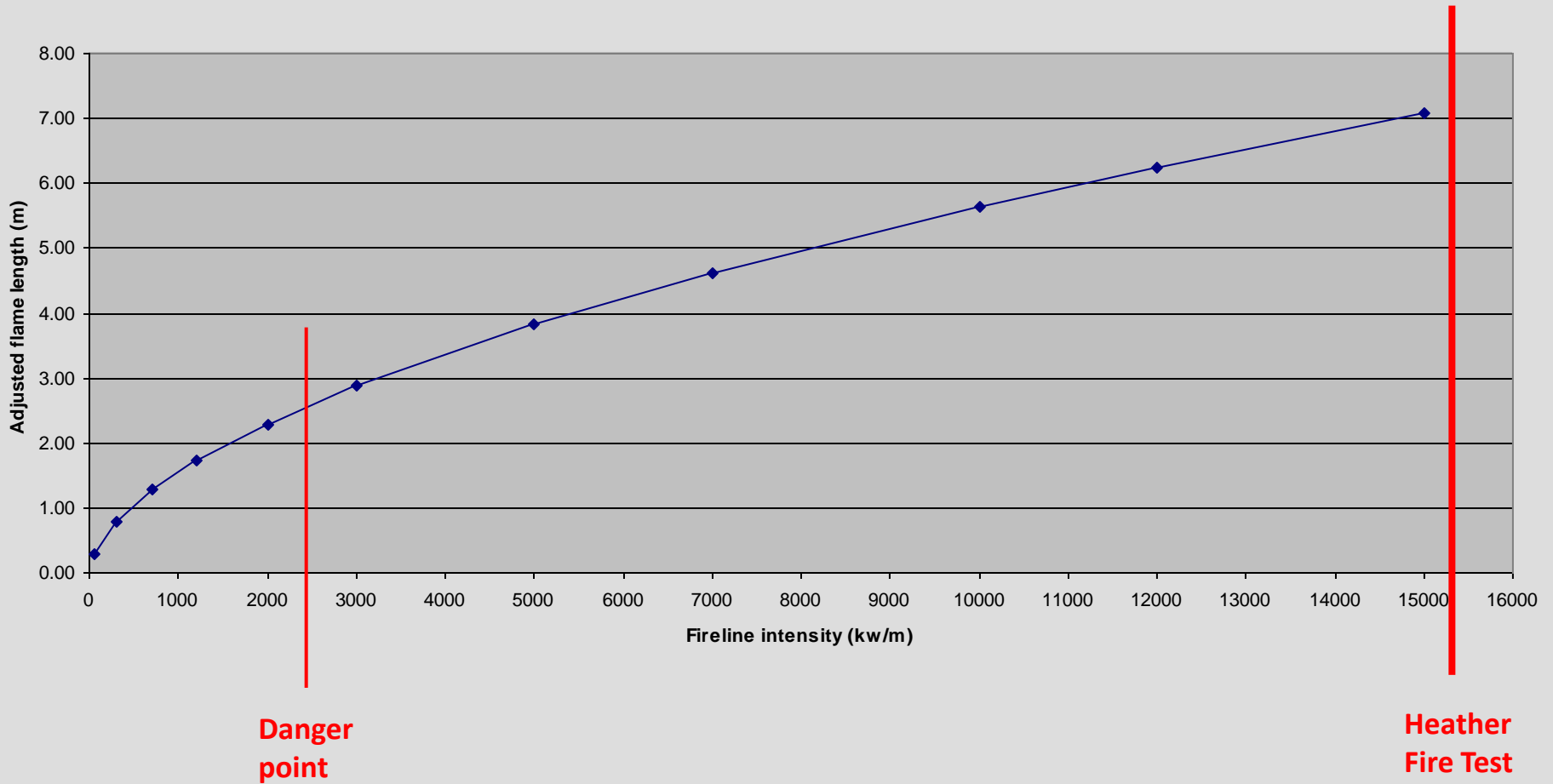


# Heather Fire Tests 2002



- Flame length  
6-8m
- Fire intensity  
15,300kW

# Relationship between heathland fire flame length and fire intensity (Catchpole 1998)



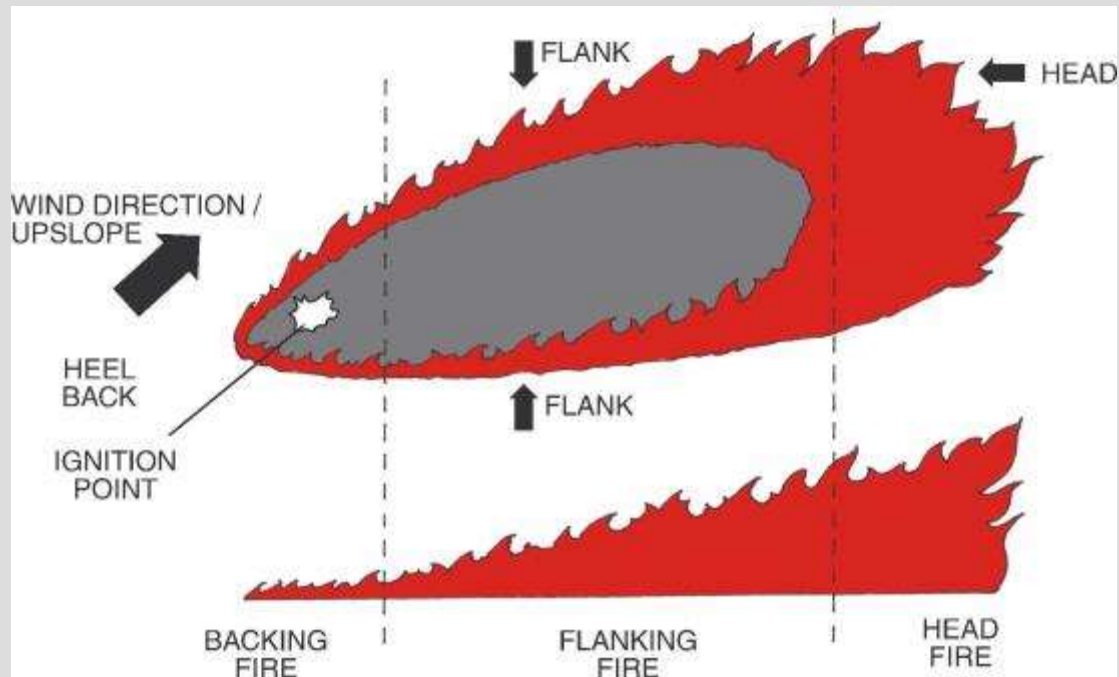
# Kintail, Ross-shire, NW Highlands wildfire 2011

*'Despite the best efforts of the crews on the ground, once the fires reached the trees, the flames leapt as high as 40 feet (12 m). At one point it looked as if the plantation might have been saved but the fires flared up again'*

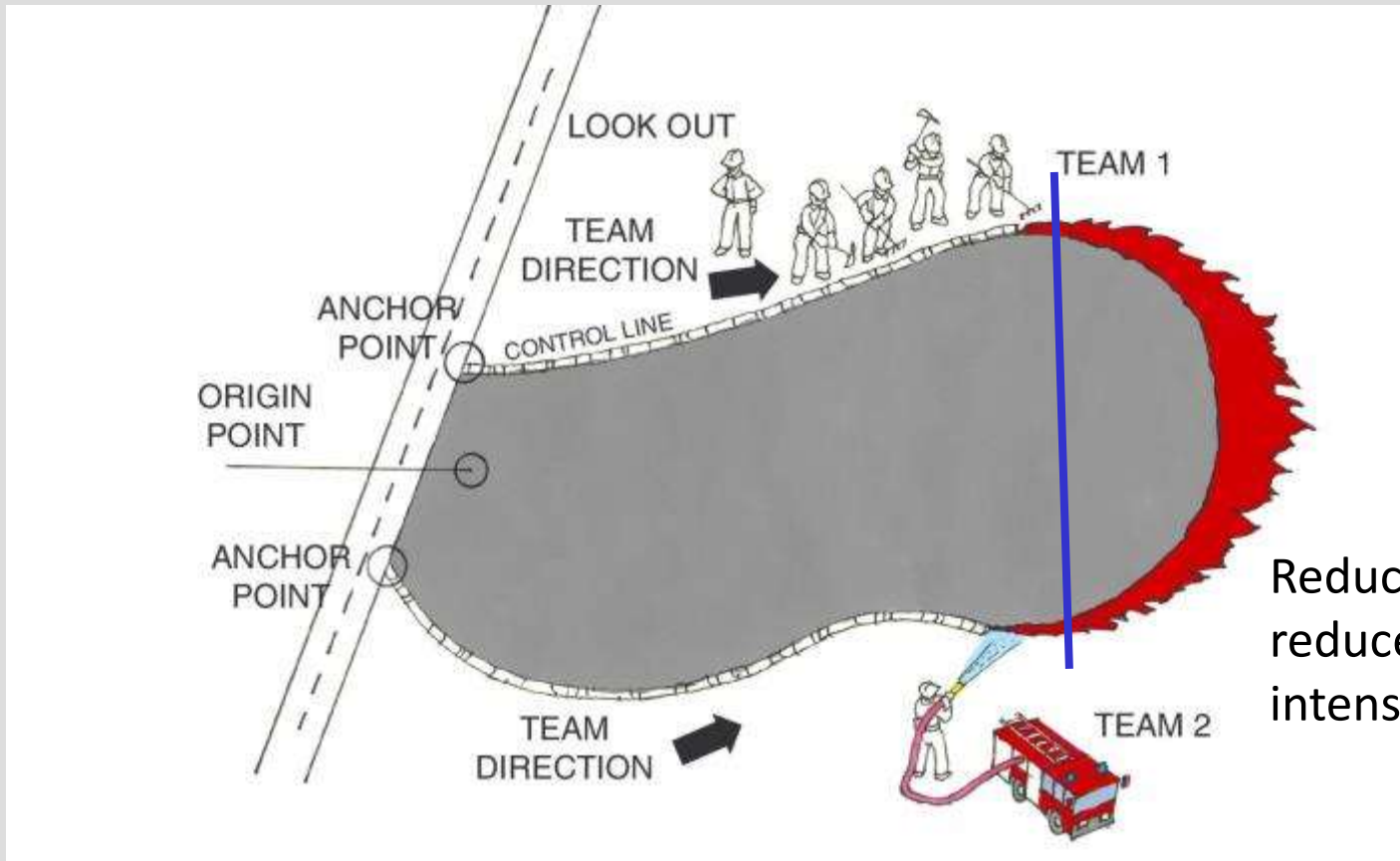
Pete Selman, 2011, National Trust Scotland,  
Director of Property and Visitor Services,



# Flame length – around the fire



# Flanking/pincer attack



# Suppression constraints

- Safety:
  - Radiant heat (distance from the fire)
  - Smoke
  - Carbon monoxide
- Fire intensity, rate of energy release – tools & tactics ability to break the fire triangle
- Resources available

# Upper limits of control - tools

- Hand tools
  - Power assisted
  - Helicopter
  - Backburning
- 500 kW/m
  - 2000 kW/m
  - 4000 kW/m
  - 10,000 kW/m

# Flame length & technique guide

Flame Lengths (m)	Significance
0 – 0.5	Fires generally self extinguish
0.5 - 1.5	Fire intensity low Hand tools can be used in direct attack to control the fire
1.5 - 2.5	Fire too intense for direct attack with hand tools Pumped water or bulldozers may be needed Flanking / parallel attack recommended
2.5 - 3.5	Fire too intense for direct attack from control line Helicopters & fixed wing aircraft drops may be needed Flanking / parallel attack depending on local flame length
3.5 - 8	Very intense fire Backburning and backfiring may knockdown the head fire Flanking / parallel and indirect attack recommended depending on local flame length.
8m+	Extreme fire behaviour Defensive strategies recommended

Flames < 1.5m – Hand tools



# Flames 1.5 – 3m – Pumped Water



# Helicopters - only 4m flames



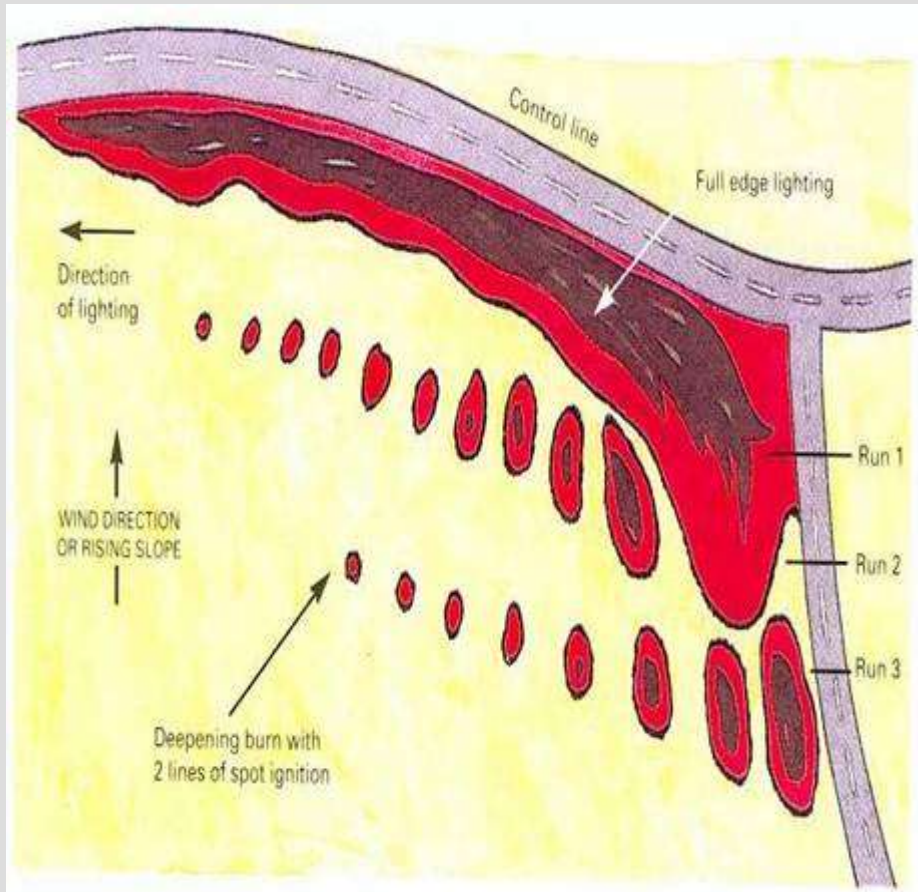
- Availability ?
- Limitations?
- Won't operate in smoke or at night



Fire in deep heather  
6 – 8 m Flames - ???



# Indirect Attack (Backburning)



- Takes time to get organised, ahead of the fire
- Highly skilled task
- Potential to create another fire

# Influences on suppression resources required

- Fire perimeter size
- Headfire Rate Of Spread (ROS)
- Flank/heel ROS
- Response time – Detection to Deployment
- Ease / difficulty of access for people, vehicles and equipment

# Tools suppression rates

- Beater – grass
  - Beater – heather
  - Fire fogging
  - Helicopter
- 180 m/hr
  - 370 m/hr
  - 400 – 700 m/hr
  - 750 m/hr

# ATV / fire fogging unit



- Good off-road
- Pump and roll capability
- Best in combination with beaters – conserve water
- Trained and experienced operators
- **Cost £40/hr**



# Helicopters



- Flexible and powerful
- Tree canopy reduces effectiveness
- Only 27% of water drops effective
- Best in combination with ground forces
- **Cost £1200/hr**

# Fire behaviour – key factors

- Wind
- Slope
- **Fuels**

# Fuels management

- Get ahead of the fire





# Firebreaks

**Reduce fuels strategically**



**Stops a wildfire – years later**



# Fire suppression summary

- Upper threshold of control for each tool & tactic
- Speed of effective response compared to rate of spread of fire
- Cumulative draw-down / exhaustion of resources

# Fuels management - summary

- As fuels reduced by half, rate of spread halves, fire intensity drops by a factor of x4
- Burned Firebreaks with most fuel removed reduce fire intensity x10 – x100-fold
- Burned firebreaks work best in combination with grazing and cutting

# Conclusions



- Prescribed burning and other fuels management is essential, to bring wildfire potential within the threshold of control
- Fuels management and firebreaks can prevent damage and make landscapes more resilient.